Research on strategies for fault diagnosis and maintenance of automobile electrical systems

Gong Naifa[1st, a*], Yi Fan[2nd,b], Hang Peng[3rd,c], Wang Junjie[4st,d], Li Zhengrong[5st,e], Huang He[6st,f]

Air Force Early Warning Academy, Wuhan, Hubei, 430070, China

[a*]Corresponding author:gong_naifa@foxmail.com
[b]yifan10101546@qq.com,[c]149064304@qq.com
[d]15172453692@163.com,[e]705361084@qq.com
[f]huanghe8989@aliyun.com

Abstract. The rapid development of the Chinese economy and technology has led to significant growth in the automobile industry. While cars are easy to use, they also have problems with maintenance, especially the detection and repair of electrical faults. Electrical system problems pose a great threat to the safe and stable operation of automobiles. Furthermore, it is imperative to enhance research efforts in fault diagnosis and maintenance of automotive electrical systems. It can not only effectively grasp the real causes of automobile electrical system faults, but also reduce the risk and ensure safe and reliable car operation. This article takes a certain equipment transport as the research object, introduces the vehicle electrical system, and analyzes the fault diagnosis and troubleshooting process. Later, a "five-step method" problem-solving process was proposed for electrical faults, which can diagnose and eliminate electrical faults more quickly. At the same time, it also classified and summarized common electrical faults of this model for reference by maintenance personnel.

Keywords: automotive electrical system, typical faults, diagnosis and troubleshooting, maintenance technology

1 Introduction

With the continuous development of social economy and the improvement of people's living standards, automobiles have become an indispensable means of transportation in people's lives. With the continuous development of automobile electronic technology, their structure, working principle and control strategy have also made great progress and changes [1]. As the number of automobiles increases, accidents caused by faults also deserve attention. Therefore, it is necessary to study the faults of automobile electrical equipment and propose diagnosis, detection and repair technologies to protect people's lives and property [2].

The electrical system occupies a high proportion in automobiles and has a strong restriction on the normal use and comfort of the vehicle. With the continuous emer-

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gence of new mechanical structures and electronic devices in automobiles, the requirements for comprehensive performance of automobiles have increased, and the automotive electrical system has undergone essential changes, leading to the diversification and complexity of automobiles. Various electrical failures will occur during the use of the car, which will not only affect the safe operation of the vehicle, but also threaten the life and health of the drivers and passengers.

Currently, there are varying degrees of research on both traditional fuel vehicles and new energy vehicles. Literature [3] analyzes the causes of difficulty in starting the engine; Literature [4] analyzes and compares the fault diagnosis methods of automobile electrical systems; Literature [5] analyzes and discusses Ford automobile electrical faults; Literature [6] analyzes and compares the fault diagnosis methods of automobile electrical systems; a case of brake switch failure of new energy vehicles was analyzed.

This article takes a certain equipment transport vehicle as an example, introduces the electrical system of the vehicle, and introduce the troubleshooting process of a certain type of vehicle. The "five-step method" process is proposed, which can diagnose and eliminate electrical faults faster, and finally classifies and summarizes common automotive electrical faults, which is convenient for maintenance personnel to refer to and use.

2 Introduction to equipment and vehicles

2.1 Vehicle parameter

This article takes a certain equipment vehicle as the research object. The basic information of this vehicle is shown in Table 1.

Table 1. Basic information of certain equipment and vehicles

Parameters	Unit	Value
Vehicle quality	Kg	5810
Vehicle fully loaded quality	Kg	12005
Vehicle size	mm	7250×2495×3100
Wheelbase	mm	3900
Engine model		BF6M2012-18E3
Engine capacity	ml	6060
Engine power	Kw	143
Fuel type		Disel
Maximum speed	Km/h	98

2.2 Introduction to automotive electrical systems

There are many types of electrical equipment on vehicles with different models, but their functions are basically the same. For the vehicle model studied in this article, it

can be mainly divided into six systems, namely power system, starting system, air conditioning system, lighting and signaling system, wiper system, electronic control system [7].

The starting system is mainly composed of starter motor, starting relay, ignition switch and other components. The function of the starting system is to start the engine and turn the engine from a static state to a running state. The automotive lighting system is mainly composed of headlights, fog lights, position lights, turn signals, brake lights, reversing lights, control relays, light combination switches, etc. [8]. The main function of the wiper system is to provide a good view for the vehicle, and the main components include wiper motors, wiper blades, etc. The car air conditioning system comprises refrigeration, heating, ventilation, and air purification components. The function of the air conditioning system is to maintain appropriate temperature and humidity in the vehicle cab and to freshen the air in the vehicle [9]. Automotive electronic control system consists of electronic control unit (ECU), sensors and actuators [10]. The role of the electronic control system is to realize functions such as automatic control, automatic alarm, and automatic diagnosis of working devices such as the engine, chassis, and body.

The characteristics of the automotive electrical system include: (1) DC power is used. The battery is not only one of the power sources of the car, but also a DC power source. After the battery is discharged, it must be charged with a DC power source. It must output direct current; (2) adopt low-voltage power supply, the rated voltage of automobile electrical system mainly has two kinds of 12V and 24V, and gasoline vehicles mostly use 12V power supply, heavy-duty diesel vehicles mainly use 24V power supply; (3) adopt single-wire system, usually under normal circumstances, the general electrical equipment is connected to the power supply. There are mainly two wires, the live wire and the neutral wire, in order to form a loop. However, the electrical equipment used in automobiles is mostly connected in parallel, so the conductivity is excellent; Iron, considering that the car mainly adopts a single-wire system, one of the two lines in the electrical system must be replaced by a metal body.

The car power system is mainly composed of batteries, generators, ignition switches, electromagnetic power main switches and other components. The function of the power system is to provide stable low-voltage DC power to the car.

3 Automobile electrical fault analysis and troubleshooting

3.1 Failure phenomena and characteristics of the electrical system

Fault diagnosis and troubleshooting of automotive electrical systems encompass a wide range of practical skills and knowledge. It not only requires observing the fault phenomenon, but also using commonly used tools and instruments to analyze and judge based on the fault phenomenon to find out the cause. Fault location, troubleshooting, recovery of the car.

User feedback that it is difficult to repair vehicle faults, especially many maintenance personnel know little about vehicle circuits. This article uses a fault case to explain the problem troubleshooting process.

The fault phenomenon is that the vehicle's double flash can be turned on, but the ignition switch is adjusted to the ON position and the main power switch does not close, and this phenomenon can be repeated. The fault phenomenon is relatively obvious, and can be determined to be an electrical fault of the vehicle.

3.2 Identification and resolution processes of the failure

It is initially determined to be a circuit fault of the power supply system of the vehicle. Next, the problems will be eliminated item by item. As shown in Figure 1, it is the circuit diagram of the vehicle power system.

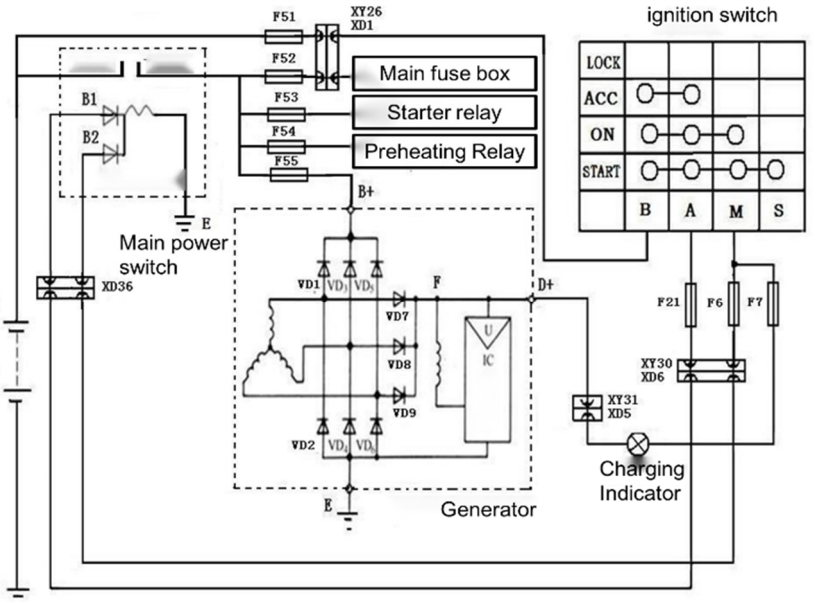

Fig. 1. Vehicle power system circuit diagram

First confirm the current direction of the ON gear circuit. The ON gear current direction is from the positive pole of the battery to the F51 fuse, to XY26, to the ignition switch B terminal, to the ignition switch M terminal, to the auxiliary fuse box F5 fuse, to the plug XY30/XD6, to the main power supply. Switch B terminal, to ignition switch E terminal, and then ground, forming a loop. After the B terminal and E terminal of the main power switch are energized, the upper and lower copper plates are attracted.

Troubleshoot problems one by one. The first step is to adjust the ignition switch to the ON position, and look for common faults. After replacing the main power switch, the fault still exists, and eliminate the fault of the main power switch; the second step is to check the electrical condition of the fuse relay. For this problem, it is fuse F6. Through inspection, it is found that the fuse F6 is not damaged. The third step is to detect the original circuit condition of the plug XY31/XD6 in the middle of the circuit, and use a multimeter to check the No. 1 hole of the connector (be careful not to pull out

the plug during the inspection process), and the voltage is 0V, indicating the fault point It is the positive pole of the battery to the middle of the plug. The fourth step is to eliminate the following circuits one by one, and finally detect the virtual connection at the rear of the auxiliary fuse box F6. The fifth step is to restore the faulty part, turn the ignition switch to the ON position, and turn the main power switch on (the sound of turning on can be heard), and the problem has been solved.

4 Failure Case Method Summary

4.1 Troubleshooting steps

Through the above problem solving, the steps of problem solving can be divided into five parts.

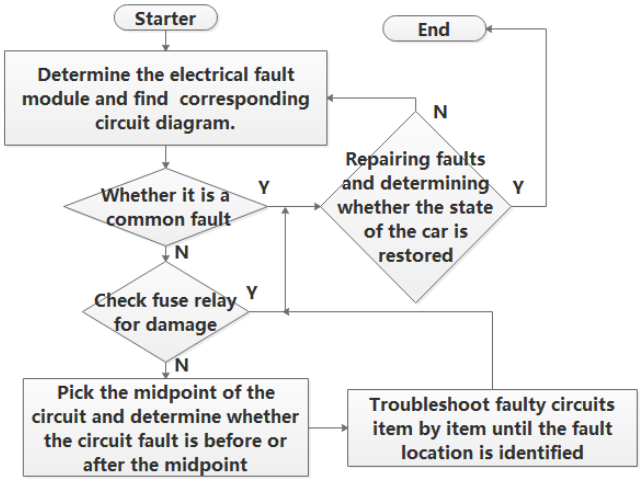

Fig. 2. Fault Diagnosis and Elimination Flowchart

The initial step involves addressing easily identifiable issues, such as burnt-out light bulbs in the lighting system, loose plugs on the front combination lights, and detached sensors in the electronic control system. If problems are found, proceed directly to step five.

The second step is to check easily replaceable parts, such as fuses and relays in the fuse box. The characteristic of this part is that it is easy to replace the parts. If any problem is found, proceed directly to step five.

The third step is to divide the circuit into two parts and determine whether the fault point of the circuit is in the front part or the rear part.

The fourth step is to use the DC voltage range of the multimeter to troubleshoot the problem part circuit by part until the final problem is determined, and then proceed to the fifth step.

Step 5: After troubleshooting the fault phenomenon, determine whether the entire vehicle has recovered. If the circuit has not recovered, jump to step 1 until the problem is resolved.

The advantages of the five-step scheme include that maintenance personnel can check faults one by one according to the process, avoid re-inspection of faults, and it is easier for new maintenance personnel to get started [10].

The specific flow chart is shown in Figure 2.

4.2 Program validation

The above method was extended to the neighboring automobile repairers, and the related failure cases were recovered and organized. A total of 47 cases were received from automobile repairers, of which 46 were problem-solving items and 1 was unsolved, with a program effectiveness rate of 97.9%. As shown in Table 2, the repair problems are categorized as shown in Figure 3. As can be seen from the figure, the automotive electrical system failure problems lighting and lighting system involves the highest frequency of problems, 29 times, probably due to the lighting and lighting system wearing parts (bulbs, speakers, etc.) is more, the power system and electronic control system problem frequency is lower. Unresolved items for the car idling state speed instability, and wait a few minutes, the vehicle stalled, the problem using the decoder to check the electronic control system related sensors, are shown to be normal, the problem may be related to the car's long service life or engine mechanical structure, to be followed up by continuous tracking.

Table 2. Maintenance case resolution

Parameters	Quantities
Number of issues	47
Number of issues solved	46
Number of issues unsolved	1
Program attainment rate	97.9%

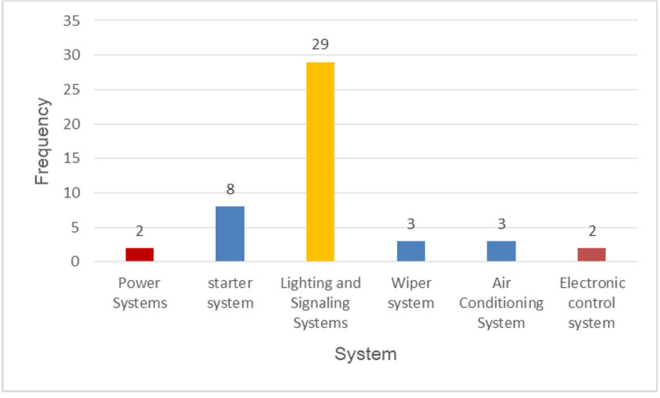

Fig. 3. Categorization of maintenance issues

4.3 Summary of common fault cases

Through communication with vehicle maintenance personnel, it was found that most of the problems were related to the first and second steps in the above process. The summary of common faults can shorten the maintenance time of maintenance personnel [11]. A summary of common problems with six automotive systems is shown in Table 3 for the convenience of automotive maintenance personnel.

Table 3. Summary of frequently asked questions about certain vehicles

System	fault phenomenon	Causes of common problems(Insurance/Relay)
Power Systems	The main switch of the power supply does not pull in; the battery is faulty; the positive and negative poles of the battery are in poor contact	Fuse: ACC gear circuit fuse F21, ON gear circuit fuse F6, charging indicator light fuse F7, normal power circuit fuse F51
starter system	Starter failure, no fuel; battery failure	Fuse: normal electric circuit insurance F51, starting relay electric insurance F53
Lighting and Signaling Systems	The lighting signal system bulb is damaged and the plug falls off	Fuse: ON gear circuit fuse F6, low beam fuse F27&F28, high beam fuse F11&F12, width indicator taillight fuse F24 relay: high beam relay J5, low beam relay J10, taillight width indicator relay J9 , Flash relay A2
Wiper system	Damaged wiper motor	Fuse: ON circuit fuse F6, wiper circuit fuse F1 Relay: high speed wiper relay J2, low speed wiper relay J1
Air Conditioning System	Refrigerant leakage; air conditioning compressor damage	Fuse: ON circuit fuse F6, air conditioning system fuse F9 Relay: air conditioning relay J4
Electronic control system	The sensor is damaged; the sensor plug falls off; and the decoder fails to read.	Fuse: ON circuit fuse F6 Relay: ECU relay J6

There are differences in repairing vehicles and fuse numbers. Repair personnel can re-create this table according to the vehicle repair or maintenance manual before using it.

5 Conclusion

(1) This article takes a certain type of equipment vehicle as the research object, introduces the basic situation of the equipment vehicle, analyzes specific problems, successfully solves the problem, and also verifies the rationality of the solution to the problem.

(2) For the steps of problem solving, a five-step method is proposed, and the problem is analyzed through five steps. This method allows electrical maintenance personnel to repair vehicle electrical problems faster, and can also be used for complex problems and multi-cause problems.

(3) A total of 47 data sets were collected in the text, and data will continue to be collected subsequently.

(4) This article only studies one model, and will analyze the rest of the models later, and will further expand common problems.

References

1. Feng NS. Analysis of automotive electrical fault detection and repair[J]. Automobile and New Power,2022,5(04): 90-92. DOI: 10.16776/j.cnki.1000-3797.2022.04.010.
2. Xu QQ. Strategic research on fault diagnosis and overhaul work of automobile electrical system[J]. Internal Combustion Engines and Accessories,2022(16): 81-83. DOI: 10.19475/j.cnki.issn1674-957x.2022.16.037.
3. Li ZT, Chen HS, Li WZ, Jiang YY. Analysis of the causes of engine starting difficulty in CA1125J[J]. Mobile Power and Vehicles,2015(04):44-46.
4. Zhang JH. Diagnosis and repair of automobile electrical system failure[J]. Times Automobile,2021(22):181-182.
5. CHEN RL, LI CM. Discussion on the case of Ford automobile electrical system repair[J]. Automobile and Driving Maintenance (Maintenance Edition),2020(11):36-37.
6. Li X. Fault diagnosis of new energy vehicle brake switch based on flowchart[J]. Internal Combustion Engines and Accessories,2023(08):46-48. DOI: 10.19475/j.cnki.issn1674-957x.2023.08.021.
7. Tao X. Research on diagnosis and repair technology of automobile electrical system faults[J]. Internal Combustion Engines and Accessories, 2022(01): 132-134. DOI: 10.19475/j.cnki.issn1674-957x.2022.01.043.
8. Wu L. Exploration of automobile lighting headlight troubleshooting[J]. Specialized Vehicles,2023(02): 80-82. DOI: 10.19999/j.cnki.1004-0226.2023.02.024.
9. Chen LJ, Wei XK. Fault diagnosis and troubleshooting of automobile air conditioning[J]. Automotive Maintenance,2023(01):31-33.
10. Han XC. Failure diagnosis and analysis of automobile engine electronic control system[J]. Times Automobile,2023(07):156-158.
11. Fu Yang. Discussion on the common failure maintenance technology of automobile electrical equipment[J]. Internal Combustion Engines and Accessories,2021(21):142-143. DOI:10.19475/j.cnki.issn1674-957x.2021.21.067.