Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Erika Johansson
Avoiding Electro Static Discharge (ESD) problems
during handling of automotive electronics
Erika Johansson

Summary
This report contains a presentation on how the electronic components are handled today at Saab Automobile AB (later in the report called Saab) with consideration on ESD (Electro Static Discharge). The report also indicates whether if the ESD demands that are put on the handling of electronic components for the car total length of life are too strong or too weak. Today Saab gets many customer complaints on electronic components that are out of order and the report estimates how much money Saab would save if they found out that the cause is because of ESD. These have been done through examination of the whole handling process, from supplier to customer.

The report starts with an explanation on the physical phenomenon behind ESD, followed by how ESD influences on electronics and how the electronic components could be protected against ESD. There are also personal opinions about the ESD problem given by leading expertise.

The report ends with some results and proceeding suggestions.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Preface

Today Saab gets many complaints that electrical components are out of order. A believable cause could be the one of ESD. The report consists of a presentation of the whole handle process of electronic components from the supplier to the customer. To find out if Saab could save money if they were more observant of the ESD problem, an investigation has been done. The examination should also show if the ESD demand that today is put on the handling of electronic components for the car total length of life is too strong or too weak.

There are a lot of persons that have helped me and answered my questions. I would like to thank them for all help. I will give a special thanks to my examiner Anna-Karin Christiansson and the members in the EMC group at Saab.

Jonas Bergqvist
Stefan Näsmark
Stefan Ohlsson
Mikael Svensson

Trollhättan 2004-01-16

Erika Johansson
# Contents

Summary.............................................................................................................................i
Preface .............................................................................................................................. ii
List of symbols ..................................................................................................................v

1 Introduction .................................................................................................................1
  1.1 Background ............................................................................................................1
  1.2 Aim and purpose ....................................................................................................1
  1.3 Scope ......................................................................................................................1

2 Physical phenomenon ...............................................................................................2
  2.1 How charges appears ............................................................................................2
  2.2 How discharges appears ........................................................................................5

3 How ESD influences on electronics ...........................................................................5

4 Protection against ESD ...............................................................................................6
  4.1 Designing electronics for ESD humidity ...............................................................6
  4.2 ESD Protected Area (EPA) ....................................................................................9
  4.3 Packages for protection .........................................................................................9
  4.4 Education ...............................................................................................................9
  4.5 Simulation models ................................................................................................10

5 Accomplishment .........................................................................................................13
  5.1 The demand from Saab at the electronic manufacturers .....................................13
  5.2 The demand at the electronic manufacturer Delphi ............................................14
  5.3 The handling with electronic components at Saab Automobile today .................15
  5.4 The rules for the packing around the electronic components that are sent to the production ..........................................................................................15
  5.5 The handling with electronic components at the assembly line at Saab ..............16
  5.6 Guarantee statistics .............................................................................................19
  5.7 When the customer handle electronic components ..............................................20

6 The Nordic ESD council.............................................................................................20

7 Results and conclusions .............................................................................................21
  7.1 Education .............................................................................................................21
  7.2 Simulation models ...............................................................................................21
  7.3 Standards .............................................................................................................21
  7.4 Results from the measuring in the production at Saab ....................................21
  7.5 Results from the guarantee statistics ...................................................................22
  7.6 The Nordic ESD council ......................................................................................22
  7.7 Co-ordination group ............................................................................................22

8 Personal opinion .........................................................................................................23

9 Program......................................................................................................................23

10 List of figures..............................................................................................................23

11 List of tables................................................................................................................24

12 References...................................................................................................................25
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Appendices

Appendix A: Measuring of materials in the factory at Saab that might generate static electricity.
Appendix B: Operating instructions about the Influence-E-Fieldmeter.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

**List of symbols**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDM</td>
<td>Charge Device Model</td>
</tr>
<tr>
<td>Dielectric constant</td>
<td>Dimensionless material constant.</td>
</tr>
<tr>
<td>EPA</td>
<td>ESD Protected Area</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic Discharge</td>
</tr>
<tr>
<td>ESDS</td>
<td>ElectroStatic Discharge Sensitive device. Components that are very sensitive for ESD.</td>
</tr>
<tr>
<td>EOS</td>
<td>Electrical Over Stress</td>
</tr>
<tr>
<td>GM</td>
<td>General Motors</td>
</tr>
<tr>
<td>HBM</td>
<td>Human Body Model</td>
</tr>
<tr>
<td>IPC</td>
<td>“Association Connecting Electronics Industries”</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>MM</td>
<td>Machine Model</td>
</tr>
<tr>
<td>RH</td>
<td>Relative Humidity</td>
</tr>
<tr>
<td>SP</td>
<td>Sveriges forsknings- och provningsinstitut</td>
</tr>
</tbody>
</table>
1 Introduction

Static electricity accrues through contact in our surroundings, e.g. at workbenches, floors, chairs, clothes, packing material, paper and plastic files. This is a big problem because it can damage electronic components. ESD (Electro Static Discharge) constitute today one of the largest threats against electronics. The sensitivity varies between different types of components, e.g. semiconductors are very susceptible to ESD. An electrostatic discharge of 10 [V] can cause damage on some components and not others. It is important to be conscious about the risks and how to protect the electronic components, printed circuit cards and systems on the best way during the whole handling process. [1], [26].

1.1 Background

The background to this project is that Saab today gets many complaints that electronic component are out of order. A plausible cause could be ESD. An examination should be done, to see if the current ESD demands on the handling of electronic components for the car total length of life are too strong or too weak. It should also be investigated if Saab could save money by being more observant of the ESD problem, in the whole handle process, from supplier to customer.

1.2 Aim and purpose

The commission is to give a theoretical model for immunity testing of electrostatic discharge and to compare with real measured levels for different case of electronics handling. An important part is also to study a lot of literature. The commission includes experiments, analysis and recommended steps for a quality secured handling process.

The purpose is to find out the reason why some electrical components are malfunctioning because of ESD and to propose good solutions for the problem.

1.3 Scope

The whole handling process is:

- Semiconductors manufacturer
- Electronics manufacturer
- Transport to the car factory at Saab or to the prototype factory at Saab
- Transport to the customer and the retailers

This investigation describes the handling process from the electronic manufacturer to the customer.
2 Physical phenomenon

Information in this part is from [1]. Two charges with different potential are attracted of each other. Negative electrons are attracted to the positive nucleus. The attraction will be weaker when the distance to the nuclear increase. Metals have their atoms in a regular design. The electrons in the external shell are “free electrons” and they care charges and a current in the conductor will appear if the atom influences from other atoms. A material with many “free electrons” is accordingly a good conductor. The power between two charges can be calculated with the law of coulomb. To better understand the phenomenon on how the power around a charge looks like the electric field intensity can be used. The electric field intensity will have different direction and strength on different places around the charge.

If ESD should occur there most be a source that cause a charge, a coupling path and a victim that will be exposed for a discharge (Figure 1).

![Figure 1 Source, coupling path and victim](image)

The RH (Relative Humidity) influence the charging and discharging to increase, especially in countries with cold climate. How many electrical charges that are created decides of the present relative humidity. The charge reduces if the relative humidity is high. The reason to this is that a thin layer with water is created on surfaces that otherwise are isolated and the charge reduces. The air can take up and keep more humidity at a high temperature than at a lower one. This means that cold air that in the winter sucks into a building and then become warm consist of a small number of humidity. The relative humidity become lowers and the charge that can be stored becomes higher. Therefore is the ESD problem big in a country with a cold climate. [1]

2.1 How charges appears

Static electricity arises when charges transmitt from one area to another and when the transmitted charges keeps at the new area.

Static electricity arises in many everyday situations, e.g. when combing the hair or walking across a carpet. In the industry the risks are especially high for production, service and reparation work and for internal and external transports. Another example of
static electricity is the thunder, where the discharging occurs through the water drops movements in the thunderclouds.

The three most common reasons for static electricity charges in a manufacture situation are:

- Triboelectric activity
- Electrostatic induction
- Direct transfer

These phenomena are explained further below.

### 2.1.1 Triboelectric activity

If two materials with different dielectric constant are connected together and then are separated, positive charges appear at one contact surface and negative charges excess of electrons on the other contact surface. This phenomenon is called triboelectric charge. The size of the charge depends on the assemblage of the material, the character of the surface and the speed when the two materials separate.

Materials that easily emit electrons are in the top of the triboelectric series (Table 1), i.e. they get charged positive when in contact with materials that are longer down in the list. The materials that are most neutral, accordingly least tending to emit or take up electrons, are in the middle of the list. [1].
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Triboelectric series

<table>
<thead>
<tr>
<th>Material</th>
<th>Polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetate</td>
<td>Positive</td>
</tr>
<tr>
<td>glass</td>
<td></td>
</tr>
<tr>
<td>human hair</td>
<td></td>
</tr>
<tr>
<td>nylon</td>
<td></td>
</tr>
<tr>
<td>wool</td>
<td></td>
</tr>
<tr>
<td>silk</td>
<td></td>
</tr>
<tr>
<td>aluminium</td>
<td></td>
</tr>
<tr>
<td>paper</td>
<td></td>
</tr>
<tr>
<td>polyurethan</td>
<td></td>
</tr>
<tr>
<td>cotton</td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td></td>
</tr>
<tr>
<td>steel</td>
<td></td>
</tr>
<tr>
<td>ebonite</td>
<td></td>
</tr>
<tr>
<td>acetate fibre</td>
<td></td>
</tr>
<tr>
<td>nickle, copper, silver</td>
<td></td>
</tr>
<tr>
<td>brass, stainless steel</td>
<td></td>
</tr>
<tr>
<td>synthetic rubber</td>
<td></td>
</tr>
<tr>
<td>acryl</td>
<td></td>
</tr>
<tr>
<td>polystyrenescum</td>
<td></td>
</tr>
<tr>
<td>polyurethanscum</td>
<td></td>
</tr>
<tr>
<td>polyestre fibre</td>
<td></td>
</tr>
<tr>
<td>polyethylene</td>
<td></td>
</tr>
<tr>
<td>polyvinyl chloride</td>
<td></td>
</tr>
<tr>
<td>teflon</td>
<td></td>
</tr>
<tr>
<td>silicon rubber</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Triboelectric series

2.1.2 Electrostatic induction

Electrostatic induction can occur when an object is charged close to another object, called objects A and B in (Figure 2). The charge on object A is positive. In the isolated conductor B (uncharged from the beginning), negative and positive charges of the same size are induced (case a). The positive charges at B divert to ground when B attach to ground (case b). When the connection to ground is broken, B still has negative charge (case c). This phenomenon is called electrostatic induction. B will keep the negative charge, even when A is removed (case d). Now there is a risk for discharge i.e. ESD damages if the components are connected to ground.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

2.1.3 Direct transfer

Direct transfer can accrue if a person is close to e.g. a viewing screen or packing material that is highly charged. If the person is insulated from ground, he/she becomes charged. If the charged person touches a sensitive point on an electronic component, he/she can damage it due to discharge.

2.2 How discharges appears

It is first when the component will be exposed for a discharge, as the ESD damages will appear. If a conductive object is charged or if a person has been charged and connect an ESD sensitive component, that is grounded or has enough capacitance to ground, can a component be damaged if a discharge happens. A component can also be damaged if the component is charged and than contact a conductive object or a person. The duration on an electrostatic discharge normally is shorter than a microsecond.

3 How ESD influences on electronics

Today is it well known that electrostatic discharges cause big problems in electronic components and systems. An ESD discharge can have a voltage over 20 [kV] and a current strength over 100 [A]. Rise times over 1 [ns], overtones more than 1 [GHz] and intensity of fields over 100 [V/m]. This made that ESD discharges can causes serious damages on electronic systems. The ESD pulse connect conductive to the disturbed electronic system, but their characteristics do that it connect very good capacitive, inductive and radio frequency. The intensity of fields at short distances is very powerful (around 100 [V/m]). That the electronic systems do not disconnect (totally) when they are attackt of an electronic discharge is because the pulse has a short duration. [26].
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Sensitive electronics must be handled, packed and designed in a correct way to avoid ESD defects. There are different ESD defects, e.g. at the electronic manufacturer one ESD defect can be on a semiconductor or at a transistor. There is always a risk for damages in the whole life cycle. Searches [2] within the electronics production show that nearly 50 [%] of all defects at electronic components are caused by ESD. One problem is that damage can appear at very low voltage, around 100 [V] with respect to the ground. This voltage is so low that a human does not notice it, because there will not be any electric shock or no sparks. It will become a latent defect; i.e. the electronics will keep on working, but is damaged and in the end there will be an acute defect. This defects can happened in all steps in the handling process. Most of the defects are latent defects. Another defects are immediate defects and intermittent damages, as comes and goes. [2].

To prove that a defect is caused by ESD, a very expensive and comprehensive defect investigation has to be done. Most companies do not have economical resources to do this, but a good and fairly cheap thing to do is to keep a careful fault statistic over the production. Perhaps it is something that the supplier can do? [3]

4 Protection against ESD

There is one fundamental rule to prevent ESD damages: Avoid charge! To take following three actions an effective protection against ESD can be received.

1. Handle all ESD sensitive products in an ESD safety area.
2. Transport all ESD sensitive components in screened boxes and packages.
3. Check and test all ESD protections to secure that the components has the right function and quality.

4.1 Designing electronics for ESD humidity

One way to protect sensitive paths is to provide the inputs and generally also the outputs with special paths that should “take care of” transients (Figure 3). The purpose with this “protection path” is that they should bound transient current and reduces over potentials. The “protection paths” can consist of many different components. E.g. varistor, effect resistans, Zener diode, capacitor, RC filter and LC filter. [6] They bound the current and short circuit a pulse of potential. ESD damages can appear even on the “protection paths”, which means that the “head function” will be very sensitive against ESD. [4]

Some electronic components with low transient durability are listed (Table 2) and also their energy durability and maximum voltage durability.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

<table>
<thead>
<tr>
<th>Components with low transient durability</th>
<th>Energy durability</th>
<th>Maximum voltage durability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analogous components</td>
<td>$5 - 20 \cdot 10^{-3}$ Ws</td>
<td>4-5 kV</td>
</tr>
<tr>
<td>Digital integrated circuits</td>
<td>$1 \cdot 10^{-3}$ Ws</td>
<td>2 kV</td>
</tr>
<tr>
<td>Transistors</td>
<td>$1 \cdot 10^{-3}$ Ws</td>
<td>3 kV</td>
</tr>
<tr>
<td>Metallic oxide, metal film resistance</td>
<td>$2 \cdot 10^{-3}$ Ws</td>
<td>3 kV</td>
</tr>
</tbody>
</table>

Table 2 Components with low transient durability

Figure 3 Different safety circuits for ESD

4.1.1 Example from the real world

To protect the “shark fin”, which is a GPS antenna, a “specially path” had been putted into this component, and that is described in more detail below.

Problems

There are some causes why Saab has had some big problems with the “shark fin”. First when the design of the “shark fin” was done was the ESD problem not taken into account. Then the people in the factory at Saab were unconscious about the ESD problem and they were not very happy about taking care of the problem. In the factory one operator drag the rear lamp out of a plastic bag, the rear lamp and the person become charged. The same operator than take the “shark fin” and put it on the car. The car, the person and the “shark fin” had different potentials and the result was very often that the “shark fin” becomes broken because of an electrostatic discharge.

Another problem was the problem with back electromotive force. An electric current through coil 2 (Figure 4) lead to this problem.

Saab was the first car factory that uses the “shark fin” and this is also a reason why they have had so many problems with this component. E.g. Saab sees the whole process with the “shark fin”, how the operator handles it, how it is packed and so on. On the other hand the supplier just see the component. This leads to that the ESD problem that
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

appears in the production at Saab does not appear at the supplier. It has also been problems with latent damages, which appear later on.

Broken “shark fin” were more common at the 9-3 line than at the 9-5 line. This was because car body was better grounded to the floor at the 9-5 line than at the 9-3 line. Today there is a new 9-3 line and the car body is better grounded now.

![Diagram of the construction of the "shark fin"](image)

**Figure 4 The construction of the "shark fin"**

**Solutions**

Today is the “shark fin” putted in an ESD safety bag, it has an ESD marking and the component is putted in an ESD safety box in the production at Saab. There is not any problem with this component in the production today. To solve the technical problem a “discharge path” for the ESD current had to be putted into the “shark fin”. One diode in the reverse direction and one diode in the forward direction in series with a Zener diode were putted in the path. If the electrostatic discharge is positive, the discharge will be lead through the diode in the forward direction in series with a Zener diode to ground. If the electrostatic discharge is negative the discharge will be lead through the diode in the reverse direction to ground. The amplifier will be protected. A discharge gap is putted in the path. It is one more way to protect the “shark fin” from ESD. The problem with the back electromotive force can be solved by putted in one more diode in the path over coil 2 (Figure 4), but this is not necessary because the “shark fin” manage the demand without that diode. But it is a measure that can be taken into account if it will be any problem with the “shark fin” in the future.

On the “shark fin” is it two metal sheets that are conductive connected through the car roof. A metal ring with four pips that are penetrated towards the lacquer makes the “shark fin” grounded to the car roof. There is also a zone division with appertaining shields at the component.
**4.2 ESD Protected Area (EPA)**

An EPA is an ESD Protected Area. The reason to have an EPA is to avoid charges and minimize the risks of electrostatic discharge. Within this area ESD sensitive components can be handled without risks for ESD damages. All equipment for ESD protection that is used in the EPA has to fulfill the regulation demand for low charge and discharge characteristics and ground connection. These restrictions are applicable for e.g. floor, workbenches, chairs, shoes, wrist strap and tools. EPA normally is found at the semiconductor manufacturers and at the electronic manufacturers.

**4.3 Packages for protection**

To avoid charges and minimize the risks for electrostatic discharge there are some different packages. The packages that should protect the components have different characteristics, e.g. low charged, conductive and screened. Low charged packages are normally chemical treated plastics. These packages have no screened characteristics, but they grow old and should be regard as a perishable foodstuff. Low charged packages are only recommended for components that not ESD sensitive (Figure 5). Conductive packages protect materials that are conductive. This package does not grow old. Screened packages have a metallic layer that prevents loadings and electrical fields to pierce. [5]

![Figure 5 Low-charged, conductive and screen packages.](image)

**4.4 Education**

One more way to protect the components from ESD is to give the personal in the handling process, from the semiconductor manufacturer to the service workshop, an education on how they can avoid damaging the components. This education is aimed for the personal that e.g. specifies, obtains, use the components in the production and the persons that leads and supervise the work. The contents in the education would be easy to understand without leave important knowledge and information out. This education should be followed up and repeated. Examples on the contents for this education are given in the IEC 61340-5-1. [8], [1].
4.5 Simulation models

There are some different test methods described in [1] to decide the durability against ESD for some different components. Three of the test methods are called HBM (Human Body Model), MM (Machine Model) and CDM (Charged Device Model). These are described below.

Birgitta Andersson is an educationalist and an electrical engineer. She is also a candidate for the doctorate in the subject electronics production with the emphasis on ESD and an author of the book “ESD-elektrostatiska urladdningar, risker och skydd vid elektronikhantering”.

Saab has internal standards [16] with ESD test that are followed. Birgitta does not have time to look in them, but generally she says that the HBM model (the model that Saab uses) is a pretty kind method. These tests do not test how big the damage is on the component, only how big the durability against radiation is.

An analysis has to be done to see what the devices are going to be exposed to. Is the greatest risk that a human causes a damage when he/she touch the devices with the fingers or is it more believable that a human holding a tool touches the device or perhaps when a human put in the contact in the connector. The two latest examples are the unsafe and in this case is the MM model the one that should be used. Generally components are more sensitive against discharges according to the MM model (metal toward metal, without series resistance). So her recommendations are that both the MM model and the HBM model should be used.

Birgitta do not think that CDM is a good simulation model, because to measure a CDM discharge is almost impossible, due to the test systems and other factors in the surroundings will affect the measuring.

IEC 61340-5-2 says that: Sensitivity of ESDS (Electro Static Discharge Sensitive device) is normally evaluated taking into account the HBM. Other models, for instance CDM and MM can also be used in evaluating ESDS sensitivity. The model should be chosen according to the situation. When the model has been established, the sensitivity for the ESDS under consideration can be established. [9].

4.5.1 HBM (Human Body Model)

This test model was the first one that was proposed to determine the sensitivity against ESD for different components. HBM simulates a discharge from a charged person to a component. A body has a capacitance at 150-330 [pF] and a resistance at 2 [kΩ] in this model (Figure 6).
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Figure 6 Electric test circuit HBM

When the switch is in its (1)-position the capacitor is charged by the $V_{ESD}$. A discharge appears through the test object when the switch goes to the (2)-position. The size and appearance of the pulse that exposes the test object depends on the RC component values and the voltage, which what the capacitor was charged to.

HBM is standardized in European standards [8], [9], [28] and is that model that Saab uses today.

A problem is that electrical data vary between different persons. Another aspect that affects the test is how clammy the skin is. These circumstances make it difficult to imitate the reality, however the data in (Figure 6) are considered to be relevant in most situations.

In the handling process this model can be used in all steps (from the electronics manufacturer to the customer), because a human can handle the components in all steps.

4.5.2 MM (Machine Model)

This model is used when machines and not human handle components and printed circuit card. When a machine is charged and causes a discharge thru the connection at the components, the result is a low-resistance and very fast way of discharge thru the component. The capacitance at the machine is considerably higher than from a human; therefore will the stored quantity of explosive be higher. Damage at a component caused by an MM discharge often appears with a lower potential than with a discharge according to HBM.

The MM model simulates a direct discharge from charged assembly equipment, a fixture or a tool, thru a component to ground. The model consists of a capacitance at 200 [pF], an inductance at 400-500 [nH] and 0 [Ω] set in series resistance (Figure 7).
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

In the handling process this model can be used at the supplier, in the production and at the service workshop.

![Electric test circuit MM](image)

**Figure 7 Electric test circuit MM**

### 4.5.3 CDM (Charged Device Model)

The sensitivity for different components increase with a discharge according to CDM compared with HBM.

CDM simulates discharges from a charged component to a conductive, ground connected object. E.g. components that shake in a component pipe will be triboelectric charged (see 2.1.1.) If the component later gets contact with a ground connected metallic object by a component leg, a very fast discharge occur. The discharge of current is also very fast, about 10 [ns]. The result will be positive and negative discharges, the discharge lapse is very fast and take just a few nano seconds. The voltage can be sufficient to cause an oxide bleeding and the current sufficient to destroy a pn-transition in a transistor.

This model has big restrictions. To measure a CDM discharge is almost impossible, because the test systems and other factors in the surroundings will affect the measuring. Therefore are CDM tests extremely comprehensive, time consuming and the reliability are not considered to be big enough.

### 4.5.4 To chose model

An analysis has to be made to see what the devices are going to be exposed to. Is it probably a human that causes the damage when he/she touches the device with their fingers? Or is it more believable that a human holding a tool touches the device? Or is it perhaps when a human puts in the contact in the connector as an electrostatic discharge appears. HBM should be used for the first example and MM for the two following examples. Generally, components are more sensitive to discharges according to the MM.
model. CDM is not a good simulation model, because it is almost impossible to measure a CDM discharge, due to the test systems and other factors in our surroundings that will affect the measuring. [1], [9].

5 Accomplishment
Below the planning of the work is described:

- Literature study.
- Research on which demands Saab puts on the electronic manufacturers.
- Handling electronic components at Saab today.
- Guarantee statistics.
- When the customer handle electronic components.
- Result and conclusion.

The examination is for Saab 9-3 Sport sedan.

5.1 The demand from Saab at the electronic manufacturers
Saab wanted that the suppliers use the standard JESD 625 A (EIA Electronic Industri Alliance), because it is free and easy to get from the Internet. For the same reason is it easy to get the suppliers to follow that standard. But Saab does not put any demand on which standard the suppliers use. Saab has a team of some persons that regular does external revision at the suppliers and they are hard as a brick that everything is okey. The team check that the people that work with the electronic components have an education about ESD. The team ask the personal questions about ESD to see if they are conscious about the problem. There should be a place there the personal could check so they not are charged. Activity the personal should not come into the premises before they have checked so they not are charged. There should be a routine at the supplier that they check the ESD protection. The team from Saab also check that the premises have correct ESD signs and that every facility are connected to ground. For about 80 percent is it okey at the suppliers, but it happens that an operator has a grounded wristband and chairs and benches are grounded but the operator has a footstool that not is connected to ground! Another problem is that someone in the personal perhaps has a fleece sweater and can very easily be charged. If this happens or something else that not are good for the ESD safety, the team from Saab send the supplier a list of measures that they should take into account. The suppliers are very happy that Saab helps them to have an ESD safety place of work.

Saab has a lot of suppliers, e.g. Delphi, Bosch, Siemens, Motorola, Autoliv, Lear and Temec. The suppliers are scattered hole over the world. [10], [11].
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Saab also has some qualitative demand at the suppliers. The qualitative demand that Saab puts on their suppliers are:

- **PPM (Parts Per Million) value**

  PPM value is a value that are measured at the assembly line at Saab, the value is also called “0 km wrong”. It is good for the suppliers to have a low PPM value. The people that handle components to the GM concern are divided into global teams. These teams are then divided into different categories and there are some teams that handle with electronic components. For electronic components has GM a demand at 25 PPM, i.e. has the supplier a higher value than 25 so will Saab not buy components from them.

- **CTS (Components Technical Specification)**

  In the CTS is the construction demand [16] from Saab at the suppliers described. The technical development specifies the CTS.

The standard that are followed for qualitative demands is 001V and is an IPC standard. This standard describes “requirements for soldered electrical and electronic assemblies”. 001V explains that ESD controls should be done according to JESD 625-A. [12].

### 5.2 The demand at the electronic manufacturer Delphi

One of the supplier that deliver components to Saab is Delphi. Delphi has their production of printed circuit card in France. The total factory is protected against ESD, e.g. can the operator not get in the factory before he/she had tested so he/she not is charged. No specially standards are followed when the team from Saab has been at the factory and approved the production at Delphi as ESD safety. For the member in the team from Saab see [30]. After the revision a report is written, but it do not inhold some special information about ESD. The printed circuit cards are packed into ESD bags and putted into ESD boxes. The components that are delivered to Saab are not protected against ESD during the transport way. They are not protected because Saab thinks the costs are too big and because Saab cannot handle the components in an ESD safety way when they arrive to Saab. Saab also sent red boxes to Delphi, which is not ESD protected, instead of sent black boxes, which protect the components against ESD. To protect these components against ESD the whole transport way has to be protected against ESD and that costs a lot of money.

Delphi does not have any ESD co-ordinator, but they have a person that is responsible for the ESD safety at the company. His name is Gerhard Grossman and his telephone number is +49 6704 912 643. [27].
5.3 The handling with electronic components at Saab Automobile today

An ESD instruction called “ESD instruction protection of prototype articles – electronics” should be followed at Saab to protect electronic components from damages because of ESD. Saab has a store at the Technical development and the people that work there should follow this instruction. This instruction has been followed since it was written (2002-08). No packages are broken in the store. No special controls are performed to control that this instruction is followed. [14].

This instruction should also be followed in a place called “frickeboa”, it is a prototype factory at Saab. Here is the instruction also followed. No packages are broken before the components are putted into the car. Nobody that works in the “frickeboa” has ESD safety equipment. There is no special controls performed that this instruction is followed. [13].

5.4 The rules for the packing around the electronic components that are sent to the production

The components that are sent from suppliers to the production at Saab are unbroken in the packages that they are lying in. ESD sensitive components are putted in black boxes called “Saab 123” (Figure 8) and have an ESD mark (Figure 9). Components that not are sensitive for ESD are putted in red boxes called “Saab 121” (Figure 8).
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

![ESD Symbol](image)

**Figure 9 ESD symbol**

The people that work in the production preparation get a list from the Technical development at Saab at the components that are sensitive for ESD. A problem here is that often starts the production of a car before an ESD test of the components are done, so it could be uncertainly if a component is ESD sensitive or not. This end in that some components that are ESD sensitive not are protected and other components that not are sensitive for ESD could be unnecessary protected. To sum up, all electronic components should be treated as sensitive for ESD until some testing have showed that the components are unsensitive. [15].

### 5.5 The handling with electronic components at the assembly line at Saab

A visit in the factory was a good thing to do to get an understanding for the handling with electronic components at the assembly line at Saab. To get an even better understanding a measuring at materials and components that suspects being charged in the factory was done. The measuring was done with an electromagnetic field indicator. There are different methods of preventing or leaking off electrostatic charges, but to find a reasonable and effective solution, the source of generation and the magnitude of the charge must be measured. This has been done with an Influence-E-fieldmeter (Appendix B). The measuring is done when a person is holding the component in his hands or when the component lying in a box. During the measuring the attention was also directed to the environment where the components are kept, if they are lying in an ESD protected bag and an ESD box and if the component has an ESD marking. As mentioned before ESD are influenced of the temperature and the RH. The day when the measuring was done, the temperature was 20 °C and the RH was 34%, which are approved values. The measuring showed that four of about 45 components have to high values according to [16] that say that no components or material should have a discharge over +/- 8 [kV] and should therefore not be charged to more than +/- 8 [kV]. In the factory at Saab no components should be charged more than +/- 8 [kV]. But the measuring showed that these four components have values between 9 and 18 [kV] charge (Appendix A). Even if these components are charged over 8 [kV] it does not
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

mean that an ESD defect has happended. If an ESD damaged should appear a discharge must have been done. Jointly for three of these four components are that they do not lying in an ESD bag, not in an ESD box and they do not have any ESD marking. The fourth one is lying in an ESD bag and in an ESD box, but the component does not have any ESD marking. More observations from the measuring are that a component could have an ESD marking, but it does not lying in an ESD bag or in an ESD box!

There are rules in the factory that the assembly personal should wear special clothes and shoes. These clothes and shoes should not be charged easy, but they are not ESD approved. SP (Sveriges Provnings – och forskningsinstitut) test and decide if the products are ESD safety or not. The technical demands for every product are as long as it possible identical with the demands due to suitable international standards. During the measuring a lot of people were observed that not use the clothes that Saab says that they should, they have their own clothes and shoes, which can be fleece sweaters or other synthetic materials. The mechanics use three different gloves. They consist of cotton and PVC, nylon and some plastic and the last one of 100% nylon. The gloves were also measured with the Influence-E-fieldmeter, the values were between 0,2 – 1,0 [kV], i.e. not harmful for the components.

The people that work in the production should have an education about ESD. But it is many years than the ESD education was carried through. The awareness about ESD among the assembly personal is almost non-existent.

There are no requirements in the production that ESD safety clothes, shoes or tools should be used. [18].

Already in the production there is a problem that components that are placed on a complete car maybe are broken before it leave the factory. At one place at the assembly line the assembly personal can see which components that are broken, but to see how they are damaged are very difficult to see. It could be many reasons to why a component is broken. It could be ESD but it is not sure. [19].

The following strategy is supported by Anders Molander (the chairman at the ESD group at VI) and Arne Börjesson (agb-consultant, before this man had the technical responsible for the ESD testing at SP). The strategy was going through during the week 15 2001. The strategy shows the differences at the safety level on an EPA and in the production at Saab.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

ESD protection

**Human beings**
- Clothes made of cotton with conducted material
- ESD shoes
- Educated
- Wrist strap

**Environment**
- 40% Atmospheric humidity in the factory
- De-ionized air at the construction places
- Continuous measuring of the levels
- ESD carpets

**Method**
- All tools and machines should be grounded
- The car-body should be grounded
- Control of ESD protection before working
- No isolated materials in machines

**Materials**
- Black boxes for electronics
- Articles should be packed in screened bags
- Material stand should be grounded
- Antistatic low charged bags around transmission network
- Dissipative protection over contacts at electronics

Figure 10 ESD-protection EPA

ESD-protection production

**Human beings**
- Saab clothes of cotton
- Saab shoes
- Educated

**Environment**
- Continuous measuring of the levels

**Method**
- The car-body should be grounded
- Assembly sequence
- Test equipment grounded

**Material**
- Black boxes for electronics
- Material stand should be grounded
- Antistatic low charged bags around transmission network
- Dissipative protection over contacts at electronics

Figure 11 ESD-protection production
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

The figures on the page before are divided into four groups, human, environment, method and material differences. The differences for human are that in an EPA the constructor have to wear clothes made of cotton and with conducted materials inside, they have to wear ESD shoes, they should have an education and wear wrist strap. In the production at Saab the operator should wear clothes made of cotton, wear Saab shoes and have an education. For the environment in an EPA the atmospheric humidity should be 40 [%]. It should be de-ionised air with the construction places, continuous measuring of the levels and ESD carpets. In the production at Saab it only has to be continuous measuring of the levels. The method in an EPA is that all tools and machines should be grounded, the car body should be grounded, a control of the ESD safety should be done before working at the construction place and no isolated materials in machines. The method at Saab is that the car body should be grounded and the test equipment should be grounded. The materials in an EPA should follow these rules: black boxes for electronics, articles should be packed in screened bags.

Material stand should be grounded. Antistatic low charged bags around wiring harness. There should be a dissipative protection over contacts at electronics. In the production at Saab the materials should follow this rules: black boxes for electronics. Material stand should be grounded. Antistatic low charged bags around transmission network. There should be a dissipative protection over contacts at electronics.

5.6 Guarantee statistics

Saab has statistics data over the components that most frequently are broken. Mostly Saab has to replace the components. Four of the fifty components that Saab has most guarantee reclamation on have been chosen to lock closer on. They have been chosen because it could be a big risk that just these components will be damaged because of ESD. But also how much money the replacement cost Saab has been taken in account. The chosen components are: CIM (Electronic control module), ICM (Front panel), the CD player and HPDC (switch panel, info display). These components are all easy for the customer to touch it is a huge risk that they are damaged because of ESD. The statistics is only for 9-3 sedan (2003).

The guarantee statistics showed that CIM is the component that cost most for Saab. According to the measuring that have been done in the production (Appendix A) an value of 10 [kV] was measured on the CIM, an observation was that the CIM does not laying in an ESD bag or an ESD box and there were no ESD marking on the component. The supplier for the CIM is Delphi and they have done a measuring (2003-09-04) of the red boxes that the CIM are lying in. Their measures showed that the electrostatic charge on the surface (after friction) was 19,5 [kV]. Allowed limits according to [16] are +/- 8 [kV] discharged, but as mentioned before the component should not be charged to more than +/- 8 [kV]. The temperature was 24,2 ° C and the relative humidity was 39,4% when the measuring was done. GM has made a measuring
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

[25] and has found out that 33% of the damages on electronic components can be caused by ESD. By using this information an estimate of cost on how much money that could be saved are done (Table 3). The column “Unsatisfactory performance el” means “functional disorder” and the column “Inoperative el” means, “default function”. The last one is for more serious faults. The measuring in the production showed that electrostatic charge on the ICM was 0,3 [kV]. This component lying in an ESD bag and an ESD box, but does not have an ESD marking. The electrostatic charge on the HPDC was 0 [kV]. The component was putted in an ESD bag and lying in an ESD box and have an ESD marking. The CD player was not measured on during the measuring in the production. [22], [23].

The measuring that GM has done [25] also showed that ESD damages were more usual than at the electronic manufacturer than at the car manufacturer. At the car manufacturer are EOS (Electrical Over Stress) damages more usual than at the electronic manufacturer.

<table>
<thead>
<tr>
<th></th>
<th>Unsatisfactory performance el</th>
<th>Inoperative el</th>
<th>Possible damages because of ESD (33%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIM</td>
<td>1 645 105 kr (46%)</td>
<td>786789 kr (22%)</td>
<td>542885 + 259641 = 802526 kr</td>
</tr>
<tr>
<td>ICM</td>
<td>958308 kr (43%)</td>
<td>378866 kr (17%)</td>
<td>316242 + 125026 = 441268 kr</td>
</tr>
<tr>
<td>CD player</td>
<td>165886 kr (37%)</td>
<td>143469 kr (31%)</td>
<td>54742 + 47345 = 102087 kr</td>
</tr>
<tr>
<td>HPDC</td>
<td>49669 kr (31%)</td>
<td>41658 kr (26%)</td>
<td>16391 + 13747 = 30138 kr</td>
</tr>
</tbody>
</table>

Table 3 Estimate of costs every year for CIM, ICM, HPDC and the CD-player.

5.7 **When the customer handle electronic components**

One component where the customers can touch the electronics is the remote control. Saab has specified that they cannot guarantee where the customer is when he/she change the battery. E.g. the customer can walk over a carpet and be charged, when he/she later on changes the battery a discharge can apper. There have not been any problems with the remote control that could be related to ESD. An explanation to that could be that ESD tests on the remote control should be done when it is open for change of battery. The problems have been more mechanical. [24].

6 **The Nordic ESD council**

The purpose of the Nordic ESD council is to prevent damages at electronic materials caused by ESD. The working team consist of some people representing a company, which handle with sensitive electronic components in their production. Some of the companies are: Volvo Car Corporation, ABB, Autoliv Electronics AB, Ericsson AB and the University of Örebro. The Nordic ESD council takes part in work with international standardisation, combine to take out foundations to directions, contribute to education about ESD through reports, courses, conferences and education material and also co-operated with SP (the test- and research institute of Sweden). [7].


7 Results and conclusions

The results and conclusions from the investigation are described below:

7.1 Education

It is very important that the personal gets an education about ESD, so they can be aware about this problem. This education should be for the personal that e.g. specifies, obtains, uses the components in the production and the persons that lead and supervise the work. The contents in the education should be easy to understand without leaving important knowledge and information out. This education should be followed up and repeated. Examples on contents for this education are given in [8].

7.2 Simulation models

Today Saab only uses the model HBM. HBM tests both functionality and parameter. However, according to [1] this test does not show how big the damage is on the component, only how big the durability against radiation is. An analysis has to be done to see what the devices are going to be exposed to. Generally, components are more sensitive to discharges according to the MM model. So [1] recommendations are that both the MM model and the HBM model should be used. Saab followed [16] when they do their ESD tests and both functionality and parameter are tested, which means that it is enough to use the HBM model.

7.3 Standards

The standards IEC 61340-5-1 and IEC 61340-5-1 have been compared with JESD 625 A (EIA Electronic Industries Alliance), to see if there are any differences between the demands. JESD 625 A (EIA Electronic Industries Alliance) establishes the minimum requirements for ESD control methods and materials used to protect electronic devices that are susceptible to damage or degradation from ESD. IEC 61340-5-1 and IEC 61340-5-1 are more detailed than JESD 625 A (EIA Electronic Industries Alliance). But the demands for EPA and ESD protected materials are nearly the same.

7.4 Results from the measuring in the production at Saab

The measuring in the production at Saab showed that four of about 45 components have to high values according to [16] that say that no components or material should have a discharge over +/- 8 [kV] and should therefore not be charged to more than +/- 8 [kV]. The measuring showed that these four components have values between 9 and 18 [kV] charge. Jointly for three of these four components are that they do not lying in an ESD bag, not in an ESD box and do not have any ESD marking. A component at Saab could have an ESD marking, but it does not lying in an ESD bag or in an ESD box!
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Results from this are that Saab is a car factory and not an electronics industry; therefore the ESD protection does not have to be at the same level as in an electronics industry. The electronic components at Saab should today be protected against ESD according to (Figure 11). Perhaps Saab in the future can put in some of the restrictions that are described in (Figure 10), but not all. It is not necessary since the components that are handled at Saab are not that sensitive as the electronic components that are handled at the electronic manufacturers. It is a question about money.

There are no restrictions in the production about ESD safety clothes, shoes or tools that should be used. The assembly personal in the production should wear special clothes and shoes that not easily get charged. A problem is that the assembly personal does not only use those special clothes, they have their own clothes and shoes, e.g. fleece sweaters or other synthetic materials. To increase the awareness about the problem with ESD among the assembly personal an education about the most fundamental ESD problem is a good thing to do. The assembly personal should have an education in most basic ESD problems, but it is many years since the ESD education was carried through.

7.5 Results from the guarantee statistics

The guarantee statistics showed that CIM is the component that cost most for Saab. According to the measuring that has been done in the production (Appendix A) a value of 10 [kV] charge was measured on the CIM, an observation was that the CIM was not lying in an ESD bag or an ESD box and there were no ESD marking on the component. The supplier for the CIM is Delphi and they have made a measuring (2003-09-04) of the red boxes that the CIM were lying in. Their measures showed that the charge on the surface (after friction) was 19.5 [kV]. Allowed limits according to [16] are +/- 8 [kV] discharge and should therefore not be charged to more than +/- 8 [kV]. GM has made a measure [25] and found out that 33% of the damages on electronic components might be caused by ESD. By using this information an estimate of cost on how much money that could be saved were made (Table 3). Only for CIM approximately 800.000 Swedish kronor could be saved per year.

7.6 The Nordic ESD council

Today Saab does not have a representative in the Nordic ESD council. Perhaps this would be a good idea because many other companies that have the same problem, with ESD as Saab has got, are members in this council.

7.7 Co-ordination group

A co-ordination group is a good thing to facilitate the work with trying to protect the electronic components against ESD damages at Saab. The members in this group shold
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

e.g. come from the purchase division, the assembly preparation, the production, the aftermarket and the Technical development. The task for this group is: that the members should co-operate more so the protection against ESD would be better.

To sum up, it is not enough to protect the electronic components against ESD at the suppliers; they must be protected in all steps in the handling process so that ESD damages could be avoided.

Strategy to avoid ESD:

“Save the electronics from the human and not the human from the electronics” [20].

8 Personal opinion

I think it has been interesting to work with the problem of ESD and understanding how ESD influences the electronic components. I am, surprised that so few people are conscious about the risks of ESD. People that are not conscious about the risks of ESD have difficulties to believe that ESD can cause such a big problem. Maybe it is because a damage caused by ESD does not have to be presented directly when the component is damaged.

Finally, I think it has been a nice period in my life to do this degree project. I have learnt a lot and I have found out that it had been interesting to e.g. keep on working with an education material about basic ESD information for employees and more researchings about how Saab could protect their electronic components against ESD.

9 Program

- Windows 2000
- Microsoft Office 2000

10 List of figures

Figure 1 Source, coupling path and victim ................................................................. 2
Figure 2 Electrostatic induction .............................................................................. 5
Figure 3 Different safety circuits for ESD .............................................................. 7
Figure 4 The construction of the "shark fin" ................................................................ 8
Figure 5 Low-charged, conductive and screen packages ....................................... 9
Figure 6 Electric test circuit HBM ........................................................................ 11
Figure 7 Electric test circuit MM ......................................................................... 12
Figure 8 Black box 123 and red box 121 ............................................................. 15
Figure 9 ESD symbol ......................................................................................... 16
Figure 10 ESD-protection EPA ........................................................................... 18
Figure 11 ESD-protection production ................................................................. 18
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

11 List of tables

Table 1 Triboelectric series ................................................................. 4
Table 2 Components with low transient durability ................................. 7
Table 3 Estimate of costs every year for CIM, ICM, HPDC and the CD-player ........ 20
12 References


[8] IEC 61340-5-1 “Protection of electronic devices from electrostatic phenomena – General requirements”.


[20] Molander A.


Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

[27] Blomberg Markus, representative for Delphi.

[28] ISO 10605 ”Testmethods for electrical disturbances from electrostatic discharge”.

[29] JESD 625 A (EIA Electronic Industries Alliance). Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices. www.eia.org


[31] 001V “requirements for soldered electrical and electronic assemblies”. It is an IPC standard.


[33] Molander Anders, The chairman at the ESD group at Vi

[34] Borjesson Arne, agb- consultant, before this man had the technical responsibility for the ESD testing at SP

Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Measuring of materials in the factory at Saab that maybe could generate static electricity

| Temp: (°C) | 20 | 2003-12-09 |
| RH: (%)   | 34 | 2003-12-09 |

### Instrument panel

<table>
<thead>
<tr>
<th>KV</th>
<th>ESD bag</th>
<th>ESD box</th>
<th>ESD marking on component</th>
<th>Not ESD bag</th>
<th>Not ESD box</th>
<th>Not ESD marking on component</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCM (tray)</td>
<td>4</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;climate house&quot;</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BCM</strong></td>
<td>18</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor BCM</td>
<td>0,2</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assemblage BCM hand (bef)</td>
<td>0,2</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assemblage BCM hand (after)</td>
<td>0,1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airbag</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assemblage airbag hand</td>
<td>0,1</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Op hand radio</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio fixture</td>
<td>0,2</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEC_MEC</td>
<td>10</td>
<td>* black styrofoam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unstar komp. (switch)</td>
<td>4</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loud speaker, treble</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HPU (info display)</td>
<td>0,2</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar sensor</td>
<td>4</td>
<td>* (20 kV)</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bubble plastic</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC (Instrument panel)</td>
<td>1,9</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>blue plastic pull of IPC</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>battery master switch</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HPDC (Switch panel, info dis)</td>
<td>0</td>
<td>* (0,2 kV)</td>
<td>* (0,2 kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CM (Front panel)</td>
<td>0,3</td>
<td>* (0,8 kV)</td>
<td>* (0,4kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor lights</td>
<td>2,5</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CIM (Electronic control mod)</strong></td>
<td>10</td>
<td>*</td>
<td>(plastic)</td>
<td>(5 kV)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Lying in an black insert</td>
<td>0,8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handspike (dryer)</td>
<td>0,5</td>
<td>*</td>
<td>* (white insert 10 kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handspike (flasher CC)</td>
<td>3</td>
<td>*</td>
<td>* (white plastic 5 kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote control</td>
<td>0,8</td>
<td>*</td>
<td>* black insert 15 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 9-3 line

<table>
<thead>
<tr>
<th>KV</th>
<th>ESD bag</th>
<th>ESD box</th>
<th>ESD marking on component</th>
<th>Not ESD bag</th>
<th>Not ESD box</th>
<th>Not ESD marking on component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission network, luggal</td>
<td>2</td>
<td>* (3 kV)</td>
<td>* (blue (3kV)</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerial amplifier</td>
<td>0,2</td>
<td>*</td>
<td>* (black plastic cradle)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insert cardboard</td>
<td>0,2</td>
<td>*</td>
<td>* (1 kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRAB (Side airbag)</td>
<td>0,8</td>
<td>*</td>
<td></td>
<td>(black hard plastic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black insert</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shark fin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antenna telephone</td>
<td>0,8</td>
<td>* (0,2kV)</td>
<td>* (1,6kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard in box</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSM roof aerial</td>
<td>1,8</td>
<td>* (1,1kV)</td>
<td>* (4kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard in box</td>
<td>1,1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMP (roof aerial)</td>
<td>1,5</td>
<td>* (0kV)</td>
<td>* (0,2kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lights + alarm module</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assemblage, hand</td>
<td>0,4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halltrack, trans network</td>
<td>3</td>
<td></td>
<td>* (4kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lights back</td>
<td>0,2</td>
<td>*</td>
<td>* (10 kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White plastic</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antisladdsystem</td>
<td>0</td>
<td>* 0.8 kV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLL control unit</td>
<td>2</td>
<td></td>
<td>* (4kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm signal komp. Siren</td>
<td>4</td>
<td></td>
<td>* (4kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard insertion</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C-lock fillercap</strong></td>
<td>9</td>
<td>*</td>
<td>* (15kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CU</td>
<td>0</td>
<td>*</td>
<td>* (0,3kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pink insertion</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bluetooth, antenna</td>
<td>0,1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black plastic insert</td>
<td>3</td>
<td></td>
<td>* (3kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVD</td>
<td>0,3</td>
<td></td>
<td>* (3kV)</td>
<td></td>
<td></td>
<td>Cardboard (1kV)</td>
</tr>
<tr>
<td>Amplifier AMP 2</td>
<td>0,1</td>
<td></td>
<td></td>
<td>Cardboard (1,5kV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REC Rear Elektronic Centre</td>
<td>0,9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assemblage, hand</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black insertion</td>
<td>0,4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kollision sensor</td>
<td>0,9</td>
<td></td>
<td>Cardboard (0,2kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission network, back</td>
<td>1,4</td>
<td></td>
<td></td>
<td>(2kV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load speaker 4&quot;</td>
<td>0,2</td>
<td></td>
<td>Cardboard (0,1kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load speaker 6,5&quot;</td>
<td>0,4</td>
<td></td>
<td>Cardboard (0,1kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load speaker 4&quot; + treble</td>
<td>1,9</td>
<td></td>
<td>Cardboard (0,1kV)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Appendix**

A:1
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

Operating instructions

Influence-E-Fieldmeter EMF58

Appendix B:1
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

1 General information on electrostatic energy

Electrostatic discharges (ESD) present a major problem in many sectors of industry, for instance in the electronic industry (integrated components), in the chemical industry (explosive substances), in printing and in packaging, in telecommunications and in the manufacture and processing of synthetic materials.

Contact charges, also known as "tribo-electricity" (Greek: tribēia = to rub), generated by the friction and the separation of dissimilar materials, cause losses in time and quality and hence substantial financial damage. Humans, clothing, materials and machinery can develop charges exceeding 10,000 V which can lead to sparking through electrostatic discharges. These effects are not only detrimental to human health in physiological terms. Electronic components, for instance, are easily damaged by electrostatic charges as low as 100 V. Sparking in explosion hazard areas can lead to ignitions.

There are different methods of preventing or leaking off electrostatic charges, but to find a reasonable and effective solution, the source of generation, the magnitude and the polarity of the charge must be measured. The EMF58 Eltex Influence-E-Fieldmeter was developed for this purpose, as well as for controlling the measures taken to prevent electrostatic charges and for monitoring the desired static charges.

2 Technical specifications, EMF58

The instrument is installed in an aluminium housing with a membrane front panel. The influence chopper electrode is starshaped. A grounded windmill-type chopper wheel at the same starshape rotates a short distance in front of the chopper electrode. These components are hard gold-plated to protect from galvanic interference fields. A ring electrode encloses the entire measuring assembly and serves as mechanical guard.

Dimensions: 180 x 73 x 178 mm (L x W x H)

Weight: 820 g

Power supply: Mains operated with power supply (included), optionally 230 V 50/60 Hz or 115 V 60 Hz

Battery: NiCd rechargeable battery 7.2 V (Eltex make, built in)

Operating period: approx. 4 hours per charge

Battery monitor: constant monitoring via µP, LED "Load" blinks with approx. 1 Hz when dropping below the discharge voltage

Charging: use only the appropriate charger (supplied)

Charging voltage: 12 V DC (for continuous duty with power supply 9 V DC)

Display: analog instrument Kl 1.5

Measuring ranges: ± 5 / ± 20 / ± 50 / ± 200 kV/m / 2 MV/m
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

3 Startup

(The figures shown in brackets refer to the EMF58 key)

Start the EMF58 by pressing lightly on the pushbutton (3) in the handle. By pressing the pushbutton again the EMF58 switches off. During the function test the unit cannot be switched off.

3.1 Function test

Place the protective cap (1) over the chopper system before starting the EMF58. Switch on the meter. The built-in microcontroller starts a self-test immediately after startup. The LEDs on the front panel begin to blink. The needle of the display instrument (13) is on approx. 4/10 of the lower scale. At the same time the amplifier runs through a complete test. After the function test the EMF58 switches over to the range ±5 kV/m and is ready for measurements (see section 5: Measuring field strengths).

Caution:

If the function test results in an error, the LEDs "± ± 5 kV/m" (10), "± ± 20 kV/m" (9), "± 10" (8) and "manual measuring range" (15) blink. Measurements cannot be taken in this case. Return the EMF58 to Eltex for inspection.

3.2 Zero point adjustment

a) Mechanical

With the meter switched off, the needle of the display instrument (13) must be located precisely over "zero" (middle of the scale). If required, the needle can be adjusted by turning the setting screw (7) to "zero" (standard screwdriver with 3 mm blade width).

b) Electrical

After switching on the unit and after completing the function test, the needle of the display instrument (13) must be located precisely over "zero" (middle of the scale). If off-centre, adjust the display to "zero" using the zero point adjuster (12).

3.3 Switching between measuring ranges

The measuring range of the EMF58 is subdivided into five sections. At the beginning of the measuring cycle the instrument is set to automatic (LED (10) lights up). Through pressing the range selector switch (11), the EMF58 switches into the manual measuring range (LED "Mode Manual" (manual measuring range) (15) lights up). Switch to the next range up (± ± 20 kV/m) by pressing the range selector switch (11) (LEDs (9) and (15) light up). Pressing button (11) again will switch the EMF58 to the range ± 50 kV/m (LED (10), LED (8) [displayed test result times 10] and LED (15) light up). Pressing the key (11) again switches the instrument to the range ± 200 kV/m.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

4 Battery monitoring

The EMF58 is equipped with a battery voltage monitor. As long as the unit is switched on, the charge of the rechargeable NiCd batteries is constantly monitored. If the charge of the batteries drops below the present limit the LED “load” (14) will light up with approx. 1 Hz. In this case recharge the built-in battery with the supplied charger: connect the charger to the charging jack (6) in the handle. Charging time is approx. 12 to 14 hours. If the LED blinks faster (approx. 3 Hz) the unit switches off completely (protection of maximum discharge).

Caution:
Maximum discharge will destroy the battery! Please note that the charger is set to 12 V. (For warranty services see section 7: Warranty.)

4.1 Mains / back-up battery operation

If continuous measurements > 4 hours are to be carried out the EMF58 may be operated directly via the mains (depending on design: 230 V 50/60 Hz, 115 V 60 Hz) using the mains power supplied with the instrument, connecting it to the charging jack (6). Therefore set the voltage adjuster of the power supply at the bottom to 9 V with a 3 mm screwdriver.

Caution:
Do not operate the instrument from the mains when using the accessory “HV measuring head EMF58 H”!

The instrument may be mounted on a tripod or support for continuous measurements. The EMF58 is equipped with a 3/8" threaded recess (4) for inserting tripods at the base of the handle. After terminating the continuous measurements reset the power supply to 12 V to achieve the maximum charge of the battery.

4.2 Grounding the Influence-E-Fieldmeter

To obtain accurate readings of magnitude and polarity of the measured field, the test instrument must be sufficiently grounded. Connect the instrument to ground via the grounding socket (2) fitted in the centre of the rear panel. It is normally sufficient if the operator is grounded properly via the appropriate safety footwear (see section 6: Warning notices).

4.3 Plotter port

A standard plotter or another external analyzing unit can be connected to the plotter port jack (5) in the handle. The output voltage is ± 1 V (R2 > 1 kΩ), rise time < 1 μsec (option: ± 1 mA [R2 < 1 kΩ], rise time < 1 mA/sec). The output signal is in any case strictly proportional to the measured field strength.
Avoiding Electro Static Discharge (ESD) problems during handling of automotive electronics

5 Measuring field strengths

To measure the field strength, remove the protection cap (1) from the chopper system after switching on the unit, checking the zero point setting and completing the function test. Then hold the chopper system at a right angle over the test object. During the measurement the distance between the test object and the electric fieldmeter must be kept constant, because the distance is integrated into the measurement. The measured field strength is displayed in kV/m. Multiplying this display (kV/m) by the measuring distance (in meters) will show the charge on the test object (in volts).

Example

<table>
<thead>
<tr>
<th>Distance</th>
<th>Test object – electric fieldmeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cm (0.05 m)</td>
<td>measured field strength = 1.6 kV/m</td>
</tr>
<tr>
<td>1400 V/m</td>
<td>0.05 m = 80 V</td>
</tr>
</tbody>
</table>

6 Warning notice

1. The EMF58 must not be opened.
(see section 7: Warranty)

2. The Influence-E-Fieldmeter is not approved for measurements in explosion hazard areas.

3. In the event of very high electrostatic charges, the electric field meter must be grounded. Take the first measurement at an adequate distance to make sure that the maximum surface potentials applied are determined from a safe test distance.

4. Avoid spark discharges onto the chopper measuring system.

5. The use of the instrument in power plants is not permitted.

6. The instrument is not equipped to detect alternating fields > 1 Hz

7. Do not operate the instrument from the mains when using the accessory "HV measuring head EMF58 H" !
(see section 7.2: Using the special accessories)

6.1 Calibration

Calibrate the instrument in the homogeneous field of a plate capacitor. Plate size 400 mm x 400 mm, plate spacing 100 mm; chopper plugged in centered into a plate.

Measure the applied test voltage using a voltmeter calibrated by a DKD agency to make sure that the country standard is complied with.

It is advisable to have Ettex recalibrate the electric fieldmeter once a year.

6.2 Maintenance

Do not touch the gold-plated components of the chopper system. If inadvertent contact has been made, clean the chopper system using a lint-free cotton cloth with some alcohol (spirit). Remove any insulating layers or coatings (e.g. dust, paint, varnish, etc.) and condensation (dew) from the chopper system.

If the electric fieldmeter is not in use for any length of time, recharge the NiCd battery at minimum intervals of six months (see section 4: Battery monitoring). Please make sure that the battery never discharge entirely.

If the battery can no longer be recharged, replace through Ettex.