

Electromagnetic Interference (EMI) Considerations in Underground Coal Mines



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National Institute for Occupational
Safety and Health



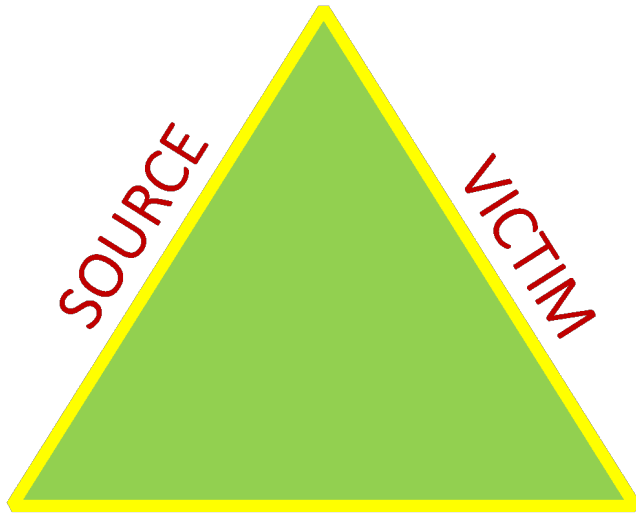
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With more electrical and electronic systems being introduced into mines, EMI is becoming a rising issue in the mining industry



The functionality of the Proximity Detection System (PDS) is impaired when placed in close proximity to a Personal Dust Monitor (PDM) due to the EMI generated by the PDM, which disrupts the magnetic fields sensed by the PDS

EMI considerations in underground mines



EMI Research

- Characterize source emission
- Evaluate victim susceptibility
- Investigate mitigation strategies

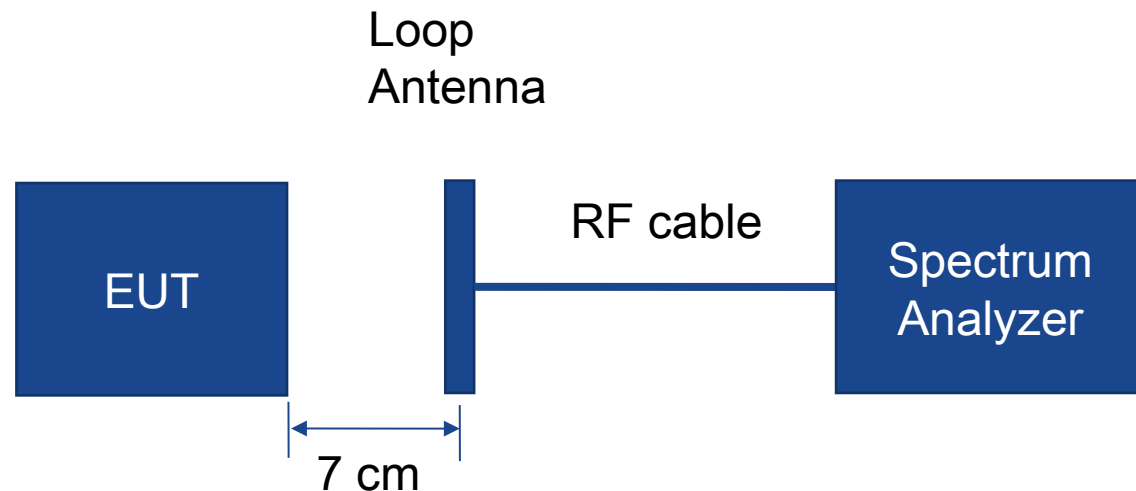
Source → Path → Victim



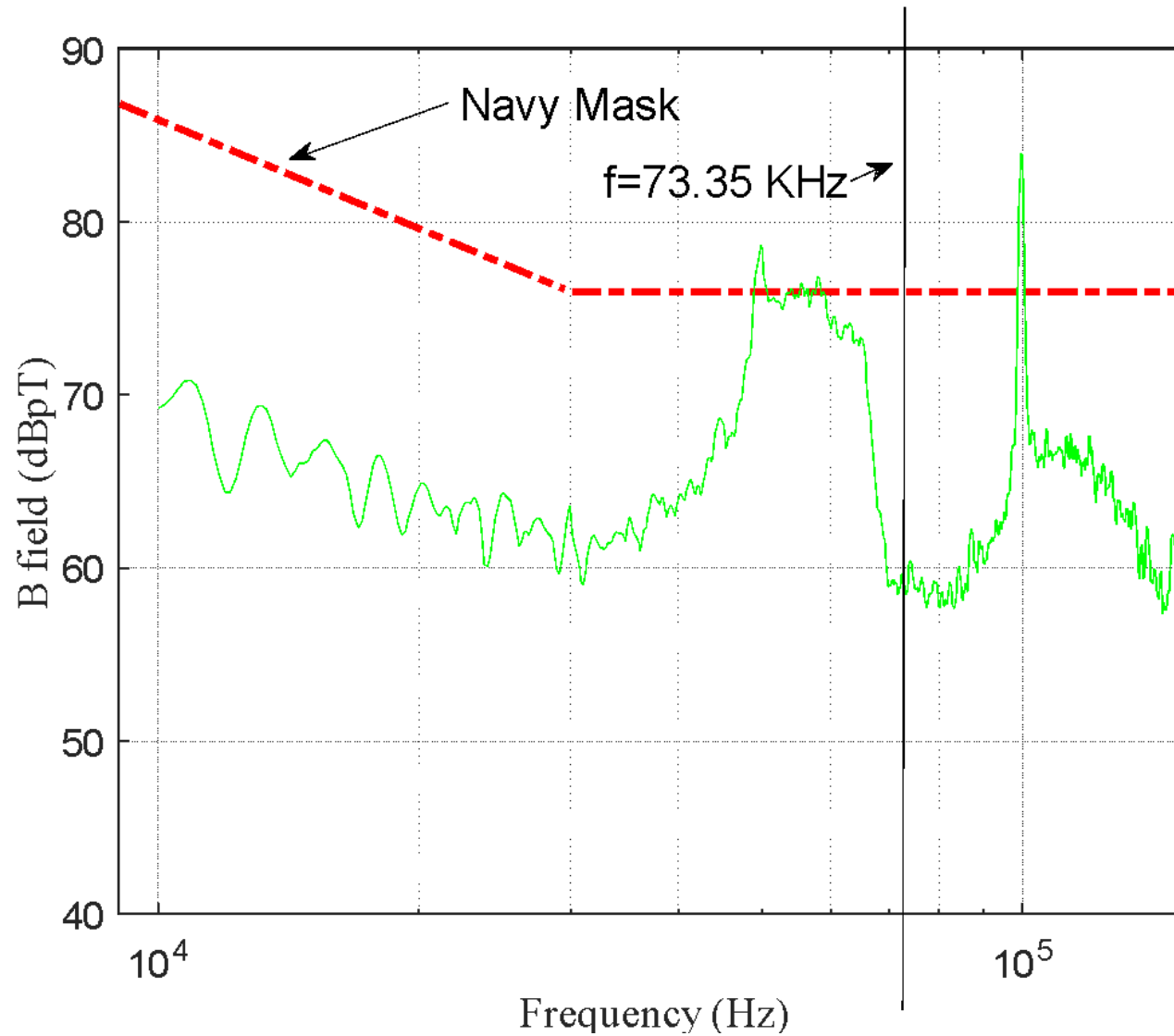
Characterizing radio emissions from an electronic device (magnetic field):

--- Experimental setup (MIL-STD-461G RE101)

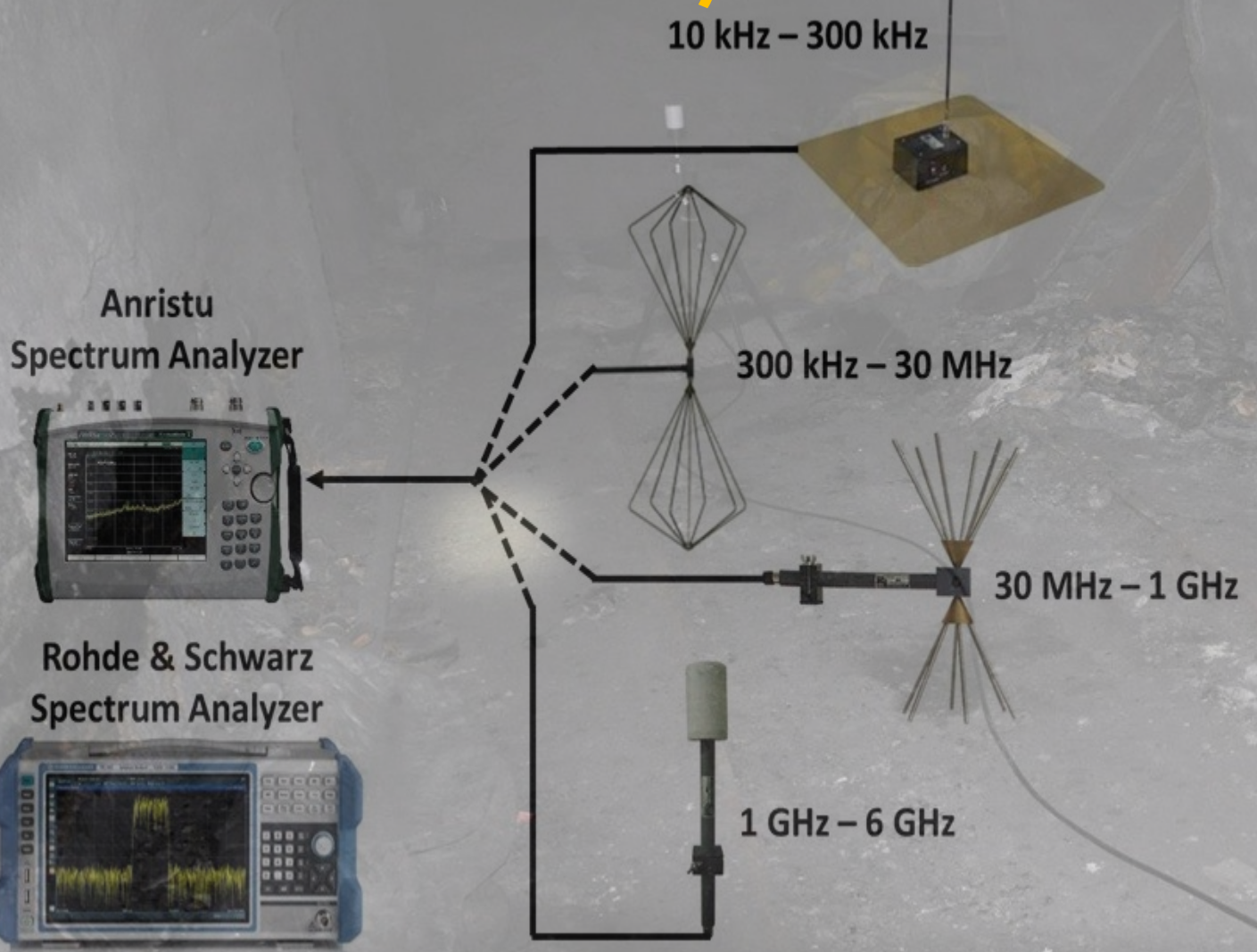
- Major equipment involved:
 - EUT (Equipment Under Test)
 - Antenna (calibrated)
 - Spectrum analyzer
- Distance (7 cm)
- Frequency (~ kHz)



Characterizing EMI source emission based on military standard RE-101: Result



Characterizing EM environments in underground mines (electric field)

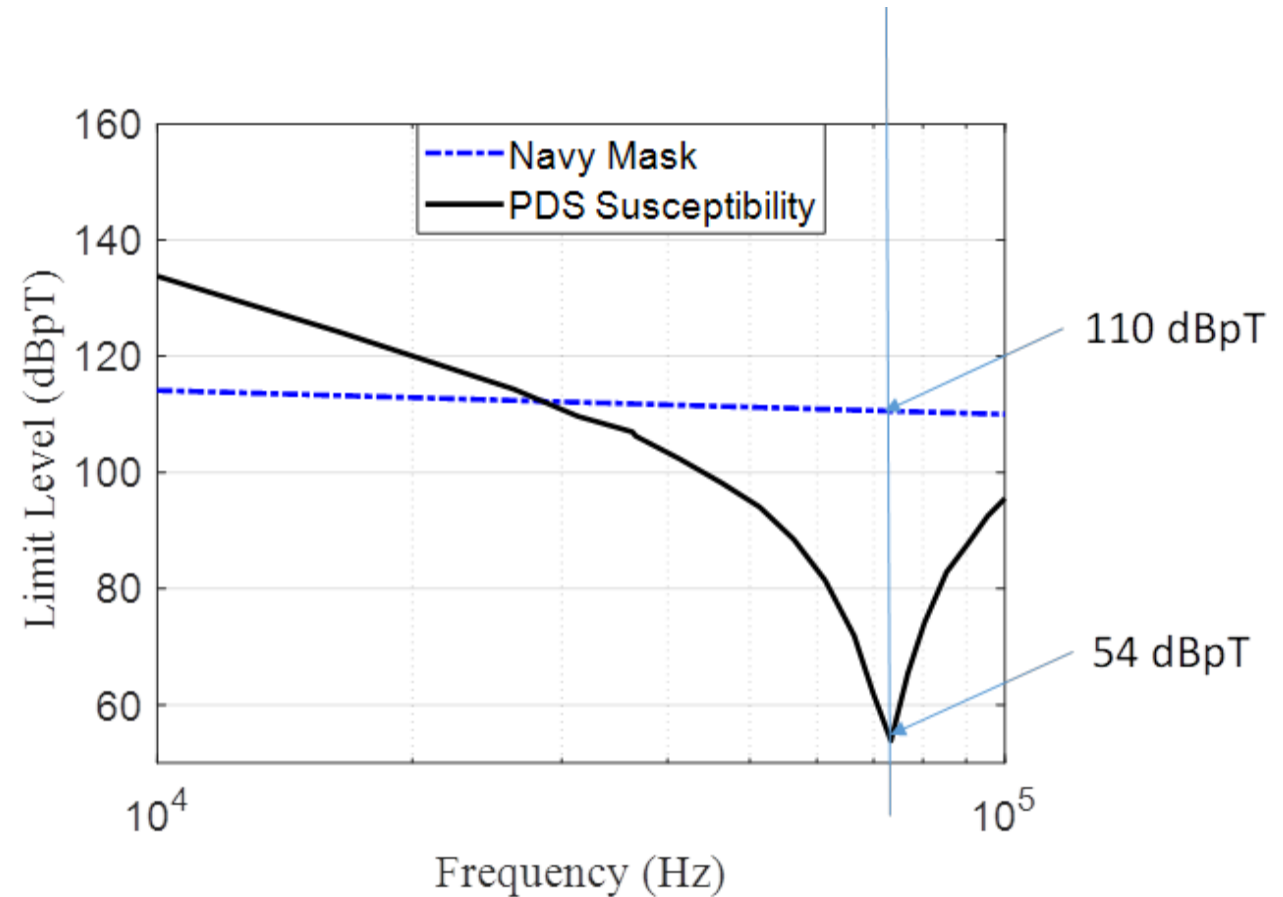


Characterizing EMI victim susceptibility based on military standard RS-101



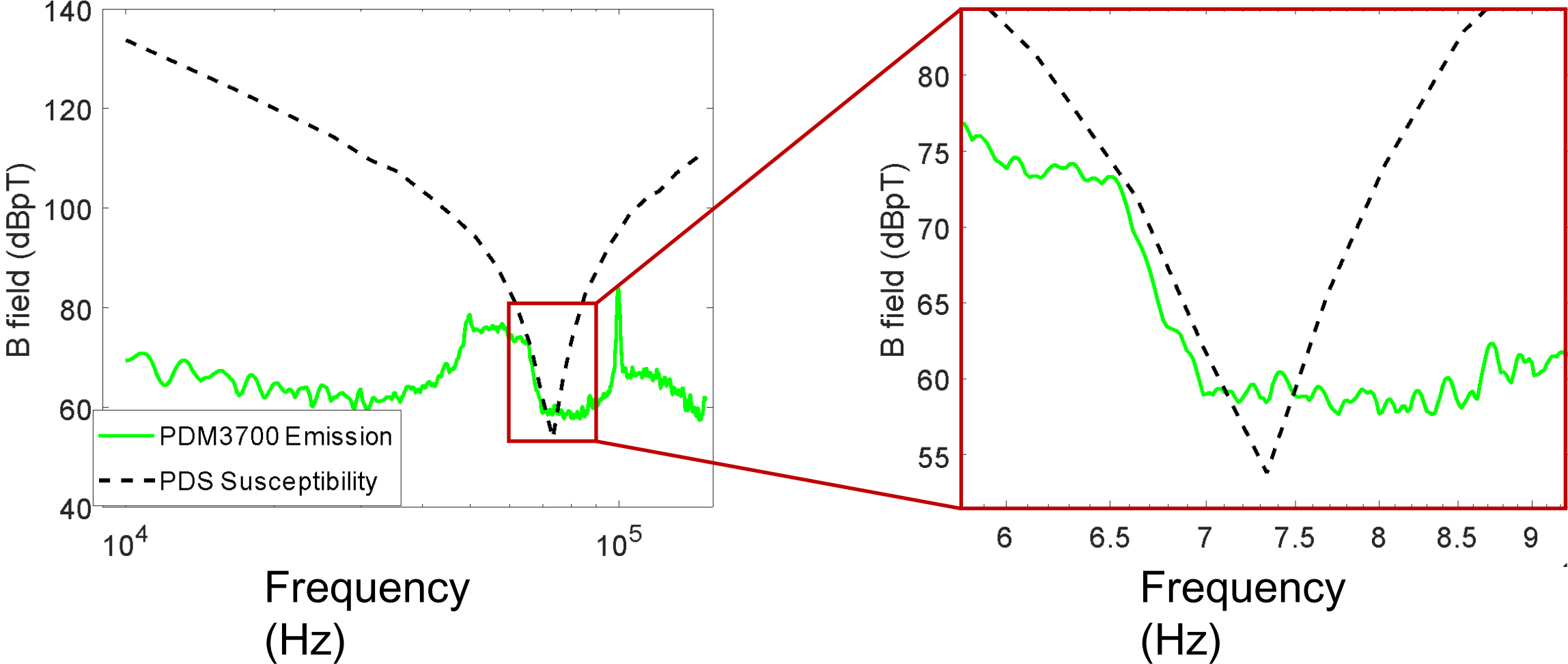
MWC Antenna
a

Experimental setup

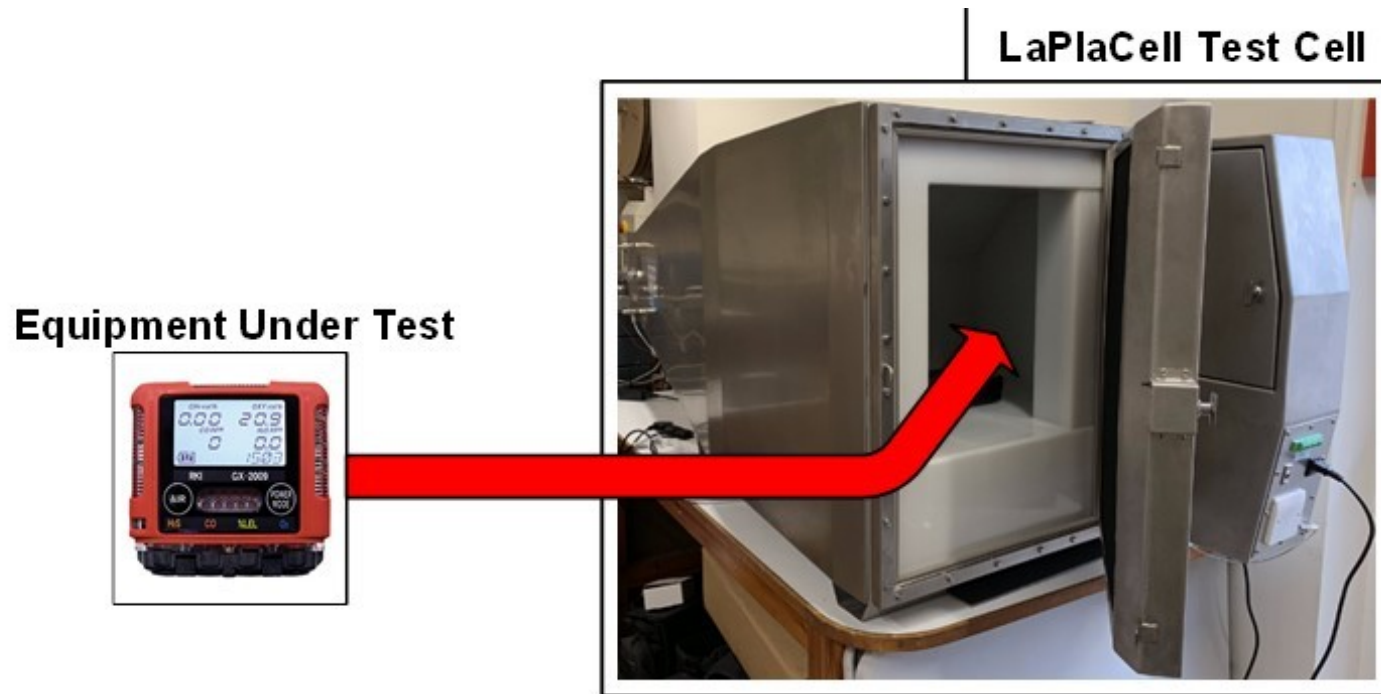


Measurement Result

EMI issues will occur when the emission of one device is greater than the susceptibility of the other device



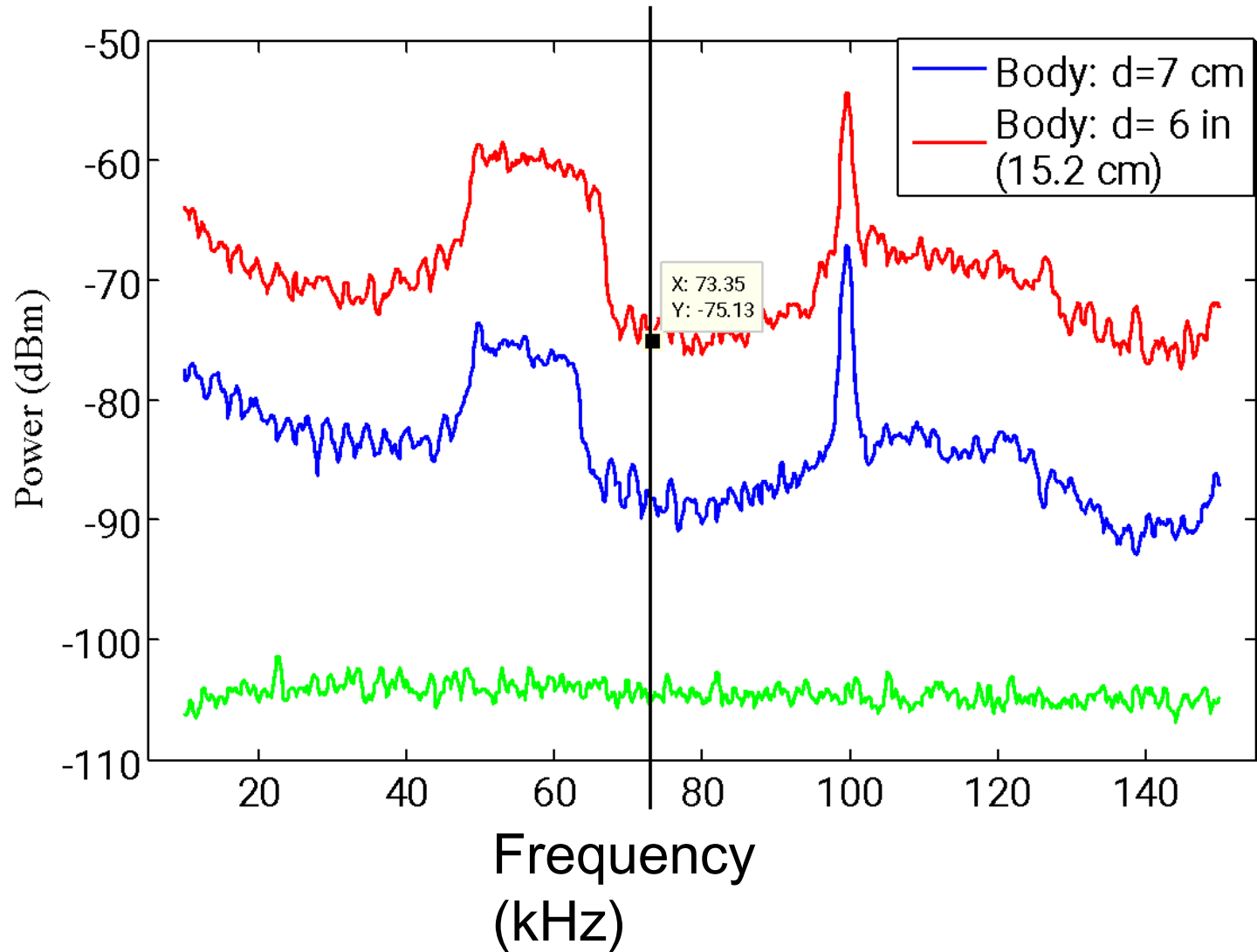
Characterizing EMI victim susceptibility at high frequencies using a LaPlaCell



- Place EUT in a LaPlaCell
- Apply controlled uniform electric field in the LaPlaCell
- Gradually increase the electric field until the EUT fails



EMI mitigation strategies: Increase separation distance

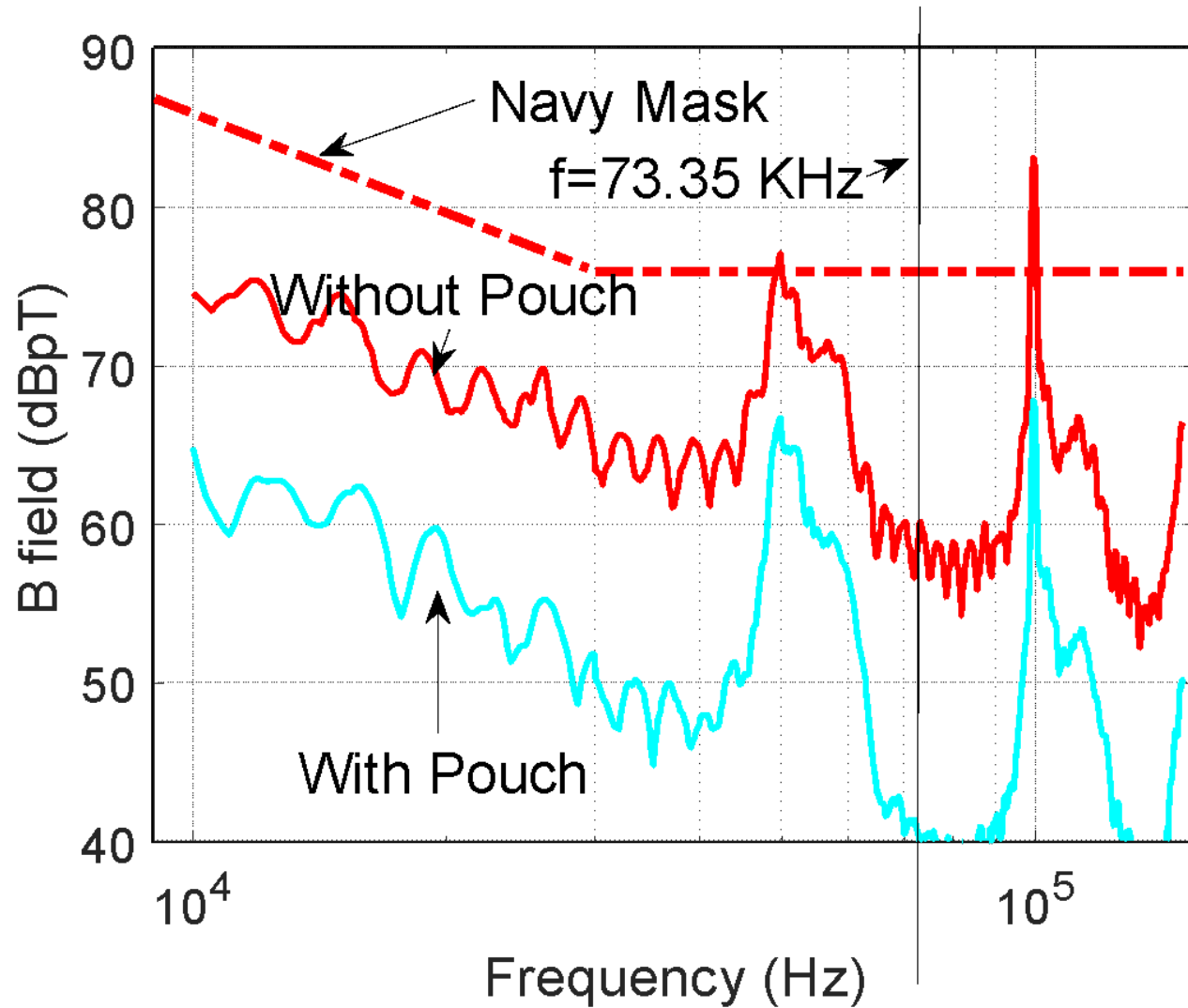


Identified and characterized electronic devices for potential underground interference sources

Device	Distance from MWC when EMI would influence PDS
PDM 3700	less than 6 inches
IS multi-gas analyzer MX4	less than 2 inches
IS multi-gas analyzer MX6	less than 2 inches
Kenwood radio	only in higher frequency
Bosch GLM 80 laser distance finder	2 inches and less
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EMI mitigation strategies: Shielding



Without Copper Pouch

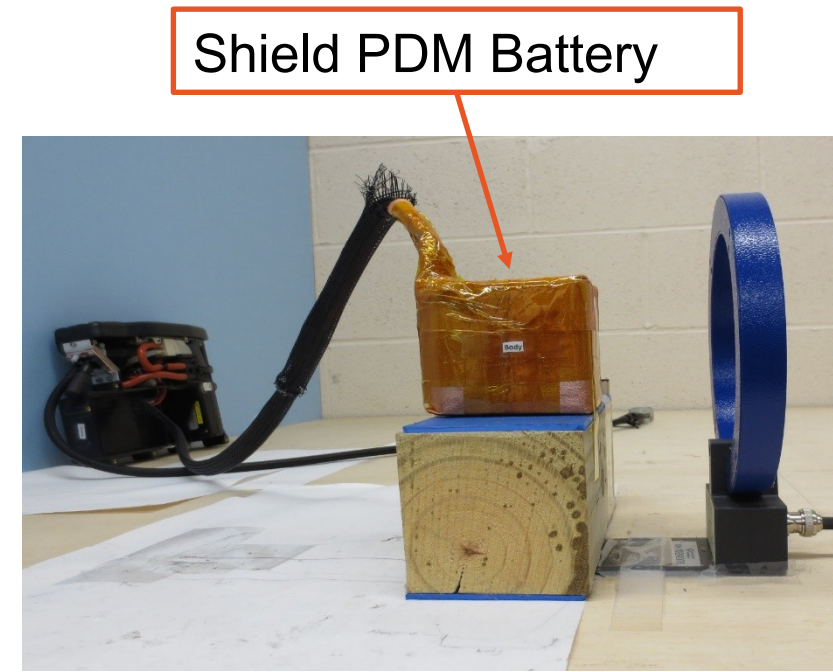
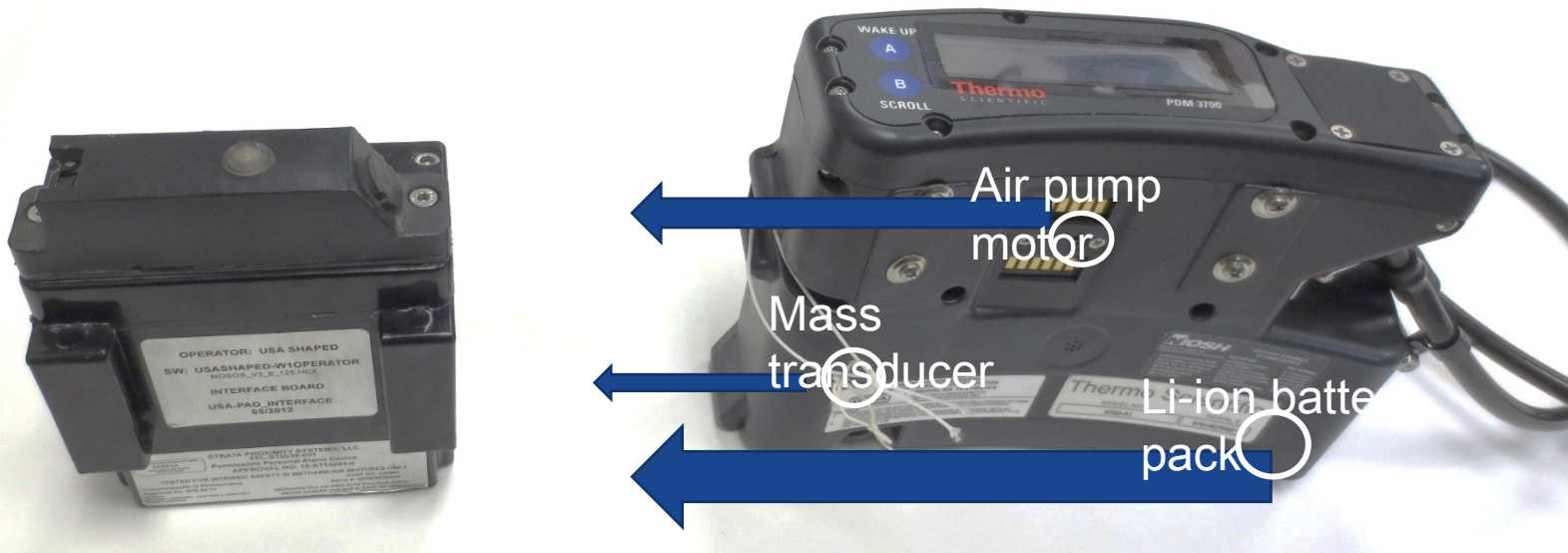


With Copper Pouch (Shielding)

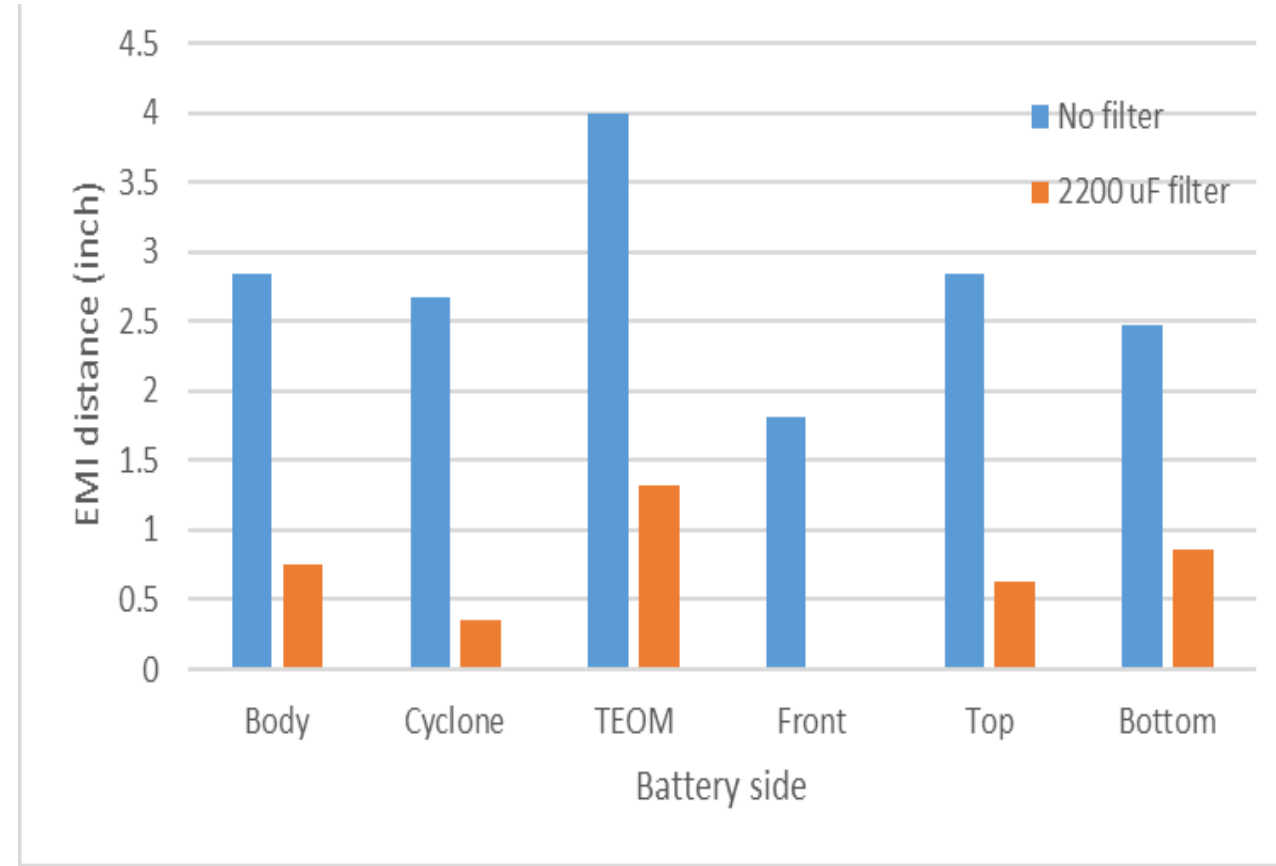
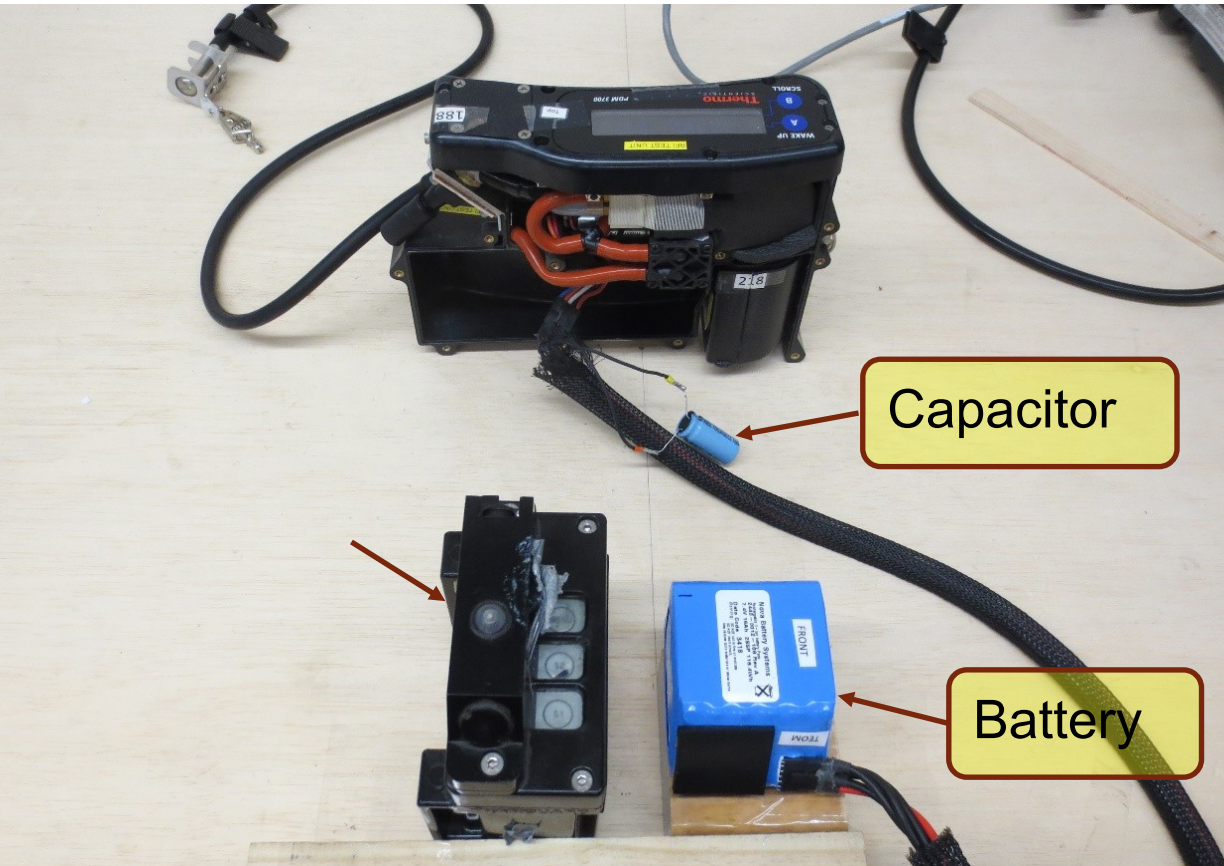
EMI mitigation strategies: Shielding internal components

Three internal components are identified as the components emit the highest EM energy:

- Battery
- Pump motor
- Mass transducer

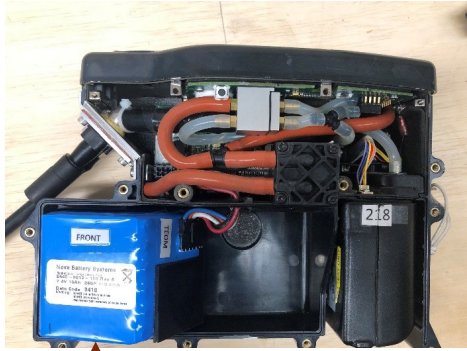


EMI mitigation strategies: Adding an EMI filter

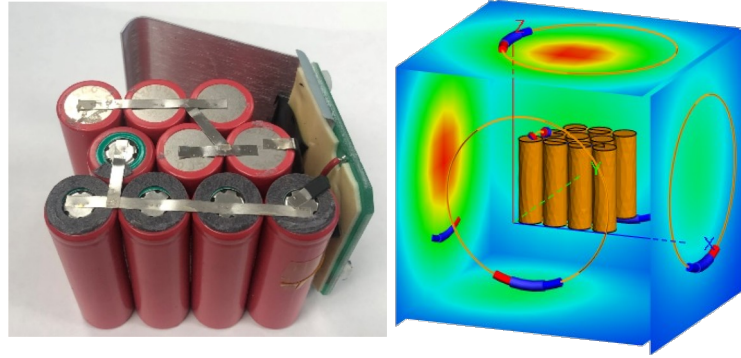


By adding a capacitor to the battery, PDM can be placed much closer to a PAD without causing EMI to the PAD

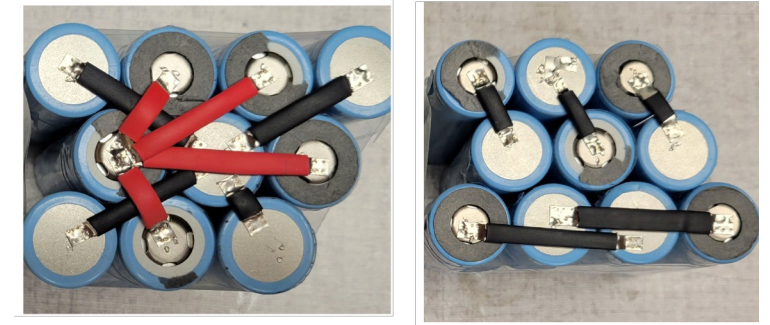
EMI mitigation strategies: Field-cancelation method



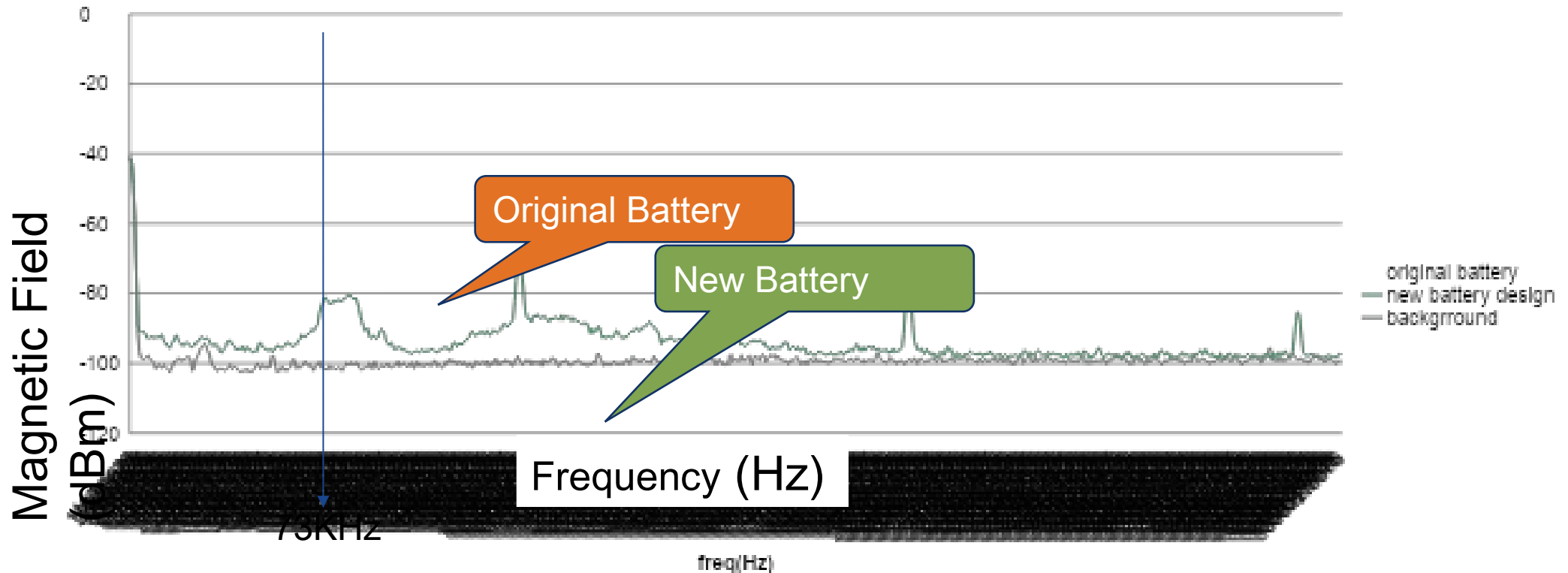
Major EM emission source



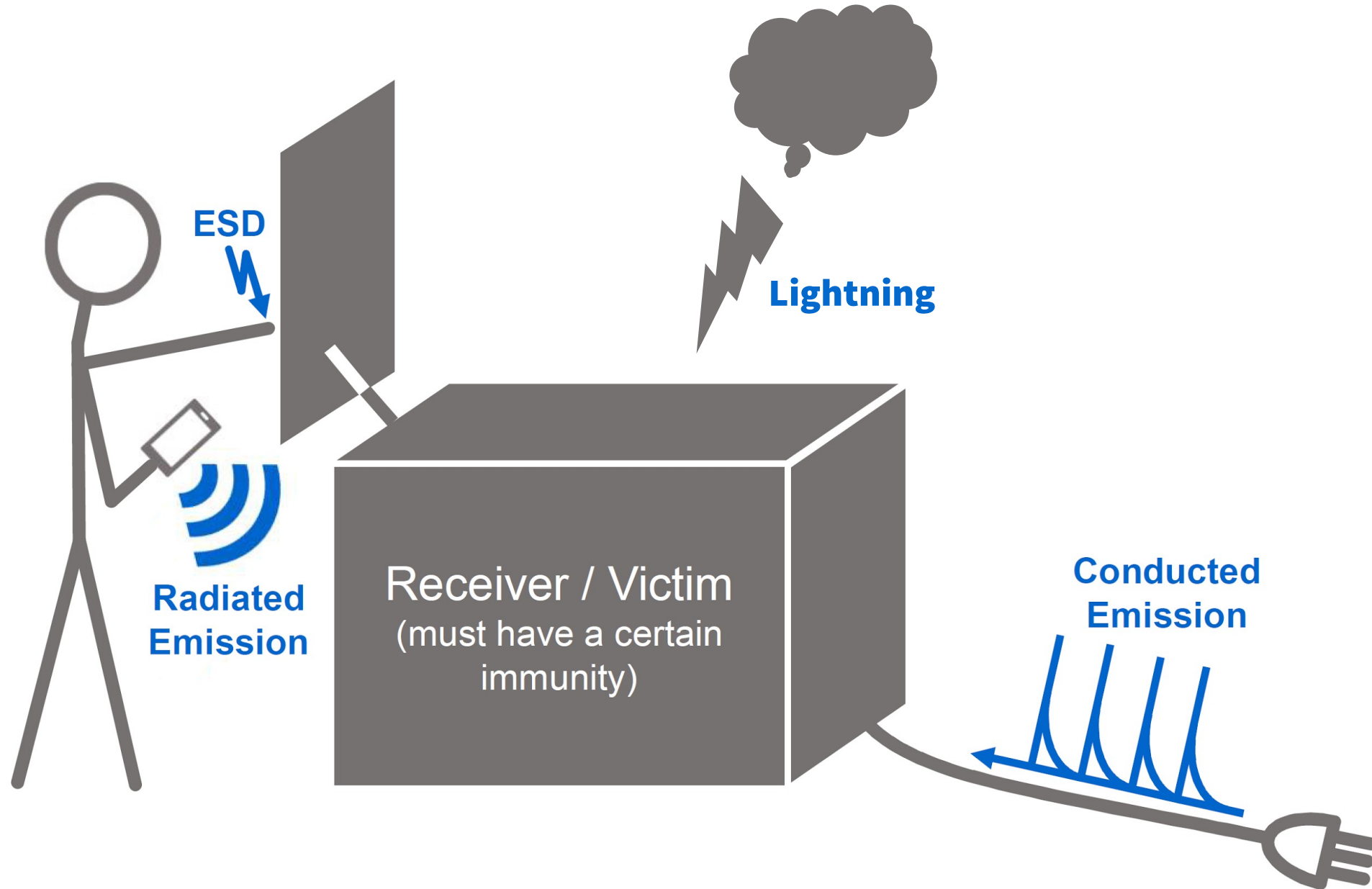
Original Battery Pack



New Battery Pack



The scope of EMI covers a variety of areas closely related to mining



Summary

- EMI issues could cause serious safety concerns in the mining industry
- EMI source emission and victim susceptibility can be characterized in a laboratory environment based on existing EMI standards
- Different EMI mitigation strategies can be applied to overcome EMI issues:
 - Increasing separation distance
 - Shielding
 - EMI filter
 - Field-cancellation method

Questions?

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Back up slides

NIOSH Mining
Program



Different standards have been developed to deal with EMI on the surface, but no EMC standard in the underground

- CISPR founded as a special committee of the IEC, dealing with interference (1933)
- FCC is established (1934)
- Modern EMC standards are often developed based on specific environments/applications
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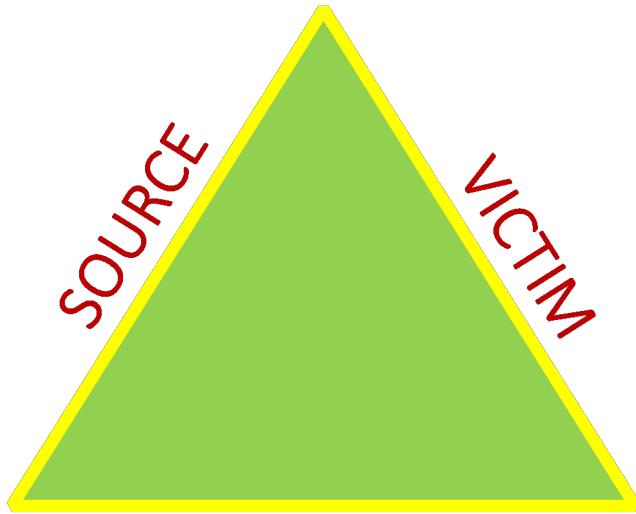
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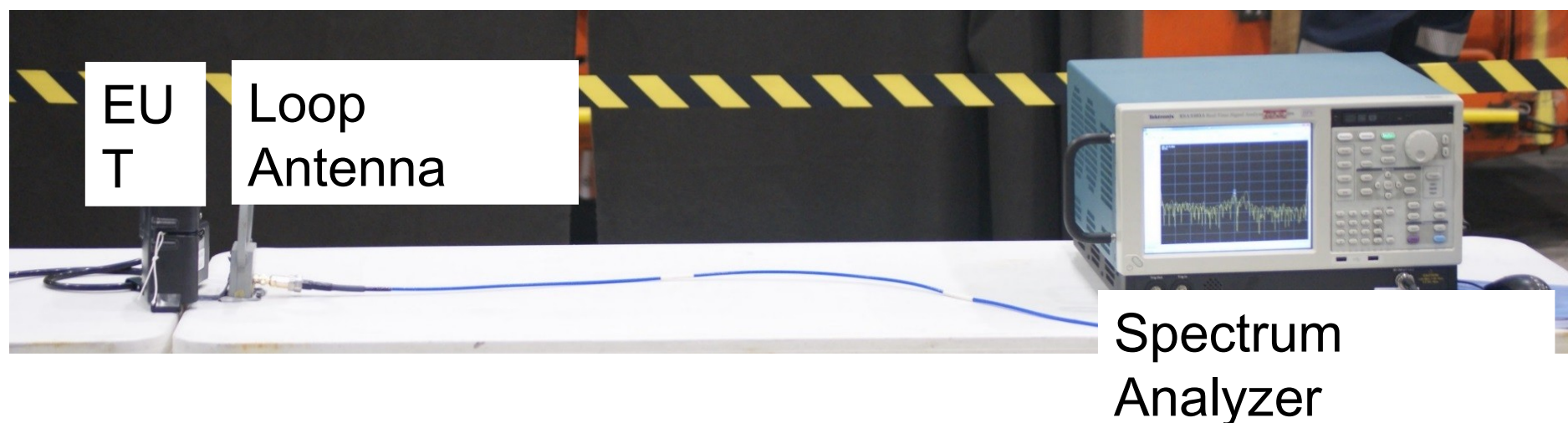
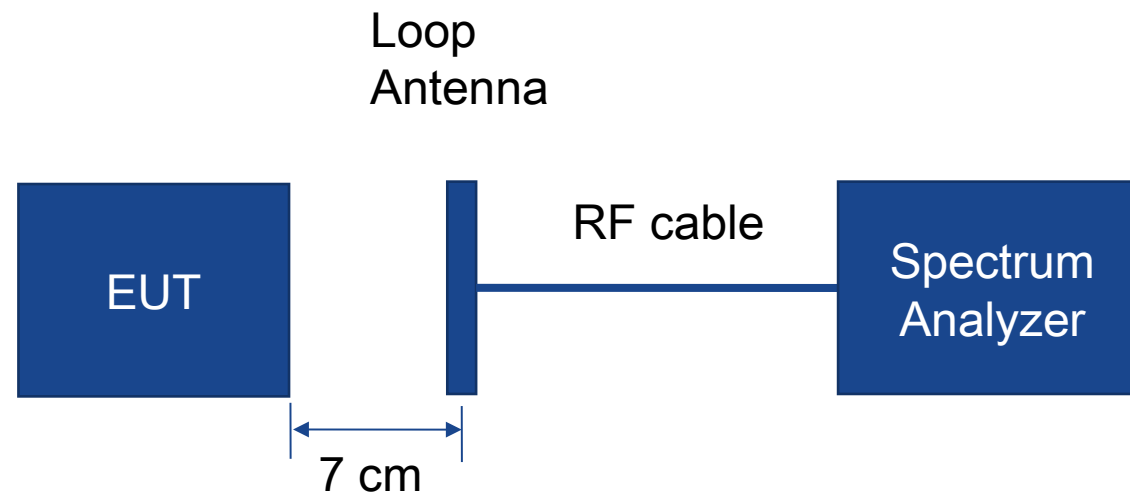
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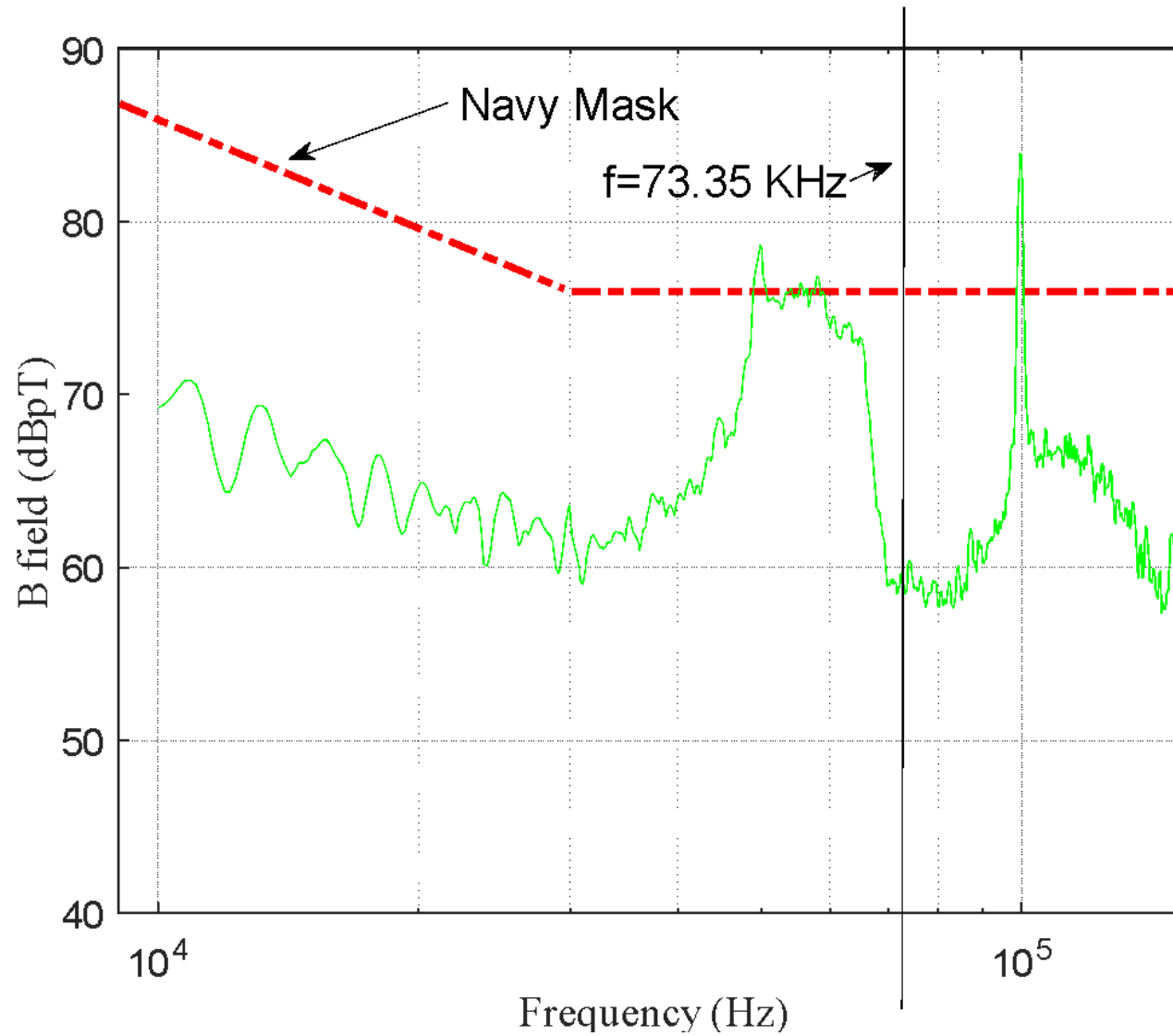
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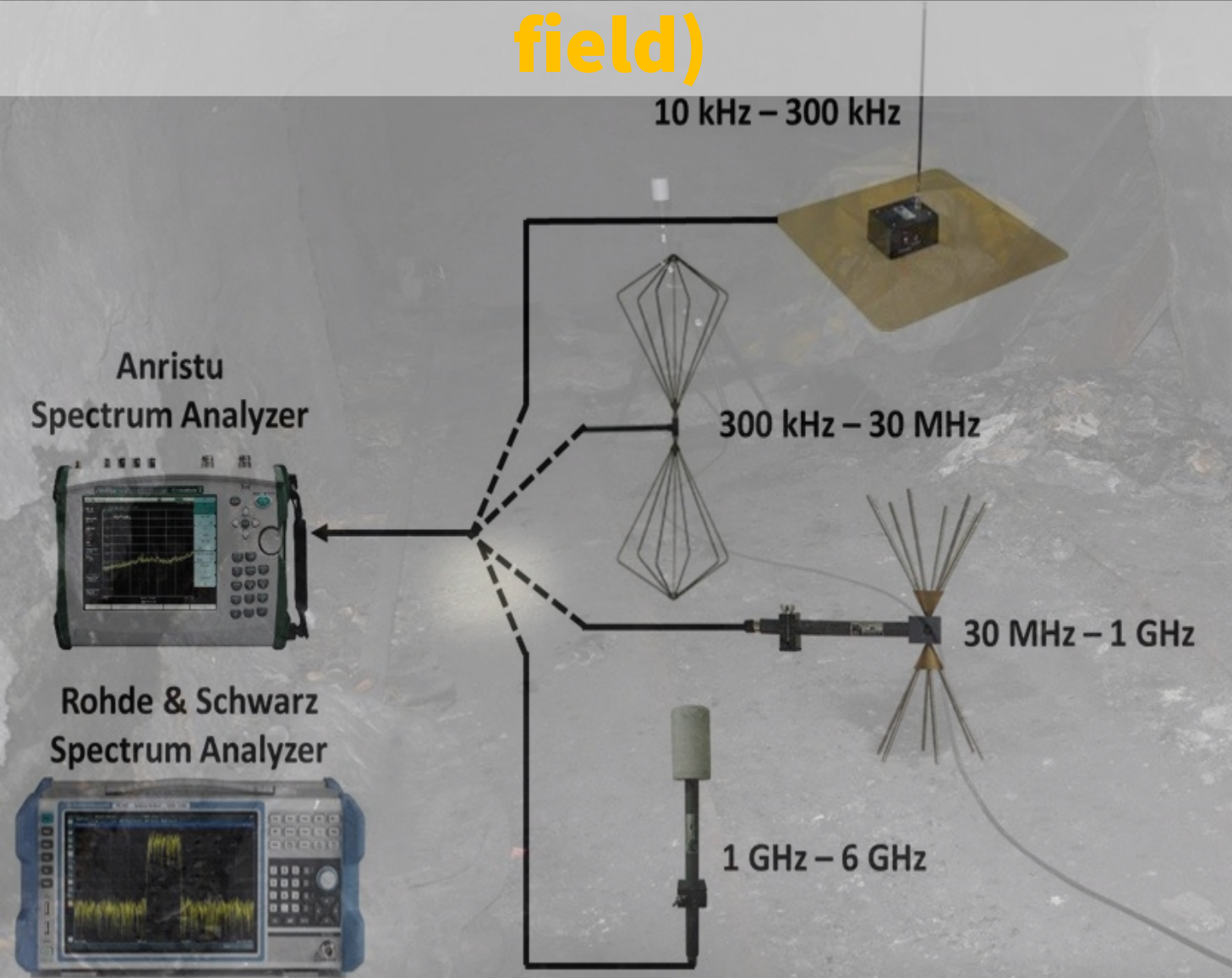
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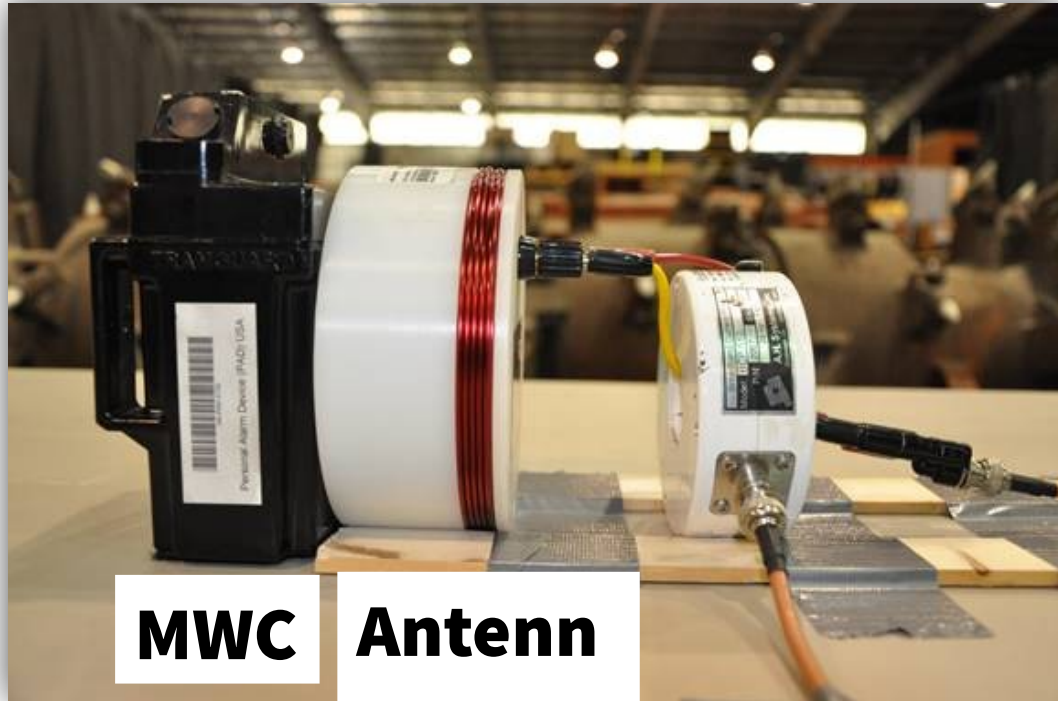
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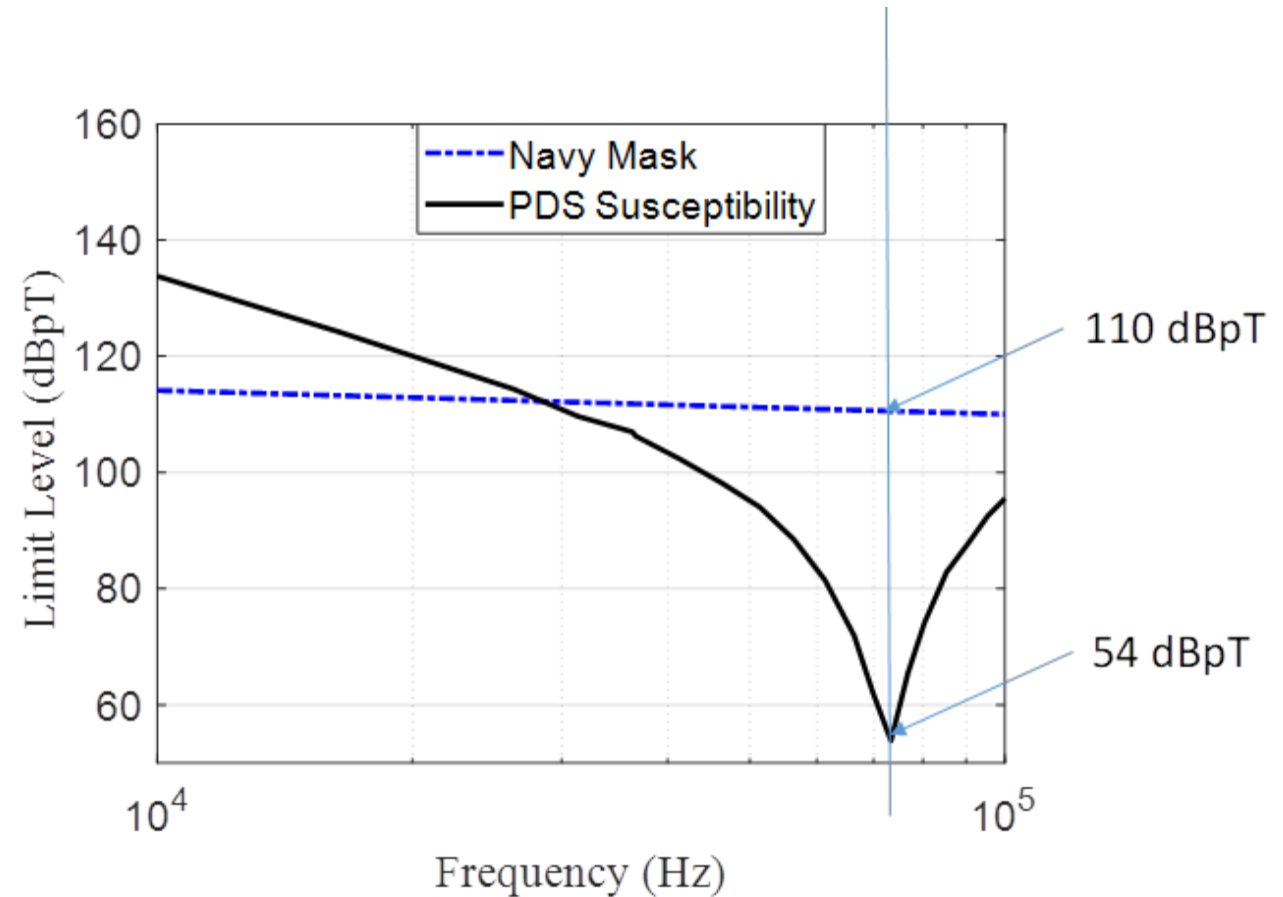


Characterizing EMI victim susceptibility based on military standard RS-101



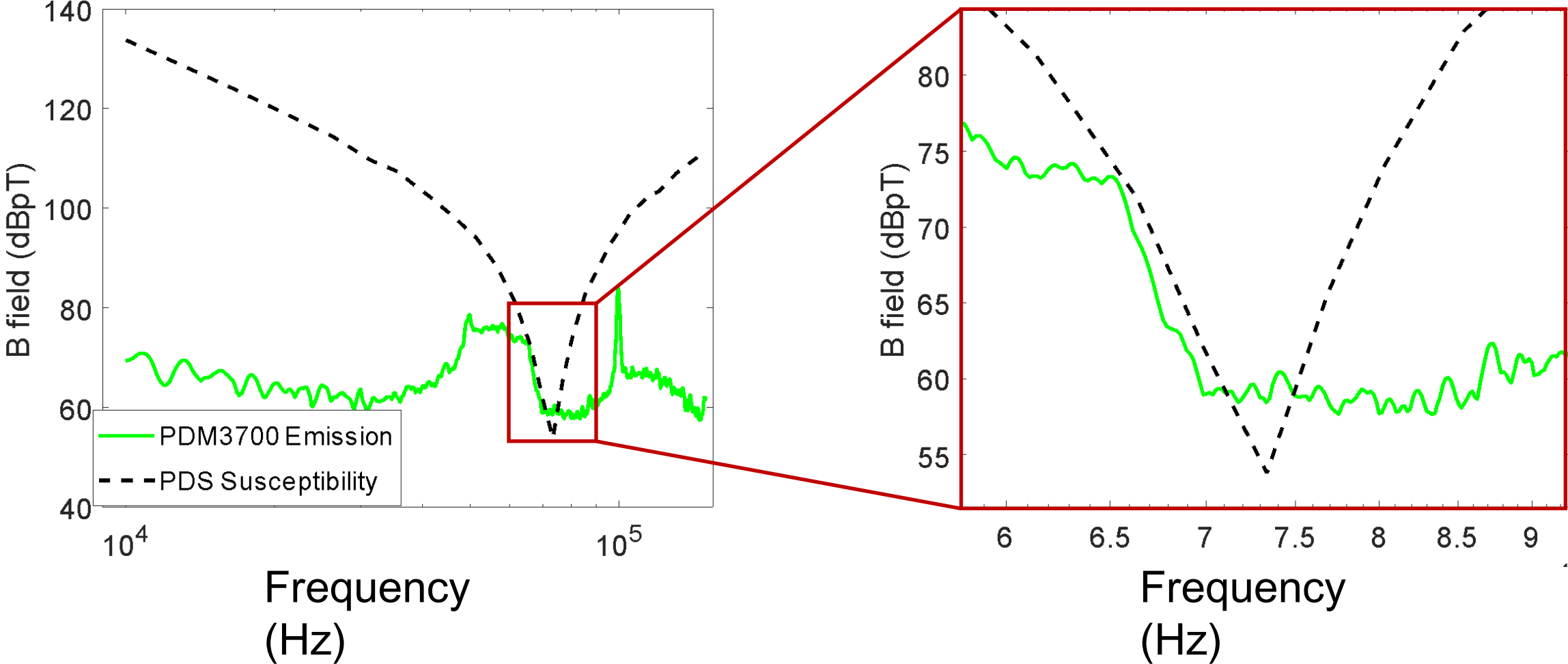
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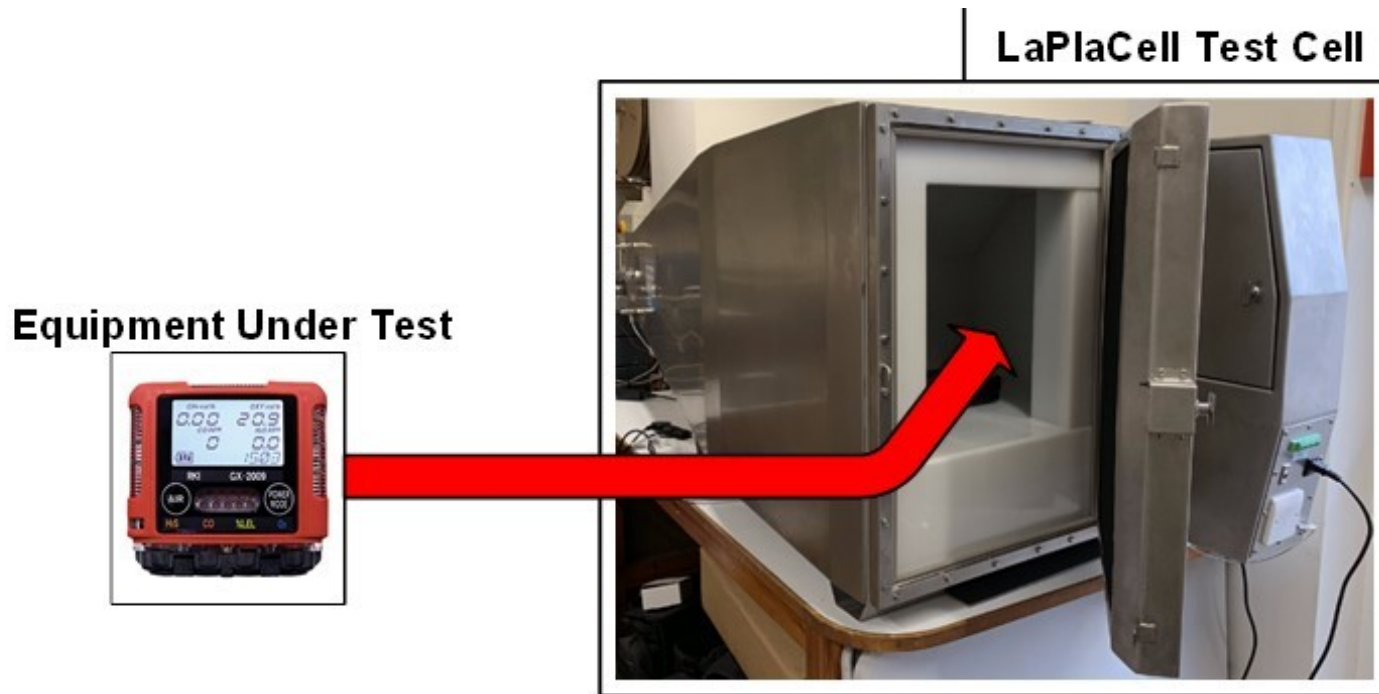


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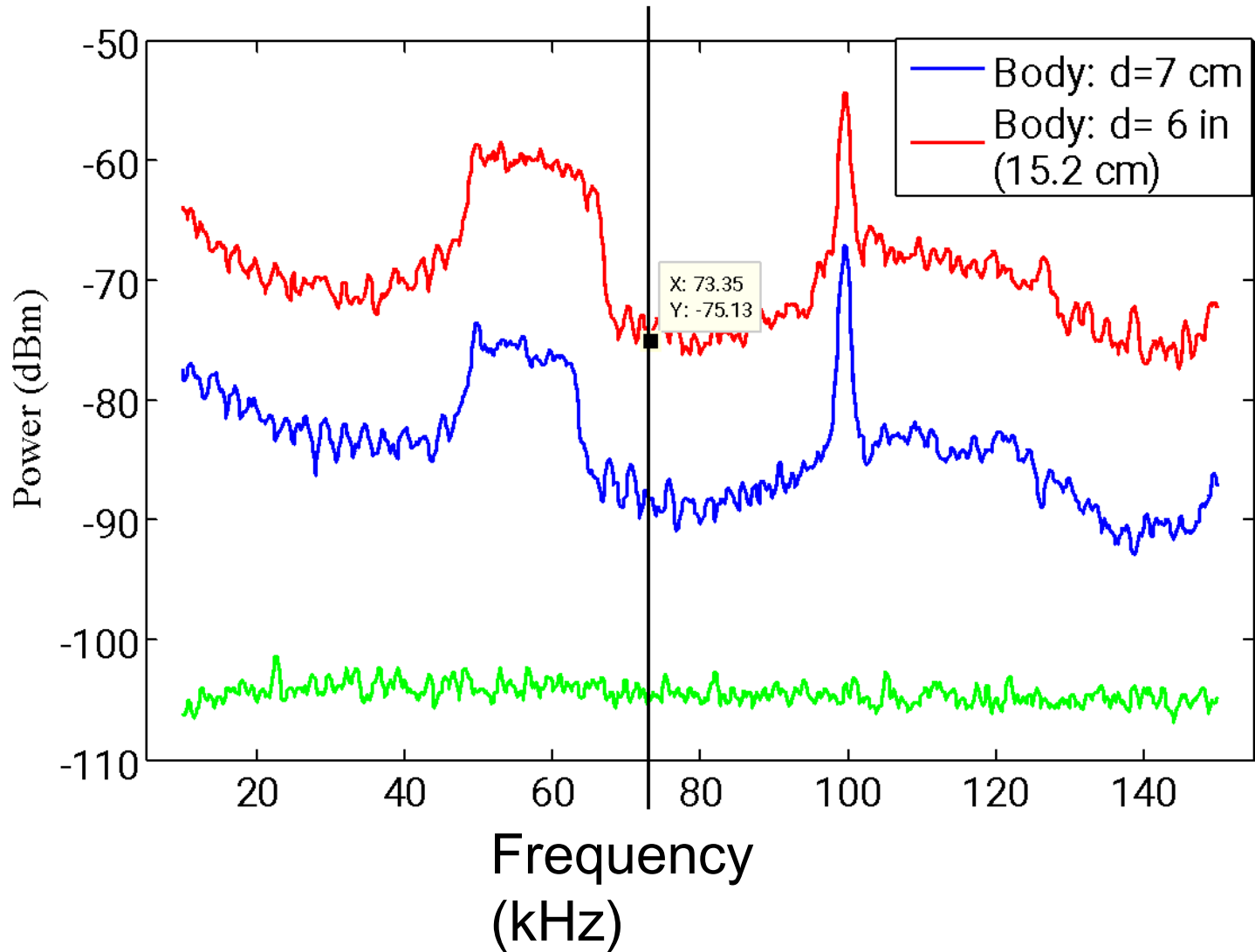
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6 inches

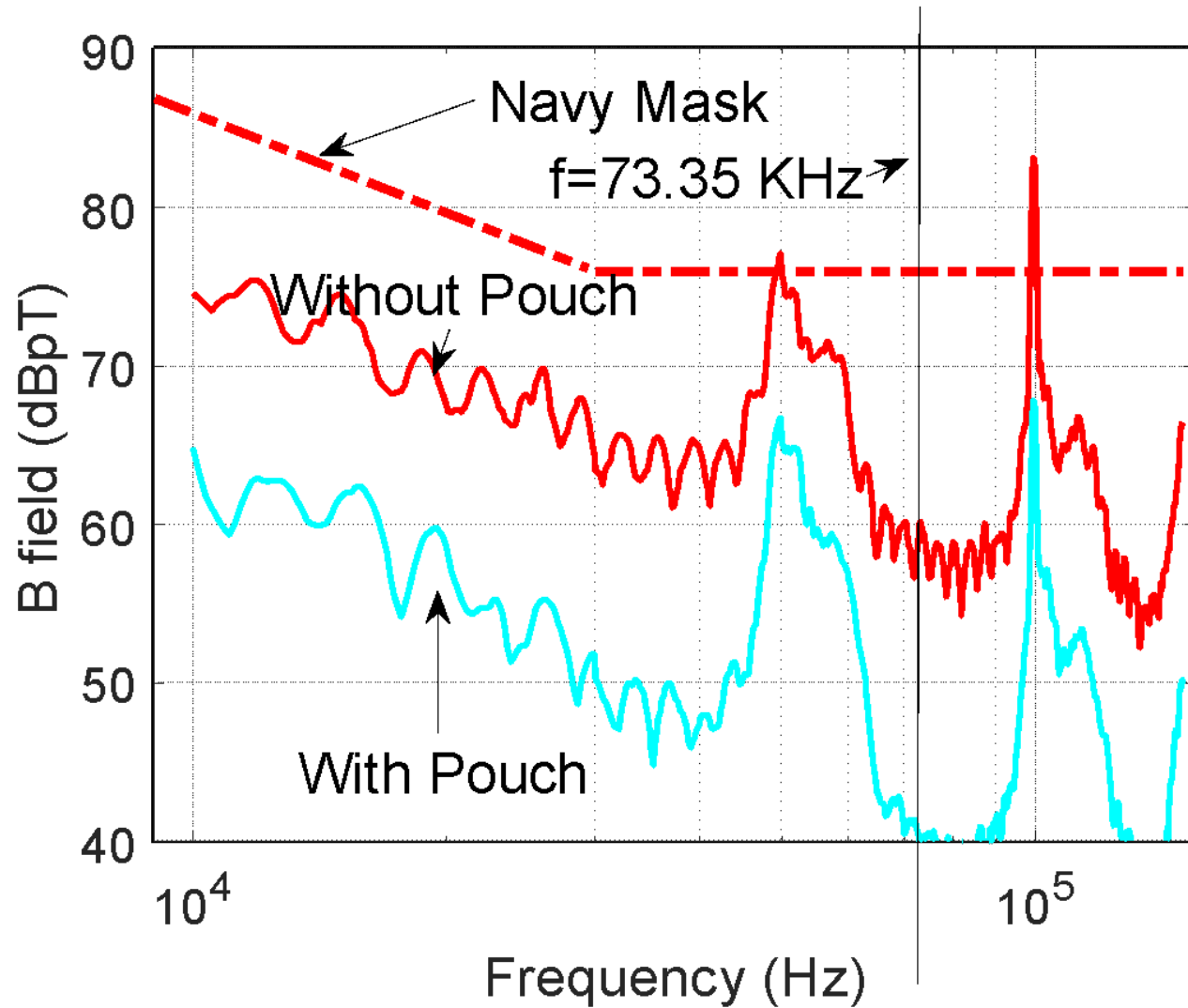


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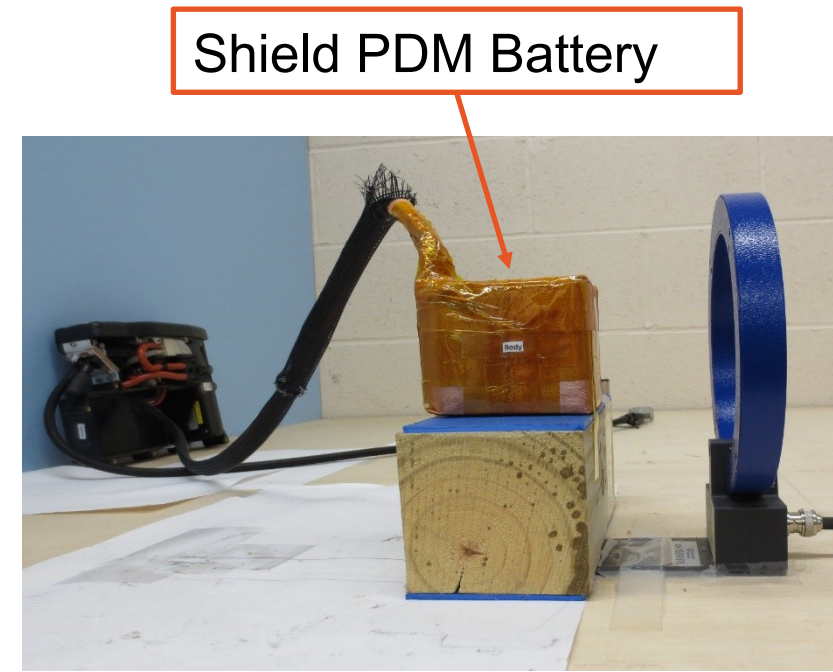


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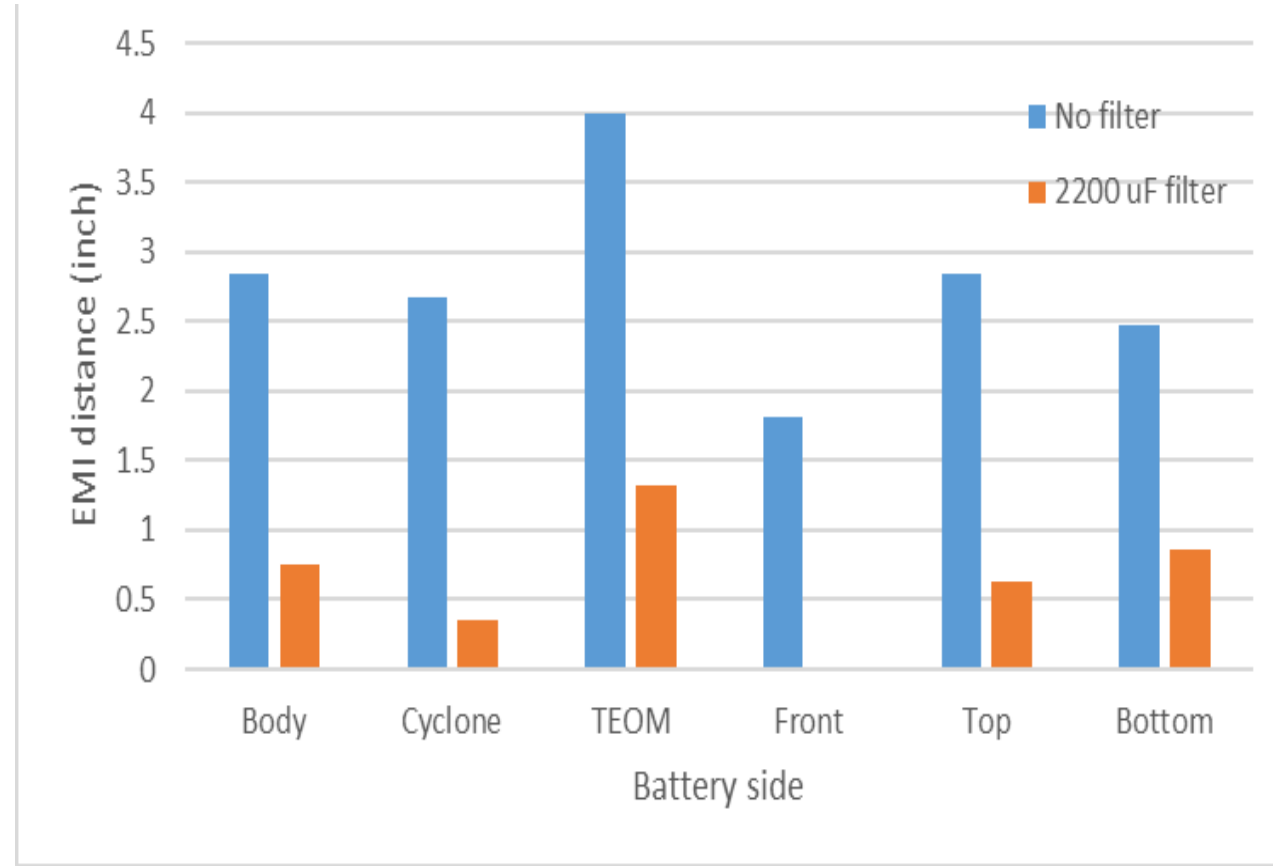
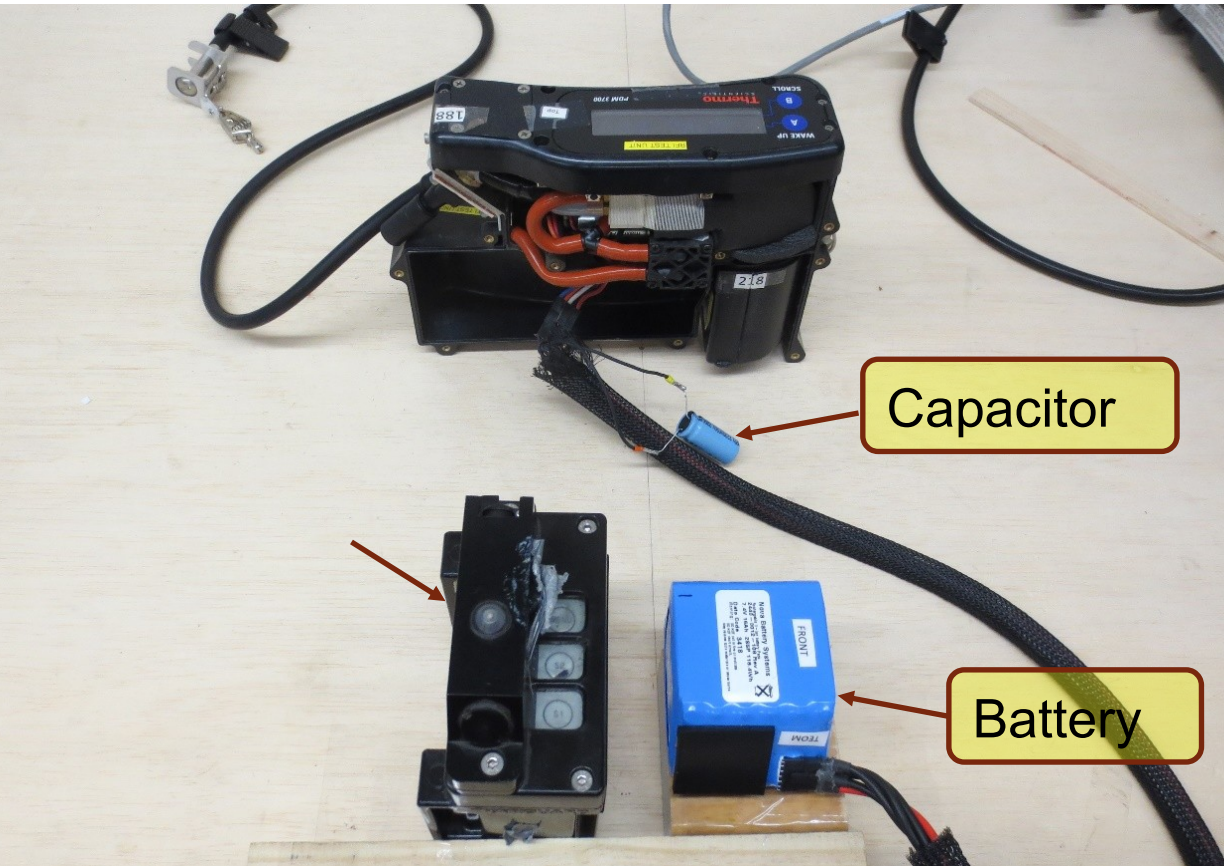
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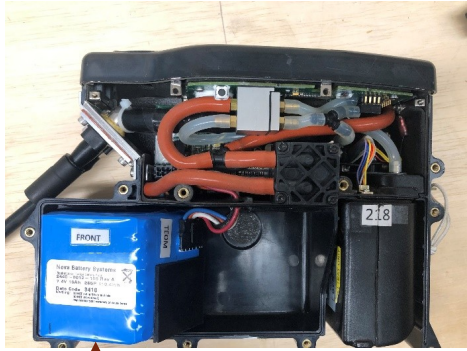


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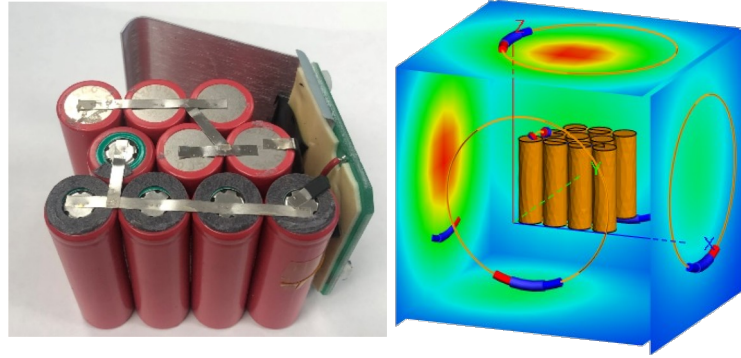


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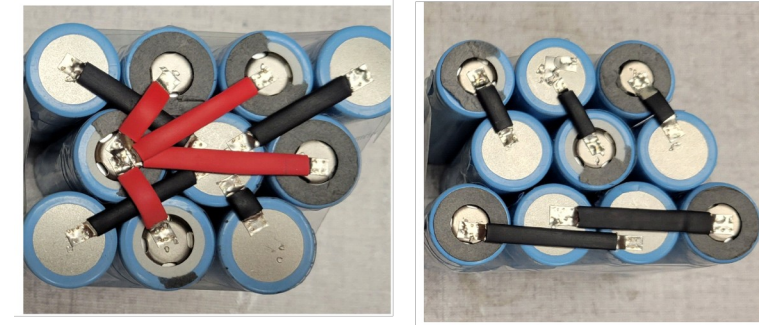
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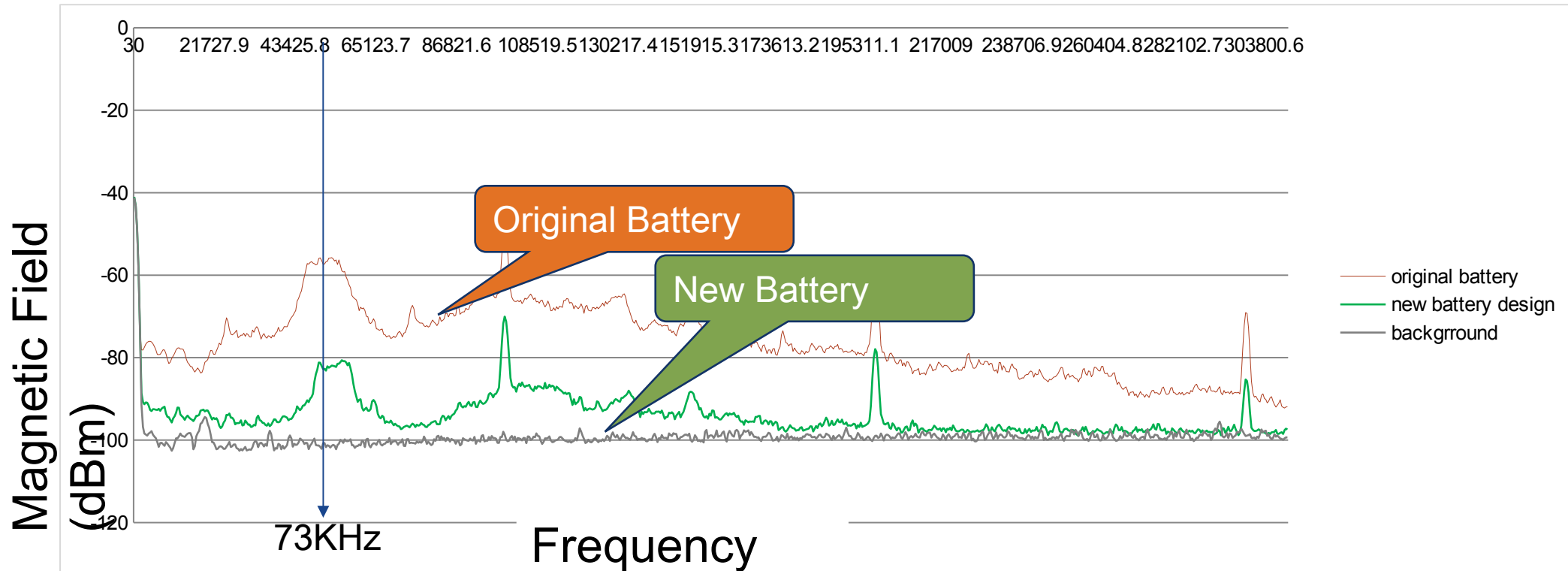
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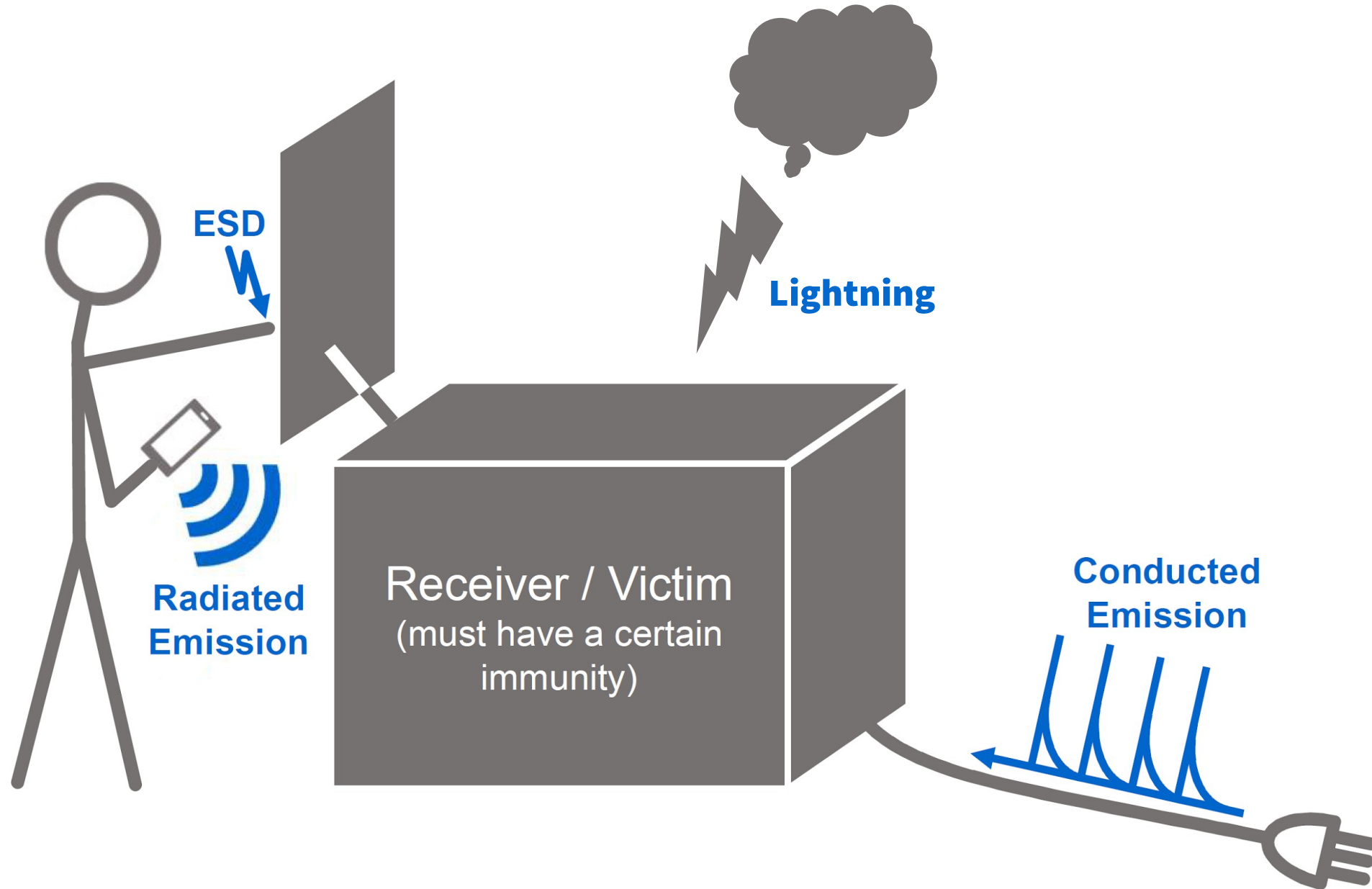
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