



a YAGEO company

ESD: A Fun Trick but Terrible For Electronics

2/1/2021

Jekaterina Stael von Holstein M.Sc.

Field Application Engineer

(+49) 172 - 82 77 599

jekaterinastaelvonholstein@kemet.com

M.Sc. Power Systems Engineering

With KEMET since January 2020

Technical Support for Central Europe

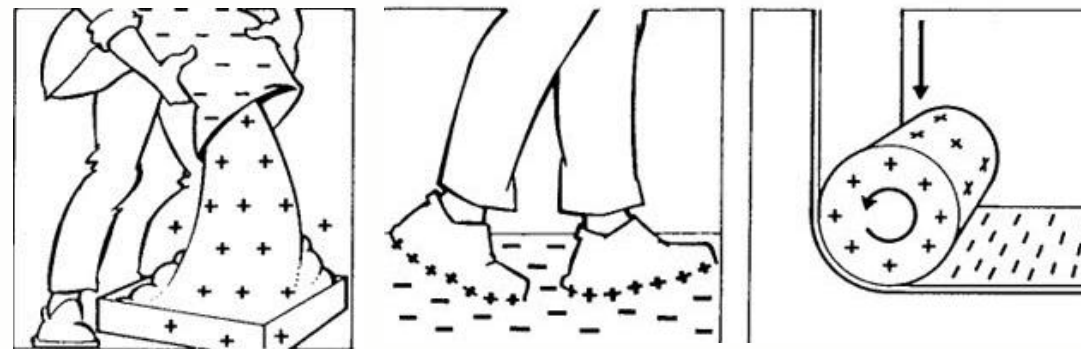


Webinar Agenda

- What is ESD and Why is it Important to be Considered in Electronics?
- What are Possible Measures?
 - General Overview
 - ESD Capacitors
- How are Protection Devices Tested?
- What is KEMET Portfolio of ESD Protecting Devices?
- Any Further Information to Consider?

What is ESD?

- ESD=Electrostatic Discharge
- Fast-Moving Transient Pulse occurs due to Discharge process of one body into another opposite charged body
- Occuring Discharge can be up to 30kV and can Produce Currents up to 30A
- High Values but the ESD transient Pulse is very low with <50mJ → no harm to human body
- The more humidity, the less static charges

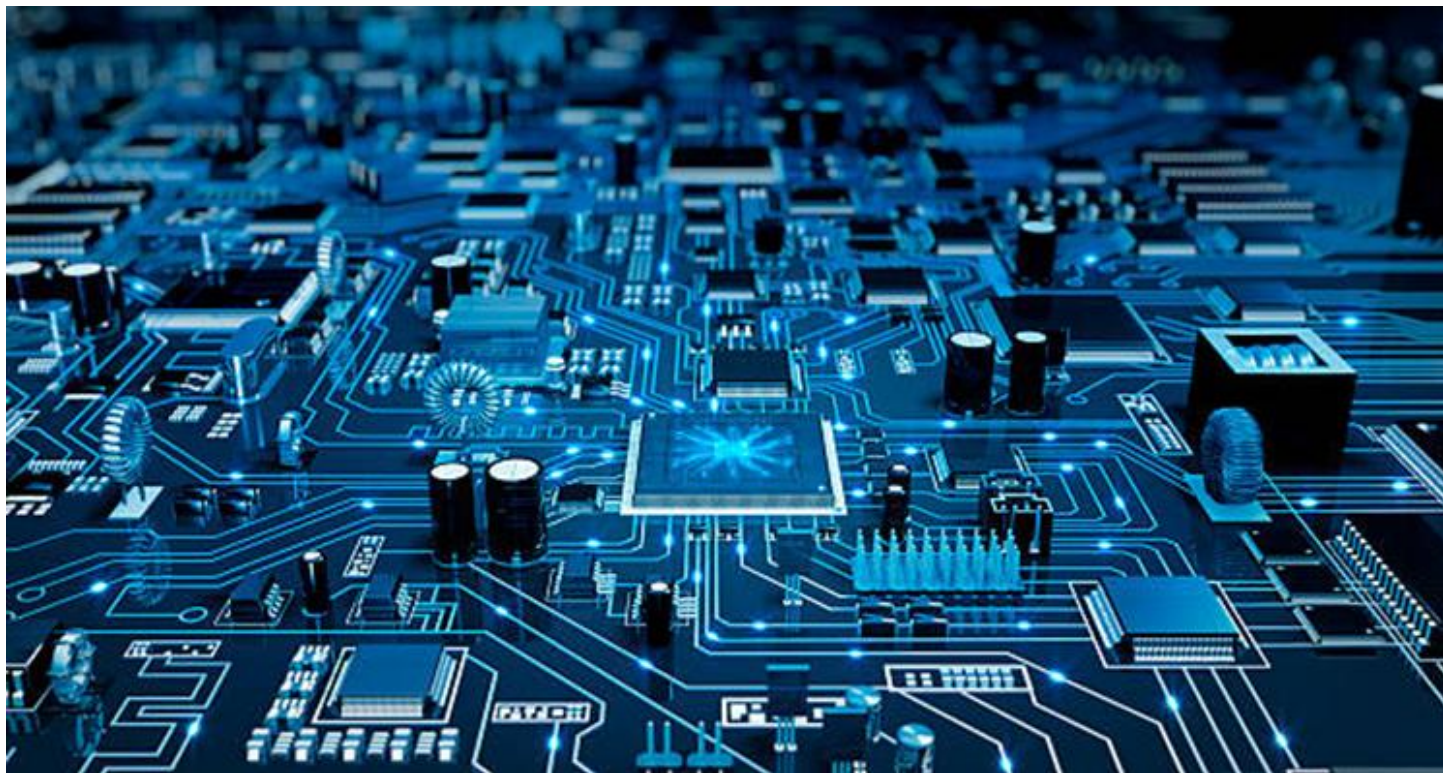


Examples of Static Generation - Typical Voltage Levels

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

Why is ESD Important to be Considered for Electronics?

- Electronic devices became faster and smaller, therefore their sensitivity increased
- ESD impacts productivity and product reliability in electronics



33% loss on
productivity



Billions of
dollars **lost**
annually

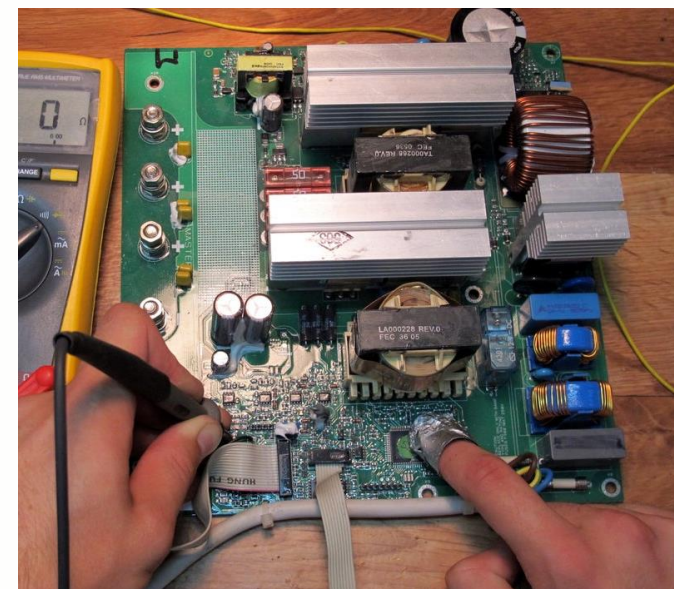


ESD Association

Where does ESD in Electronics come from?

- ESD pulses can come from...
 - Manufacturing environment
 - Testing
 - Packaging
 - Shipping
 - System and End User Environment
 - Etc.
- It only takes one ESD strike to **permanently** damage a device!

→ Tip: Discharge a board before touching it!



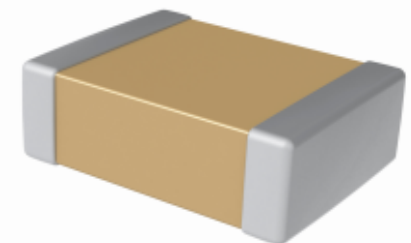
ESD Failure Types in Electronics

- Catastrophic Failure
 - Destructive
- Latent defects
 - Not detected during final testing
 - Costliest failure for electronic devices
- ICs are made of transistors
 - The dielectric can be easily broken down with ESD



What are Possible Measures against ESD?

- In the ESD protection circuit both, ESD components and the internal circuit, need to withstand the ESD current
- ESD protection common ways:
 - Spark Gap on PCB
 - Zener Diode/TVS
 - Varistor
 - SMD MLCC
 - Combination



What are Possible Measures against ESD?

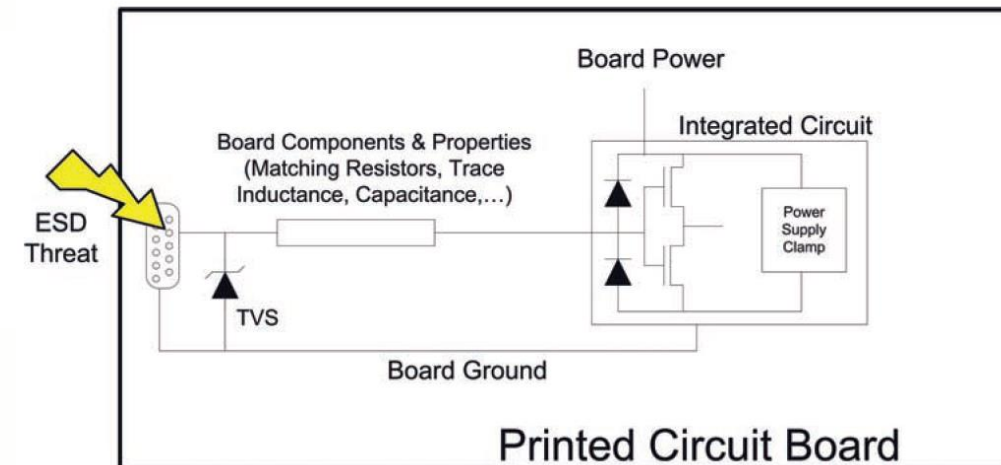
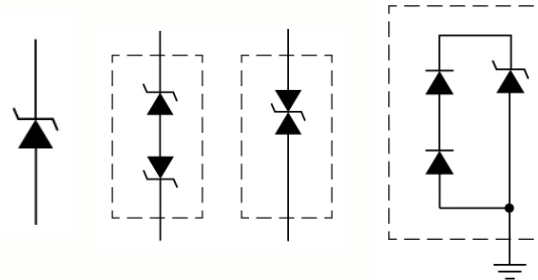
- Spark Gap on PCB

- Lowest cost
- Discharge voltage >2kV
- Longest response time
- Performance becomes worse after several discharges



- Zener Diode/TVS

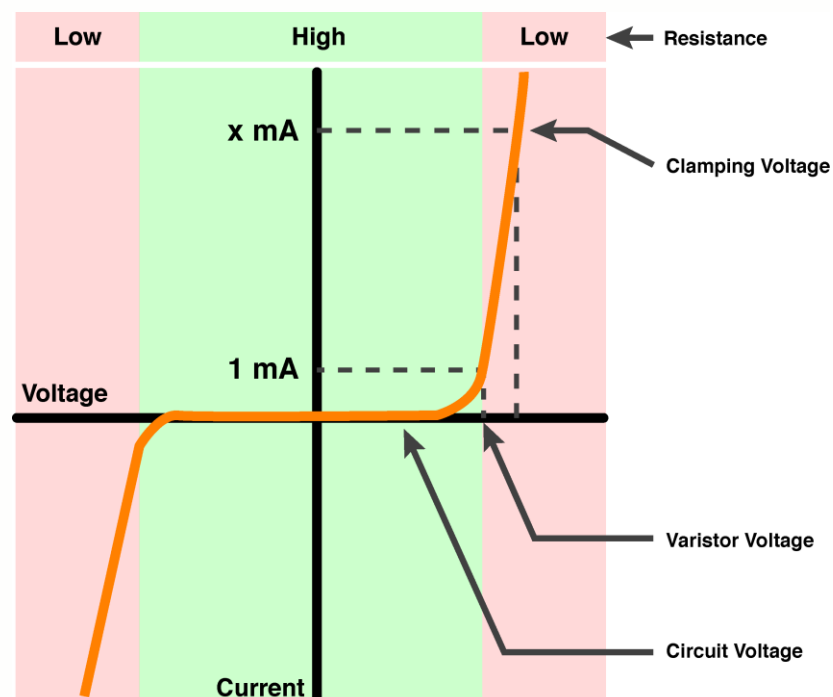
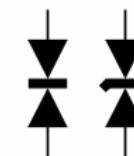
- Fast response time in ps
- Clamping voltage and operating voltage low
- Lowest capacitance impact on load
- Higher costs, performance temperature related



Source: ROBERT ASHTON PH.D., EL-info Elektronik Informationen 2/2013, p-46-49, "ESD-SCHUTZ FÜR HOCHENTWICKELTE HALBLEITERPROZESSE"

What are Possible Measures against ESD?

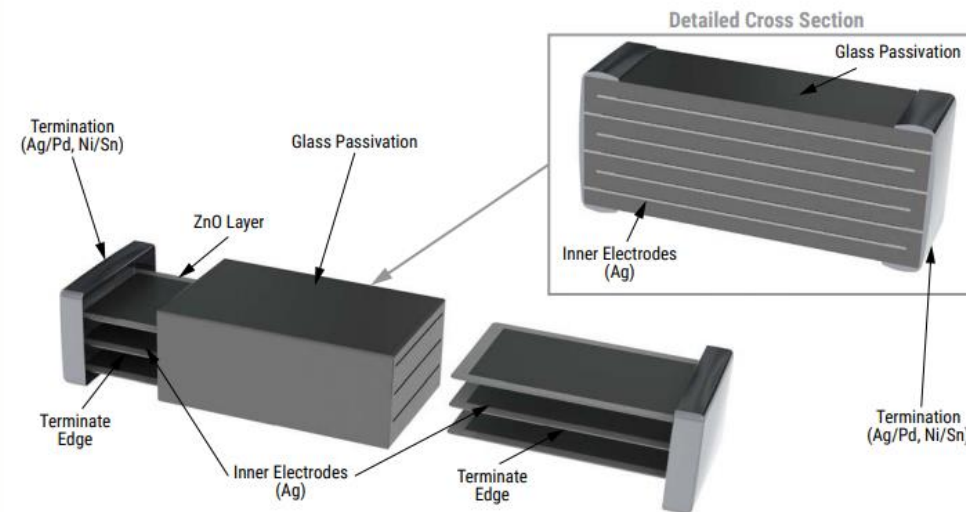
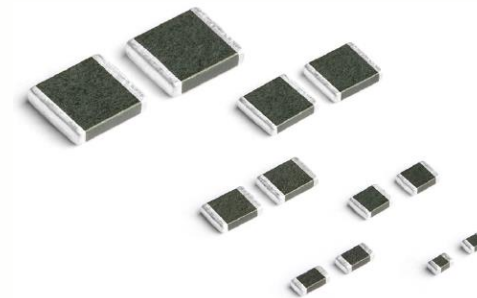
- Varistor (Variable resistor)
 - Voltage dependend resistor consisting of ZnO ceramics
 - Bidirectional
 - High surge current and high power capability
 - Quick response time <0.5ns



	Varistor	TVS
ENERGY CAPABILITY	Higher energy capability	Lower energy capability
RESPONSE TIME	Slower response time (2-5ns)	Fast response time (below 1ns)
SURGE CURRENT CAPABILITY	High in all range	Low to moderate especially in high voltage range
CLAMPING VOLTAGE	Higher clamping voltage	Lower clamping voltage
POLARITY	Bipolar	Unipolar & Bipolar
TEMPERATURE DEPENDENCE	Temperature dependent	Temperature dependent
CONFIGURATION	SMD & Through-hole	SMD & Through-hole
SIZE	Small, high energy capability	Bigger, limited in Power
LIFE	Degradation over time of operation	No degradation
COST	Lower	Higher

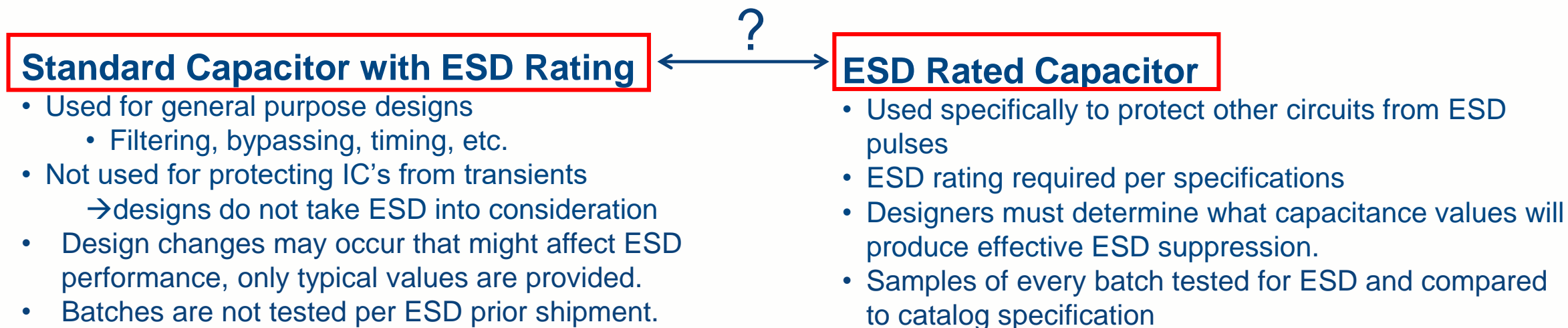
KEMET Varistor for ESD Suppression

- VG Series – Multilayer Varistor ESD Suppression SMD series
 - Industries: Low voltage board level products, telecommunications, computing and data processing
 - Suitable for high frequency attenuation and low-pass filter functions
 - Short response time
 - VDC: up to 18V
 - Dimensional and weight savings
 - UL, CSA and RoHS compliant / AEC-Q200 qualified Grade 1



What are Possible Measures against ESD?

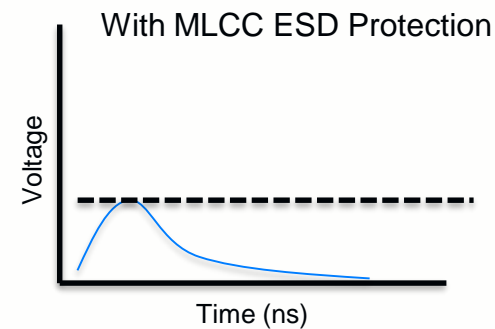
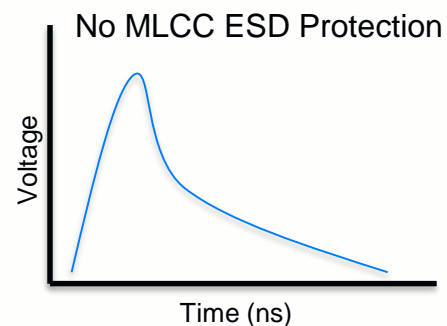
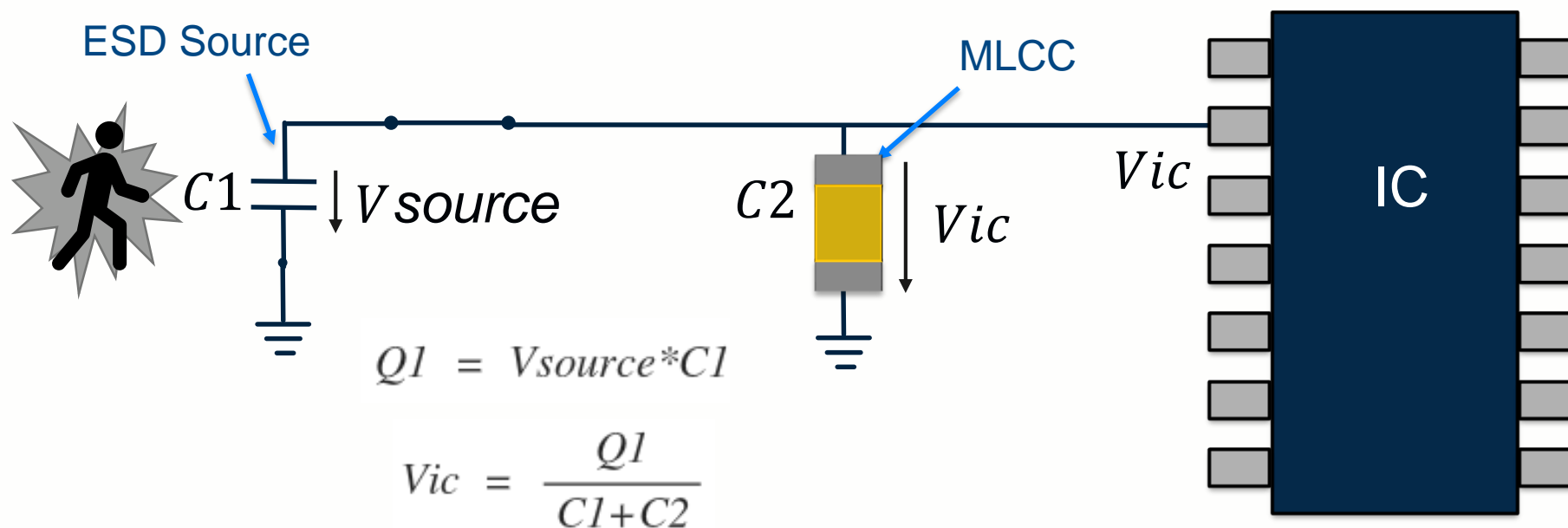
- ESD MLCC
 - ESD capacitor is a capacitor that is rated to a specified ESD value using standardized testing such as AEC-Q200 or IEC 61000-4-2 and is design controlled throughout the lifetime of the part to maintain the ESD rating.
 - Low cost!
 - Slower response time in ns
 - X7R capacitors has a capacitance change with DC Bias



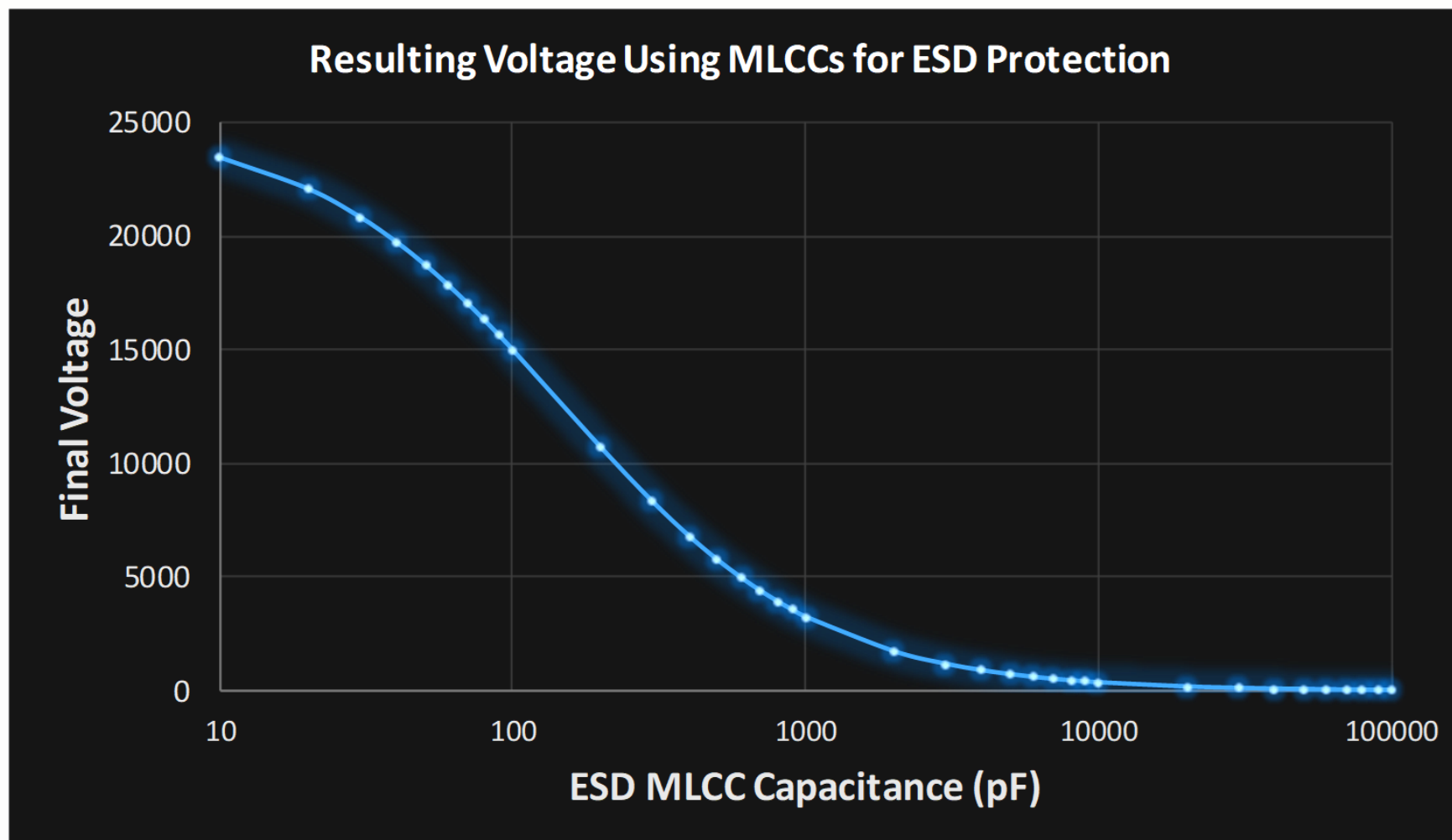
Just because an ESD capacitor has a high ESD rating, it doesn't mean it's good for protecting against ESD!!

What are Possible Measures against ESD?

ESD MLCC



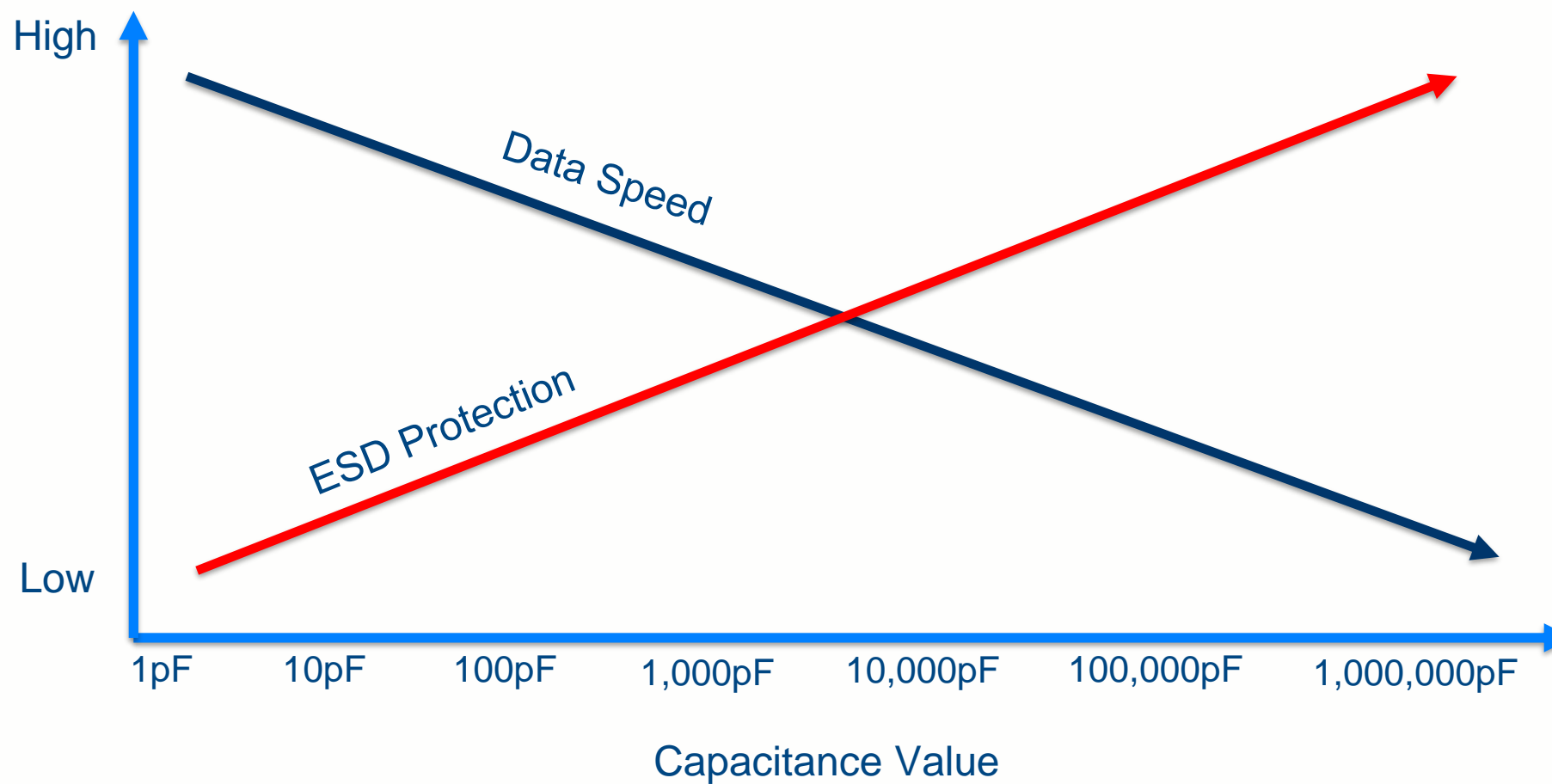
ESD MLCC



ESD Voltage: 25kV
Source Capacitance: 150pF

ESD MLCC

The Tradeoff



How are Protection Devices Tested?

- **HBM: Human Body Model**

→ Standard to simulate a person becoming charged and discharged from bare finger to ground through circuit

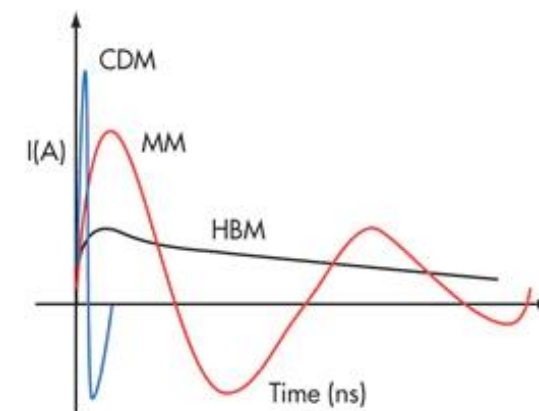
- **MM: Machine Model**

→ Simulates a charged inductive object (e.g. machine), which is discharged through device to ground

- **CDM: Charged-Device Model**

→ Simulates an IC becoming charged and discharged to a grounded metal surface (no galvanic isolation)

- **Many More and Variations**



How are Protection Devices Tested?

ESD Testing using Human Body Model Per AEC-Q200-002

- **Test Apparatus**

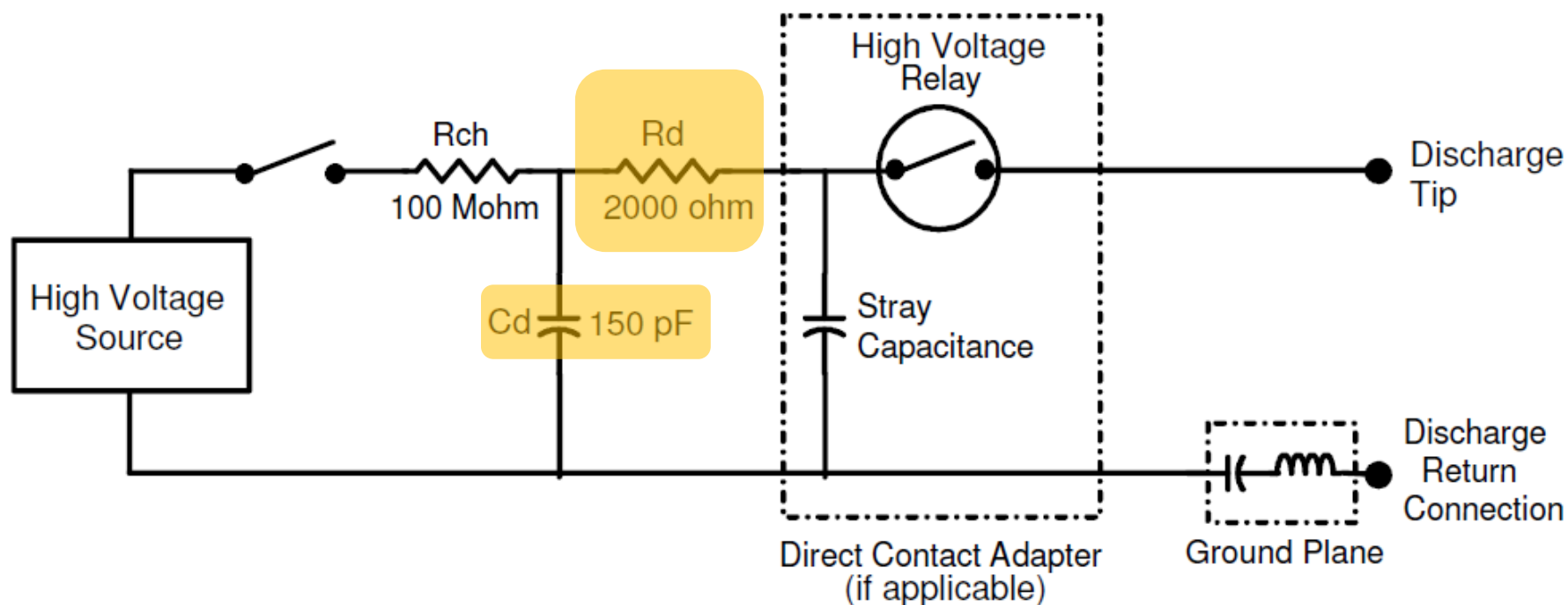


Figure 1: Equivalent *PASSIVE COMPONENT* HBM ESD simulator circuit

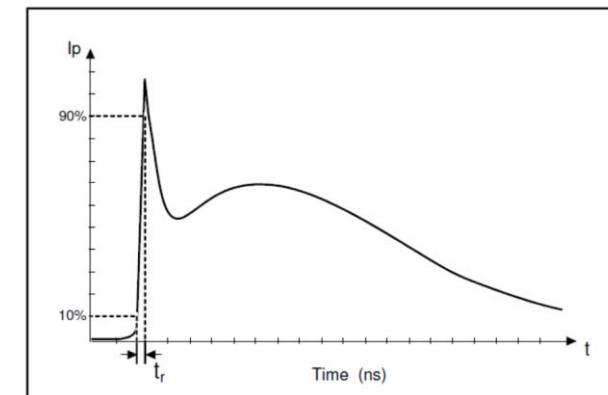


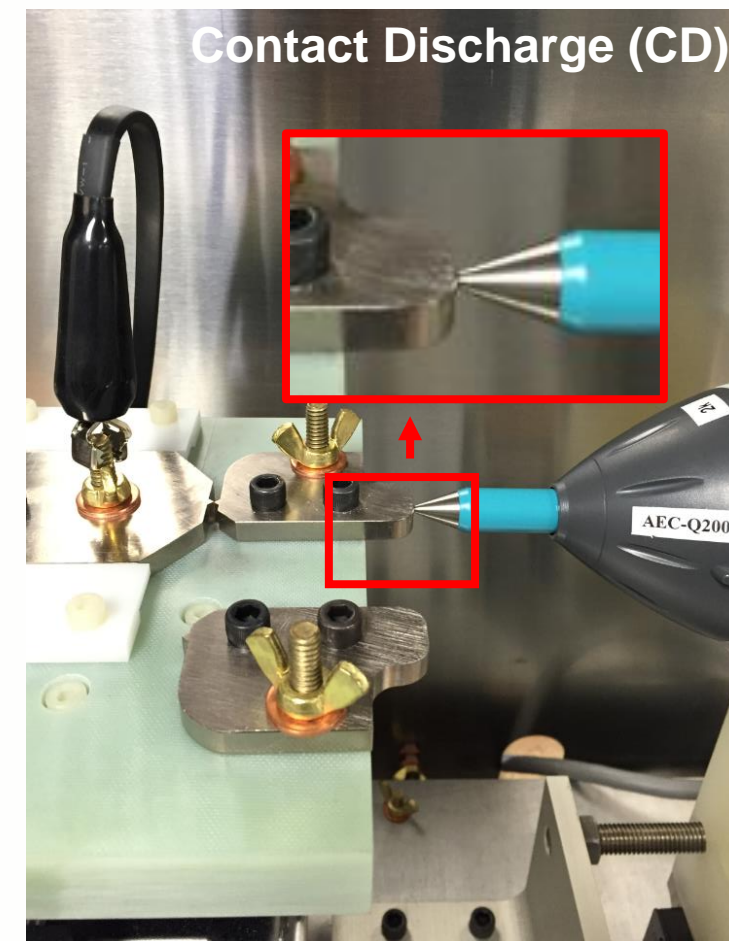
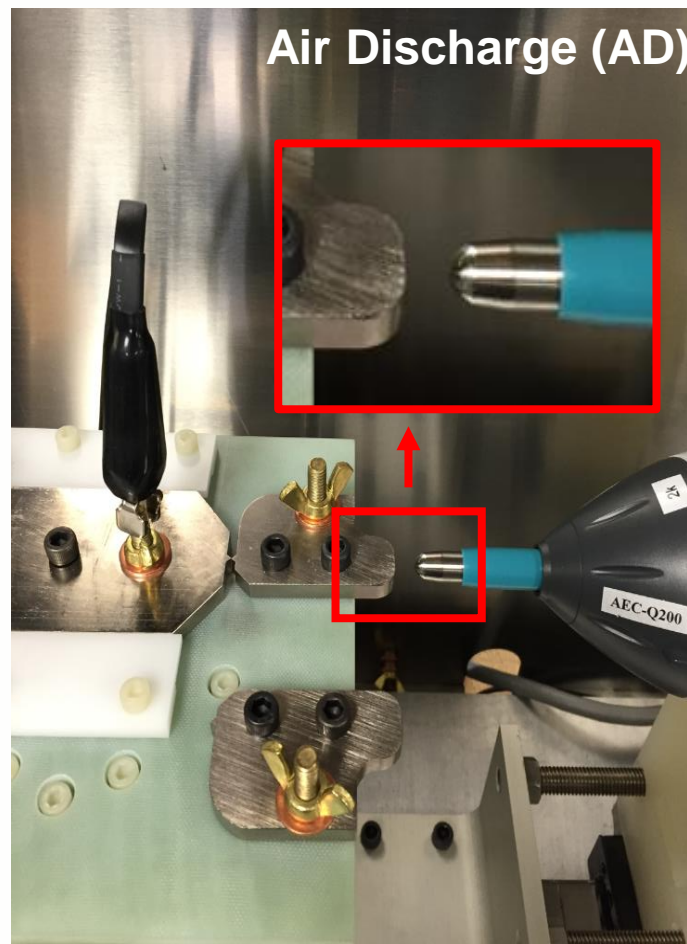
Figure 3: Typical Direct Contact and Air Discharge *PASSIVE COMPONENT* HBM ESD Discharge Waveform to a Coaxial Target



How are Protection Devices Tested?

ESD Testing using Human Body Model Per AEC-Q200-002

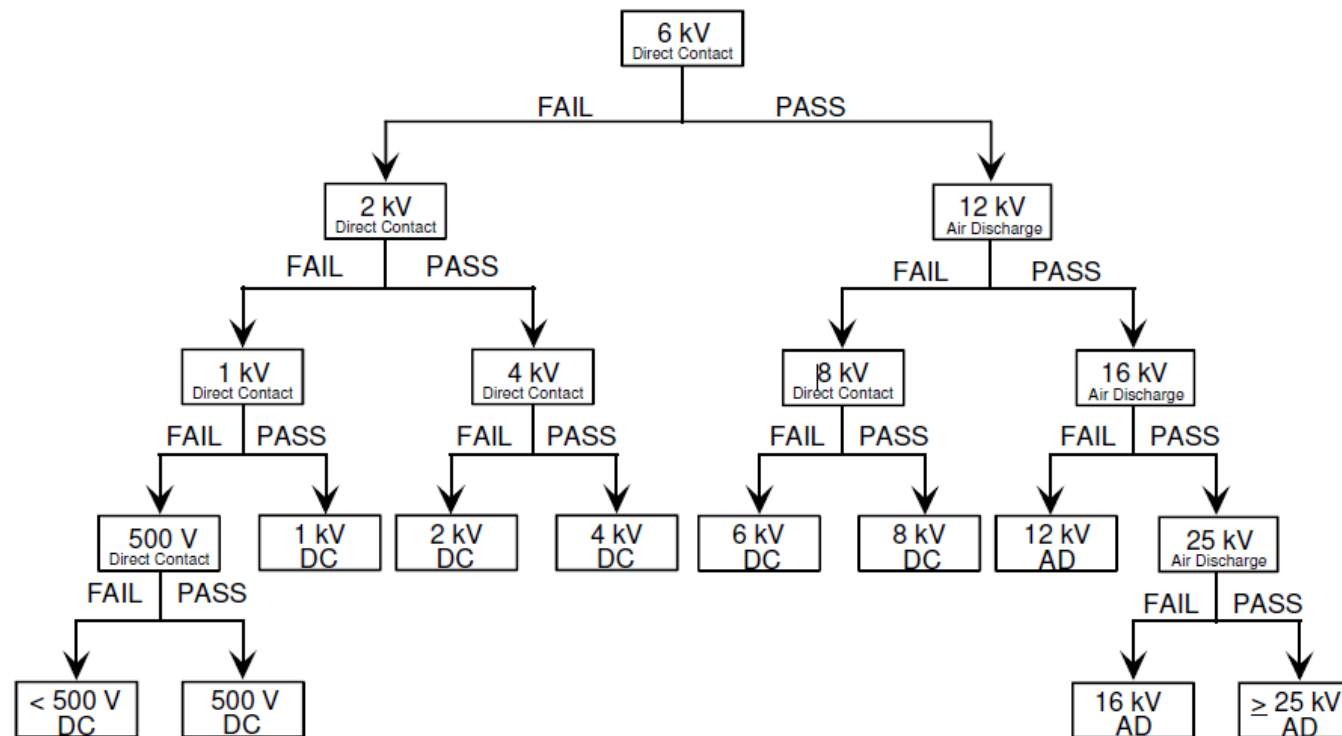
- **Equipment**



ESD Testing using Human Body Model

Per AEC-Q200-002

- Test Method flow: One pulse each polarity, resistance of 2000 Ohm, capacitance of 150pF.



Note 1: Classify the components according to the highest ESD voltage level survived during ESD testing.

KEMET ESD (Electrostatic Discharge) MLCCs

C0G & X7R Dielectrics

ESD Qualified per HBM - AEC Q200-002

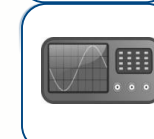
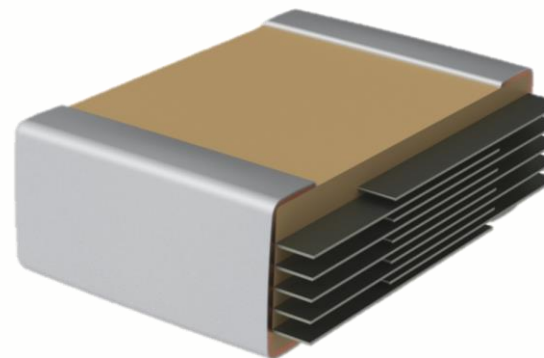
EIA 0402, 0603, 0805 & 1206 Case Sizes

Capacitance Range from 1nF to 2.2 μ F

DC Voltage Ratings of 16 – 250V

RoHS, Pb-Free & Halogen Free

Flexible Termination available
Commercial & Automotive Grade



Further Information to ESD

- MLCCs as “ESD Sensitive”
 - Although MLCCs can break down due to ESD, they’re not considered “ESD Sensitive”. ESD Sensitive components are components that can fail at much lower ESD voltages and require ESD protection
- Packaging of ESD components
 - The packaging can cause ESD and therefore KEMET’s Tape and Reel packaging uses anti-static materials and therefore do not produce static.
- Design Tip: Keep components to protect away from the joints or holes!



ASK your KEMET FAE or PM!

- <https://ec.kemet.com/>
- <http://www.kemet.com/>
- <https://ksim3.kemet.com/>

Key Takeaways

- ESD events cost billions of dollars a year in the electronics industry.
- Varistors have several benefits in comparison to TVS diodes.
- One of the primary methods of ESD protection are ESD capacitors.
- KEMET offers both C0G and X7R ESD rated capacitors.
- KEMET's ESD offering is tested per AEC-Q200 Human Body Model
- Any capacitor can be used for ESD protection but ESD rated capacitors are guaranteed to meet certain ESD requirements.

Q&A

