Hong Kong Productivity Council 香港生產力促進局

Quality Issues & Solutions in Display Applications

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Generic Quality Issues

Temperature/Humidity Chamber
Model: Heraeus HC7055

Thermal Shock Chamber
Model: Votsch VT7012

Liquid Thermal Shock Tester
Model: Votsch VFS 2/07/15/2

Highly Accelerated Test System (HATS)
Model:IRTS

Autoclave
Model: Express Test ET-244P

Vibration Test System
Model: IMV VS-500-4

Universal Tensile Tester
Model: QTest-II

Weiss WK-480/70/15 Climatic Test Chamber
Model: Weiss WK-480/70/15

HKPC can help companies achieve a high reliability level of their products and equipment

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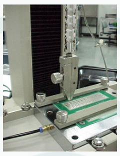
Quality



- Quality:
  - Quality = fitness for use
    - (see *Quality Control Handbook, Joseph M. Juran, McGraw-Hill, 1988)*
  - a **SUBJECTIVE** characteristic which changes along with customer expectations
  - So quality specification should be defined from the view point of the customer
- Customer demands and competitive pressures continue to motivate continuous improvement in product quality.

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Poor Quality

- Defects
  - i.e. failure or non-conformance of a product with the specified requirements, or non-fulfillment of user expectations
    - Patent defects:
      - Defect in material and/or workmanship that may cause failure or malfunction of an item, and is discoverable upon its inspection or test procedure without the need for stress screens.
    - Latent defects:
      - Hidden defect in material and/or workmanship of an item which may cause failure or malfunction, but is not discoverable through general inspection.
      - Will appear as early or premature failures in the operating environment after some time of operation
- Degradation in Performance
- Unsafe to the user
- Interferences to the other equipment
- Pollution or damage to the natural environments

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Quality Characteristics

- the peculiar features of a product:
  - Appearance
  - Dimension
  - Performance
  - Length of useful life
  - Dependability
  - Reliability
  - Durability
  - Maintainability
- Other public interests relevant requirements, e.g.
  - Safety
  - Electromagnetic Compatibility (EMC)
  - Environmental Protection Requirements

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Quality Measurements

- To justify and present the conclusion of product quality:
  - Need to OBJECTIVELY measure product quality
  - By means of defining quality in terms of CONFORMANCE, i.e.
    - the degree to which the product conforms to a DESIGN or SPECIFICATION
  - Verification of conformance is primarily by means of
    - Inspection or testing against specification

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Why Quality Management

- To maximize market share and profits and
- minimize risks and costs

- Dr. Deming's Philosophy:
  - (a) When people and organizations **focus primarily on quality**, defined by the following ratio,
      - Quality = (Results of work efforts)/(Total costs)
    - Quality then tends to increase and costs fall over time.
  - (b) However, when people and organizations **focus primarily on *costs*** (often dominant/typical human behavior),
    - costs (due to not minimizing waste, ignoring amount of rework occurring, taking staff for granted, not rapidly resolving disputes, and failing to notice lack of product improvement—plus, over time, loss of customer loyalty) tend to rise, and
    - quality declines over time.

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Consequence of poor quality

- Risk of exposure to liability claims
  - reduced if the 'state of the art' technology is applied in the design and manufacture
  - Liability claims can be very costly indeed.
    - e.g. there is no limit to the civil damages that can be awarded under the Product Liability Directive (85/374/EEC) in the UK and some other EU member states.
- Loss of customer confidence can cost a great deal more than a liability claim,
  - because it is possible for a company to lose the good reputation it has built up over generations, and for some companies this can be worth billions.
- Negative publicity
  - Most of liability cases are settled out of court, because the company fears the negative publicity.
  - But safety incidents that attract media attention (such as rail or plane crashes) cannot be kept quiet in this way.

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Seven Deadly Diseases

- Efforts or costs burdening a company with NO positive outcome:
  - Lack of constancy of purpose.
  - Emphasis on short-term profits.
  - Evaluation by performance, merit rating, or annual review of performance.
  - Mobility of management.
  - Running a company on visible figures alone.
  - Excessive medical costs.
  - Excessive costs of warranty, fueled by lawyers who work for contingency fees.

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Total Quality Management

- Quality Control =
  - The entire collection of activities through which we achieve quality
- Quality requires
  - top-level management commitment and
  - the participation of all organization,
    - Marketing,
    - Design
    - Manufacturing
    - Field support

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Product Specification

-Defines what is required for a product to perform as expected by customer
-Shall include quality specification

- Product name
- Product description
- Performance
- Drawing or standards
- Verification requirements
- Tests
- Inspections
- Supporting data
- Sampling plan
- Accept / reject criteria
- Safety
- Noise and environmental restriction
- Regulatory requirements
- Packaging and shipping
- Handling and storage
- Labeling, warning, identification, traceability
- Shelf life
- Reliability
- Maintainability
- Supportability
- Standardization

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Quality Specification

- Quality specification of an equipment should take account of:
  - all credible faults
  - environmental extremes and ageing
  - specific criteria in missions and applications
  - reasonably foreseeable use, or misuse
  - *over the whole lifecycle of the equipment.*

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Product life cycle and quality assurance (QA)

- QA process spans all the 3 phases of the product life cycle
  - Each phase incurs cost to the product manufacturer
    - i.e. Life-cycle cost (LCC).

Design / Development →	Production →	Use / Maintenance
Reliability Maintainability Testability Manufacturability	Quality Control Process Capability Process Control	Operation Maintenance Warranty

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Life-cycle cost (LCC)

- Life-cycle cost (LCC) =
  - The total cost of ownership of a product, including cost of acquisition, operation, maintenance, conversion and/or decommission.
- LCC is directly borne by customer, but will be shared or transferred to the manufacturer or supplier
  - Via product liability claims, after-sales service and warranty, etc.
- Achieve the right level of quality and reliability will minimize the LCC.
- The majority of LCC (i.e. 75% – 80% of the total LCC) is determined in product design and development.
  - So **design excellence** is essential to achieve high quality and hence minimize LCC

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Design Excellence

- Robust design
- Adopt design rules
- Environmental stress analysis and testing
- Design evaluation

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Robust design

- Design a product which is **insensitive** to variation in
  - Manufacturing process
  - Operator and maintenance procedures
  - Usage environment

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Design rules

- A general set of design rules should include
  - Include quality and reliability in specification
  - Select high-quality components
  - Seek simplification
  - Maximize standardization
  - Judiciously apply safety factors
  - Test over a wide range of parameter values under a wide range of conditions
  - Minimize preventative maintenance
  - Design for maintenance
  - Provide overload protection
  - Avoid overdesign
  - Avoid short-life materials
  - Perform stress analysis
  - Cooperate with manufacturing, maintenance, user
  - Use mature manufacturing processes
  - Use designs of proven reliability where possible

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Environmental Stress

- Environmental stresses causes failures
  - Vibration and temperature cycling
    - Lead to fatigue failures of components and solder joints
  - Elevated temperature
    - Provide activation energies for degrading chemical reactions
    - Hence accelerate failures of electrical components and materials
  - Humidity
    - contribute to corrosion mechanism of electrical contacts and connectors
  - Contamination during production process
    - Affect functions of integrated circuits
  - Dust
    - Cause failures of electrical connections in integrated circuits

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Environmental stress screening (ESS)

- ESS = the process of
  - exposing a newly manufactured product or component (typically electronic) to stresses such as thermal cycling and vibration
  - in order to force latent defects to manifest themselves by failure during the screening process.
  - The surviving population, upon completion of screening, can be assumed to have a higher reliability than a similar unscreened population.
- Developed to help electronics manufacturers detect product defects and production flaws.

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ESS Tests

- To catch some simple (latent) defects that would otherwise be encountered by the end user very soon after the product was first used.
- Tests may include the following:
  - Temperature variations
  - Vibration tests
  - Pressure
  - Flexibility tests

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Some other quality issues

- The following two issues are sometimes ignored or overlooked, or not included in quality control / management system:
  - Electromagnetic Compatibility (EMC)
  - Electrostatic discharge (ESD) control

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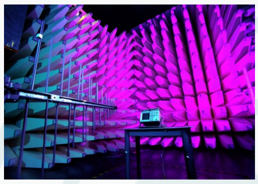
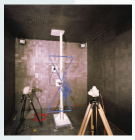
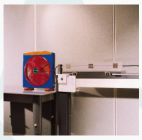


Electromagnetic Compatibility (EMC) concerns for display technology products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EMC Requirements

- EMC requirements are usually specified in product/equipment family standards
  - So display units for different products shall complies to different standards
    - e.g., EN55022 and EN55024 for ITE, EN/IEC 60601-1-2 for medical devices, etc.
- Non-safety critical equipment:
  - Regulatory EMC requirements should generally be good enough
    - e.g. CE marking requirements in EU, and FCC part 15 requirements in USA
  - But not a guaranteed protection
    - If still cause interference to the other equipment or system, may be ordered to withdraw from service or recall from the market
- Safety-critical equipment:
  - Compliance to regulatory requirements may not be good enough
    - Due to the risk of legal liabilities and claims, and cost of recall
  - Manufacturers may have to create and apply their own EMC standards or specifications
    - e.g. Automotive OEM standards

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Applicability of EMC Tests

- Port and enclosure port:
  - Port:
    - Particular interface of the specific equipment with the external electromagnetic environments, e.g., power ports, signal ports earth port
  - Enclosure port:
    - The physical boundary of the equipment through which the electromagnetic field may radiate or impinge
- Applicability of EMC Tests:
  - Tests shall be applied to the relevant ports of the equipment, and
  - shall only be carried out where the relevant port exists
- Apart from the enclosure port, a stand-alone display unit usually has only one port, i.e., the AC power port, on which the EMC tests are applicable
  - The video signal input and control terminals are not considered as ports because they are not connected to equipment out of the host system, unless
    - the length of the signal / control cable is longer than as specified in standard(s), say 3 m

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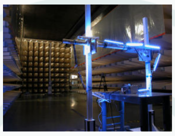
Typical EMC Tests



- Measurements of Emissions
  - Conducted emissions (150kHz – 30 MHz)
  - Radiated emissions (30 MHz – 1GHz, or 6GHz)
  - Harmonics Currents
  - Voltage fluctuations and flickers
- Immunity Tests
  - ESD
  - Radiated RF Immunity (80MHz – 1GHz)
  - Conducted RF Immunity (150kHz – 80MHz)
  - Power-frequency magnetic field
  - Electric fast transients (EFT) / Burst
  - Surges
  - Voltage dips and short interruptions

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Operation modes and general operation conditions under EMC tests

- Exercising all primary functions
- in the most representative mode
- consistent with typical application
- Apply minimum configuration of auxiliary equipment necessary to exercise the ports

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Special requirements for Video Display Units for emission measurements

- **Per Section 11.1.3. ANSI C63.4-2003**
  - a) Set the contrast control to maximum
  - b) Set the brightness control to maximum or at raster extinction if raster extinction occurs at less than maximum brightness
  - c) For colour monitors, use white letters on a black background to represent all colours
  - d) Select the worse case of positive or negative video if both alternatives are available
  - e) Set character size and number of characters per line so that the typical maximum number of characters per screen is displayed
  - f) For a monitor that has no graphic capabilities, regardless of the video card used, a pattern consisting of a random text shall be displayed.
  - g) For a monitor with graphic capability, even though another video card may be needed to accomplish a graphic display, a screen pattern consisting of lines of scrolling H's should be displayed
  - h) For a monitor that has no text capabilities, use a typical display. That pattern should be used for the remainder of the tests.

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A brief discussion in Electrostatic Discharge (ESD) Control

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Electrostatic Discharge (ESD)

- Electrostatic discharge (ESD)
  - the sudden and momentary electric current that flows between two objects at different electrical potentials
- Cause of ESD
  - Static electricity:
    - generated through tribocharging,
      - the separation of electric charges carried by atoms of two materials
      - when they are brought into contact and then separated
      - thus creating a difference of electrical potential that can lead to an ESD event
  - Electrostatic induction:
    - when an electrically charged object is placed near a conductive object isolated from ground,
    - the presence of the charged object creates an electrostatic field that causes electrical charges on the surface of the other object to redistribute
    - Even though the net electrostatic charge of the object has not changed, it now has regions of excess positive and negative charges.
    - An ESD event may occur when the object comes into contact with a conductive path

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How does ESD damage electronic devices

- ESD can drive high current levels into circuits.
- It may puncture a hole through junction of the circuits' transistors, and may also cause metallization traces to melt
  - Patent defect:
    - A large hole will cause immediate device failure
  - Latent defect:
    - A small hole may not immediately be detectable, but will eventually alter the operating characteristics and cause the device to fail

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ESD is a serious quality issue

Informal Summary of Losses due to failures caused by ESD

Description	Min. Loss	Max. Loss	Est. Avg. Loss
Static Losses Reported			
Component Manufacturers	4%	97%	16-22%
Subcontractors	3%	70%	9-15%
Contractors	2%	35%	8-14%
User	5%	70%	27-33%

Source: Stephen Halperin, "Guidelines for Static Control Management," Eurostat, 1990.

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ESD Sensitivity of Electronic Devices

- The degree of ESD protection required is determined by the ESD sensitivity of electronic components
- ESD sensitivity of electronic devices
  - the device's ability to dissipate the energy of the discharge or withstand the voltage levels involved
  - It determines damage to an device by the ESD event

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ESD Sensitivity Levels

- Many electronic components are susceptible to ESD damage at relatively low voltage levels.
  - Many are susceptible at less than 100 volts,
  - many disk drive components have sensitivities below 10 volts.
  - Current trends in product design and development pack more circuitry onto these miniature devices, further increasing their sensitivity to ESD and making the potential problem even more acute.

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Devices or Parts with Sensitivity Levels of 0-1,999 volts (HBM)

- Microwave devices (Schottky barrier diodes, point contact diodes and other detector diodes >1 GHz)
- Discrete MOSFET devices
- Surface acoustic wave (SAW) devices
- Junction field effect transistors (JFETs)
- Charged coupled devices (CCDs)
- Precision voltage regulator diodes (line of load voltage regulation, <0.5%)
- Operational amplifiers (OP AMPs)
- Thin film resistors
- Integrated circuits
- AMR and GMR Disk Drive Recording Heads
- Laser Diodes
- Hybrids
- Very high speed integrated circuits (VHSIC)
- Silicon controlled rectifiers (SCRs) with Io <0.175 amp at 10˚C ambient

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Devices or Parts with Sensitivity Levels of 2,000 to 3,999 volts (HBM)

- Discrete MOSFET devices
- JFETs
- Operational Amplifiers (OP Amps)
- Integrated circuits (ICs)
- Very high speed integrated circuits (VHSIC)
- Precision resistor networks (type RZ)
- Hybrids
- Low power bipolar transistors, Ic <100 milliamps

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Models of ESD events

- Use of Models of ESD Events:
  - Test procedures based on the models of ESD events help define the sensitivity of components to ESD.
- Most commonly applied models of ESD events:
  - **ESD in the Manufacturing Environment**
    - Human Body Model (HBM)
    - Machine Model (MM)
    - Charged Device Model (CDM)
  - **The ESD Standard for System Level Testing**
    - Body Metal Model (BMM)

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Human Body Model (HBM):

- Phenomena simulated:
  - a person becoming charged and
  - discharging from a bare finger **to** the leads of an ESDS (electrostatic discharge sensitive) device or assembly of the circuit under test and return to reference ground, possibly causing device damage
- Parameters:
  - Standard: IEC 61340-3-1
  - C/R = 100pF/1,500 ohms
  - Range of peak Vo/Is = 250V/0.17A – 8kV/5.33A
  - Rise time = 2ns to 10ns
- ESDS Devices = electronics components / devices
- Component level test
- Controlled ESD environment

Panel Test System in the IPC-9151A PCB Standard Testing Centre (Only site outside U.S.A)
美國以外唯一的 IPC-9151A 線路板標準拼板測試系統

- Purpose:
  - intended to ensure that components and devices (such as integrated circuits) survive the manufacturing process
- The trend towards automated assembly in manufacturing process would seem to solve the problems of HBM ESD events. However, it has been shown that components may be more sensitive to damage when assembled by automated equipment.
  - So MM and CDM environments should be considered
- In the manufacturing environment, ICs are usually only specified to survive 2KV HBM, although some have been specified as high as 8KV.

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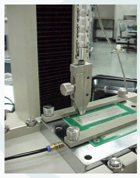
Machine Model (MM):

- Phenomena simulated:
  - a charged manufacturing machine, discharging through the device to ground
- Parameters:
  - Standard: IEC 61340-3-2
  - C/R = 200pF/0 ohms
  - Range of peak Vo/Is = 100V/1.7A – 800V/14.0A
- ESDS Devices = electronics components / devices
- Component level test
- Controlled ESD environment



- Purpose:
  - intended to ensure that components and devices (such as integrated circuits) survive the manufacturing process
  - Widely applied in Japan and EU

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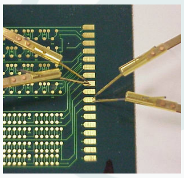
Charged Device Model (CDM):

- Phenomena simulated:
  - a charged component or device, discharging through the manufacturing machine to ground
  - Static charge may accumulate on the ESDS device itself through handling or contact with packaging materials, work surfaces, or machine surfaces, e.g.
    - A device may become charged from sliding down the feeder of automatic manufacturing machine.
    - If it then contacts the insertion head or another conductive surface, a rapid discharge occurs from the device to the metal object.
- Parameters:
  - Standard: ESD STM5.3.1-1999
  - Typical C/R = 6.8pF/0 ohms
  - Range of peak charging Vo = 125V – 2000V
- ESDS Devices = electronics components / devices
- Component level test
- Controlled ESD environment



- Purpose:
  - intended to ensure that components and devices (such as integrated circuits) survive the manufacturing process
  - Widely applied in US

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Body Metal Model (BMM):

- Phenomena simulated:
  - a person becoming charged and
  - discharging from the tip of a metallic tool held by the person's hand **to** a system in a system end user environment
- Parameters:
  - Standard: IEC 61000-4-2
  - Typical C/R = 150pF/330 ohms
  - Range of peak charging Vo / Is = 2kV/9A – 15kV/70A
- ESDS Devices = a finished equipment or system
- Equipment/system level test, because
  - While HBM is usually sufficient for the controlled ESD environment of the factory floor, it is completely inadequate for system level testing.
  - The levels of ESD strikes, both the voltages and the currents, can be much greater in the end user environment.
- Uncontrolled ESD environment
- Purpose:
  - to ensure that finished products can survive normal operation and
  - it is generally assumed that the user of the product will not take any ESD precautions to lower ESD stress to the product.

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Some other models of ESD events

- Charged chip model (CCM)
  - Simulating ESD event between die of IC resting on insulation membrane and metallic tooling picking up the die during IC manufacturing process
- Charged package model (CPM)
  - Simulating ESD event of standalone components or devices charged via tribocharging with plastic packaging materials
- Charged board model (CBM)
  - Simulating ESD events between charged PCB assemblies and reference ground through metallic tools
  - NOTE
    - ESDS devices soldered or installed on a PCBA can often be damaged by a LOWER discharge voltage than the voltage in CDM or HBM causing the similar damage

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Human Body Model (HBM) vs. Body Metal Model (BMM) in IEC61000-4-2 (A)

- *Source: XtremeESD, California Micro Device, WP Jan 2008*
  - **The amount of <u>peak current</u> and I^2R power released during a voltage strike**, e.g.
    - the peak current discharged during an 8KV HBM strike is less than the peak current discharged during a 2KV BBM strike,
    - at 8KV (a common system level ESD requirement), the peak current for an BMM strike is over 22 times higher than what most high performance semiconductors are designed to withstand
    - Hence, it is possible that a chip protected to 8KV HBM can be destroyed by a 2KV BMM strike
    - So system design engineers shall not rely on HBM ratings of the chip in its specification to determine whether a system will survive an ESD strike after it is shipped to end customers.

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Human Body Model (HBM) vs. Body Metal Model (BMM) in IEC61000-4-2 (B)

Source: XtremeESD, California Micro Device, WP Jan 2008

- **The rise time of the discharging current strike**
  - The HBM model specifies a rise time of 25nS, while
  - An BMM pulse has a rise time of 0.7 to 1 nS and dissipates most of its energy in the first 30nS.
  - So if an IC takes 25nS to respond, the device rated using the HBM specification can be destroyed before its protection circuits are even activated
  - In the other words, a protection circuit of an IC designed to withstand an HBM pulse may not even turn on before the “protected” chip is destroyed in an BMM pulse.

Human Body Model (HBM) vs. Body Metal Model (BMM) in IEC61000-4-2 (C)

Source: XtremeESD, California Micro Device, WP Jan 2008

- **The number of discharging strikes repeated in the tests**
  - The HBM standard requires only a single positive and single negative strike to be tested, whereas the IEC61000-4-2 test requires at least 10 positive strikes and 10 negative strikes.
  - It is possible for a device to survive the first strike, but fail on subsequent strikes due to damage sustained during the initial strike.

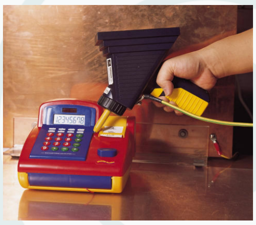
No automatic guarantee by integrated ESD protection of electronic devices (A)

- It is critical for a system designer to check
  - which standard was used to rate the ESD level of a component or device.
    - i.e. whether HBM or BMM is applied
- Devices tested using the HBM or other non-IEC61000-4-2 standards should not be considered to automatically have adequate ESD protection integrated against the minimum system level ESD requirements.
  - For example, CMD recently tested an HDMI switch from a vendor prominently marketing that they integrated 8KV of ESD protection. When tested, this device failed and was destroyed by a 6 KV IEC61000-4-2 standard discharge test.

No automatic guarantee by integrated ESD protection of electronic devices (B)

- If the system designer is not aware of this potentially misleading marketing information, it can cause costly program slips and redesigns.
- System designers need to be familiar with the differences between various ESD test standards.
- The ratings that are used for protecting ICs in the manufacturing environment such as HBM and CDM are not equivalent to system level ESD tests such as the IEC61000-4-2.
  - Each standard has a legitimate purpose, but misapplying these standards can result in design delays and/or product returns.
- For system level ESD ratings, always use the IEC61000-4-2 standard or the other updated or appropriate specifications.

THANK YOU!



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