SMART PAYMENT ASSOCIATION

Electrostatic Discharge (ESD) in Payment Terminals

The SPA Position

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1. Introduction

The SPA is committed to working closely with the payment industry to resolve electrostatic discharge (ESD) issues associated with payment cards. SPA members are involved in improvement programs to optimize card reliability by best practice in design and manufacturing, as well as implementation of stringent testing procedures.

However, it is important to recognize the role played by all component manufacturers in the ESD context, and the fact that the SPA membership cannot act in isolation. Our common experience is that failure due to ESD discharge can be eliminated very effectively if terminals are designed in such a way that their conductive surfaces are properly grounded.

For the SPA is it crucial to avoid any duplication of standardization efforts for ESD testing procedures. We would therefore like to draw the attention of the industry to the ISO JTC1 SC17 WG1 published in 2009. This work, we believe, offers the opportunity to assess ESD performance in the field and prevent ESD-related failures.

2. Occurrence and Prevention of Electrostatic Discharge (ESD) in Payment Terminals

Failures due to electrostatic discharge (ESD) were subject to less vigorous investigation in the past due to the challenging nature of developing a representative mathematical model of, and test procedures for, the problem. However, the widespread use of charge-accumulating low conductivity materials and polymers, in combination with electronic devices sensitive to ESD, is increasingly raising concerns with regards to ESD-induced failures.

In the smart card industry, smaller feature sizes make current semiconductors more sensitive to electrostatic discharge. As device geometries continue to shrink, their sensitivity to ESD will increase. At the same time, new types of ID and payment cards incorporate conductive features on the surface or within the body of the card, which enable the discharge of static electricity through the smart card or terminal electronics.

ESD damage is caused by an electrical overstress to an insufficiently protected electrical component in the discharge path during a discharge of static electricity to ground. The degree of damage caused is dependent on the size of the charge, determined foremost by the capacitance of the charged object, and the discharge rate, determined by the input resistance of the device into which the discharge occurs. Immediate failure resulting from excessive ESD exposure is easily detected because the damaged component no longer works. However, not all devices exposed to ESD instantly fail. Some may remain active, but have sustained damage which can impact long term reliability.

In order to minimize the risk of ESD events in a payment terminal environment, the following preventive measures can be taken:

- (1) Prevent the generation of electrostatic charge.
- (2) Eliminate potential discharge paths between charged devices and ESD-sensitive components.
- (3) Use electronic components with adequate ESD protective circuitry.

The generation of electrostatic charge depends on factors outside the control of card or terminal vendors. Consequently, card and terminal must be designed with adequate safeguards against ESD events:

1. Cards should be ESD resistant, meaning that when handled they do not accumulate significant levels of charge
2. Smart card electronics must be ESD resistant. Chips used in smart cards are, as a minimum, protected
3. The card construction should not facilitate a conductive path between the source of the electrostatic charge, typically the user, and the terminal. Metallic foil cards in particular are more prone to conduct charge than traditional white cards
4. The terminal should be protected against ESD events by appropriate measures, e.g. grounding or shielding to prevent the ESD from reaching sensitive hardware
5. Electronic components within the terminal should be fitted with adequate ESD protection circuitry.

The SPA believes that shielding vulnerable circuits within the terminal from the disturbing signal is the most important and efficient measure to implement.

3. Card Manufacturer Experience: Discharge Mode Description and Model

3.1. Discharge path

When using a chip card in a payment terminal, the following elements are involved in transmitting an electrostatic charge into the terminal.

3.1.1. The card user / card interface

The card user typically acts as the generator of static voltage. Under unfavorable environmental conditions a user can accumulate a significant charge, which is transferred to the card body. This may result in the card being charged to a voltage of several kV. During dry, cold winter conditions with Relative Humidity less than 20%, 5,5 kV has been recorded.

In the laboratory, this scenario is represented by the Human Body Model (HBM), which consists of a charged capacitor, representing the charged user, in series with an ohmic-resistive element, corresponding to the electrical resistance between the user and the card. The resistance is variable and depends on the pressure the user exerts onto the card surface. It limits the amount of current driven from the human body to the grounded terminal connector.

3.1.2. The card / terminal interface

This interface is part of the electrostatic discharge path. It is characterized by the serial impedance of the card, which is modeled by a capacitor in parallel with inductive and resistive components. The terminal connector is modeled as input impedance, whose characteristics depend on the electrical design of the input stage. It is represented by a capacitor in parallel with a resistive component.

3.2. Modeling of the card

A further element is the card itself. This represents an impedance determined by the conductivity of the card materials, and by the presence of embedded conductive elements, for example metallic foils or antennas.

Depending on the card structure, the following models can be applied:

- A standard plastic card can be modeled as a capacitor
- A card incorporating metallic foils is modeled as a capacitance in parallel with an impedance, which facilitates the discharge transfer from the human body to the terminal connector.

3.3. Discharge mechanisms

Generally the discharge mechanism works as follows:

1. When no card is inserted the terminal connector is grounded according to ISO/IEC 7816-3 requirements
2. Upon card insertion an electrical connection is established between the charged card body and ground via the chip module embedded into the card, the terminal connector, and the grounded terminal power supply. This opens a discharge path for the electrostatic charge on the card
3. The card voltage is progressively decreased to ground, following a pattern determined by the card impedance and the input impedance of the terminal connector.

In practice different electrical discharge modes are observed:

1. Continuous discharge

The discharge can occur as a steady flow of charge along a moderately conductive path. In this scenario:

- The card body discharges a small current over a significant time span
- This current can be so small that it is often undetectable
- The discharge is harmless for the terminal.

1. Pulse discharge

Alternatively the discharge can take the form of an abrupt charge recombination, typical when high potential gradients are involved:

- A high current is discharged often over an extremely short period of time
- This current can be so small that it is often undetectable
- The discharge is harmless for the terminal.

The effect of the discharge is to disturb the terminal power supply as significant electrical currents flow into contact. As a result of this discharge two scenarios can be observed:

- If the terminal microcontroller is slightly disturbed the discharge is considered as an attempt of attack and the terminal switches to RESET mode
- If the terminal is highly disturbed it switches to a SECURITY mode (meaning that cryptographic keys must be reloaded before normal operation can resume).

4. Experimental Tests Results

4.1. Test set

Tests were performed with a foil card under the following conditions:

Terminal: Gemalto MAGIC C3 X
Discharge Generator: Schaffner NSG 45 charged up to 6 kV
Card: Metal foil contact chip card

Pass/Fail criteria: the fail criteria means the message shown by the display is 'security status fail'

Two modes of applying the electrostatic generator on the card were used:

- Charge of the card on its surface (simulates the card being held by end)
- Charge of the card on its edge (card is 'pushed' into the terminal slot with the thumb).

4.2. Test results

ESD Charge Level	2 kV to 3.5 kV	4 kV	5 kV	6 kV
Contact point on card edge	No effect on terminal	No effect on terminal	30 % Tests the terminal switches to RESET	NP
Contact point on the card top side	No effect on terminal	No effect on terminal	NP	Terminal switches to SECURITY mode

NOTE: Some tests performed on unprotected terminals have resulted in Reset Mode starting from < 1 Kv.

4.3. Test result analysis

1. The level of charge disturbing the terminal is >4kV

2. The discharge mode is between the fingers and the power supply card connector
3. Some discharges may occur (if<4kV) without disturbing the terminal operation – although these are detected by the ESD generator
4. The difference of sensitivity between protected and unprotected terminals can explain a significant percentage of failed transactions, or worse, a key blocked software
5. It has also been observed that cards containing a magnetic stripe show a higher discharge current via the chip module than cards without a stripe.

5. ISO Standardization Activities

- In 2007 WG1 was asked to extend the scope of ISO/IEC 7810 to cover influences such as the conducting of electrostatic discharge currents. The purpose of this request was to harmonize requirements for ESD in different standards applying to contact cards and contactless cards
- As a result of this resolution WG1 started to work on test methods on the surface conductivity of cards. The particular objective was to limit the use of very conductive card technologies
- The work is progressing well. SPA members have been active throughout this initiative
- Several test configurations have been defined and discussed, all based on ESD between a probe and an element of the card connected to ground (module, card surface etc)
- The remaining challenge is to find? a correlation between a selected level of card conductivity and the sensitivity of different terminals in the field
- SPA supports the approach of EMVCo to align with this on-going ISO standardization activity as the best way to fix any ESD issues in EMVCo transactions.

6. Summary

1. Under particular conditions electrostatic charge generated by a card holder can be transmitted inside the terminal
2. Specific card types, especially metal foil cards, are more likely to propagate the charge (and therefore discharge inside) than conventional full plastic cards
3. Many terminals are protected against the risk of discharge. However there is a proportion of terminals in the field with a very low level of protection. These terminals are particularly vulnerable to ESD
4. Implementation of appropriate ESD protection for terminals is the most efficient way to control ESD problems in the field
5. If a terminal is protected against ESD, cards may, in extreme conditions, still disturb the communication electronics and cause a Reset, but no permanent damage will occur.