

**Electrostatic Discharge (ESD) Technology Roadmap**

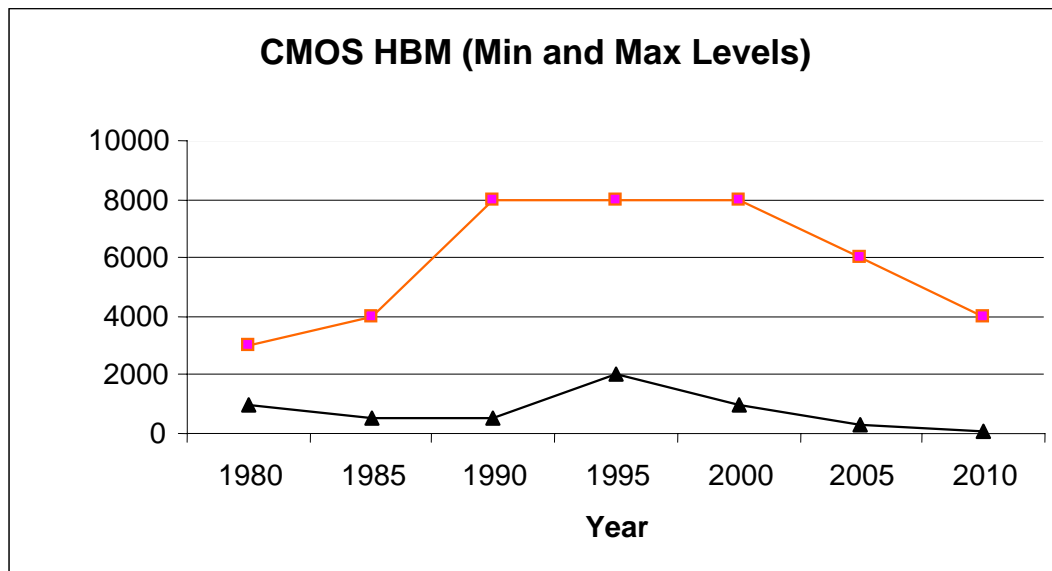
**Introduction**

In the late 1970s, electrostatic discharge, or ESD, became a problem in the electronics industry. Low level ESD events from people were causing device failures and yield losses. As the industry learned about this phenomenon, both device design improvements and process changes were made to make the devices more robust and processes more capable of handling these devices.

During the 1980s and early 1990s, device engineers were able to create protection structures that made the devices less sensitive to ESD events. Technology changes during this time also helped design engineers to develop more robust devices.

In the mid to late 1990s however, the requirements for increased performance (devices that operate in the Giga-Hz range) and the increase in the density of circuits on a device caused problems for traditional ESD protection circuits. To achieve the performance and density numbers required by industry, the devices have become more sensitive to ESD events since the late 1990s. The current trend, which is expected to continue, is circuit performance at the expense of ESD protection levels. This is especially the case for RF circuit applications.

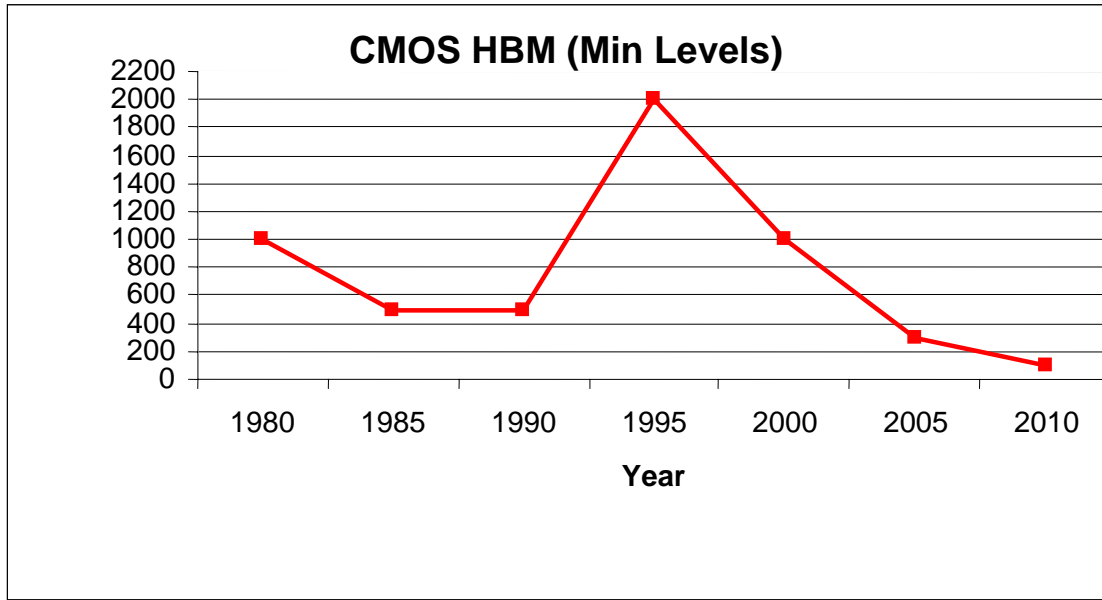
The following graphs show the device ESD sensitivity trends based on three ESD models: Human Body Model (HBM), Machine Model (MM) and Field Induced Charge Device Model (CDM). The sensitivity limits, as shown in figures 1 through 6, are based on projections by engineers from IBM, Intel, and Texas Instruments through to the year 2010. The minimum and maximum lines represent the ESD sensitivity boundaries for the majority of the CMOS (including RF) devices over this period.



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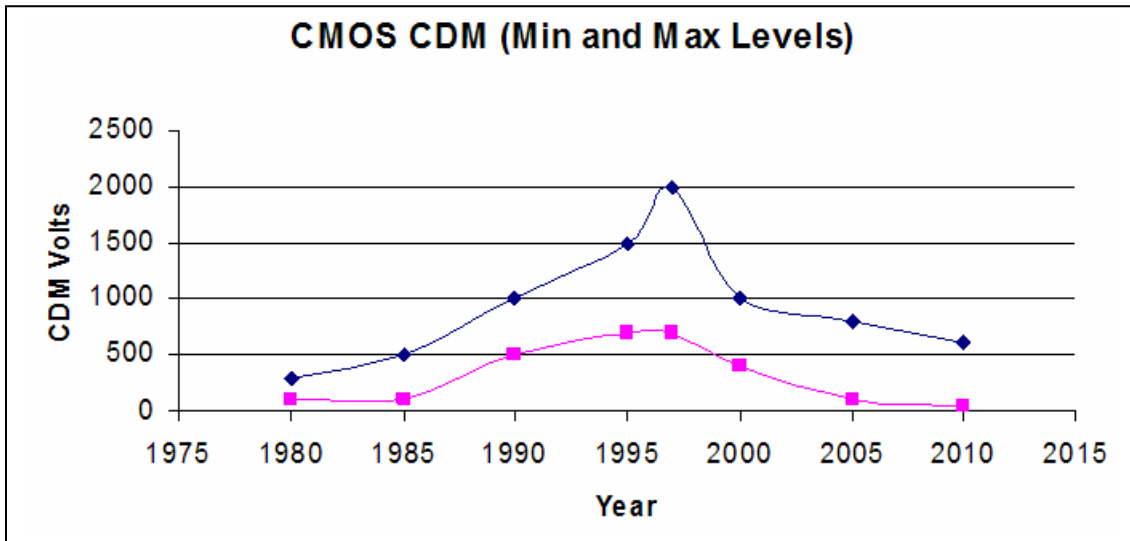
Figure 1. Human Body Model Sensitivity Limits based on ANSI/ESD STM5.1-2001

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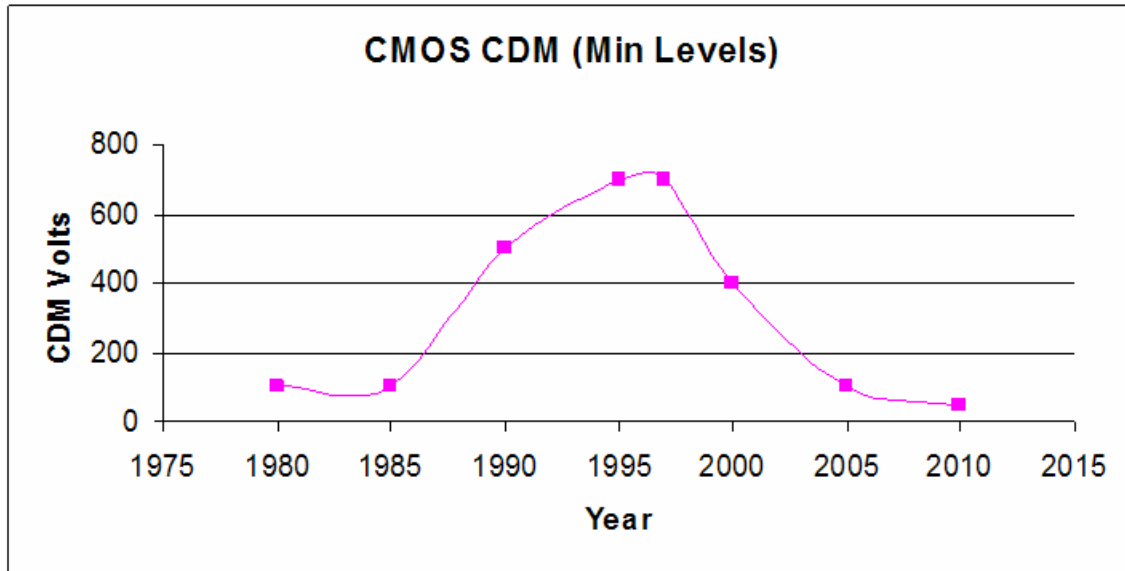
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Figure 2. Human Body Model Sensitivity Minimum Trend based on ANSI/ESD STM5.1-2001



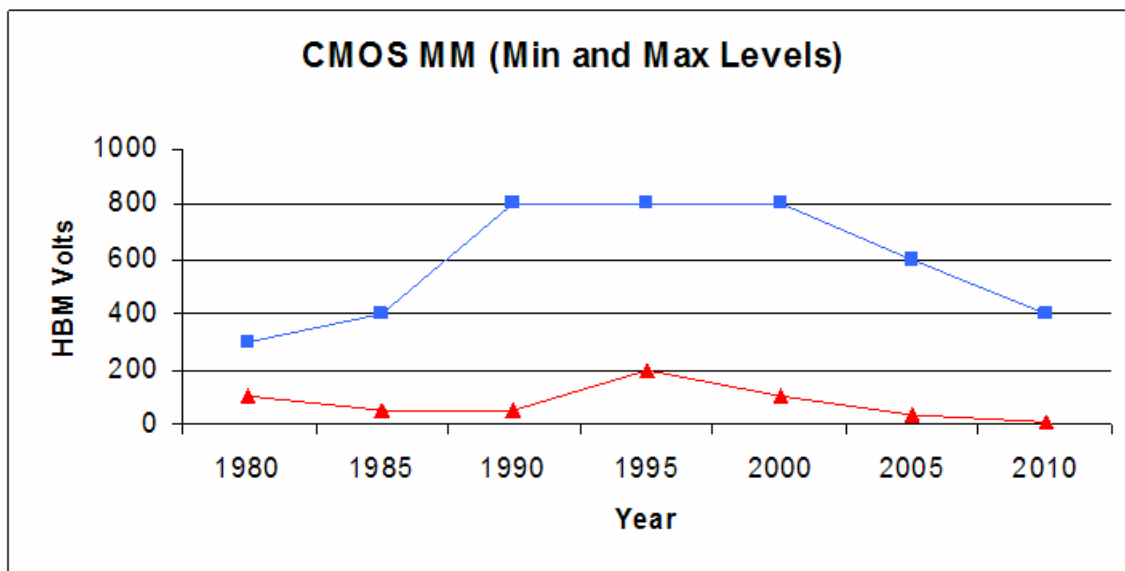
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Figure 3. Charged Device Model Sensitivity Limits based on ANSI/ESD STM5.3.1-1999



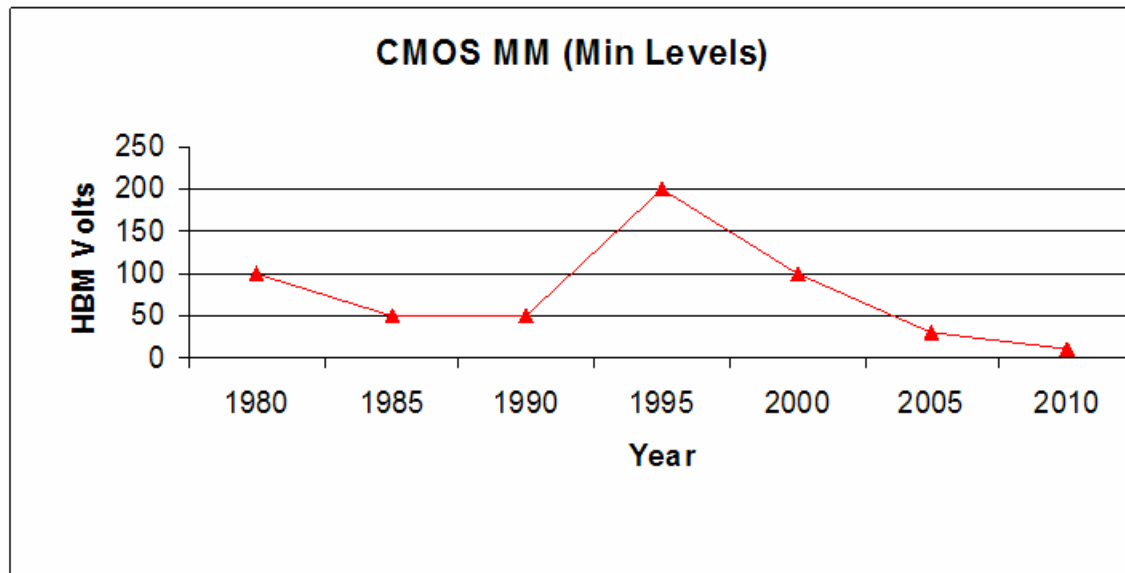
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Figure 4. Charged Device Model Sensitivity Minimum Trend Based on ANSI/ESD STM5.3.1-1999



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Figure 5. Machine Model Sensitivity Limits Based on ANSI/ESD STM5.2-1999



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Figure 6. Machine Model Sensitivity Minimum Trend Based on ANSI/ESD STM5.2-1999

### **Process Capability**

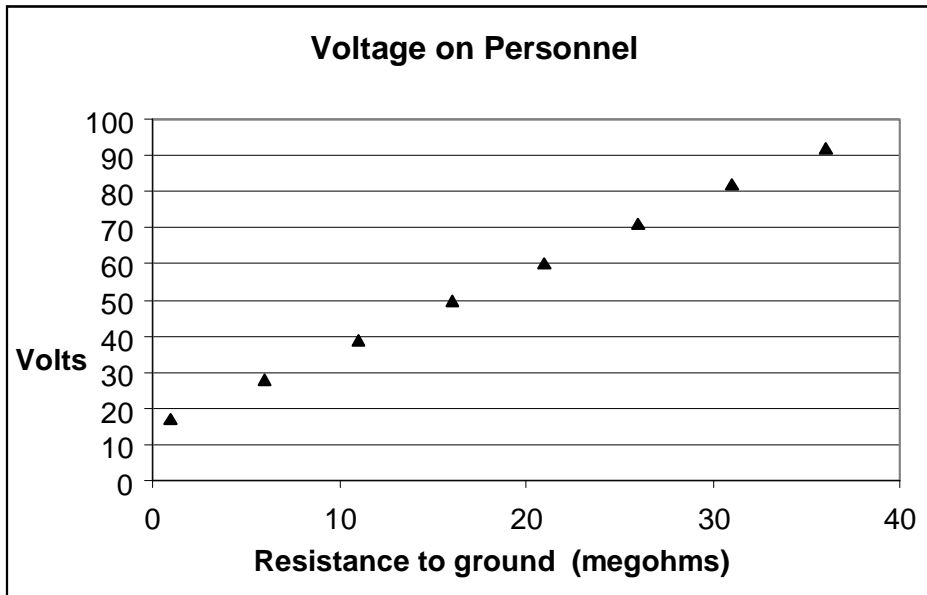
These ESD sensitivity trends will have a major impact on manufacturing process yields over the next five years. Companies need to verify that the installed ESD processes are capable of handling these devices.

When designing ESD control processes, they must be repeatable and consistent. In addition, there must be a way to evaluate how effective the ESD control items are based on the sensitivities that are expected to be handled. The following notes provide guidelines on how to evaluate ESD control processes.

### **Human Body Model (HBM)**

It has been shown that for a wrist strap system, the resistance of the person to ground has a direct correlation to the maximum voltage on a person. For wrist straps, Figure 7 may be used.

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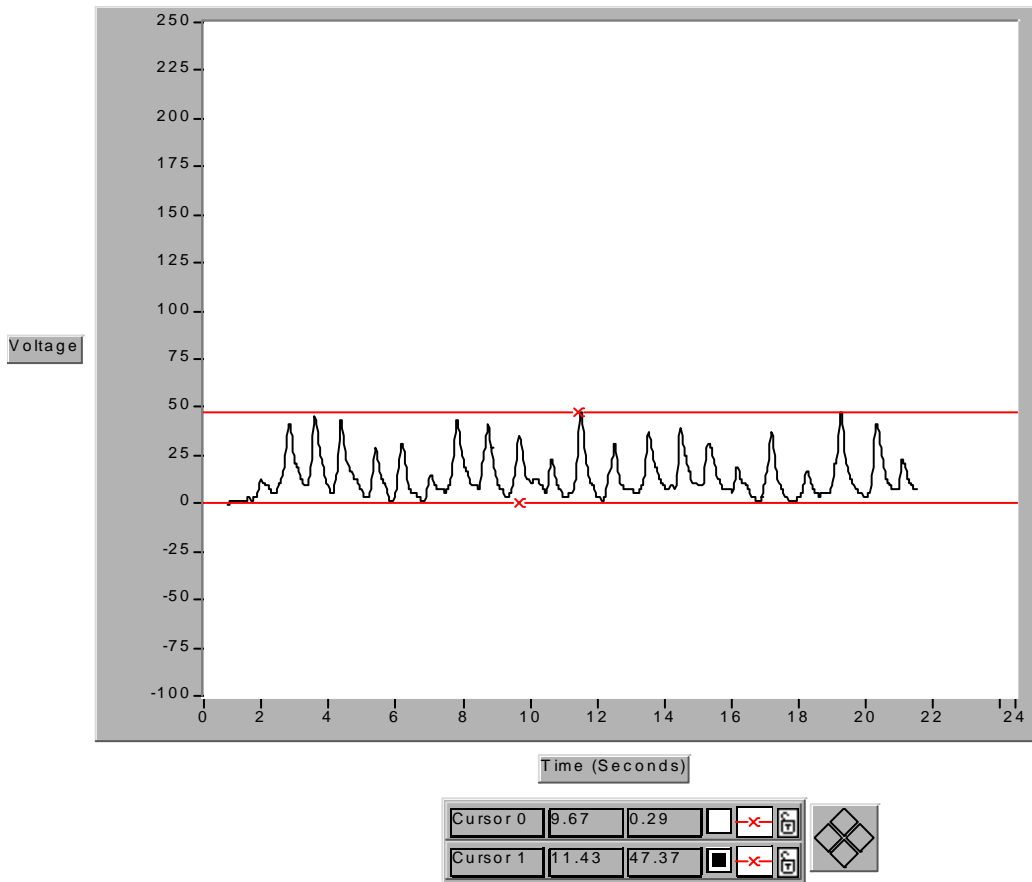


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Figure 7. Resistance in a Wrist Strap System

For an ESD control program that uses ESD footwear and flooring to ground personnel, the situation is more complex. As people walk across an ESD floor while wearing ESD footwear, it is difficult to predict the voltage on a person’s body due to the constantly changing body capacitance and the continuous charging and discharging of the person.

ANSI/ESD STM 97.2-1999 can be used to determine the process capability of the footwear flooring system. An example of the type of information provided can be seen below in Figure 8.



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Figure 8. Determining Process Capability of a Footwear/Flooring System Using ANSI/ESD STM 97.2-1999

**Machine Model (MM)**

Machine model discharges occur when charged, conductive surfaces come into contact with ESD sensitive devices. To minimize Machine Model discharges, ensure that all metal surfaces that come into contact with ESD sensitive devices are grounded. Measurements should be made to ensure that moving parts remain grounded throughout the process.

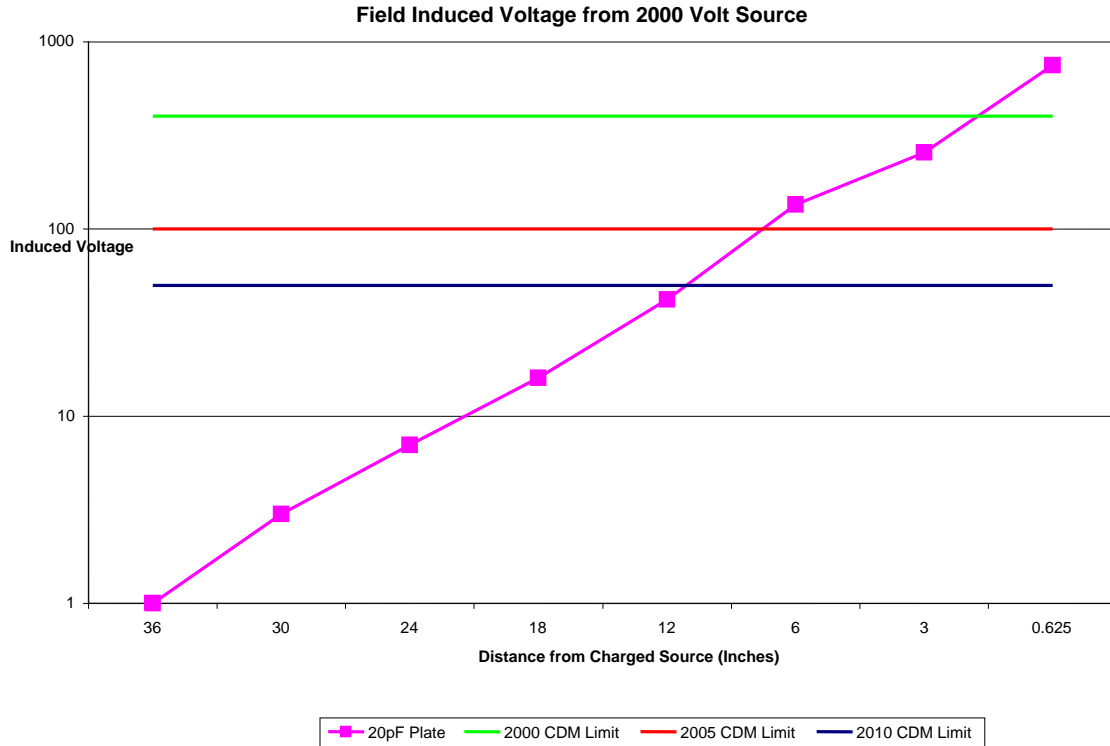
**Field Induced Charge Device Model (CDM)**

CDM damage from an electrostatic field occurs when a charged item is brought into close proximity to an ESD sensitive device and the device is then grounded while in the presence of the field. Effective ESD control programs ensure that process required insulators will not induce damaging voltage levels onto the devices being handled.

Figure 9 shows the voltage induced onto a 20 pF parallel plate capacitor from a 2000 volt uniform voltage source at varying distances. Overlaid onto the chart are the minimum CDM levels from the CDM roadmap for the years 2000, 2005, and 2010. Since the devices will become more sensitive over time it will be necessary to either

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- A. Increase the distance between the ESD sensitive devices and the charged source or
- B. Reduce the charges on surfaces to levels that will limit the induced voltage to levels that will not damage ESD sensitive devices.



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Figure 9. Voltage Induced onto a 20 pF parallel plate capacitor from a 2000 Volt Uniform Voltage Source at Varying Distances.

**Conclusions:**

With devices becoming more sensitive through the year 2010, it is imperative that companies begin to determine the ESD capabilities of their handling processes.

For people handling ESD sensitive devices, personnel grounding systems must be designed to limit body voltages to less than 100 volts.

To protect against Machine Model ESD discharges, all conductive elements that contact ESD sensitive devices must be grounded.

Finally, to limit the possibilities of a field induced CDM ESD event, users of ESD sensitive devices should ensure that the maximum voltage induced on their devices is kept below 50 volts.

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