An Auto Lighting Device for Backlight System Detection

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Abstract. In the manufacturing of electronic products, the quality of backlight always affects the final rate of good products. To date, the quality of backlight is usually detected by manual eyes. In this article, an auto lighting device used for backlight system detection was fabricated with STM32 chip which based on the ARM core. Firstly, the FPC was pressed closely on the dense goldfinger. Then, positive or negative weak current signal was sent respectively from the transistor array which was controlled by the STM32 chip. Thirdly, the positive or negative of FPC electrode was judged intelligently by the STM32 chip. Finally, according to the judgment results, the operating power with corresponding electrode polarity was provided to light the backlight system. The auto lighting detection of the backlight quality could be realized perfectly by this device.

Introduction

In recent years, the popularity of intelligent mobile has promoted the rapid development of mobile phone LCD screens. It is reported by NPD Display Search [1] that, in the first half of 2014, the output of mobile phone LCD screens in China was more than 300 million pieces. Generally, the LCD screen consists of backlight unit, liquid crystal screen and lenticular raster system [2]. As the core part of the LCD screen, the productivity of the backlight unit has a heavy influence on the shipment of LCD screens.

In order to ensure the quality of electronic products during the production process of the backlight unit, it is necessary to inspect the backlight unit one by one to sort out the unqualified products. Some kinds of defects in the backlight unit need to be inspected under the condition of lighting. In the manual inspection, the worker needs to position the backlight unit on the fixture mechanically and ensure the correctness of the FPC electrode polarity which is on the top of the backlight unit. Then, aligns the electrode polarity of FPC on the fixture and presses them by hand. At last, the worker lights the backlight unit and inspects the quality. Obviously, the efficiency of manual operation is very poor and the test standard is hard to unify. Facing with the pressure of huge demand for products and shortage of labor force in the electronic manufacturing industry, the machine vision equipment has been developed to improve the efficiency and quality of the production [3] [4]. In fact, the key technology of the backlight unit inspection device is how to light the backlight unit automatically and quickly. Due to the mechanical manufacture deviation, there are printed deviation and registration deviation with FPC electrode on the backlight unit. If utilizing traditional counterpoint lighting method in automatic detection equipment, there would be some possibility that FPC electrode connects with the positive and negative electrode of fixture at the same time, which would result in the good product to be judged as NG product. It will seriously affect the detection results and detection efficiency of the inspection equipment. Therefore, it is urgently required to invent an efficient automatic lighting device.

In this research, an automatic lighting device has been developed through the analysis of the traditional manual lighting inspection. The connection mode of traditional lighting device is replaced by the connection between FPC electrode and dense goldfinger which contains numerous tiny electrode filaments. The polarity of electrode filament can be set intelligently according to the detected polarity of FPC electrode on the backlight unit. In this way, the contact deviation resulted from mismatch between FPC electrode and dense goldfinger electrode...
of the fixture can be ignored. It is equivalent to that the electrode polarity of electrode filament can move forward according to the polarity of FPC electrode. Experiment results showed that different types of backlight unit can be lighted by the auto lighting device fast and accurately.

**Manual lighting inspection**

The traditional lighting inspection device consists of fixture and power supply system. During the inspection of backlight unit, the worker needs to fix the backlight unit on the fixture mechanically and make sure the FPC electrode and the electrodes on the fixture are aligned, showed in Fig.1(a). Then, inspects the quality while pressing the FPC electrode and lighting the backlight unit up. In fact, there are two main problems of the traditional lighting inspection.

1. (1) Poor universality. One type of the fixture of traditional light device is only suitable for certain types of FPC electrode. If the FPC electrode type of backlight unit has changed, it needs to change the fixture type at the same time, which will raise the processing cost.
2. (2) Easy to misjudge. In testing process, the stress and the alignment error between FPC electrode and electrode filament are controlled by workers. Working in high-tension condition, it is difficult to ensure the accuracy and consistency of the inspection that would lead to misjudge of the backlight quality because the backlight unit couldn’t be lighted.

The working principle of the auto lighting device

On the background of increasing backlight output and high scale of production automation, it’s a general trend to apply the on-line automatic detection equipment. However, there is printed deviation of FPC electrode due to mechanical manufacture deviation. If directly adopting the traditional counterpoint lighting method in the on-line automatic detection equipment, it is very possible to lead to the trouble that FPC electrode contacts with wrong electrode of fixture. In this situation, the backlight unit couldn’t be lighted normally.

Fig.2 shows the system construction of auto lighting device, including dense gold finger, FC connector wire, intelligent control system, DC stabilized power supply and the encapsulation shell. The intelligent control system includes gold finger connector, transistor array, main control panel and control power supply.

![Fig.2 Scheme of auto lighting device](image-url)
Fig. 1(b) shows the dense goldfinger. It can be seen that the dense goldfinger comprises many tiny electrode filaments, every electrode filament connects with two DTR drive transistor which are included in the transistor array independently.

The working principle of the auto lighting device is as follows. Firstly, press the FPC electrode on the dense goldfinger closely and ensure that at least one electrode filament of gold finger contacts with the FPC electrode. Secondly, the dense goldfinger connects with the intelligent control system through FC connector wire. Positive or negative weak current signal is sent rapidly and orderly from STM32 control chip which is located on main controller board to the dense goldfinger. Through transistor array and sampling circuit, the intelligent control system can recognize automatically where the FPC electrode are situated on the goldfinger and judge the polarity relationship between goldfinger electrode filaments and FPC electrode. Thirdly, according to the judgment results, the intelligent control system classifies the electrode filament into two categories (anode and cathode) and finds out the boundary between anode and cathode of electrode filament. At last, the operating power is provided with working voltage or working current to light the backlight unit.

Fig. 1(c) shows the contact model of FPC electrode and dense goldfinger. There are two electrodes in the FPC. A represents positive electrode and B represents negative electrode. There are 13 electrode filaments on the goldfinger which are tagged with letters from a to m. The A electrode contacts with the electrode filaments marked with c, d, e. The B electrode contacts with the electrode filaments marked with g, h, i.

Take the electrode type of FPC (shown in Fig. 1(c)) as an example to explain the detecting principle. Firstly, set the interval number as three with the control program before inspecting. Then, STM32 control chip controls transistor array to transmit weak positive and negative signals to goldfinger sequentially and quickly. It can be seen that the electrode filament can’t connect with FPC electrode to form the current loop while electrode-a flows through positive current and electrode-e flows through negative current. And the same situation will happen if electrode-b flows through positive current and electrode-f flows through negative current. The current circuit will be achieved until electrode-c flows through positive current and electrode-g flows through negative current. At the same time, the sampling circuit received the signal and feeds back to the STM32 control chip. The STM32 control chip judges that if the electrode-c filament contacted with the positive FPC electrode and the electrode-g filament contacted with the negative FPC electrode or not. When the current loop is formed, the negative signal on electrode filament will keep the same while the positive signal moving forward. Then, the electrode-g filament keeps negative signal and electrode-d flows through the positive signal. By such analogy, the positive signal keeps moving until electrode-f flows through the positive signal and the current loop is destroyed simultaneously. Therefore, the intelligent control system is able to determine that electrode-f filament of dense goldfinger is the boundary between anode and cathode of electrode filaments relative to FPC electrode. At last, the operating power was provided to light the backlight unit with corresponding electrode polarity by controlling the transistor array. Under the control of STM32 control chip, the positive charge flows through electrodes from a to e and the negative charge flows through electrodes from g to m while electrode-f without power supply.

The fabrication of auto lighting device

According to the principle and method above, the auto lighting device has been fabricate. Fig. 3 shows the PCB board of control system. The STM32 control chip works as the core of control system which is exploited by STMicroelectronics. The STM32 control chip has powerful extending function with ARM as the core architecture and 16kb RAM and 4kb ROM, which totally satisfy the design requirement of auto lighting device. The densegold finger is one of the most important parts in the device. It serves as interface channel and electric channel to connect the backlight unit with the FPC electrode. The dense goldfinger includes a lot of tiny electrode filaments. Every electrode filament connects the control system by FC connector wire. The inspection signal and voltaic signal is sent from transistor array to FPC electrode under the control of
STM32. The power of control system and backlight unit is supplied by power management system separately.

Through applying auto lighting device in backlight inspection, it only needs to press the FPC electrode dense gold finger tightly and ensure that the FPC electrode contacts with at least one electrode filament. Under the control of STM32 chip, transistor array transmits weak positive and negative signals to gold finger sequentially and quickly. According to the inspect signal fed back by sampling circuit, the STM32 chip is able to find out the polarity boundary of electrode filament relative to FPC electrode. Based on the result above, the operating power is provided to light the backlight unit with corresponding electrode polarity. In the inspection, it will cause misjudgment if two electrode filaments with opposite polarity contact with the same FPC electrode. In order to avoid this situation, the distance between two electrode filaments with opposite polarity must have a certain interval, the interval must be larger than the width of a single FPC electrode and smaller than the total width of entire FPC.

![Fig.3 The PCB board of control system](image)

Detection result obtained by auto lighting device was shown in Table 1. The width of electrode filament is 0.1 mm. The interval between two electrode filaments is 0.1 mm. The size of backlight is 2.4 inch. Three kinds of FPC, (0.35mm+0.35mm)×4PIN, (0.4mm+0.4mm)×5PIN, (0.6mm+0.6mm)×5PIN, were chosen as the testing sample. In order to inspect the entire types of FPC above, the interval between two electrode filaments was set as 3. Therefore, the whole width from positive electrode filament to negative electrode filament is 0.7 mm. During the inspection test, the unlighted backlight unit needs to be inspected again by traditional manual lighting device to analyze whether misjudgment existing. Experiment results showed that there was no misjudgment existing in two types of FPC with reasonable preset of auto lighting device. However, the result of (0.35mm+0.35mm)×4PIN FPC electrode type was non-ideal. After carefully analysis, it was found that the length of electrodes in this FPC type is too short to contact well with the dense gold finger.

<table>
<thead>
<tr>
<th>The standard of FPC/ (mm+mm)×PIN</th>
<th>Test number</th>
<th>Lighted number</th>
<th>Number of misjudgment</th>
<th>Rate of misjudgment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.35+0.35)×4</td>
<td>500</td>
<td>372</td>
<td>61</td>
<td>12%</td>
</tr>
<tr>
<td>(0.4+0.4)×5</td>
<td>500</td>
<td>476</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(0.6+0.6)×5</td>
<td>1000</td>
<td>927</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Conclusions

In this research, the dense gold finger which includes many electrode filaments has been taken as the contact medium to link up the auto lighting device and backlight unit. The polarity of every electrode filament can be set by the pair-share electrode of backlight unit intelligently. It is equivalent to the mechanism that the electrode filament can be moved according to the polarity of FPC electrode. In this way, the contact deviation resulted from mismatch between FPC electrode and dense golden finger electrode can be ignored. Experiment results showed that the backlight unit with different types of FPC could be lighted quickly and accurately with the same dense gold finger. The auto lighting device has strong adaptability and accuracy in backlight system detection.
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References