ESD for Amateurs

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Don's Brief Bio…

- Retired, widower, licenced amateur since 2001
- 40 years past business experience in R & D, Quality Assurance and Regulatory Affairs, - Medical Electronics, Power Audio, Automotive Electronics, and Electronic Components.
- Hobbies are power boating, Ham Radio, digital photography, solar/wind energy, …
- Member of IEEE, ARRL, SPARC, VHARC.
- I have implemented ESD control programs in Electronics Labs and large Assembly Plants, as well as trained many Engineers and Assembly workers in ESD control techniques.

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AREAS TO BE DISCUSSED

- ESD History
- What is ESD ??
- What does it do ??
- What are “Latent” Failures
- Vulnerability or Susceptibility to ESD
- How to minimize the risk of ESD
- Folklore and myths
- Prevention Measures
- Keypoints Review and DEMO’S

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ESD HISTORY

…static electricity has been a serious problem literally for centuries

- **In the 1400's, forts in Europe and in the Caribbean actually used basic static electricity control procedures, to prevent the ESD ignition of black powder (gunpowder) stores.**
- **In the 1860's, paper mills had to develop basic procedures to dissipate static electricity from the moving paper, to keep it from sticking. (flame ionization, steam drums, and grounding)**
- **In the 1960's, premature and unexpected ignition of rocket engines on NASA launch-pads, caused many deaths and resulted in what we know today as *"Pink Poly"***

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ESD HISTORY

FROM THE 1980's TO THE PRESENT DAY, LOSSES IN THE ELECTRONICS INDUSTRY DUE TO ESD IS IN THE ORDER OF BILLIONS OF $$$$ ANUALLY

Table 2 Examples of Static Generation Typical Voltage Levels		
Means of Generation	10-25% RH	65-90% RH
Walking across carpet	35,000V	1,500V
Walking across vinyl tile	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

An electrostatic charge also may be created on a material in other ways such as by induction, ion bombardment, or contact with another charged object. However, triboelectric charging is the most common.

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HINDENBURG EXPLODES DUE TO ESD

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Exploding sugar refineries

In February this year an explosion at a sugar refinery in Georgia (US) was blamed on the reaction between static electricity and sugar dust in a storage silo. Following the explosion six people were killed, 62 taken to hospital and many more injured at what was described as "a small war zone" by fire crews when they arrived.

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Exploding oil tankers

There have also been numerous explosions on oil tankers blamed on the build up of static electricity.

Two crew members were killed on a Japanese ship carrying 4000 tonnes of ethanol, whilst a fire started by an ESD spark sunk a 570-foot oil tanker just off the US coast.

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ESD fires at petrol stations

Explosions and fires breaking out at petrol stations have also been blamed on the static electricity generated by people in their cars.

It's believed that the main reason fires occur at petrol stations is because of the static generated when people get back into their cars, rub against the seats and then release the static discharge when they return to the fuel pump.

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WHAT IS ESD ??

ESD IS A SPARK !!

- It is an electric discharge - passing from one charged conductive surface to another.
- An ESD spark literally blasts it's way through air and sometimes --- through whatever else is in between.
- An ESD spark, destroys semiconductors and electronic equipment.

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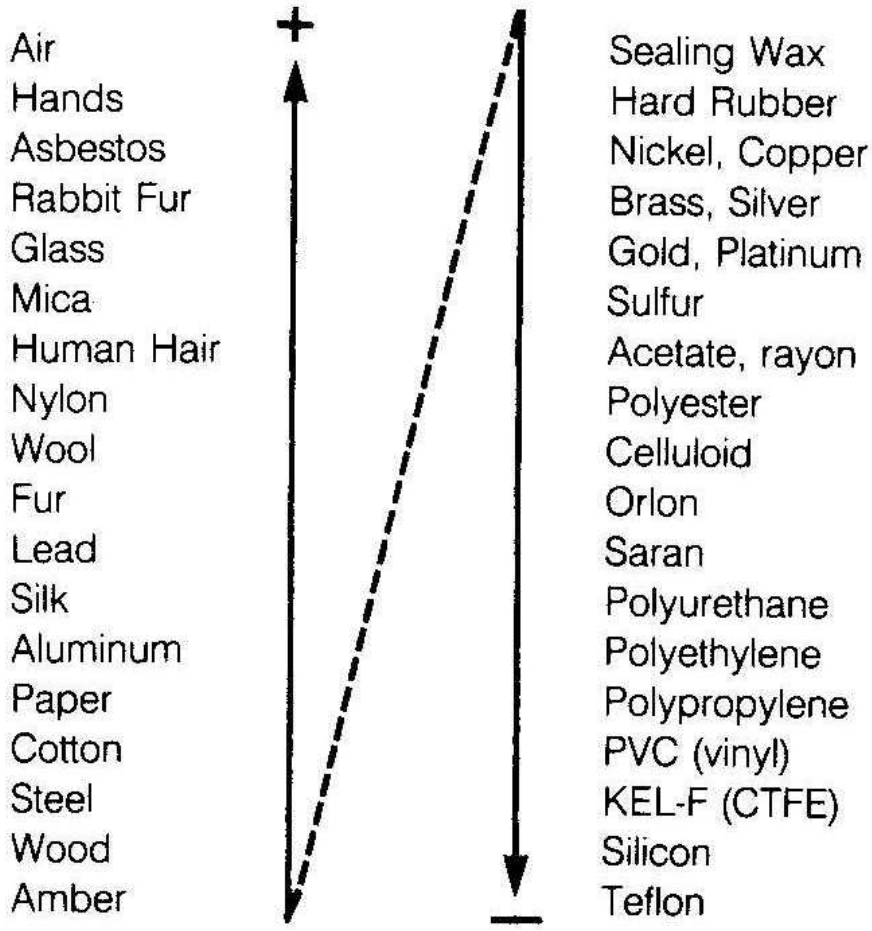
THE TRIBO-ELECTRIC SERIES



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WHAT DOES IT DO ?

ESD CAN and DOES CAUSE :

- **Fires explosions, heat, light, sound, EMI & RFI**
- **Catastrophic electronic part and system failures**
- **D.O.A. (dead-on-arrival) pcb assemblies & products**
- **Latent failures (>70% of field failures)**
  - **degraded components**
  - **“walking wounded” parts or assemblies**
  - **field failures**

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LATENT FAILURES

- **Up to 90% of all ESD-damaged components are "soft" or latent failures**
- **This happens where the ESD damage done to a part was *not quite enough* -- to cause obvious, immediate destruction, but it will result in eventual, or latent, product failure. *(otherwise referred to as the "walking-wounded", always resulting in field failures)***
- ***Latent ESD failures are the cause of more than 70% of all electronics field failures!!***

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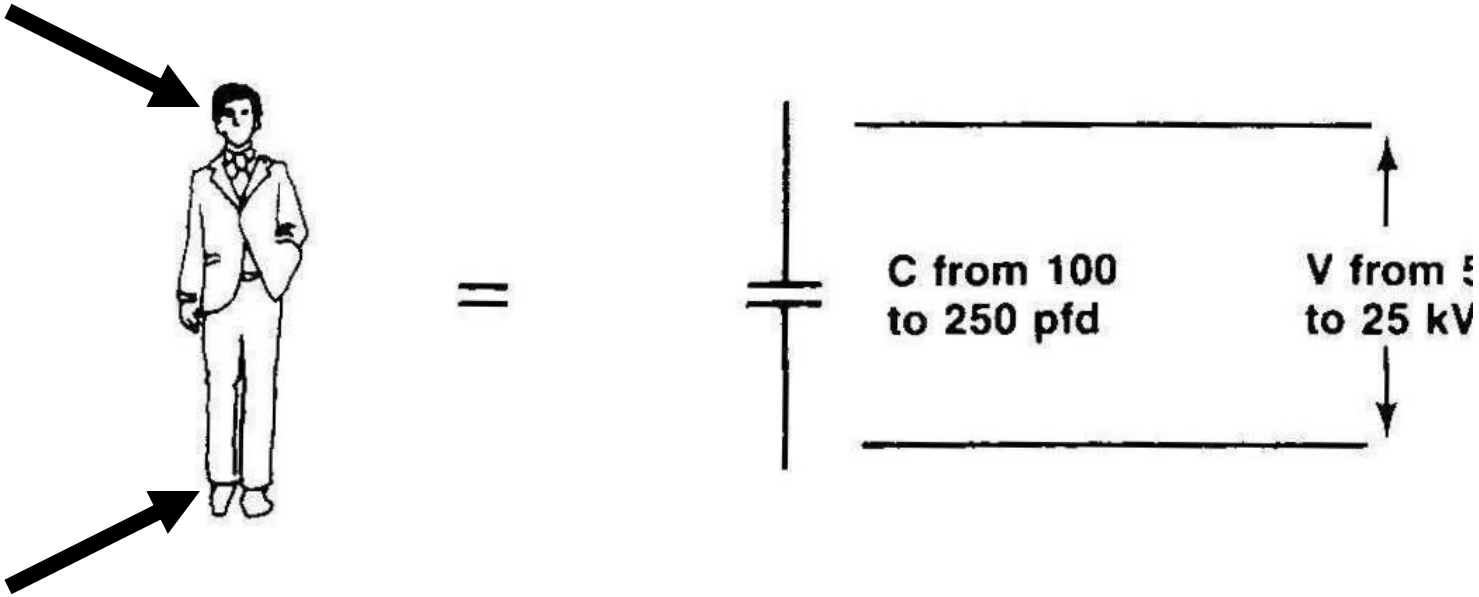

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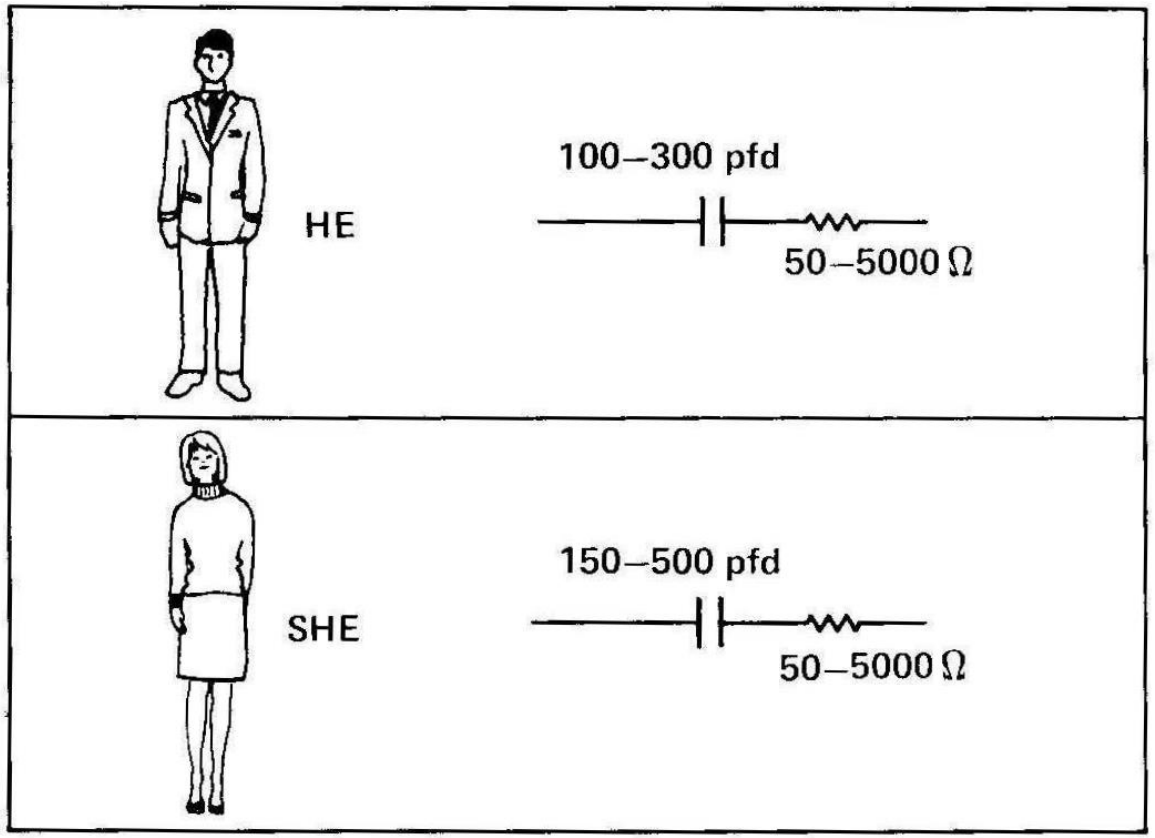

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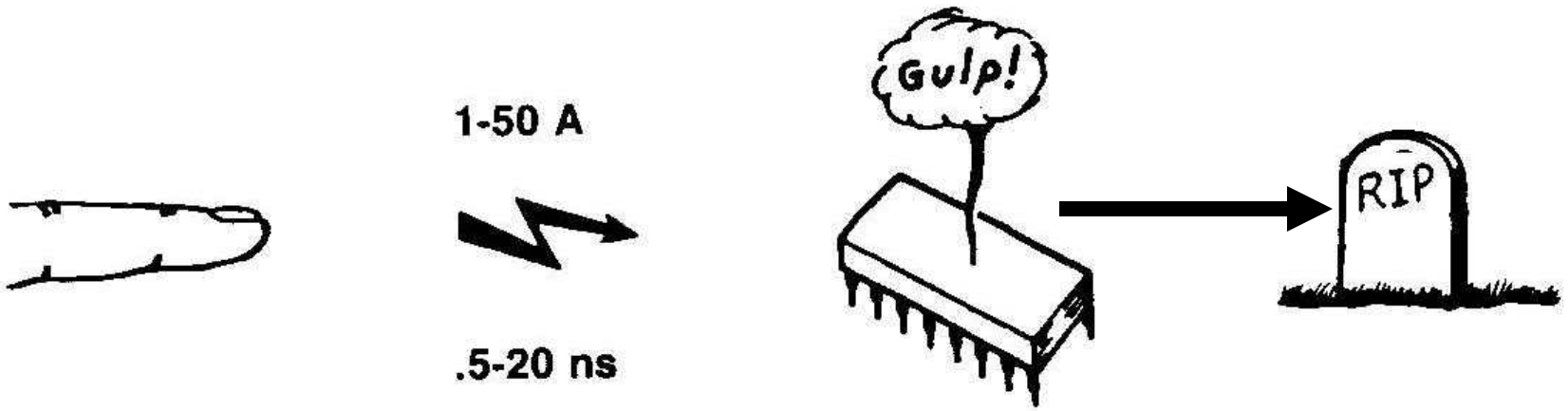

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BREAKDOWN VOLTAGE

BETWEEN 2 CONDUCTORS IN AIR

Spacing mm	Spacing inches	Break-down voltage
254	10	250,000
25.4	1	25,000
2.5	0.1	2,500
0.25	.01	250
0.025	.001	25
0.0025	.0001	2.5

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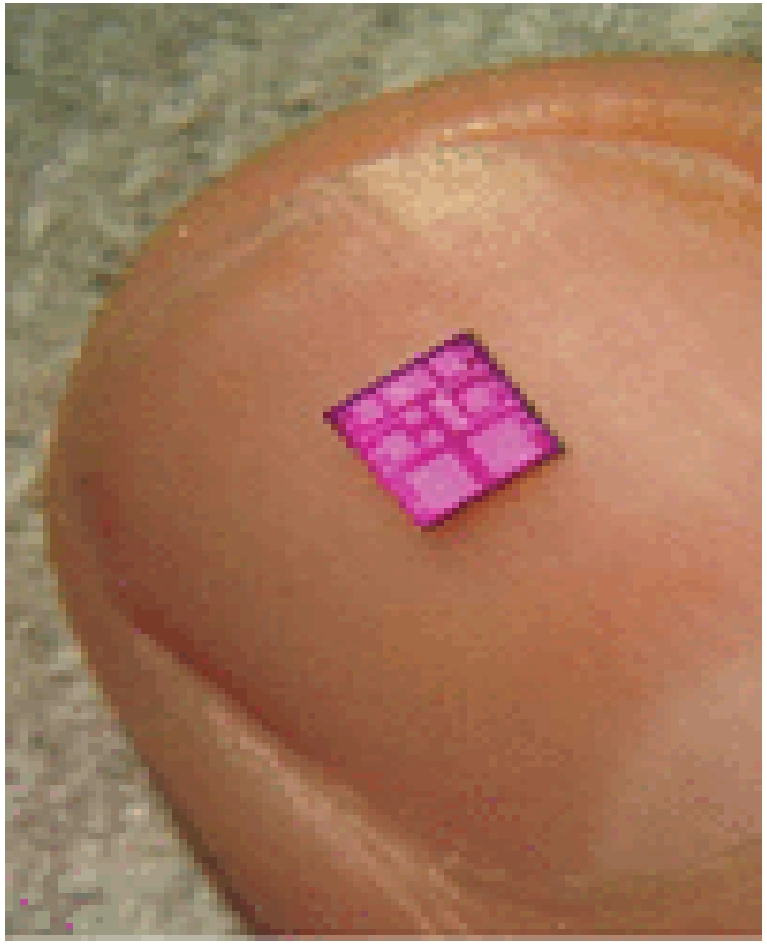

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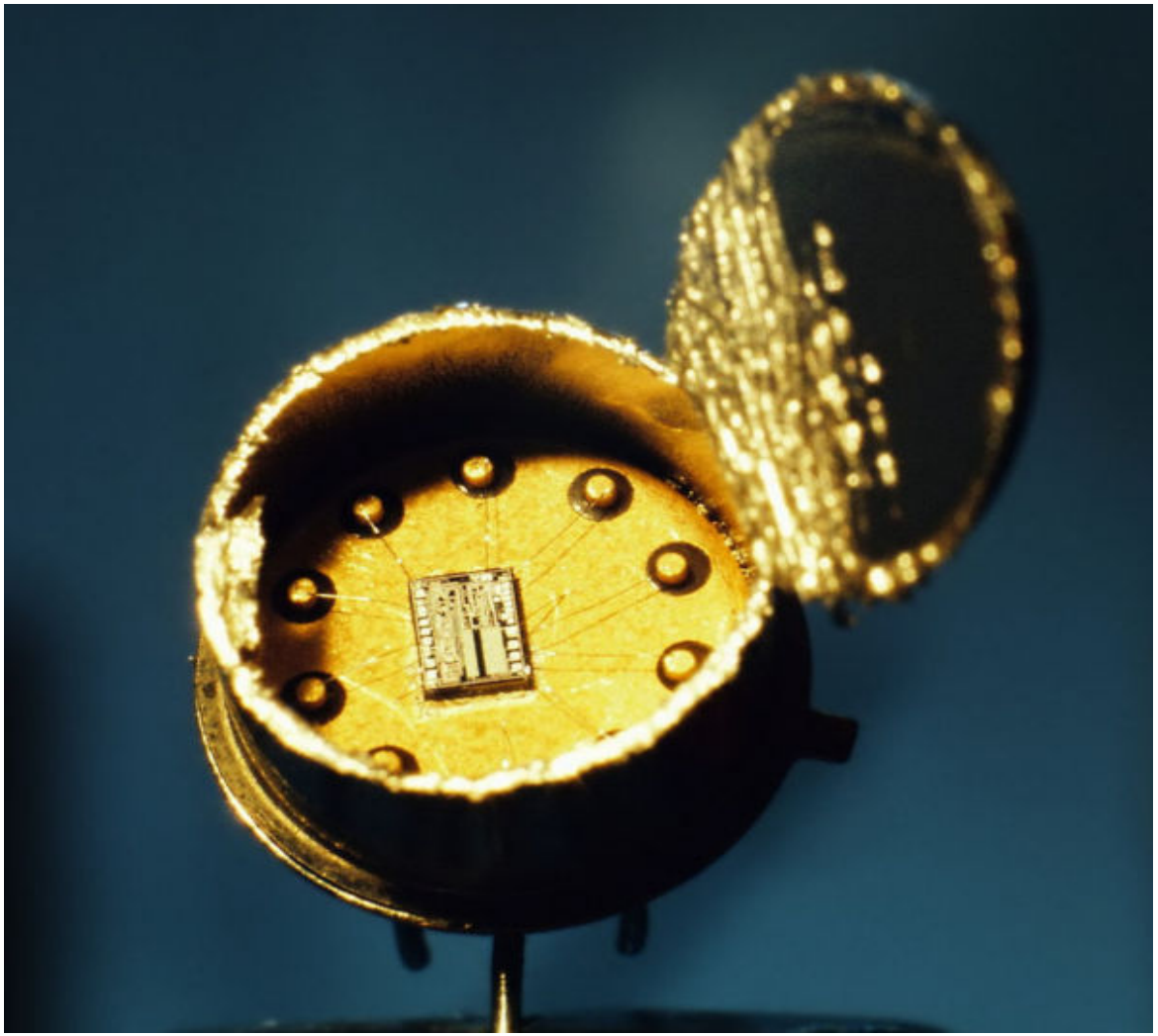

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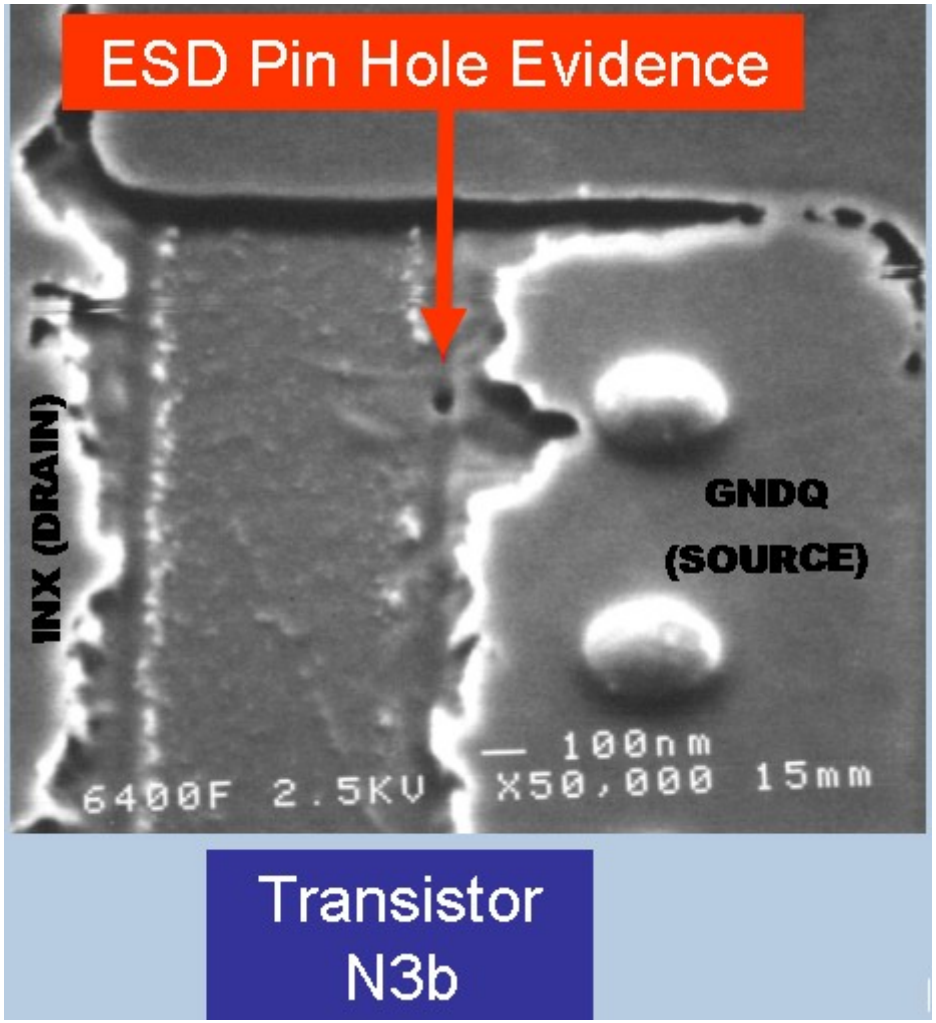

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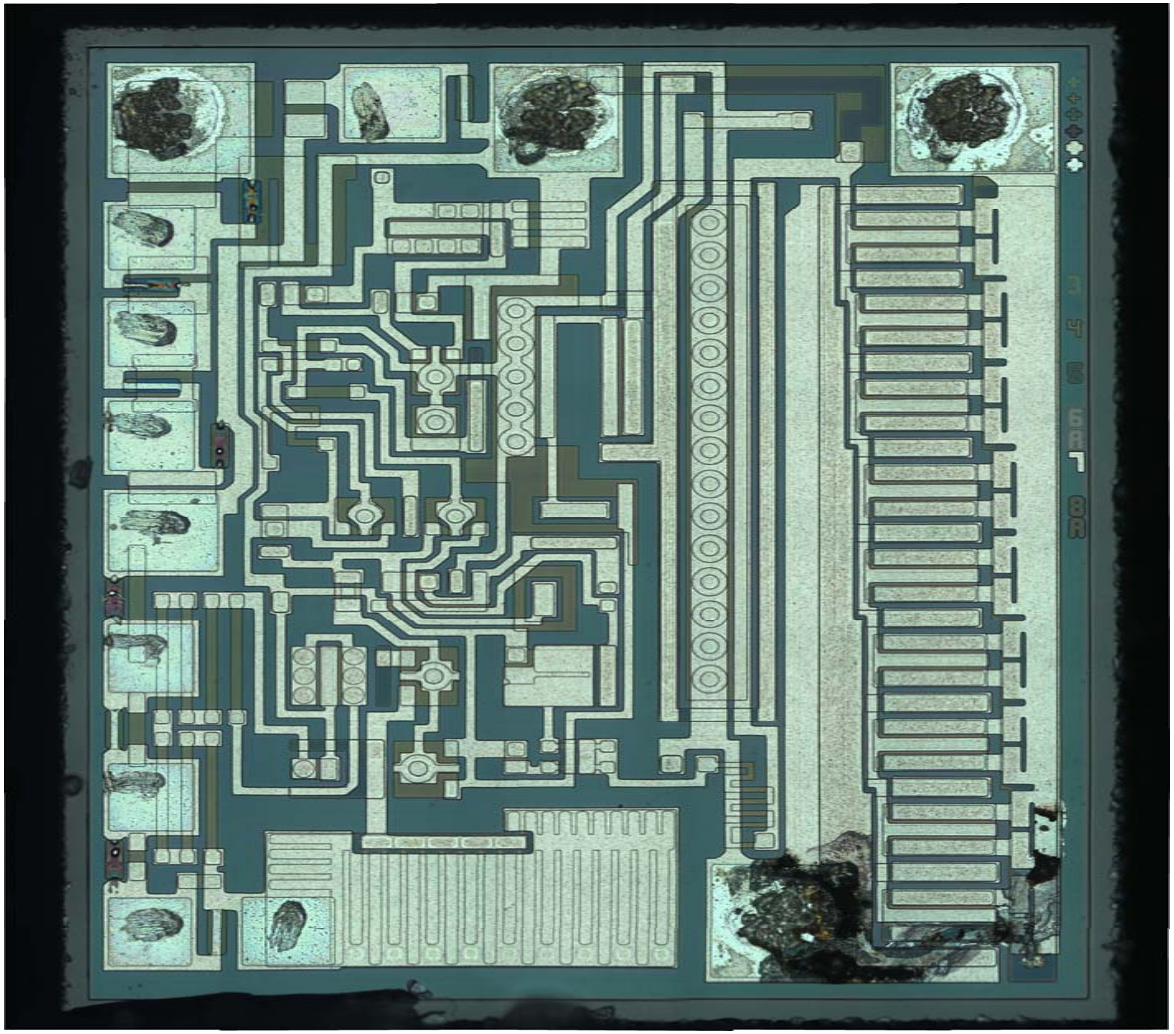

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WHAT IS VULNERABLE TO IT ?

Level 1 (very vulnerable)

- **Most all loose semiconductor devices, or unassembled parts**

Level 2 (significantly vulnerable)

- **Sub-assemblies, like pcbs, modules etc.**

Level 3 (less vulnerable, *design dependent*)

- **Finished products, ham radios, computers, TV's etc**

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FOLKLORE or MYTHS

- **"*High humidity will solve the handling problem with ESD"***
  Truth: Increasing humidity will only help. It would be more accurate to say that low humidity will aggravate existing ESD problems
- ***"Components are ESD safe once they're soldered onto the Pcb boards"*** **Truth: Surprisingly, they can be at very high risk. Handling of pcbs, can easily discharge containers and/or people through the boards; in production, in test, or during field service.**
- ***"If an electronic assembly passes final test, it means the components on it were handled properly"*** **Truth: No Way! Not at all! Latent ESD damage can still cause field failures, including hard to isolate intermittents, for one to two years after final test and shipment!**

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MINIMIZING THE RISK OF ESD

(What can we do?)

- **Wear wrist-straps as a minimum, when handling your electronics parts and assemblies (*and/or heel straps*)**
- **Use conductive workstation mats, on workbenches.**
- **Never touch i/o pins, circuit traces or bare components unless properly protected as above.**
- **Use anti-static (pink) or conductive shielding (black/gray) packaging and bags to transport open, sensitive, assemblies**
- **Keep plastics and foam out of your work area**
- **Same for wool or polyester clothing, dangling long hair.**
- **Keep humidity > 30%**

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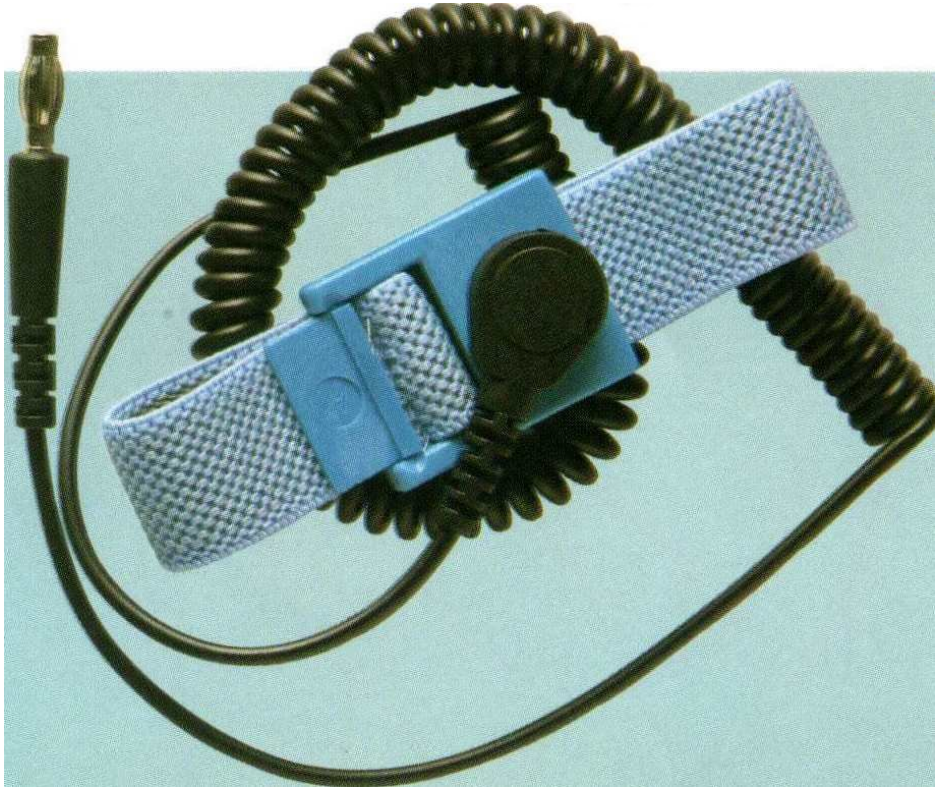

WRIST STRAP

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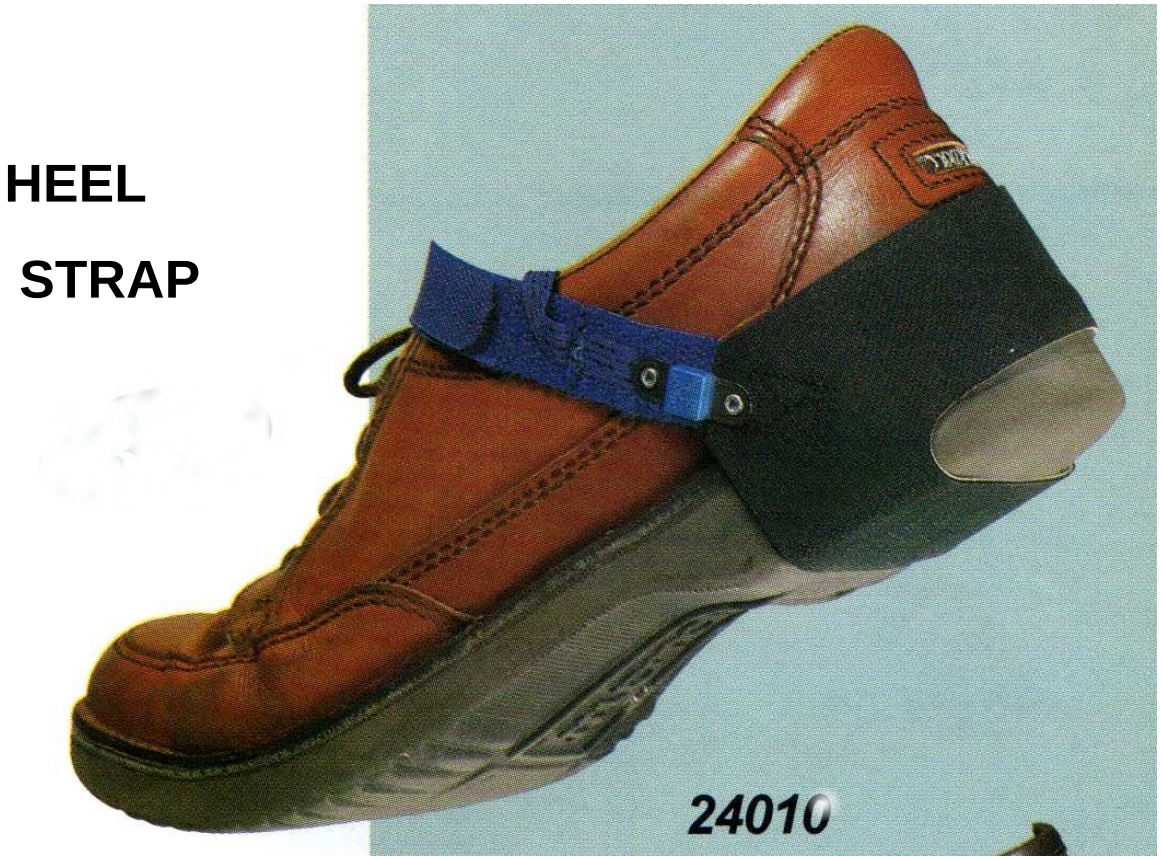

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SERVICE TYPE, ESD SAFE, WORKSTATION

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ESD KEY POINTS REVIEW

1. *(E)lectro(S)tatic (D)ischarge -- what is it ? ----> ESD*
2. *Any semiconductor can be damaged by ESD -- but some types are more sensitive to damage than others.*
3. *ESD sensitive components can be damaged by ESD without anyone even touching them ! (damage by induction)*
4. *ESD sensitive components can still be damaged even after they are soldered into an assembly. (handle pwb assys by the edges, keep hair & clothing away.*
5. *ESD failures can be either catastrophic (immediate) or latent (those that fail later). Latent failures are the biggest concern.*

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ESD KEY POINTS REVIEW

6. ***ESD safe work areas must not contain ANY stray plastic, styrofoam or other static generating materials.***
7. ***Static shielding materials are conductive, and are often grey or black in color. (but not always !!)***
8. ***Anti-static materials are dissipative, and are often pink in color. (but not always !!)***
9. ***Wrist straps, Heel straps and conductive footware***
   - ***Drain off static charges from the body, not clothing or hair***
   - ***Require regular checking and must be worn and maintained properly***

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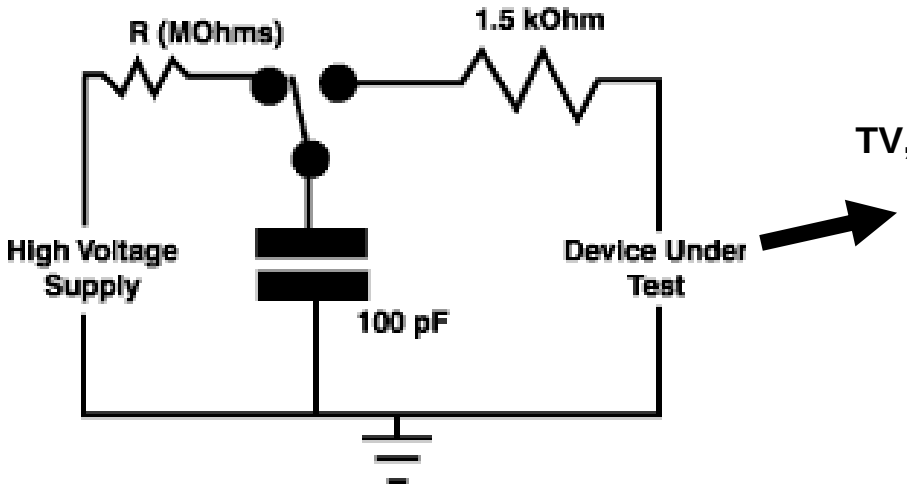
WHAT CAN MANUFACTURERS DO to MINIMIZE THE EFFECTS OF ESD ?

Basic Test circuit



TV, Radio, Ipod, Ham Radio, & other Electronic devices

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ESDS Component Sensitivity Classification
Human Body Model

Class	Voltage Range
Class 0	< 250 volts
Class 1A	250 volts to < 500 volts
Class 1B	500 volts to < 1,000 volts
Class 1C	1000 volts to < 2,000 volts
Class 2	2000 volts to < 4,000 volts
Class 3A	4000 volts to < 8000 volts
Class 3B	> = 8000 volts

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THE END

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