Improvements for electrostatic discharge immunity in thermal printing head

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Abstract. Electrostatic discharge (ESD) is one of the important sources of electromagnetic interference which would cause a reversible or permanent damage in modern electronic equipment. ESD may be introduced by the human body operating the electronic equipment or accumulated by friction, heating or other reasons when the electronic equipment is working. In this paper we use the print head of the thermal printer (TPH) suffered from electrostatic hazard as an example to analyze the reasons of the ESD happening, and some necessary improvements measures for protection of the TPH are also suggested.

1. Introduction
ESD is one important reason that electronic products work disorder or do failure. With the development of the technology and improvement of products’ complex degree, people pay more attention to ESD which disturbs electronic circuit and damages components, CMOS circuit and interface circuit. As an important content of electromagnetic compatibility test, ESD of electronic equipment is written into national standards and international standards [1-3].

The resistance to perturbation of electronic products’ ESD is directly related to the product, including applicable environment, product performance, product post-sale service cost, product brand image and so on. So manufacturers and designers have made more concentration on ESD immunity and improved the competition ability of production.

Thermal printer is an electronic device using the joule heating for printing. Because of its working environment and the working characteristics, thermal printer is disturbed or damaged by the human body operating or accumulated by friction, heating and other reasons when it is working. This paper explains the interference sources and channels as well as analyses the reasons why ESD products are damaged and then puts forward the specific preventive measures.

2. The analysis of electronic product’s static failure
The core part of thermal printer is thermal printing head (shown in figure 1), which includes the PCB, IC and the package, SBS ceramic circuit boards, aluminum heat sink, socket, etc. The main problems of the product confronted in using process includes:

- Heating unit breakdowns due to violation of electrostatic;

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• The interior IC of print head is damaged from static intrusion;
• The restarting of CPU and motherboard is caused by static accumulation during printing.

![Figure 1. The structure of TPH.](image1.png)

When ESD happens, the mode of energy transmission has two kinds, namely, conduction mode and electromagnetic radiation mode. In the conduction mode, the discharge current spreads along the electronic products without shield conductor and invades circuit, which makes chip produce false action. In the electromagnetic radiation mode, the electrostatic discharge produces large current (human body discharge instant \( t_r = 1 \) ns). When the current flows through the wire, it also will radiate strong magnetic field (about 300 MHz, upper limit can be more than 1 GHz). The electromagnetic field can directly go through case or the hole, crack, ducts, input/output cables, which couples to the sensitive circuits. When voltage or current is more than the product's resistance to flexibility limit, the circuit performance will decline or lose efficacy [1,2].

According to the result of the electronic product' antistatic failure, we analyze the way of electrostatic invading, which includes three main ways, as shown in figure 2.

![Figure 2. The invasion way of ESD.](image2.png)

• Heating element parts produce static, which resulted from plastic roller, TPH and paper rub during printing;
• Socket parts invade from printer cable;
• Invading through the joint parts between the cooling plate and the printer on the aluminum heat sink.

3. The improvement measures of ESD immunity for electronic product

3.1 The general design principle to protect electronic products’ ESD [1]
The protection measures of electronic products of ESD are designed according to interference channels, conduction modes and product failure mechanism. Generally speaking, we can improve sensitive equipment from the following several aspects:

The internal sensing device, which may be directly contact to electrostatic, should be buffered with high pressure clamping circuit or filter before we send a signal to the external device or connector. And the sensitive wire of connection parts should be hidden.

Enough insulation or physical spacing should be provided between outside area and any internal conductive parts or in the circuit routing which connect directly or indirectly with ESD sensitivity (ESDS) components. For example, we can add nonconductive films or shell with closed hull or screw hole in the circuit routing. At the same time, the discharge energy should be transferred from ESDS with conductive pathways or a shielded body.

In the process of restraining conduction or radiation noise, the conductive metal shielding body can shield radiation noise. But at the same time conduction coupling will happen because of the second arc from circuit to shielding. So shield should be separated with circuit. Insulation can't prevent radiation ESD noise coupled to the circuit.

The lead of the PCB is the antenna receiving ESD radiation field. So the lead must be as short as possible and the loop area is as small as possible.

ESD in the cable will induce out high voltage and current. Cable is also the biggest antenna receiving ESD radiation field. So cable shielding set should connect to the metal cabinet as a grounding path. And cable should be as short as possible. And each of the electric cable root course should be placed next to the loop line in physics. For example, ribbon cables, each signal line should have a ground wire placed next to it.

3.2 The protection design of ESD for thermal printers

According to the protection design principle of ESD for the electronic products and considering the product structure and site easily damaged by electrostatic, we mainly improve the resistance ESD of the product from the following several aspects.

(1) PCB socket with high pressure clamping circuit can keep invasion of electrostatic from the socket.

(2) The PCB with the ground is short circuit with a large area conductor. Reducing the accumulation of charge and increasing the coupling capacitance can make the static voltage reduce to IC or the range of heating element withstand.

(3) The part which is above SBS to the heating element should be covered with some conductive film. The conductive film connects with power. Electronic charge resulted from rubbing between TPH and paper can be transferred away immediately to avoid the charge accumulation.

(4) The edge of PCB and SBS can not leave a conductive body or isolation. Using multipoint connection fills the ground near the socket.

3.3 The effects after taking antistatic measures

According to the ESD standard IEC61000-4-2 for electronic products, the test for contact discharge is 8kV and for air charge 15kV. Table 1 shows the test standard and test equipment.

| Test items | Test objects | ESD gun and test equipment | Test standard |
|------------|--------------|----------------------------|---------------|
| ESD immunity test for the device (HBM model) | Different position of the thermal printer | TC-815R and ESS-2000 | IEC61000-4-2 |

According to the condition shown in table 1, the good effects of antistatic for the device are obtained.
• Completely using the design of the SBS strengthens anti-static electricity about 20-40%;
• Increasing each signal control area increases anti-static electricity about 40% ~ 60%;
• Exchanging higher anti-static IC enhances anti-static electricity about 20% ~ 60%;
• Adding high pressure clamping circuit between terminal and the ground enhances anti-static above 100%;
• Adding conducting film enhances anti-static electricity above 100%;
• Adding static brushes reduces static voltage about 20% ~ 40%;
• BASE discharge enhances electrostatic anti-static electricity about 20% ~ 40%.

4. Conclusion
ESD is one important reason which can disturb the electronic product and cause the equipment disorder or failure. The static electricity protection is only to reduce the damage, but complete elimination of the ESD is impossible. So enhancement of electronic equipment and protection from system for ESD is our urgent need to address the actual problems. This is the only way to reduce the production cost and improve the quality of product. In addition, how to get the accurate the electromagnetic characteristics of ESD events is the effective method solving the electrostatic interference of electronic product.

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