Control House and Relay Design Considerations for EMP Resiliency

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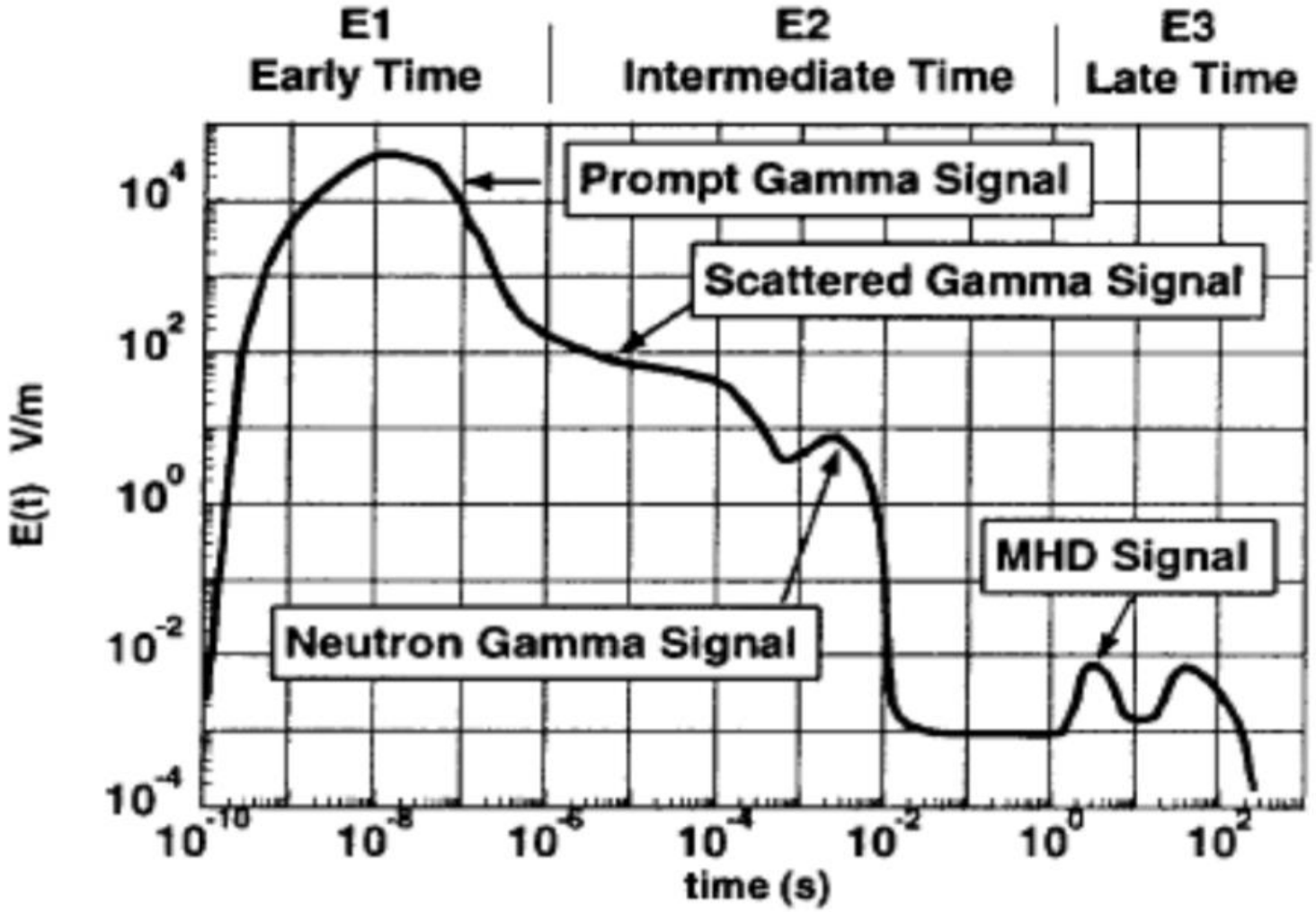
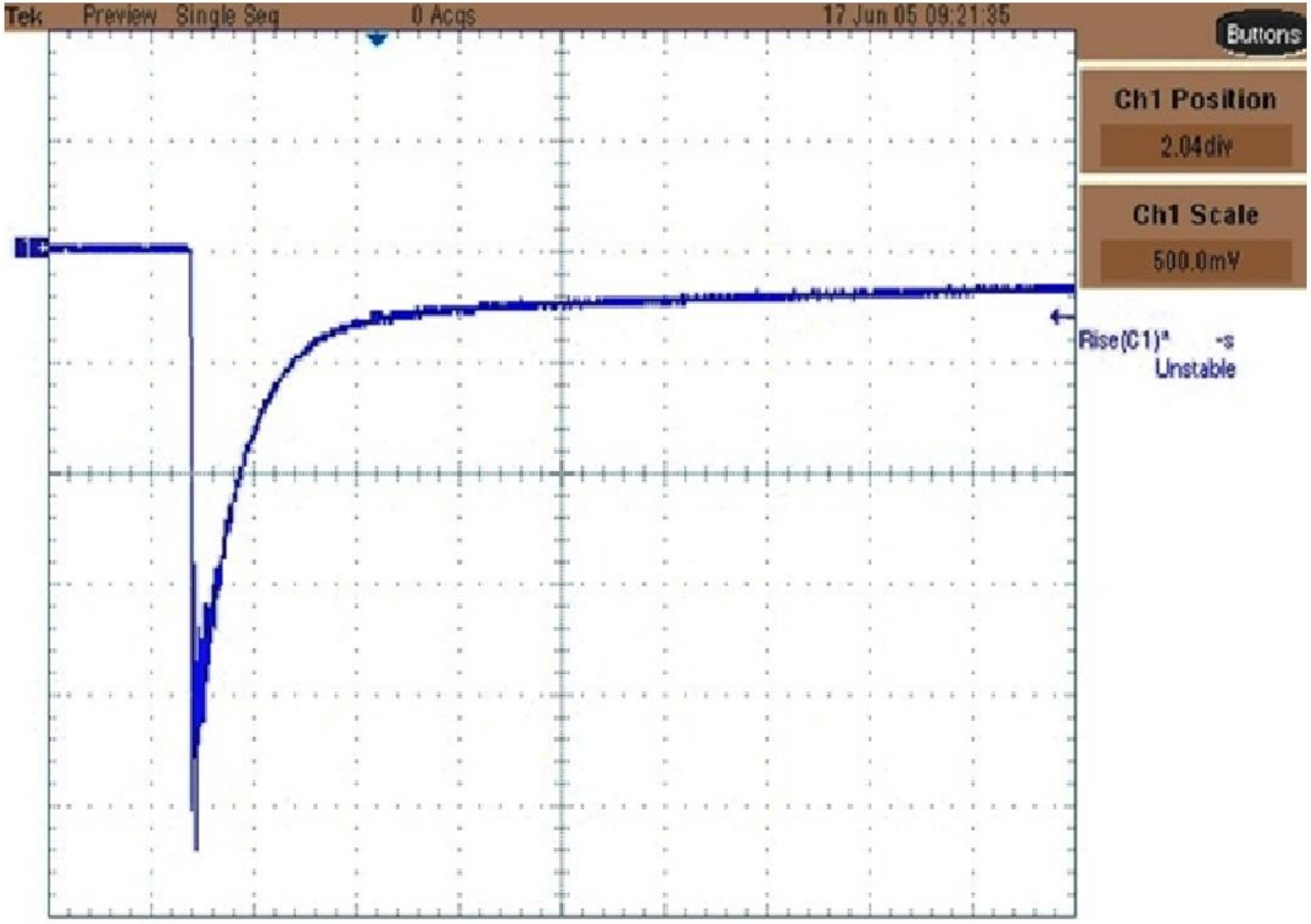
Electro Magnetic Pulse - EMP

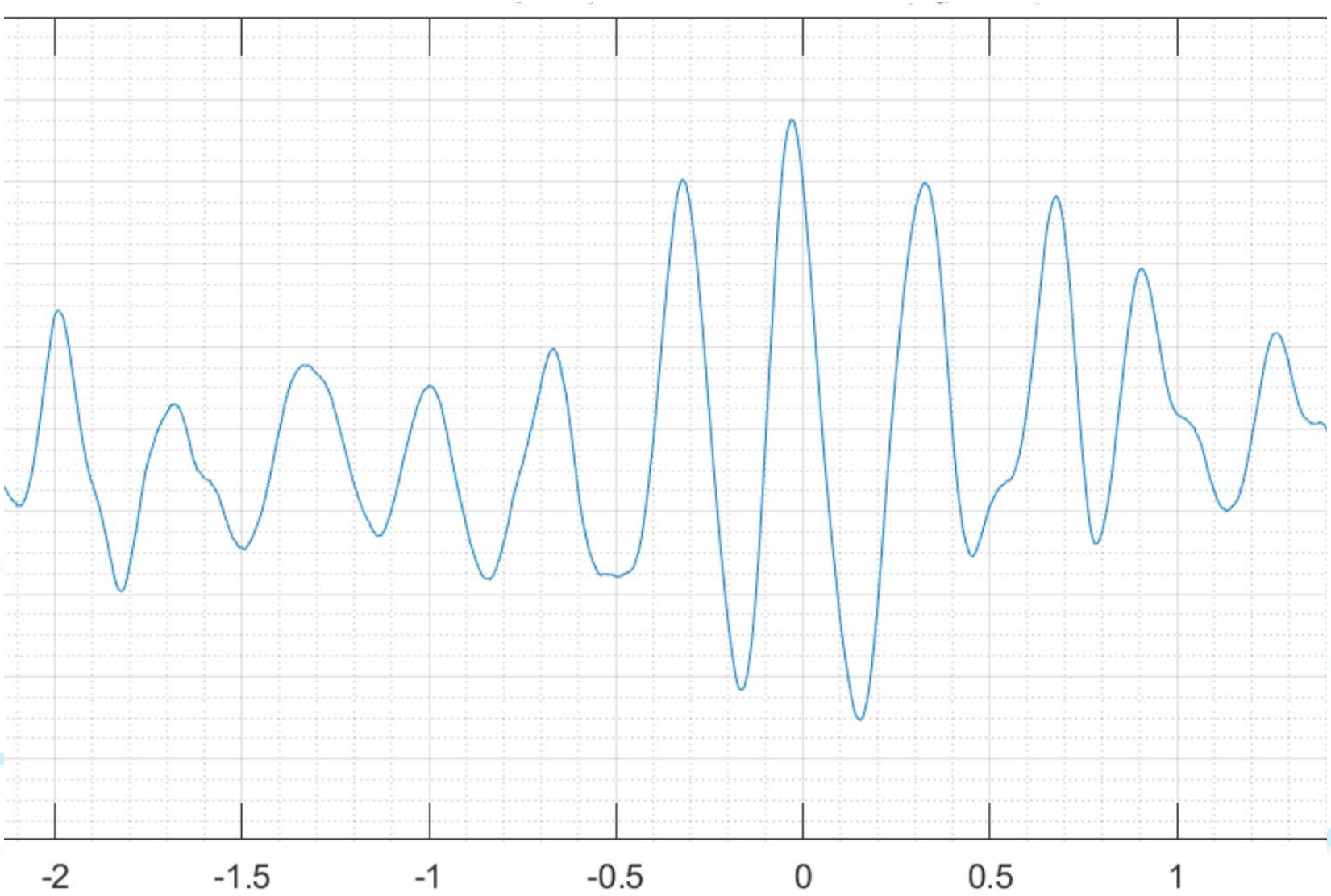


Classification of wave into 3 time frames

EMP E1 Pulse Shape – Rise Time ≈ 1 nsec

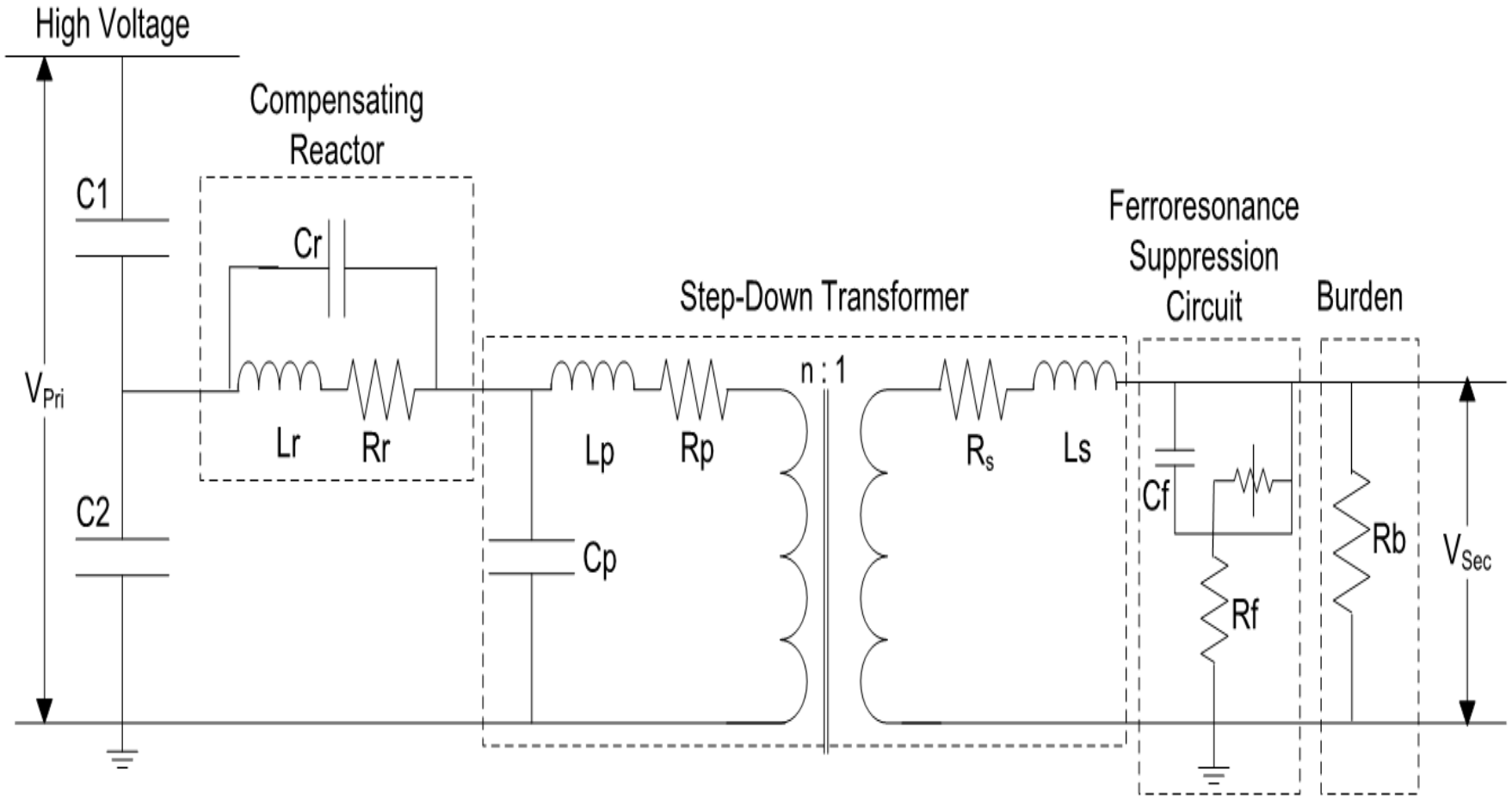


Man-Made EMP Pulse Shape – Before tuning

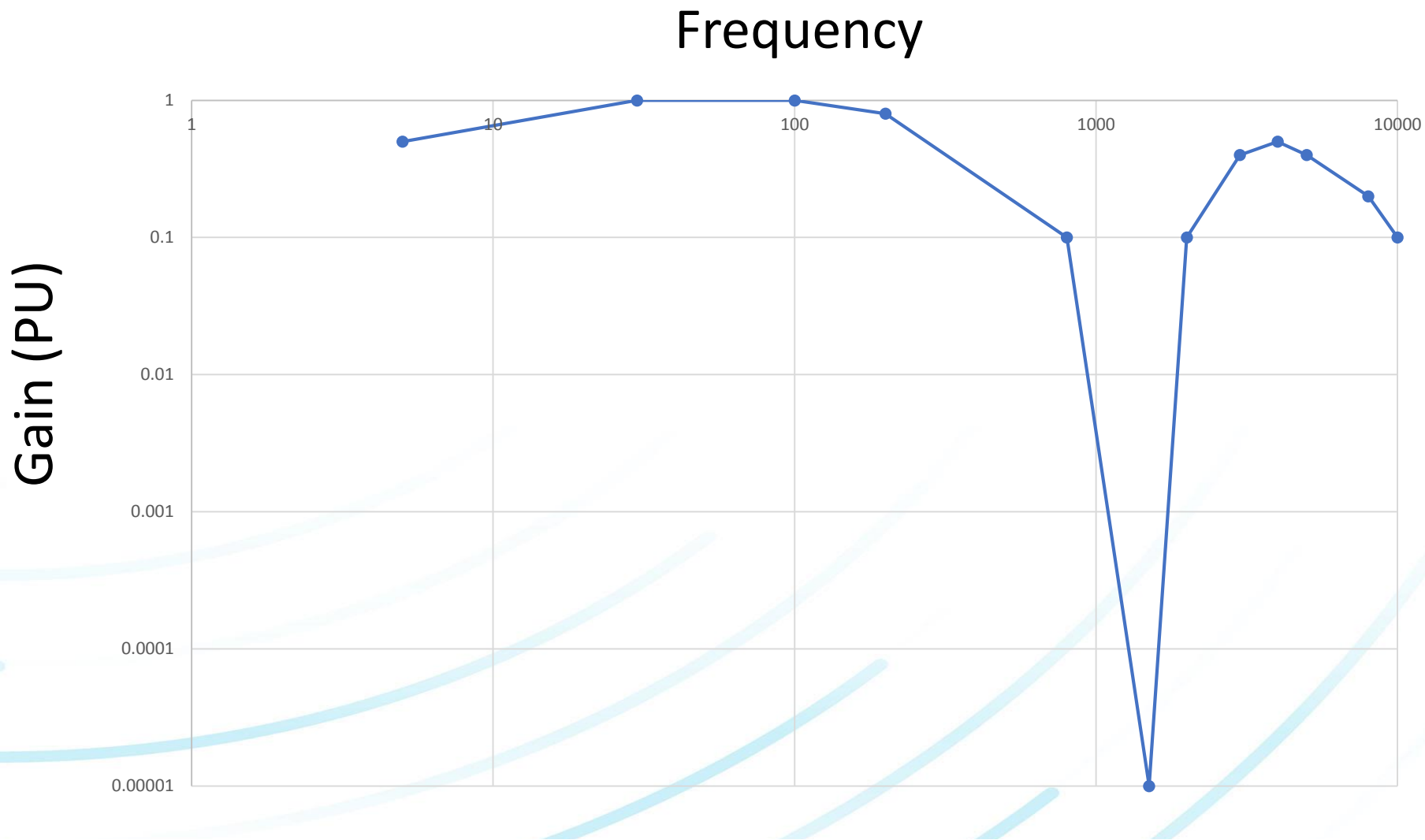


Time Scale: 10 nsec/div

Conducted EMP Path: CCVT



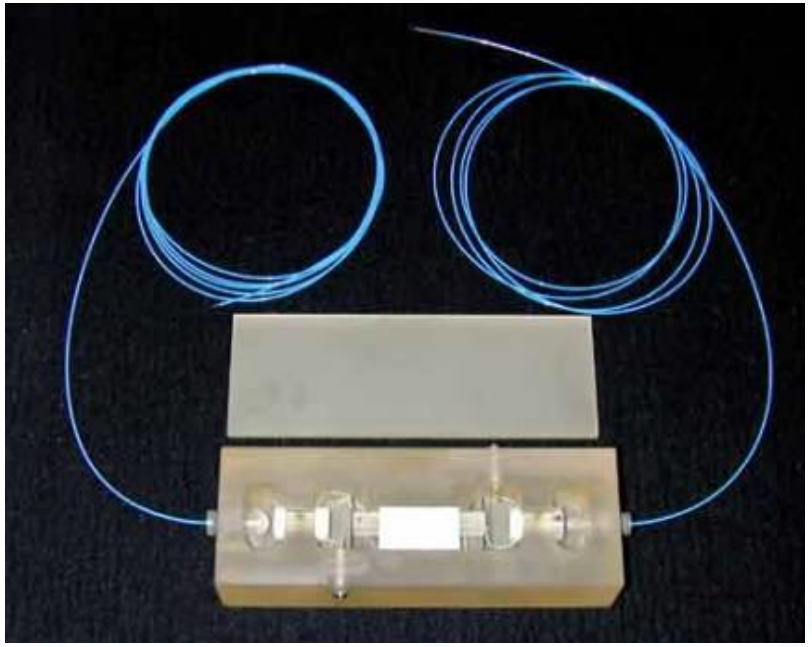
CCVT Frequency Response Plot



One Source Of Conducted EMP – With Attenuation…

Conducted EMP Mitigation: Optical Sensing

Faraday Current Sensor



Pockels Voltage Sensor

Provides Complete Electrical Isolation from Conducted EMP

STRATEGY
FOR
PROTECTING AND PREPARING THE HOMELAND AGAINST THREATS OF ELECTROMAGNETIC PULSE
AND
GEOMAGNETIC DISTURBANCES

October 9, 2018

DHS Goals to Address EMP and GMD Events

- GOAL 1: Improve risk awareness of electromagnetic threats and hazards
- GOAL 2: Enhance capabilities to protect critical infrastructure from the impact of an electromagnetic incident (including new technology)
- GOAL 3: Promote effective electromagnetic-incident response and recovery efforts

“Best” EMP-Resistant Design Practices: Grounding

- Low impedance ground conductors are essential
- 6 inch wide by 0.08” copper is a good size for facility grounds
- Sub-surface ground systems should be low impedance mesh of welded copper straps rather than a single heavy round wire at the perimeter of the protected area
- Round wire grounds should be avoided at all costs. They are inherently high impedance and reflect fast pulses rather than passing them to ground.
- All cable shields must be grounded at Point of Entry (POE)

“Best” EMP-Resistant Design Practices: Buildings

- Conductors and buildings should be shielded with solid metal which covers all surfaces
  - Best performance: Seams/joints welded or soldered
- All cable entries must use proper shielding and bypass techniques
  - Waveguide style cable Points of Entry (POE) are essential
  - Cable shields need to be grounded to the exterior of the waveguide POE
- Doors must have a continuous electrical contact around their perimeter when closed
- Battery banks should be inside the shielded buildings, and include shielded vent for hydrogen venting

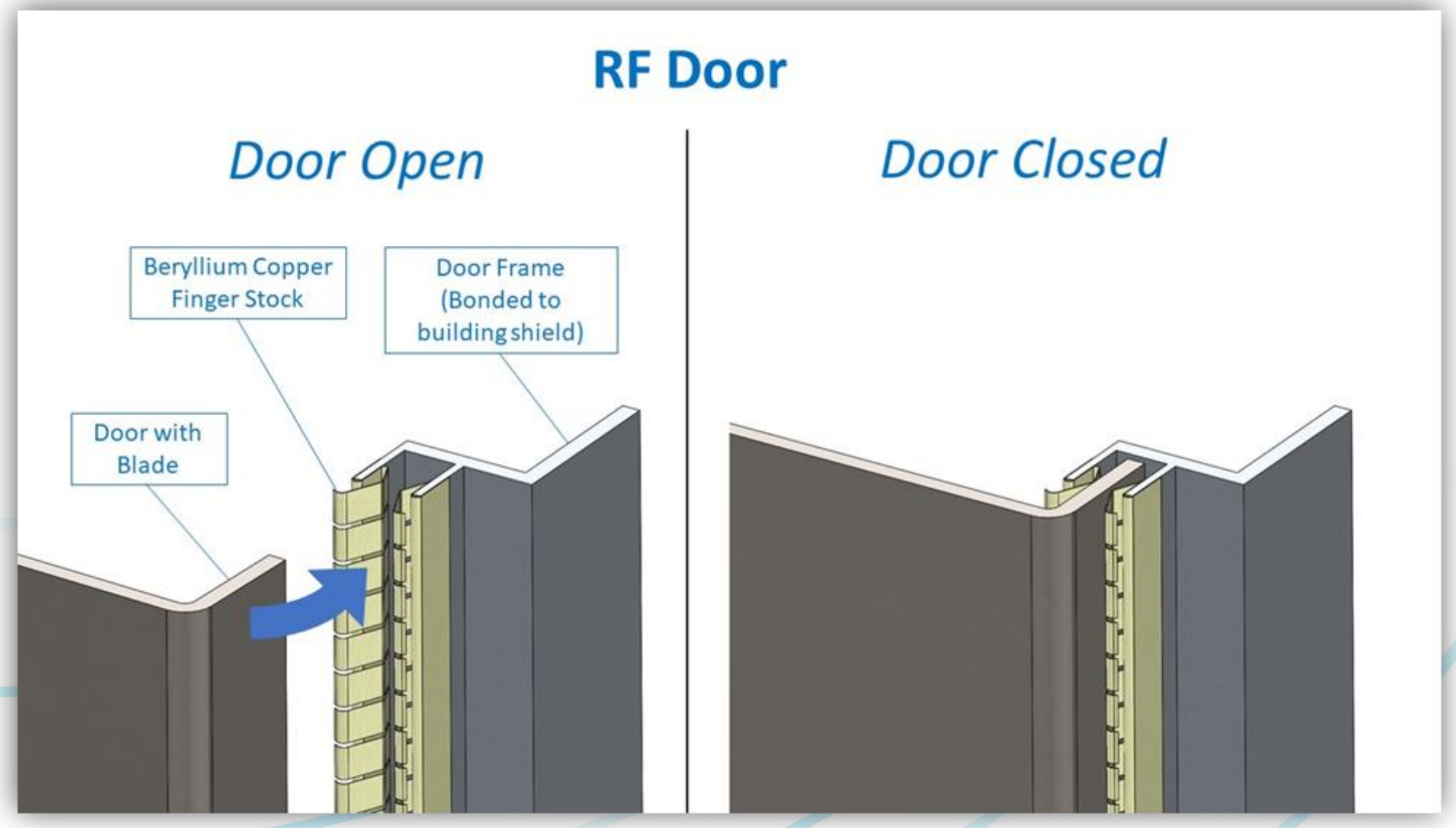
“Best” IED Design Practices

- Metal shielding on IED modules and chassis
- Use of Transient Voltage Suppression (TVS) Diodes
- Use of copper strap/braid due for lower inductance ground
- Use of Hardware Watchdog Timers
- Use of Error Correcting Code (ECC) Memory

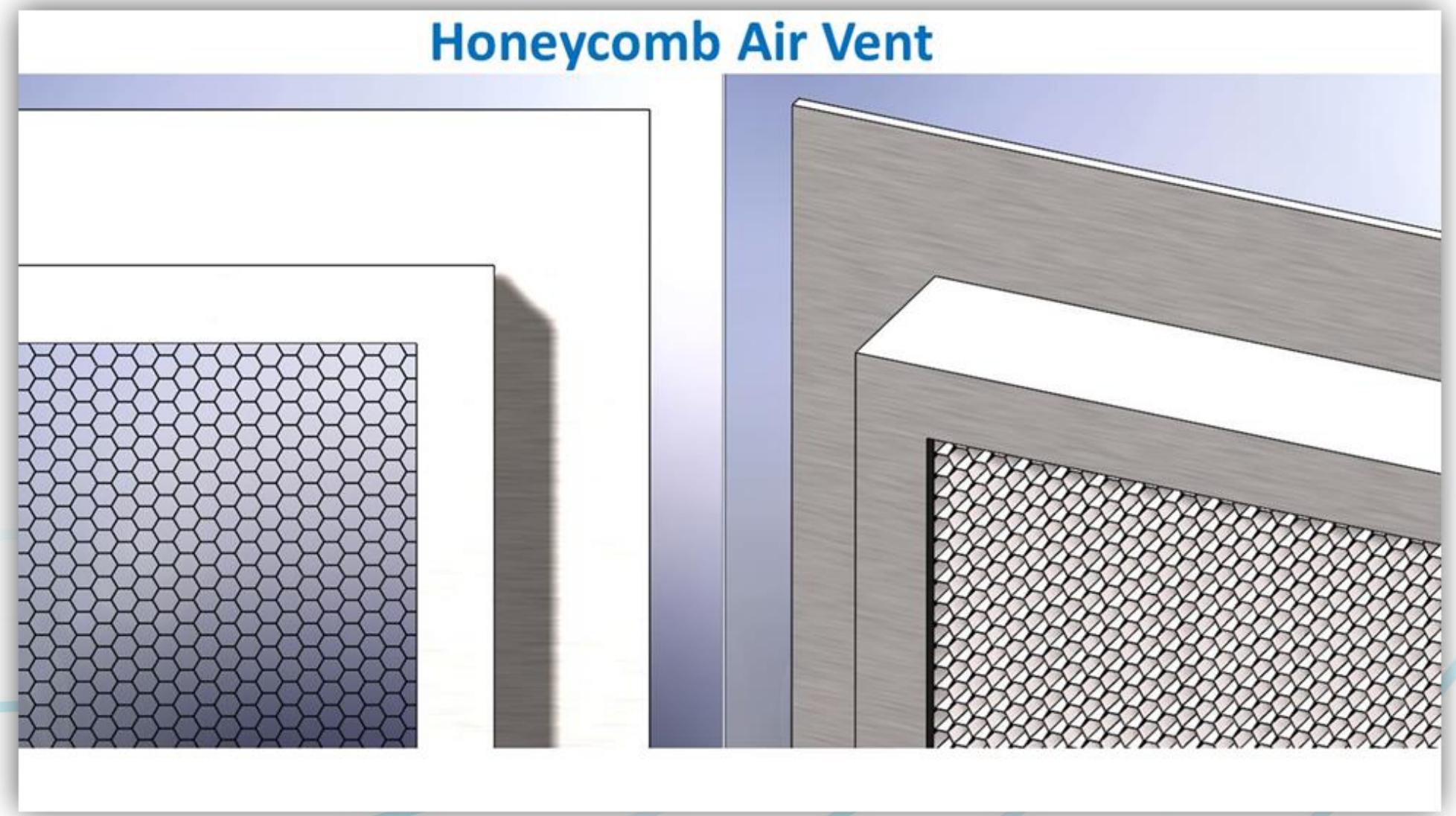
Overall Control House View

Corner joints are electrically bonded by continuous, mechanically-fastened, conductive brackets

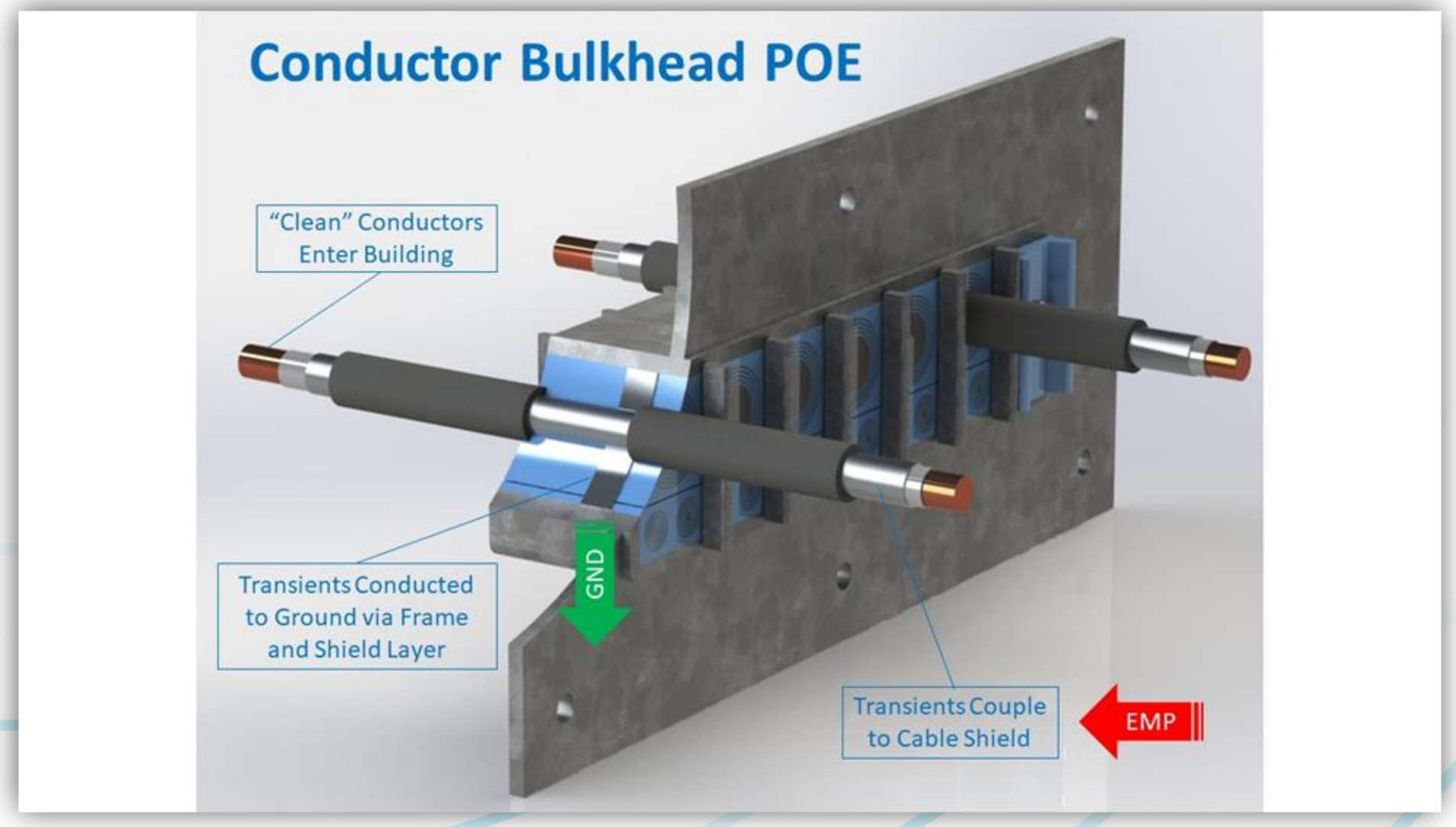
“Sealed” Door Design



Air Exchange Design

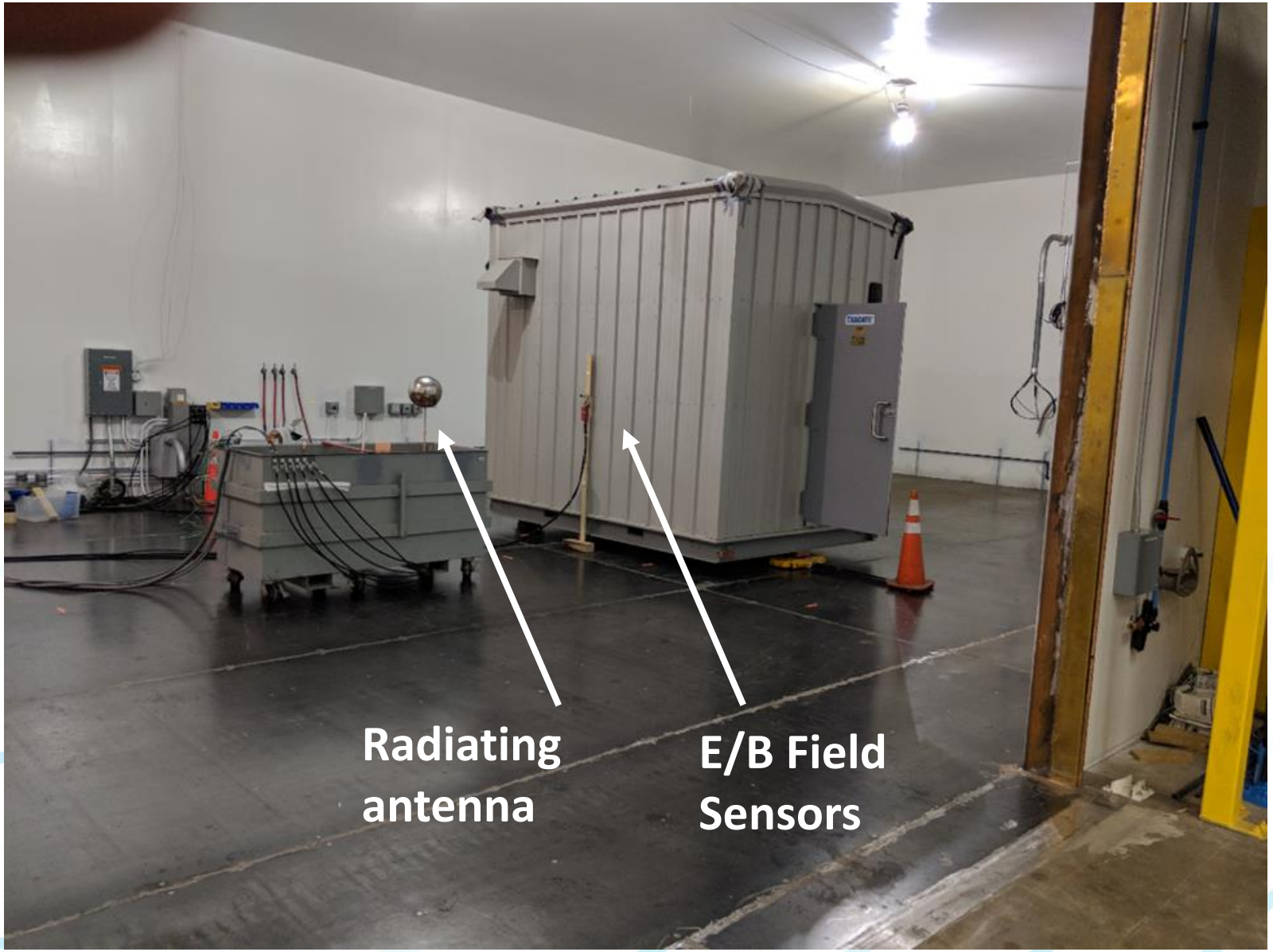


Cable Entry/Exit System

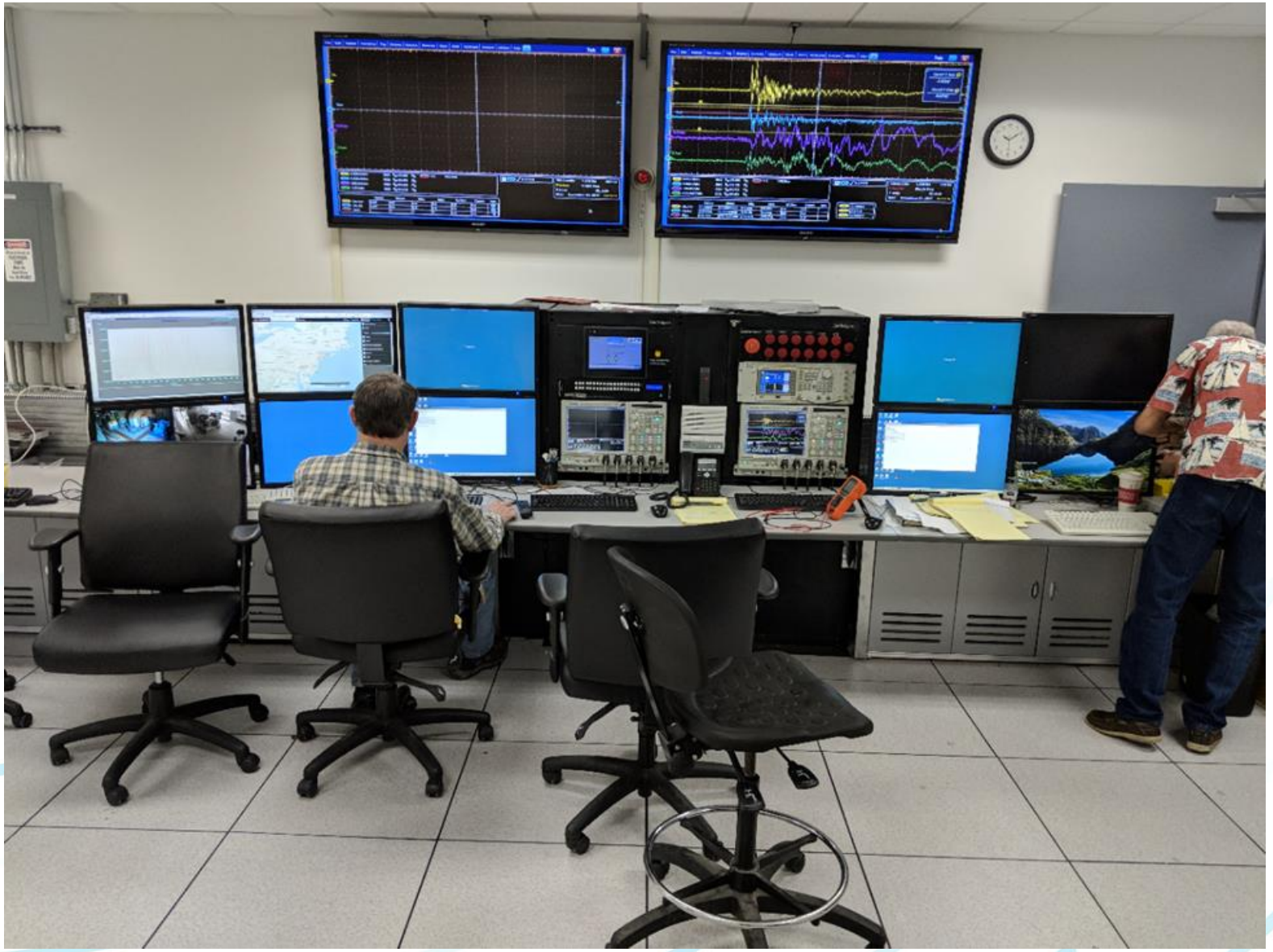


Cable Entry/Exit System via Waveguide

Test Chamber with Test Generator and Control House



Control Room with Pulse Displays



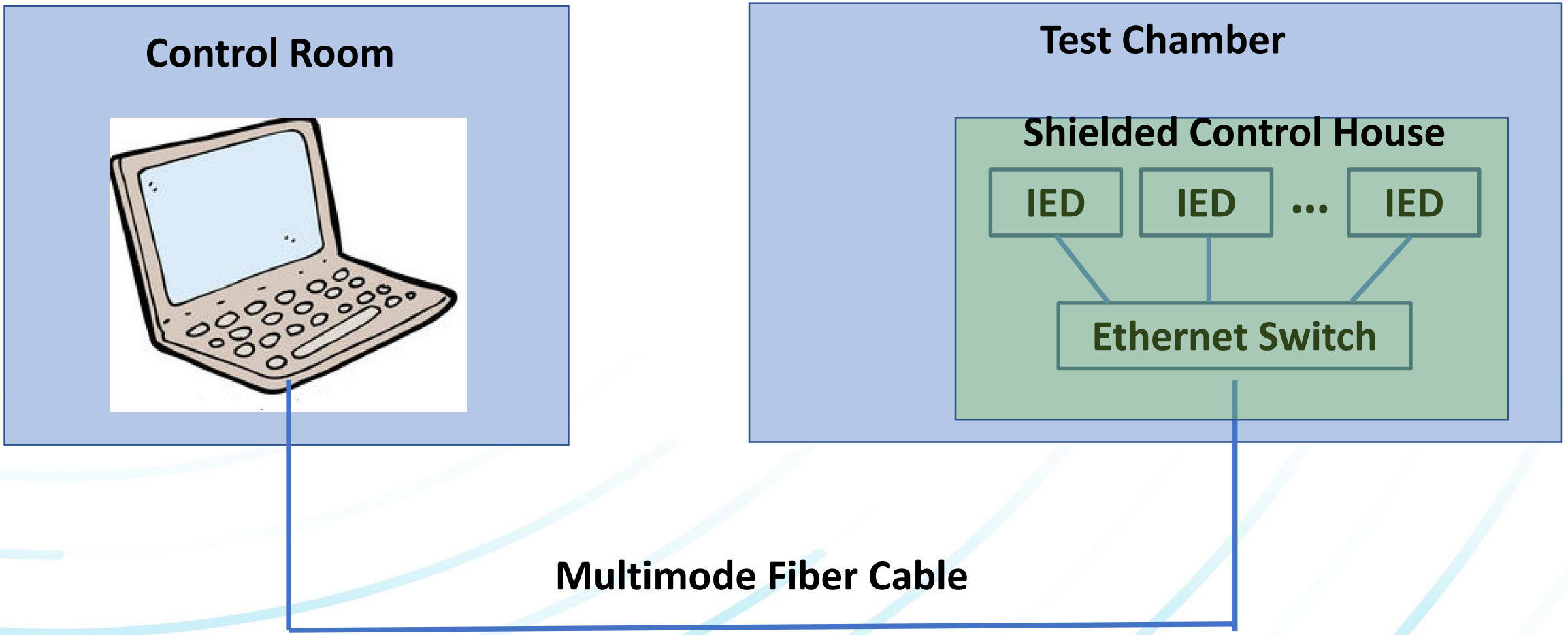
IED Performance Categories

Category 1: There were NO IED component failures and the IED continued to operate without interruption

Category 2: There were NO IED component failures, however, the IED locked-up and had to be reset or auto re-booted

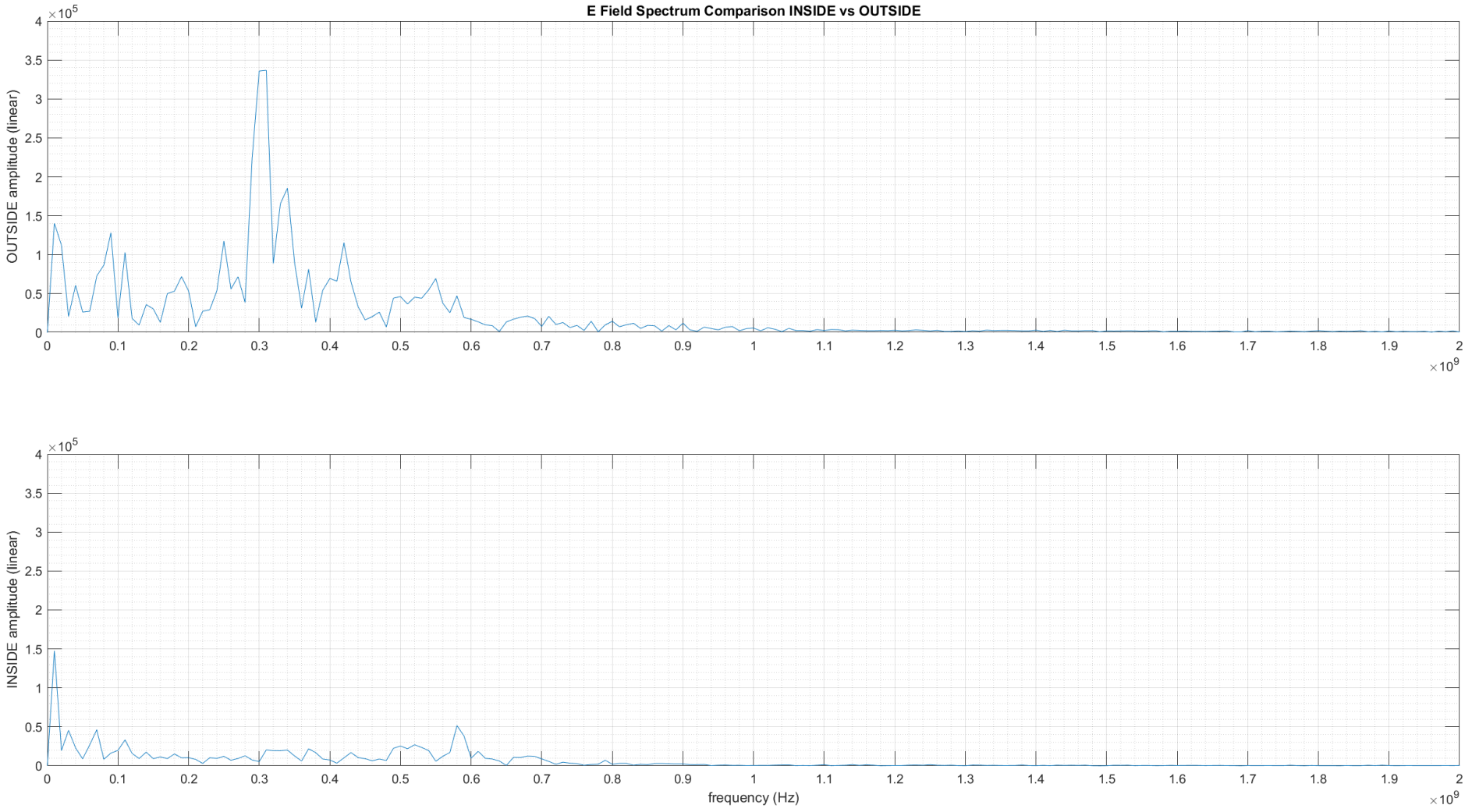
Category 3: There were component failures in the IED and normal operation was no longer possible

IED Monitoring – Communicating and Re-boots

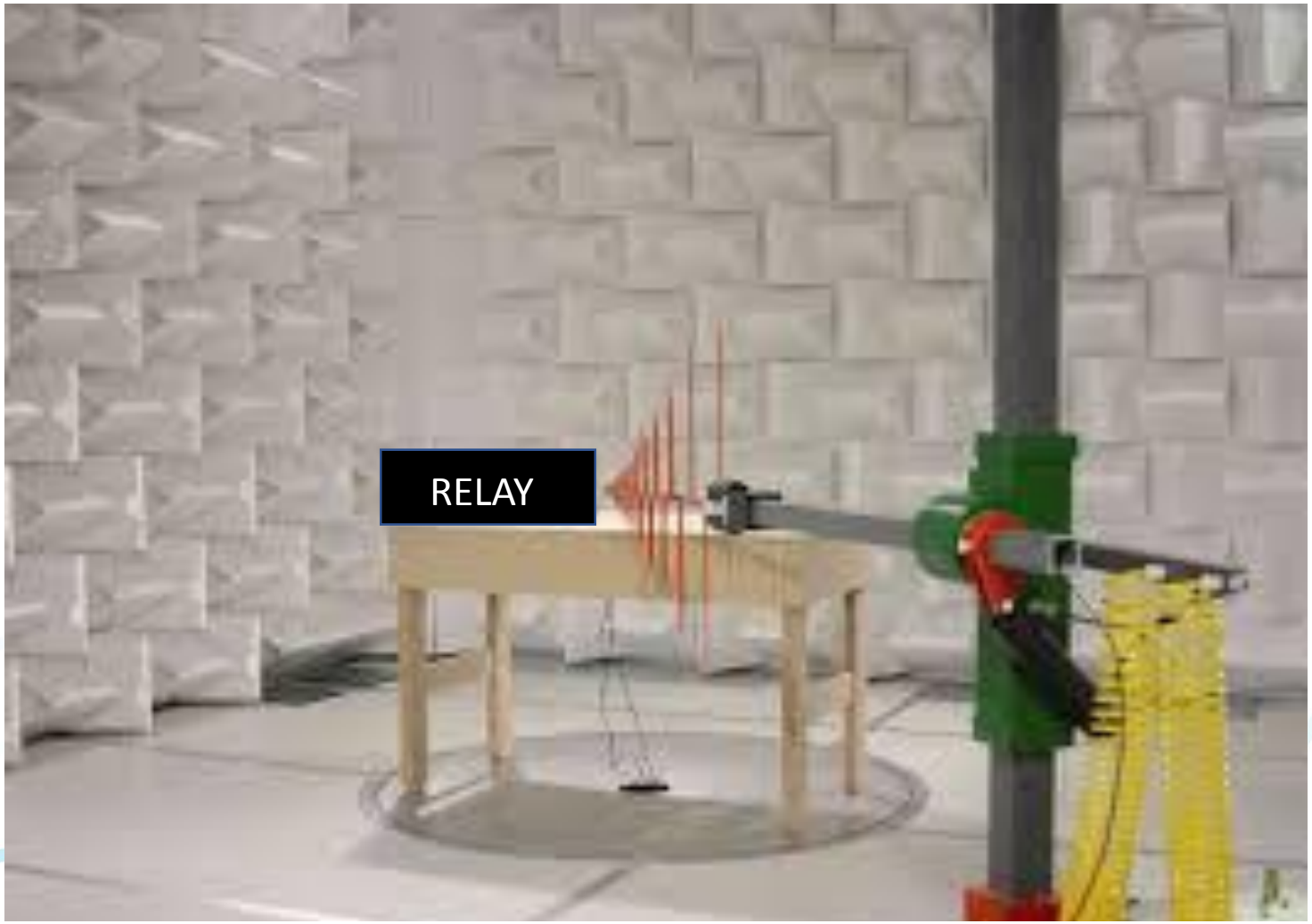


All IED found to be communicating – No Re-Boots or Lock-ups

Control House Attenuation (with cables into house)



Direct EMP Signal Radiation



IEDs have Passed the Radiated 50kV/m EMP Test with NO HW failures and NO Lockup

Conclusions

- Nuclear EMP is a low probability / high consequence event
  - Man Made EMP is more probable but only has one wave
- EMP effects manifest themselves through both Radiated and Conducted signals
- There are many design practices that can be employed to mitigate effects from both Radiated and Conducted signals
- Testing has demonstrated how a shielded and well grounded control house can minimize effects from both Radiated and Conducted EMP
- Testing in the industry in ongoing

Thank You

Questions?