ESD requirements on the packaging of electronic components outside of an EPA - measurements

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***Abstract*— All electronic components are electrostatically sensitive. That's why they have to be transported in a shielding packaging outside of an EPA (ESD Protected Area). The existing requirements only apply to flat bags. It is difficult to classify all other packaging materials into this category. One reason is that only a measuring method for the evaluation of flat plastic bags does exist. All other materials, that could be suitable for transportation, cannot be proved metrological. Furthermore, many users apply incorrect or unsuitable materials for the transport of ESDS outside the EPA. Options for measuring method are discussed in the following article.**

I. INTRODUCTION

There are different packages with various properties on the market. However, not all of these packages are suitable for all applications. Accordingly, the selection of the correct packaging is difficult, because the existing measurement methods are insufficient for the different properties of the packaging materials. Conductive packaging materials can be classified with a resistance measurement, but it is getting more difficult for dissipative materials, especially for such with very high resistances. Former methods of measurement, such as the measurement of discharge time are used to determine the material properties. The measurements of shielding properties or field shielding properties are complex. So far, there is only one measuring method for flat foil pouch. The measurement is sufficient for dissipative materials at a resistance not greater than 1 x 10^{11} Ω in comparison to conductive materials, where it is much more difficult.

Table 1 Requirements for packaging material for ESDS inside/outside of an EPA

	Electrostatic conductive	**Electrostatic dissipative**	**Electrostatic shielding**	**Electrostatic field shielding**	**Notes**
Inside	**X**	**X**	X[3]	X[3]	
Outside	-[1]	-[2]	**X**	**X**	

[1] on limited applications
[2] only in combination with other materials
[3] not required inside of an EPA, can used

Table 2 Electrical properties of special packaging material for use with ESDS

	Resistance	**Electrical properties**
Electrostatic conductive	$\geq 1 \times 10^2\ \Omega$ to $\leq 1 \times 10^4\ \Omega$	
Electrostatic dissipative	$\geq 1 \times 10^4\ \Omega$ to $\leq 1 \times 10^{11}\ \Omega$	
Electrostatic shielding		Energy smaller 50 nJ
Electrostatic field shielding	$< 1 \times 10^3\ \Omega$	

II. BASICS

The current measurement methods for determining the shielding properties of flat bags use a HBM generator, a fast Scope and a special sensor (see Fig. 1 at ANSI/ESD STM11.31-2012 bags [3]. A HBM discharge of 1000 V is applied to the metal electrodes, and the incoming pulse is recorded with the capacitive sensor. The sensor's dimensions are ANSI / ESD STM11.31-2012. A deviation from the norm was recognized at the calculation of the capacity. For this reason, the following parameters were calculated: capacitance and capacitor connected between two metal foils.

Additionally, the question whether a cardboard box with air is a shielding packaging was considered. This is neither a capacitor nor is it able to shield electrostatic fields. The electrostatic charges pass through the cardboard onto the electronic components.

From today's view, the question whether the test with a HBM pulse is still relevant could be discussed. Generally, we see CDM discharges. Only flat films can be measured with these measurement methods. Nevertheless, what's with all the other packaging? Particularly affected are: cardboard boxes, black conductive plastic container, trays, reels etc. These packages cannot be used for the existing Measuring arrangements. The ESDS or PCBs lie or stand in these packages, touch the packaging or do not have any direct contact. Furthermore, there are combinations of packaging, such as cardboard boxes and bags (or non-shielding or shielding bags), multilayer cardboard boxes.

Basically, the following requirements apply:

Outside an EPA and ESDS and PCBs must be transported in a shielding box. The packaging must be like a faraday cage to protect the components. All other packaging is usually worse, more or less. Based on the classification of the components' sensitivity as well as the assemblies' sensitivity specific packaging requirements arise.

III. Measurement Methods

1. The existing measurement process with sensor and HBM discharge will be presented.
2. Measurement methods with electrostatic charges of 1000 V and a CPM as field sensor
3. Shielding properties of cardboard, etc.

Calculation
For the evaluation of the measured electrostatic charge, the following calculations must be considered:

1. Calculation of the capacitance of the sensor according to the standard ANSI/ESD STM11.31-2012 and EC 61340-4-8 Ed. 1.0 2010-01 [4]:

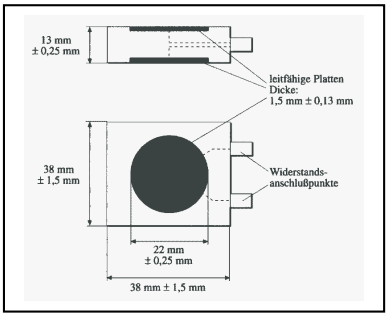

Fig. 1. Field sensor [3]

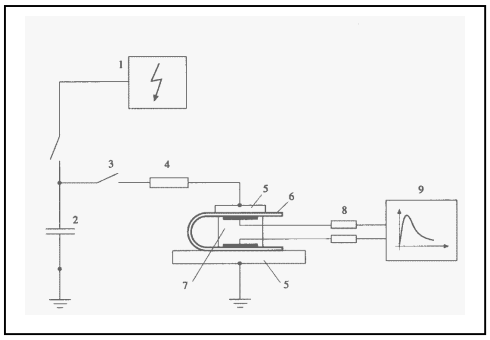

Fig. 2. Structure of the test build up [3]

1 HBM generator; 2 capacitance; 3 switch; 4 resistor; 5 discharge plate/ground plate; 6 sample/test sample; 7 sensor; 8 resistor; 9 scope

For each parameter, the following values are obtained from the calculations:

$$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

with probes, round

$$A = \frac{\pi}{4} d^2$$

without probes, square

$$A = l_1 \times l_2 \qquad \text{with} \quad l_1 = l_2$$

2. Calculation of the capacitance of different sensors (charge plate assembly) from the hardware configuration field meter and charge plate assembly:

Table 3 Calculation of the hardware configuration

standard device construction	Diameter of the probe cm	distance between the plates cm	Dielektrikum[1]	required capacitance pF	calculated capacitance pF
ANSI/ESD STM11.31	d = 3,8 cm ± 0.025 cm	1.3 ± 0.025	Polycarbonate or Acrylic ε_r = 3 … 3,4	8 ± 2	2,95
IEC 61340-4-8	d = 3,8 cm ± 0.025 cm	1.3 ± 0.025	Polycarbonate or Acrylic ε_r = 3 … 3,4	8 ± 2	2,95
PFK 100[3]	Fläche l_1 x l_2 3,25“ (8,25 cm) x 3,25“ (8,25 cm)	0,6“ (1,6 cm)	Air ε_r = 1,00059	10 ± 1	3,76
CPM 760[4]	Fläche l_1 x l_2 6“ (15 cm) x 6“ (15 cm)	0,9“ (2,3 cm)	Air ε_r = 1,00059	20 ± 2	8,66

Notes: [1] Relative Permittivity of some substances in 18 °C and a frequency of 50 Hz
[2] $\varepsilon_0 = 8{,}86 \times 10^{-12}$ As/Vm
[3] with Field meter

3. In the calculation of the capacity of material combinations, for example a PCB is housed in a plastic bag in a cardboard box the following consideration must be established:

The ESDS / PCB are located in a bag, which has in each case an undefined distance from the underside and top of the cardboard box. Adopted at a distance of approximately 1 cm above and below, now a series of capacity must be calculated;

Capacity of top / lid to the bag top, then the actual bag, and ultimately of the bag bottom to the bottom of the package.

In the following, a simple measuring device without bag is considered theoretically. For this purpose, the capacity and the possibility of stored charge can be calculated. The total capacity C_s divided into the following individual capacities:

$$\frac{1}{C_s} = \frac{1}{C_{air}} + \frac{1}{C_{cpa}} + \frac{1}{C_{sp}}$$

with equation

$$Q = C \times U$$

or

$$C = \frac{Q}{U}$$

as follows

$$\frac{1}{\frac{Q_s}{U}} = \frac{1}{\frac{Q_{air}}{U}} + \frac{1}{\frac{Q_{cpa}}{U}} + \frac{1}{\frac{Q_{sp}}{U}}$$

The voltage U is always the same.

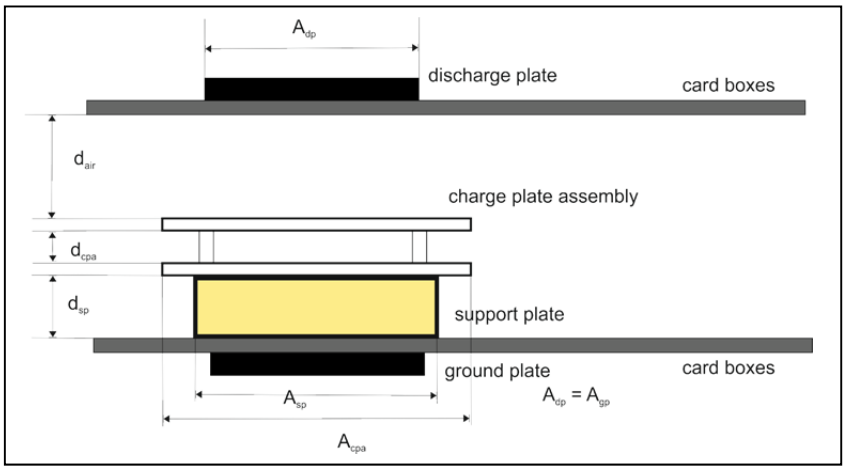

Fig 3. Shielding measurement assembly in a card box

IV. MEASUREMENT RESULTS

The Fig. 4 shows the actual results from the measurement/test with card boxes (see Fig. 5.)

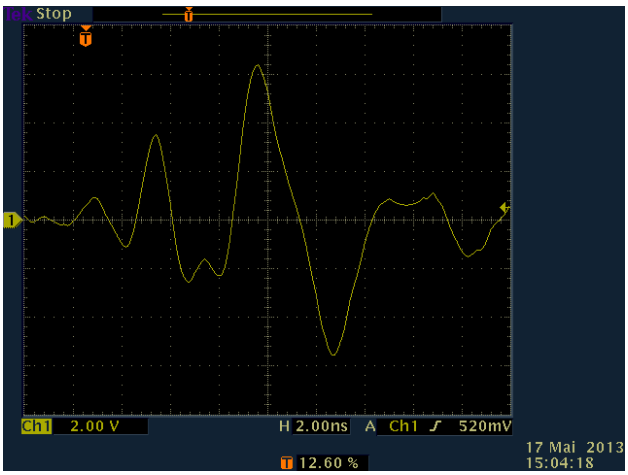

Fig. 4 Test results from Scope with Blue Card Box.

Table 4 Test results

Test	**Electrostatic Voltage**		**Notes**
	min	**max**	
1	480 V	520 V	
2	600 V	> 800 V	
3	250 V	400 V	

Fig. 5a + 5b Test assembly with Blue Card Box

V. CONCLUSION

It might be noted that the existing measurement method according „ANSI/ESD STM11.31-2012 Bags“ are not suitable for cardboard packaging. Very good comparable results are measured with the simple construction according [1, 2]. The first tests with the new assemblies for the card boxes delivered different results. In the next time it's necessary to made many measurements with different card boxes. The other questions, which value of electrostatic charge/voltage we can calculate? The best way for practice is the proposed measurement assembly.

References

[1] *H. Berndt:* Experiences at the measurements of packaging material for electronic devices according to the standard IEC 61340-5-1 and the requirements from the standard ANSI/ESD S541-2003; Proceedings Electrostatic Society of America 2006

[2] *H. Berndt:* Experiences at the measurements of packaging material for electronic devices according to the standard IEC 61340-5-1; Proceedings Electrostatic Society of America 2004

[3] ANSI / ESD STM11.31-2012: Standard test method provides a method for testing and determining the shielding capabilities of electrostatic shielding bags.

[4] IEC 61340-4-8 Ed. 1.0; 2010: Electrostatics Part 4-8: Standard test methods for specific applications – electrostatic discharge shielding – Bags