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Quality, Reliability, Performance

EMP Filter Design

Addressing Global HEMP/IMEI Market requirements

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de Nederlandse EMC-ESD Vereniging
EMC-ESD Event 2023

Hotel van der Valk Vianen
Dinsdag 21 november

MPE Credentials

MPE Formed in 1925

Portfolio of over 20,000 proven designs

Supplied over 10 Million filters in the last 30 years

Product return level below 0.012%

Export to 28 territories around the world

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MPE Credentials

World's largest supplier of HEMP protection filters

Largest supplier of HEMP protection filters to the USA DoD

Member of the IEC SC77C international standards committee

Trusted subject matter expert to INFRAGARD (FBI organisation) in USA

Only non US organisation consulted during the Mil-Std-188-125-1A update

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Overview

1. What is EMP?
2. Design Principles of EMP Filters
3. EMP Market, Trends & Drivers

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What is EMP?

An electromagnetic pulse is a fast-acting burst of electromagnetic energy.

The origin of an EMP can be natural or man-made, and can occur as a radiated or conducted pulse.

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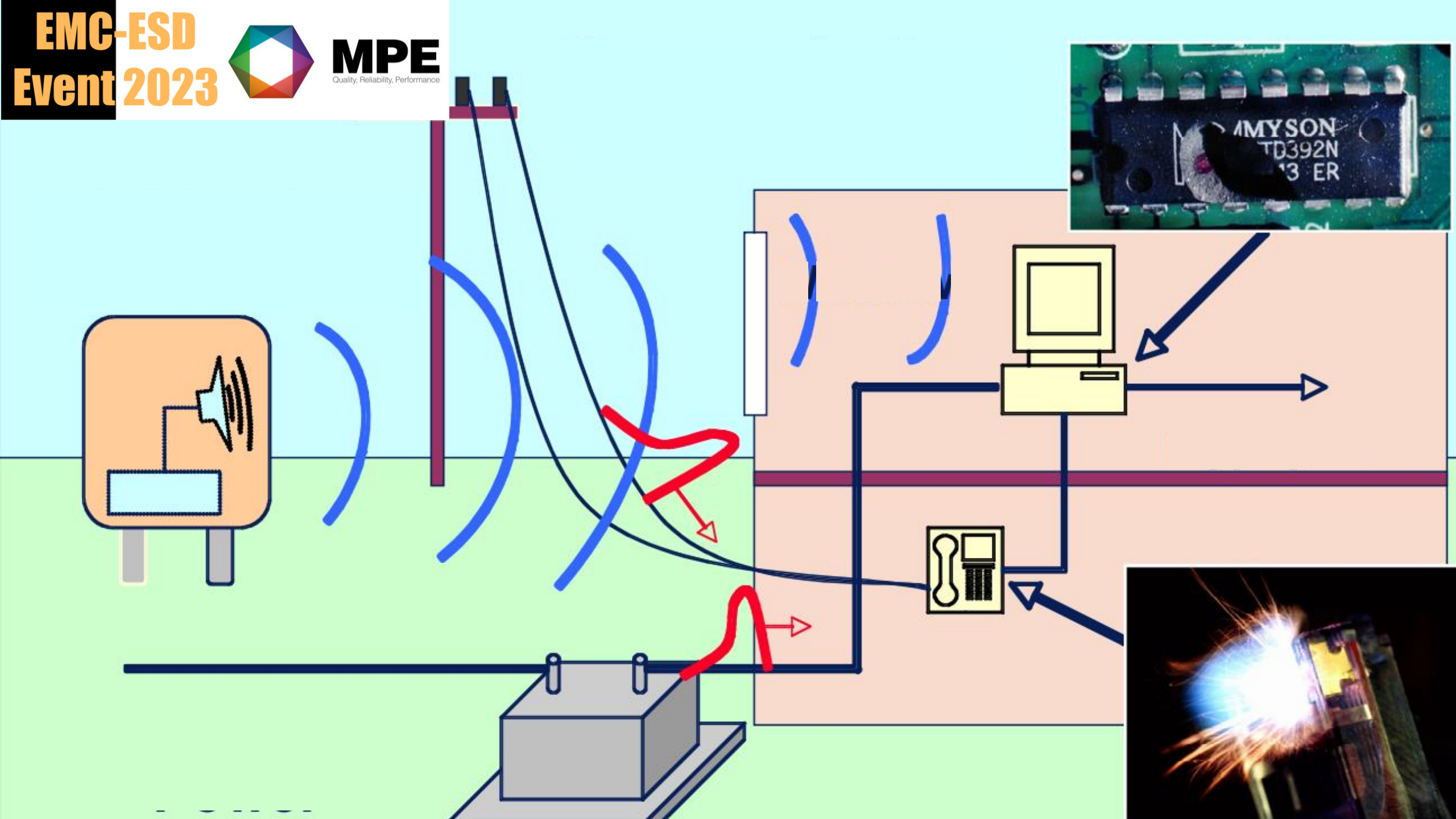

Natural Threats

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High Altitude Detonation

HEMP

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IEMI

Intentional malicious generation of electromagnetic energy introducing noise or signals into electric and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes.

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IEMI Devices

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EMP
“Triple Threat”

Natural threats

The Sun & Lightning

HEMP

High Altitude detonations

IEMI

Intentional Electromagnetic Interference

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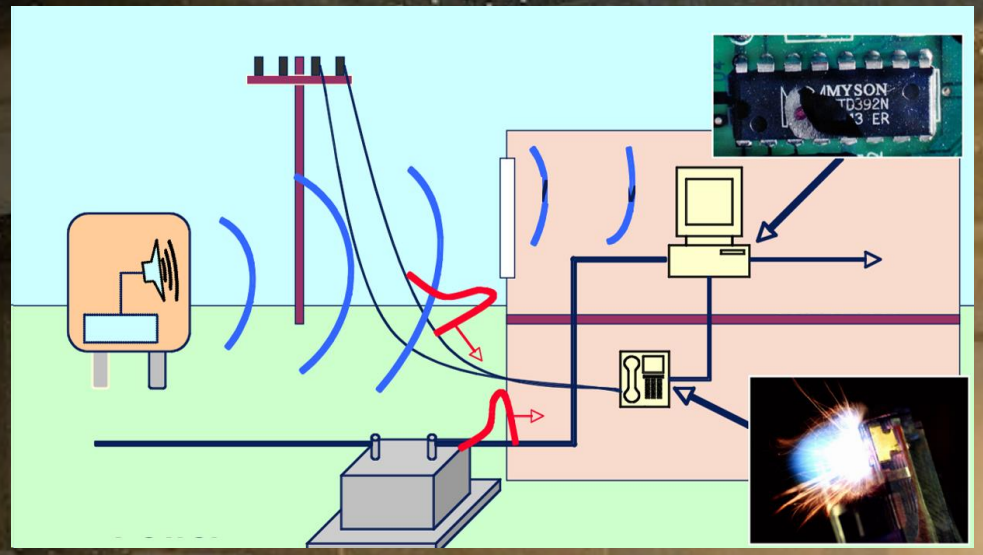

Shielded Rooms

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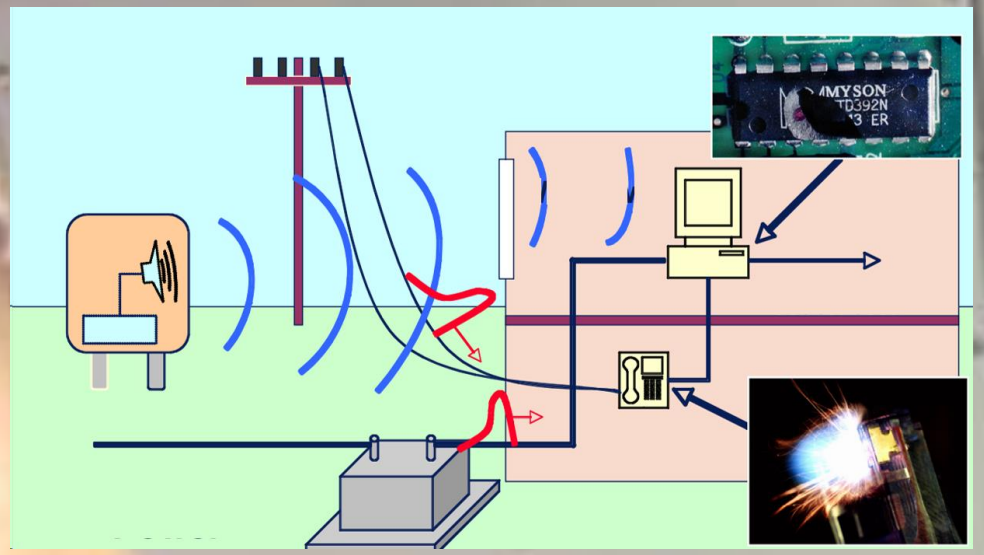

Filter Electromagnetic Pulses

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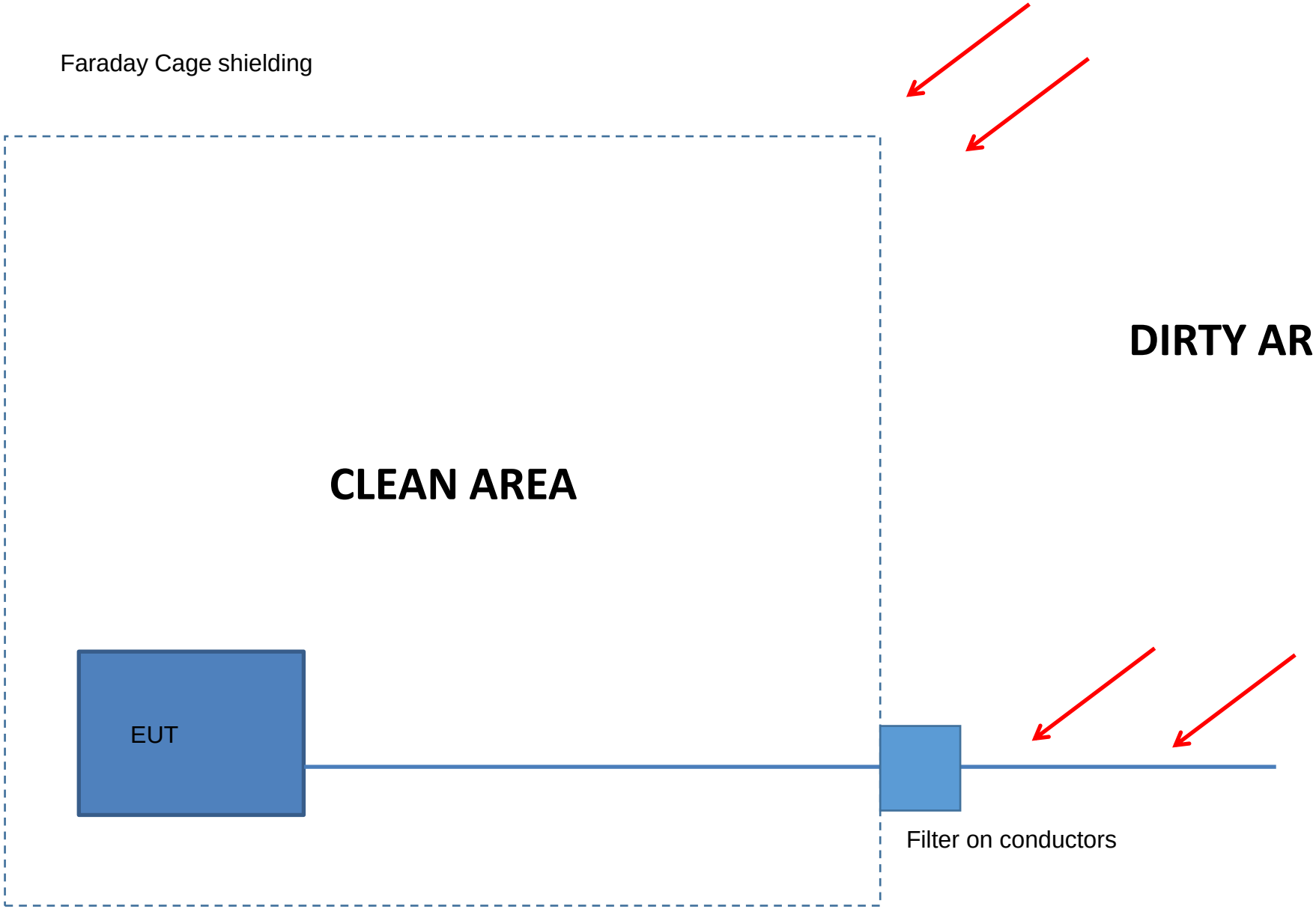
Faraday Cage shielding



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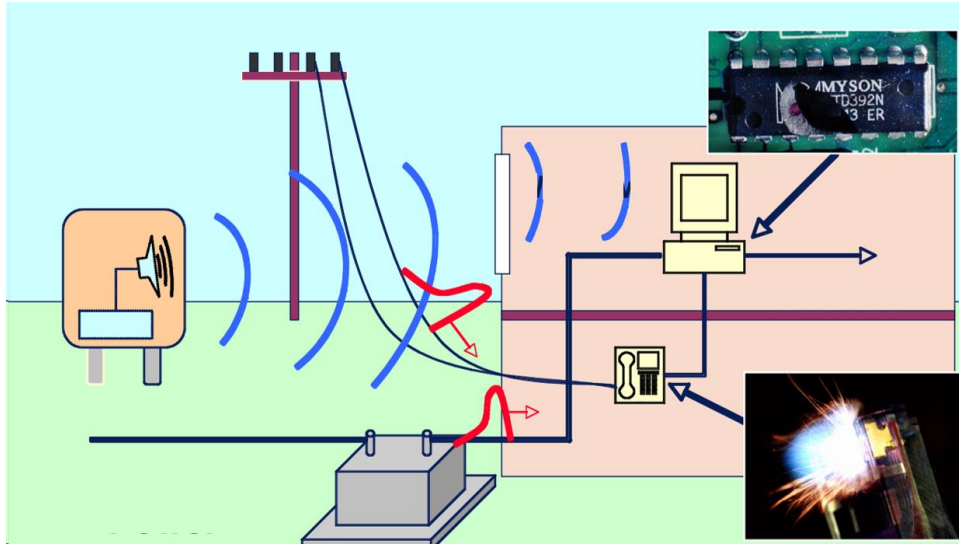

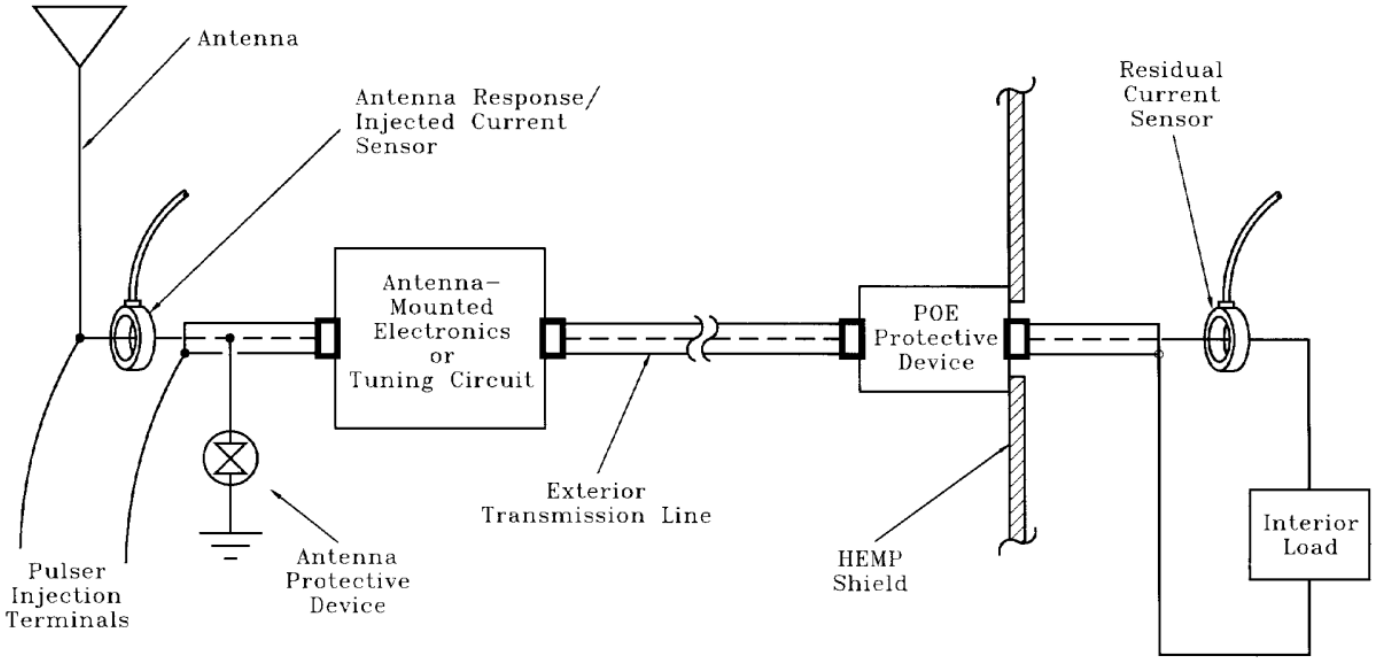

Functions of an EMP Filter

- Allow required power or signals into the shielded environment
- Maintain ‘Shielding Effectiveness’ of the protected environment
    - Prevent radiated emissions/emp entering
    - Filter unwanted frequencies from the conductors
- Divert the conducted pulse to ground
- Filter/block any residual pulse current

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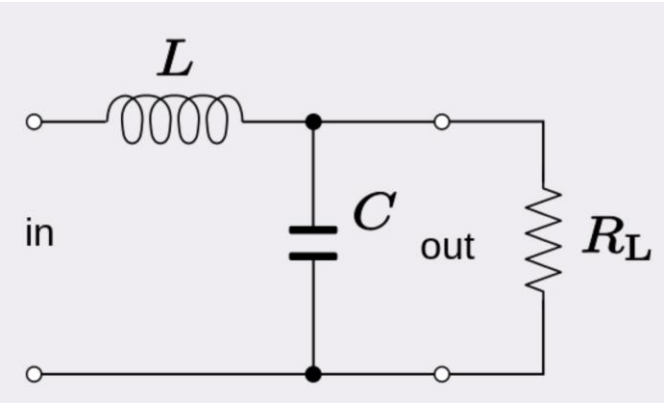
HEMP Filter Design Basics

- Metal Oxide Varistor or MOV
  - – Diverts electrical power above specified current/voltage to ground
- Inductors
  - Allow low frequencies to pass through e.g. 50/60Hz power
  - Block high frequencies
- Capacitors
  - Divert high frequency signals to ground
  - Block desired signals from taking the path to ground e.g. 50/60Hz power
- Enclosure is a Faraday Cage which maintains the shield
- Behaviour of inductors and capacitors is complex across the frequency range



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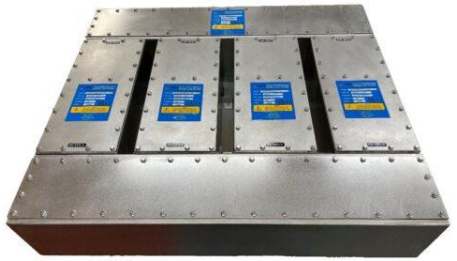
Current Market Trends & Drivers

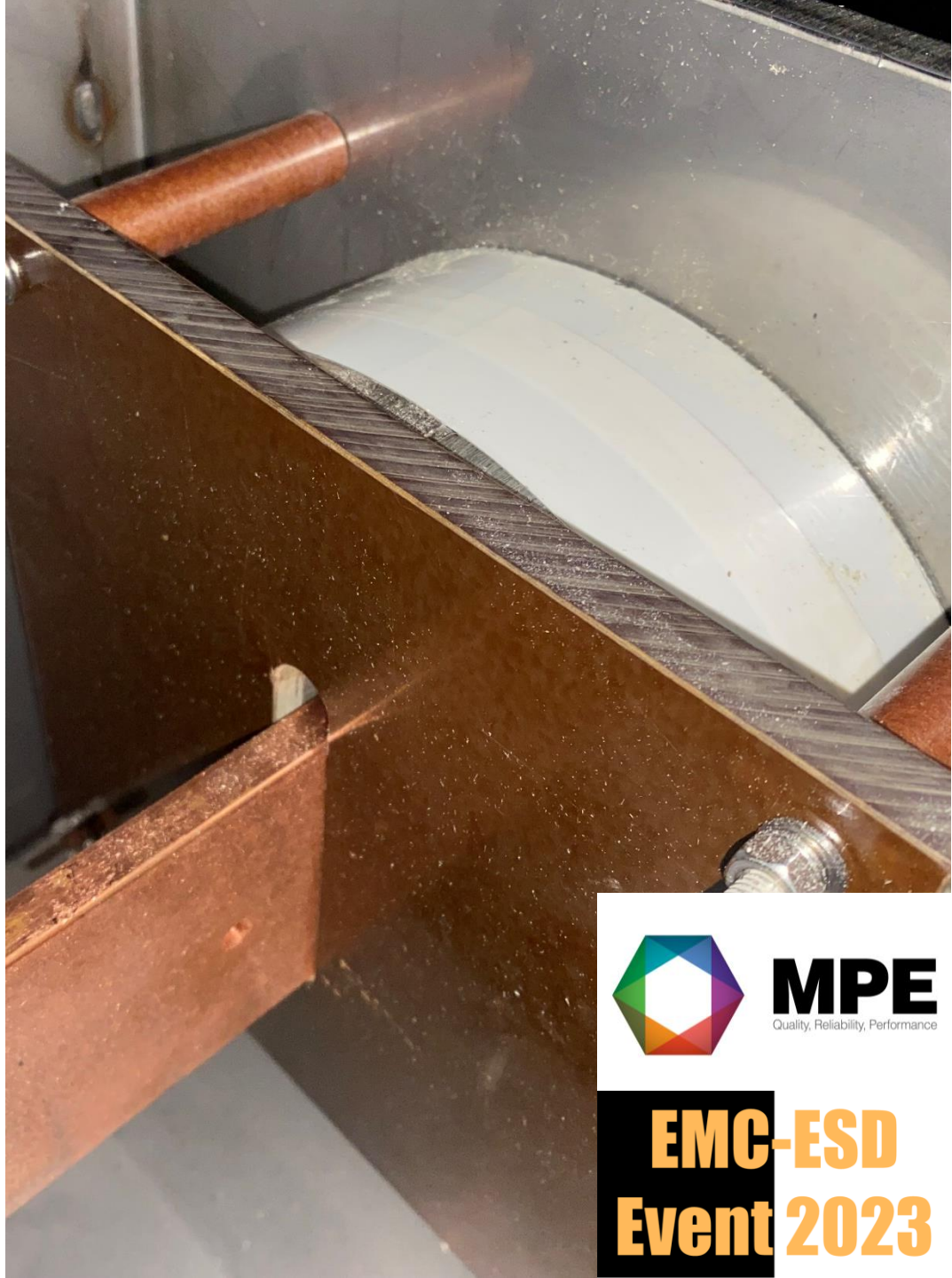
- Increased commercial (civilian) demand
    - Power & utilities, data centres, finance
    - Hubs, Government
    - Legislation, Insurers, & real-life events

- Update to MIL-STD-188-125
    - Filters are passing “Acceptance” but failing “Verification” testing
    - Reflects real world conditions
    - Now the “current” Standard



- Higher current ratings up to 6000A TP&N
    - Changes in physical design required
    - COTS Components not available

- Focus on **reliability** of filters, specifically overheating



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Anecdotal reports from the US DoD, DTRA, Jaxon, Sara and others, place ‘infant mortality’ **failures within indigenous (US) manufactured filters as high as**

10%

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Common Causes of Filter Failure

Overheating

- Poor filter design that does not consider harmonics from variable speed drives
- Incorrect inductor material selection
- Large real-world current due to transient currents

Overvoltage conditions

- Dielectric breakdown of the capacitor material
- Breakdown of insulation between inductor windings
- Arcing corona discharge

Overcurrent conditions

- Damage to mechanical interfaces of the capacitor electrodes
- Sustained over-current conditions will lead to thermal runaway of the inductor
- Magneto restriction causes vibration & noise

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Controlling Temperature Rise

- Custom design of components

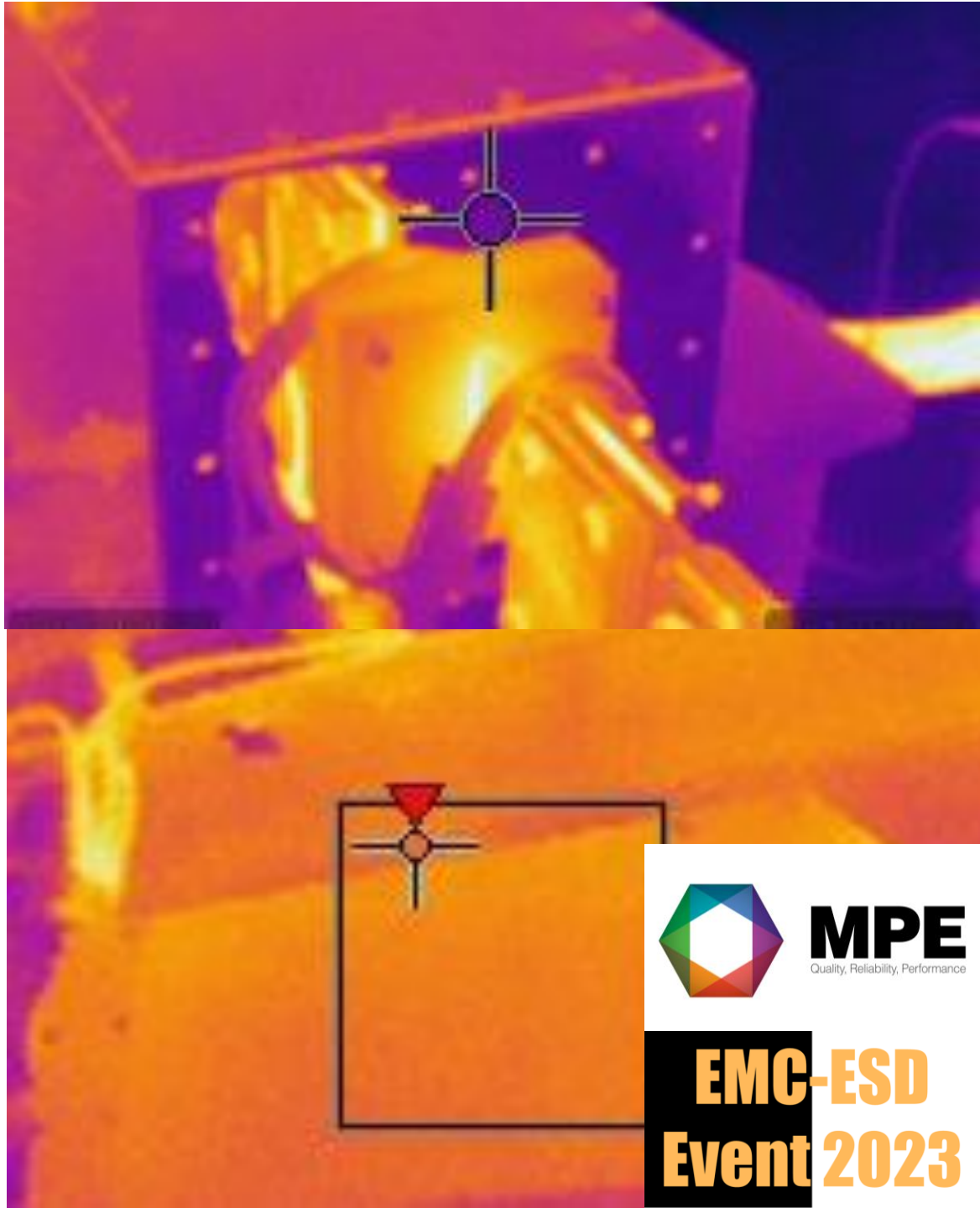
- Careful specification of current carrying components

- Careful selection of materials

- Rigorous design testing of individual components under load

- Rigorous testing of completed products under load

- Collaboration with end users and authorities



Standards & Compliance

- MIL-STD-188-125-1&2 MIL-STD-188-125-1A
- DEF-STAN-188-125-1&2 equivalent to MIL standard
- IEC 61000-4-36 IEMI immunity test methods for equipment and systems
- IEC 61000-4-23 & 24 Radiated & Conducted HEMP protection
- IEC 61000-5-10 Guidance on HEMP and IEMI
- SC77 Committee
- European Program for Critical Infrastructure Protection
- EU Directive on the resilience of Critical Facilities (CER Directive)

Ministry of Defence

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Summary

1. EMP is an electromagnetic pulse that can come from 3 main sources
    1. Natural
    2. HEMP
    3. IEMI
2. EMP Filter Design
    1. Maintaining shielding effectiveness
    2. Preventing conducted EMP reaching equipment
    3. Filters use varistors, capacitors and inductors to “divert” and “block” the pulse
3. The market for EMP is growing and is driven by:
    1. Increasing civilian requirements
    2. Updated National and International standards
    3. Increasing power requirements
    4. Unreliability of existing filters

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