# Determining ESD Threats for a Human-Furniture Model in Motor Vehicles

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***Abstract-*** The paper presents some performed measurements and investigations in the framework of the triboelectricity developed in a motor vehicle. The concern about ESD induced failures is growing up in the same manner as the electronic content of an up-to-date car. Assuming the furniture ESD model, were measured or evaluated its parameters for the situation "person inside the vehicle" and "person getting out from the vehicle". With an electrostatic head were measured the different values for ESD charging inside the vehicle. This study offers useful information in order to develop an ESD simulator and to reduce the fails and errors due to ESD phenomena in a modern car.

## 1. Introduction

One of the contemporary trends in automobiles (design and exploitation) is the continuous growth of electronics as importance and density. But a functioning car is a very adequate place for triboelectricity generation, with so many different materials rubbing together and then rapidly separating. In this framework, ESD received an importance alike other EMC investigations, in the assessment of motor vehicle performance [1]. Dealing with ESD in automotive environment, a few particular models, tests and parameters have to be used, quite dissimilar to those operating in other industries. Some common questions have always to be put: what are the most appropriate values for the charge capacitance, the body resistance and the corresponding discharge voltage level? For instant, it is obviously than the capacitance formed between someone inside a car and vehicle metallic body is significantly greater than the usual capacitance, developed between a person and the device in the neighbourhood [2].

## 2. Starting point

Some quasi-unexpectable (and random) errors were encountered at the ordinary operation of the registering apparatus, equipping the taxi-cars. The greatest error incidence was met for the seat material being polyester or vinyl and the human clothing being nylon. No errors were reported for the combination leather seat and cotton clothing. Also differences were met due to the thickness and the material of the shoe sole. Due to such observations and other related ones, it was almost natural that static, triboelectricity to be blamed for these fails and errors.

## 3. Car-chair and static charge

It is useful to identify the types of car chairs, their materials and coverage potentially discharging to electronic components. We used for the evaluation of the discharge characteristics, the measured values for the capacitance and the discharge current. Three values for the capacitance have relevance: the separated, individual capacitance, the capacitance of the chair to a 0.1m x 0.1m grounded aluminium discharge plate oriented for utmost coupling and the same capacitance with the plate oriented for least coupling. According to the ergonomic shape and involved materials, the uncoupled capacitance take values between 55 and 115 pF, (mean value 85 pF), for maximal coupling the values are between 105 and 155pF (the average is 130 pF), while for minimal coupling, the interval lies from 65 till 125 pF (having its middle at 95 pF). So, we conclude that the average maximum coupling to the discharge plane is 130-85=45pF, while the mean minimum coupling is 95-85=10pF. The whole average coupling to the plane is the arithmetic mean of these two values, about 27 pF.

Charging the chair close to 1900 V produced the discharging current wave shape, into the 0,1 $m^2$ discharge plane brought in the proximity. In order to exactly localize the discharge point and to view the current waveform, we used a copper stick with a broadband current probe.

For 1900V initial charge, the measured peak currents ranged from 4A to 30A (while the correspondent first inverted peak was from 3 to 14 Amperes), with the rise time between 3 and 9 nanoseconds. Following the method described in [3], we extracted from the discharge current waveforms, the values of the resistance, capacitance and inductance producing comparable waveforms.

Actually, assuming the contact discharge, the values settled for the proposed simulator are 10Ω, the equivalent inductance is around 300nH, 140 pF could be the approximation for the whole capacitance and 25 pF for the coupling capacitance. Accepting the air discharge, the equivalent resistance increases to 85 Ω. Due to this low impedance source, the current waveshape is similar to a damped sinusoid, with fast rise time and great peak magnitude. Wanting to verify an ESD simulation model, we have to take into consideration the electric and magnetic field accompanying an ESD incident, mainly because the associated current flow through metallic case. Electric fields mainly interfere with high impedance, voltage sensitive circuits. Magnetic fields are more "dangerous" for low impedance, current sensitive devices. Considering the radiation determined by the discharge, the peak current is essential in the close field, while for the far field behaviour, the main factor is the rise time of the current.

## 3. Measuring the static charges inside the car

For our determinations we used a dividing capacitive static detection head and a terra-ohms input voltmeter, figure 1. The switch "S" is for discharging the measuring capacitances. The magnitude of the voltage owing to the charge transfer from the "subject" to the detector is computed by multiplying the capacitive ratio with the electrometer input (usually, higher than $10^{13}$ Ω).

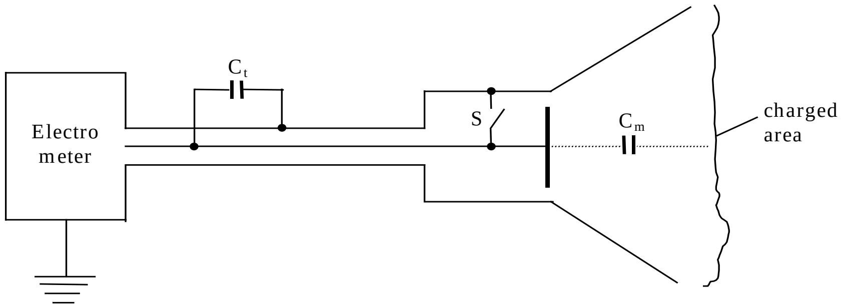


Figure 1. Electrostatic detection head connected to an electrometer

According to our measurements, the highest charge voltage was reached for polyester seat-nylon wear combination, (18-19 kV), while less dangerous values (0,5-0,8 kV) were developed for leather or even viscose seat versus cotton or linen wear.

## 4. ESD furniture model when passenger is going out from the car

The registered waveshape of the discharge current was like a damped sinusoid, with a fast rise time(6ns) and a high peak amplitude, being a sign of low impedance (tens of ohms) source. This was a reason to assume the furniture discharge model for our tests [4]. Discharge voltage transients were captured on a digitiser, through a 300Ω dividing network to ground, [5].

The assumed diagram representing the ESD model of a person "acting" inside a vehicle is quite classic: the capacity of the body, the intrinsic resistance of the "occupant" and most important (due to its large dispersion), the impedance of the discharge path to the car chassis.

The factors to be tested when dealing with the amplitude of the static tribo-generated voltage could be grouped in four categories:

- the relative tendency of the directly rubbed materials to become positively or negatively charged (position in the triboelectric series);
- the speed of relative rubbing and of the following separation;
- the polishing degree of the materials in contact;
- the humidity in atmosphere (balancing the charges) and in the intrinsic content of materials in contact (decreasing the surface resistance).

A person inside the car could be modelled with the resistor/capacitor combination. For measuring the body capacitance on an insulated ground plane, we charged from a high voltage power supply and analysed the discharging current waveform. Knowing the capacitance and the RC time constant, is possible to calculate the body resistance. Discharge voltage transients were captured on a digitizer through a 150Ω +150 Ω dividing circuit to ground.

The proposed schematic model for human leaving the charged vehicle is shown in figure 2.

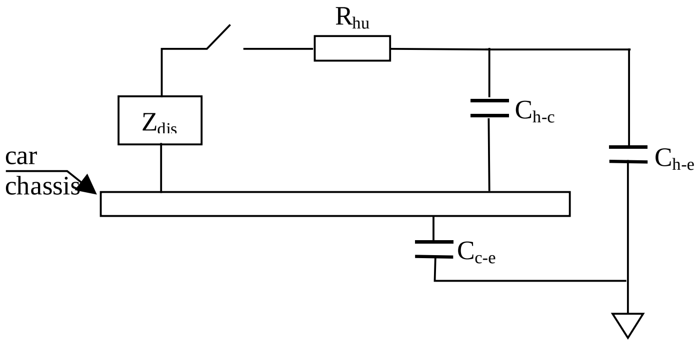


Figure 2. Capacitive charging-discharging model for a passenger getting out the car

$R_{hu}$ is the resistance of the human person within the vehicle, (measured and calculated at values around 2000Ω).

$C_{h-e}$ represents the capacity "human passenger to earth plane" and has values spread from 110 pF to 1,1 nF, such differences mainly due to the shoe-sole material: rubber, leather or plastic.

$Z_{dis}$ is the impedance at the discharge point, $C_{h-c}$ is the capacity "human to car", while $C_{c-e}$ is the "car to earth" capacity.

For calculating the human body resistance we used the following method. We assume (according to existing tables) a vehicle occupant charging capacity (around 200pF, depending on the car-size, the height, weight and position of the passenger). Considering the scope registration of voltage from the discharge across a calibrated resistor, we evaluate the RC time constant and, by dividing the result to the occupant capacitance, we obtain a decent approximation (about 2000 Ω )for the human body resistance. Speaking about the body capacitance of a person inside a vehicle, there is a significant dispersion, from 100 pF till more than 300pF. The main factors of influence are the height and the weight of the person, his position (driver with/without hands on wheel or simple passenger) and the type itself of the car., mainly its size.

## 5. Conclusions

The performed measurements and investigations are important for reducing the fails due to ESD in a modern vehicle, presenting a large density and complexity of miniaturized electronics. To determine the parameters values for the furniture ESD model is useful when designing and then testing a simulator dedicated to vehicle tests. Useful advice regarding adequate combinations for seat and cloths materials inside a vehicle prevents an over-accumulation of static charges.

## Acknowledgements

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