

# Study on Intermittent Failure Phenomenon of the Automotive Environmental Light Sensor

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Abstract: According to the failure or intermittent failure of the FC-3AB ambient light sensor that feedback from the production site of Geely Automobile, the vehicles in this condition were tested and it is found that after the key hits the ignition lock ON file and switch the AUTO file, ark light environment (palm cover sun sensor) lights automatically open function is failure. When the car headlight is turned on manually, the headlight can be turned on, indicating that there is no problem with the car headlight. In this paper, the factors that cause the failure are collated and analyzed, and the fish bone map is drawn. Through the analysis of the quality of the ambient light sensor and the analysis of the process steps, it is determined that the solution is to seal the sensor assembly to ensure that the internal circuit of the shell does not fail due to moisture, the headlights of the car can be turned on normally, and the light in the car can be automatically adjusted. Eventually, the correctness of the solution is verified through experiments, and the failure rate of the automotive ambient light sensor is minimized, effectively improving the reliability of the ambient light sensor and the safety of driving.

## 1 INTRODUCTION

With the rapid development of power electronics technology, electrical control systems are increasingly integrated (Wu gang, wang xiaoyu, zhang Yang, liu jia, 2015) Among them, the safety fault of automobile ambient light sensor is directly related to the safety of driving and can not be ignored. The failure or intermittent failure of the ambient light sensor will prevent the car headlights from turning on automatically, resulting in a greater probability of accidents in traffic when a tunnel or dark light section is encountered, which will seriously affect the safety of the occupants. At the same time, it also poses a threat to facilities outside the car and pedestrians or other vehicles (Zhang deqian, hong yuanquan, zhao yongquan, 2017) And ... According to statistics, about 5,000 traffic accidents are caused by driving fatigue during driving each year, of which about 400 directly cause death, and the situation in Europe is roughly the same. In June 2017, there were 63 failures or intermittent failures of the FC-3AB ambient light sensors that were feedback from the production site

of the Xiangtan Geely Automobile Assembly Workshop. The phenomenon was that the vehicle was charged (the key hit the ignition lock ON file) + after switching the AUTO file. Dark light environment (Palm cover sun sensor) lights automatically open function failure. In this paper, the failure rate of vehicle ambient light sensor is minimized and the reliability of ambient light sensor is improved.

## 2 ANALYSIS ON THE CAUSES OF FAILURE OF ENVIRONMENTAL LIGHT SENSOR

### 2.1 Environmental Light Sensor Voltage Testing

After testing, the input level V2 of the normal part is less than the output level V3 under dark light condition, and the headlamp can be turned on

normally; under dark light condition, the input level V2 is larger than the output level V3, and the headlamp is not on. By testing the voltage of the circuit, it can be determined that there is a quality problem with the ambient light sensor assembly. Voltage test values are shown in table 1 and table 2.

Table 1. Test results for normal parts.

Coding	Input Voltage V2(V)	Output Voltage V3(V)	Ispection Results
1	373	125	qualified
2	396	142	qualified
3	367	119	qualified
4	402	183	qualified
5	421	166	qualified
6	385	152	qualified
7	397	169	qualified
8	372	143	qualified

Table 2. Test results for failure pieces.

Coding	Input Voltage V2(V)	Output Voltage V3(V)	Ispection Results
1	298	672	unqualified
2	421	683	unqualified
3	361	1220	unqualified
4	200	872	unqualified
5	375	872	unqualified
6	321	962	unqualified
7	298	738	unqualified
8	342	697	unqualified

## 2.2 Photodiode Fault Troubleshooting

The photoelectric sensor fault screening, the most important is whether the screening is photodiode whether there is a quality problem, so the photodiode also to carry out voltage testing. The test of photodiode is also to verify the relationship between input voltage and output voltage. As is

known to all, photodiode has one-way conductivity, and if the photodiode is reversed, the resistance will become infinite. The corresponding voltage will also change, and this test is based on this principle to verify whether the photodiode is qualified or not.

As shown in table 3 and table 4, the photocell ratio of the two groups of components is basically the same, and it can be seen from the voltage test that they have one-way conductivity, which proves that there is no fault of the two groups of photodiodes, so the fault of the photodiode itself is eliminated.

Table 3. Photodiode voltage test results for normal components.

Coding	Input Voltage V2(V)	Output Voltage V3(V)	Ispection Results
1	19.26	1	qualified
2	19.14	1	qualified
3	19.24	1	qualified
4	19.07	1	qualified
5	19.33	1	qualified
6	19.12	1	qualified
7	19.27	1	qualified
8	19.36	1	qualified

Table 4. Photodiode voltage test results for fault components.

Coding	Input Voltage V2(V)	Output Voltage	Ispection Results
1	19.27	1	unqualified
2	19.36	1	unqualified
3	19.14	1	unqualified
4	19.36	1	unqualified
5	19.33	1	unqualified
6	19.17	1	unqualified
7	19.07	1	unqualified
8	19.32	1	unqualified

### 2.3 Red Rubber Reflow Soldering Step Checking

The so-called reflow soldering is to melt the solder paste (solder paste) so that the surface-assembled components and PCB boards are firmly bonded together (Qi cheng, 2011). The equipment used is a reflow soldering furnace located behind the mounter in the production line. For example, table 5 is the reference temperature of common red adhesive reflow welding process, and the reference temperature of three kinds of solder paste commonly used in the table is at different temperature zones. Table 6 is the equipment parameters of the manufacturer. The solder paste used is SN63PB37. You can see, the equipment parameters and reference parameters are consistent basically, because considering the time cost, this will be a thing or two, three or four low temperature region merging, and slightly increased the welding temperature, but these smaller factor changes will not affect the process to produce waste, therefore rule out the possibility that this process has a problem.

In addition, it is necessary to consider whether the quality of the patch is affecting the overall effect of the photoelectric sensor. So first check the patch model, found no error. After the replacement of the normal pieces of the patch, the products are OK. Then check whether the patch position of the fault parts is correct, and find that there is no part beyond the welding pad at both ends, so there is no problem with the patch. Therefore, there is no problem with the process.

Table 5. Three solder paste reflow soldering temperature Settings at 8 temperature zone.

Temperature Range	SN63PB3 7	SN42BI5 8	SN96.CU O
1	130 °C	80 °C	130 °C
2	140 °C	110 °C	160 °C
3	150 °C	130 °C	180 °C
4	160 °C	150 °C	200 °C
5	175 °C	160 °C	220 °C
6	190 °C	180 °C	240 °C
7	210 °C	190 °C	255 °C
8	200 °C	180 °C	235 °C

Table 6. Equipment parameters of manufacturers

1,2	3,4	5	6	7	8
140 °C	170 °C	190 °C	200 °C	220	190

### 2.4 Wave Crest Welding Procedure Inspection

First consider whether the parameters for this process are set correctly. First, consider preheating. The tin furnace temperature of this process is kept at 250 °C, which is consistent with the reference value. Therefore, there is no problem with the process. Then consider the transport speed (stripping speed). Generally speaking, too fast stripping speed will lead to PCB preheating not reaching the ideal temperature, and too slow will lead to too high temperature, which may damage PCB board. Therefore, the speed is usually set at 1100mm-1200mm, which is consistent with the manufacturer's production parameters. Finally, the quality of flux was considered. The flux model was RF800, and the manufacturer was found to have the production qualification, so there was no problem with the model. However, it was observed that the surface of the fault parts could help with flux residue, and it was considered that poor contact of the circuit was caused by flux residue. Therefore, the surface of the fault parts was cleaned with washing board water, and then assembled and tested. It was found that the product could work normally, so we considered that the intermittent failure of the ambient light sensor was caused by the quality of flux. In order to further confirm this idea, we applied for trial production of 500 pieces of GOLF nh-4 flux and put them into the refrigerator for moisture regain. The final test results showed that no such phenomenon occurred in all products. Therefore, it can be concluded that the quality of flux causes intermittent failure of ambient light sensor.

### 2.5 Wire Harness Welding Inspection

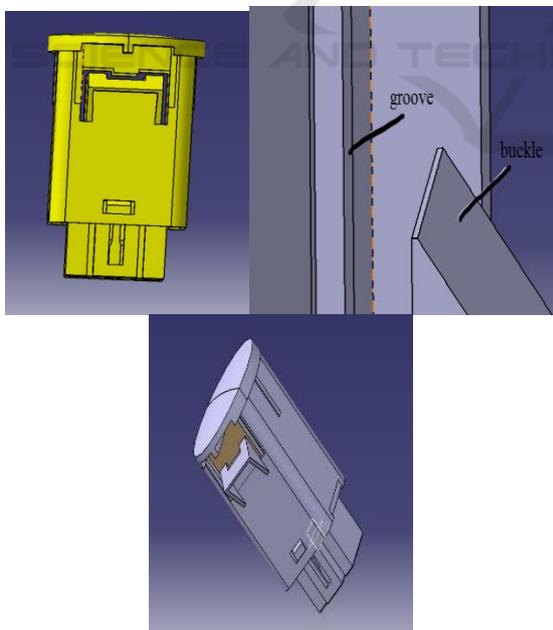
No broken skin or core leakage was found in the wiring harness inspection. Therefore, the quality problem of the two hardware is excluded. The welding method is manual welding, and the temperature is 350 °C, which conforms to the specified temperature.

Based on the above tests, it can be concluded that the intermittent failure of ambient light sensor is caused by short circuit due to poor flux quality. In order to verify that the fundamental factor is the quality of flux, make the following test again: clean the flux residue of the failed parts with washing board water, and then dry the test, and find that 100% of the failed parts can be used normally. Then a control group was made again. Another part of the defective parts were cleaned with plate washing

water and then dried naturally. Then they were put into the refrigerator for moisture regain for two hours. It is concluded that the flux residue absorbs a certain amount of moisture and leads to short circuit.

### 3 IMPROVED DESIGN

As shown in Fig.1 (a), there is no gap in the buckle part of the shell to prevent the water vapor from entering, but the buckle cannot be recessed when under pressure, so the sensor assembly cannot be easily installed in the car. If a large pressure assembly is used, it may crack the sensor housing and cause water vapor to enter. It is planned to set an impervious groove in the location of the buckle. Before drawing the groove, the dimensions of the buckle and the shell should be analyzed. In the modeling process of the original part mentioned above, the shell thickness is defined as 1.05mm, and the buckle height is 3.6mm. Suppose the groove depth is defined as 1.0mm, the sensor assembly moves the distance of the buckle to the inside when assembling, which is 1.0mm, making it difficult to assemble. Therefore, to increase the depth of the groove, the inner wall of the shell should be thickened. The improved design is shown in Fig.1 (b) and Fig.1 (c).



(a) Fault component model, (b) The design of the grooves, (c) Improved model

Figure 1. Comparison of models before and after improvement.

Because the size of the base is designed according to the outline of the bottom of the shell, there will not be too large gaps in the assembly. Sealing performance, in order to guarantee the assembly requirements shell and base are assembled on the base of the surface coated with sealant, if adopts the integration of welding seal due to the welding quality is not controllable, can cause there is not roa (Zhang cao, 2008), and the price of this product is very low ambient light sensor, when the sensor in the cause of the problem, only need to replace the sensor, so apply sealant is appropriate.

### 4 IMPROVE THE EXPERIMENTAL VERIFICATION OF THE DESIGN SCHEME

Considering the contingency of failure, 300 pieces of environmental light sensor with improved design were trial-produced, and the test results were 100% qualified rate, and the voltage was V2 less than V3. Therefore, the possibility of deviation of experimental results caused by product quality problems is excluded.

Although the sealing technology is not a leading technology, it is often a decisive key technology (Chen feng, zhang wei, wang xunming, 2011). The sealing technology in this paper is related to the safety and reliability of vehicles, so it is necessary to conduct an extreme environment test for the inspection link. Check the sealing performance of the product, put the product in the refrigerator for moisture regain, so as to expose the product to the air with the relative humidity of 100%, and simulate the air environment with extreme humidity as much as possible. In order to verify that the product can be used reliably in a humid environment for a long time, the moisture return time is specially set as 3 days. After the return of moisture, the voltage of the ambient light sensor was tested, and it was found that 100% of the input voltage of the product was lower than the output voltage, and the voltage was normal. The product is then assembled into the vehicle, and the headlights can be started and opened in the case of dark light. Cover the sensor with your palm, and the headlights can be automatically opened without failure.

## 5 CONCLUSION

Based on the ambient light sensor failure phenomenon appears in the car caused headlight, opening and closing failure first detect the quality of optical sensor, found the photodiode itself there is no quality problem, second to the ambient light sensor process troubleshooting steps, mainly check the reflow, wave soldering process, and found in wave soldering, flux residues led to the sensor failure, the last light sensor wiring harness for testing, test is normal, thus determine only flux residues led to the failure in the product. The failure reason is that the flux is affected by moisture and water absorption, resulting in short circuit of the circuit board. According to the failure reason, the improvement plan is to seal the shell, mainly to improve the size and position of the shell and base buckle. Define grooves to ensure that the buckle can move inward under pressure and ensure the sealing of the shell; In order to ensure no gap between the base and the shell, interference fit is adopted. The rationality of the improved design is verified by the sealing and reliability test of the new product.

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