# Electromagnetic Modeling to Improve Railcar EMC Design

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# Team


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# Agenda

1. Challenge and Response
2. EMC Modeling Tools Uses
3. General Approach
4. Case Study:  Dynamic Brake Inductive Emissions
5. Conclusion

# Challenge

- Today's EMU railcars are "too short"
- Limited space undercar, locker, and rooftop
  - High power Propulsion and Aux
  - Sensitive electronics
- We need the right spacing, shielding, isolation, cancellation to guarantee Electromagnetic Compatibility (EMC)
- **How much is enough??**

# Response

- Use Electromagnetic Field (EMF) modeling tools, e.g., ANSYS Maxwell or CST Studio
- Low frequency EMF simulation of railcar EMF sources, paths, effects
- Quickly estimate the effects of a specific emitter
- Try design alternatives:
  - Before prototypes are built
  - Vary materials, sizes, thicknesses, placement, connections, arrangements, shields, filters…

# EMF Modeling Tools Uses

Use Modeling tools to control:

- Inductive emissions during dynamic braking
- Cab Signal Interference (CSI)
- Box shielding design

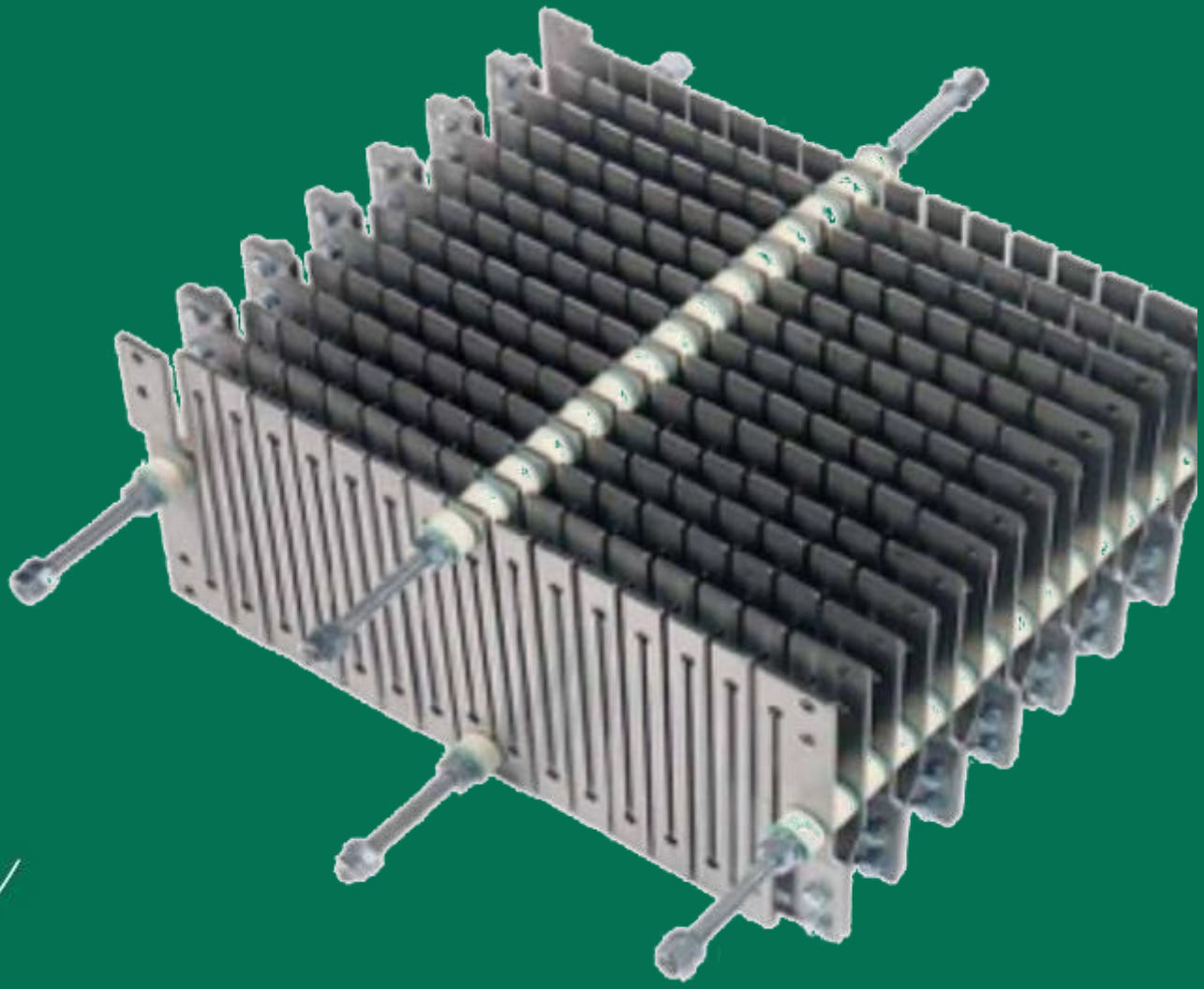
# General Approach

Goal: Avoid "Cut it twice, still too short" in the real world

Steps:

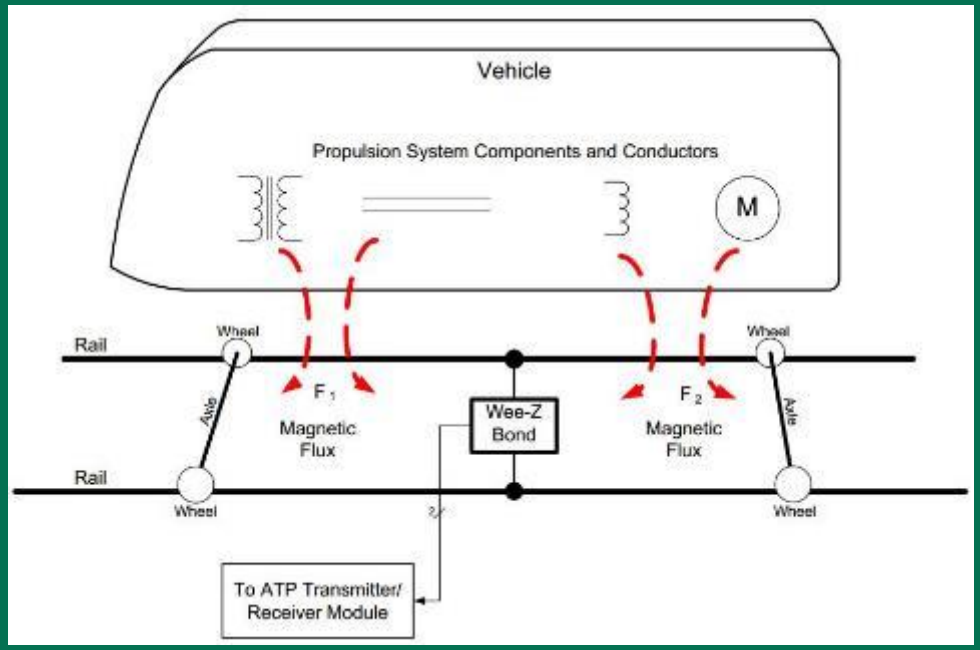
1. Make a model. Try for 'realistic enough.'
2. Run some cases, compare to real world data, adjust model. Get 'in the ballpark.'
3. Vary configurations, and rerun the model to understand the effects

# Case Study: Dynamic Brake Inductive Emissions



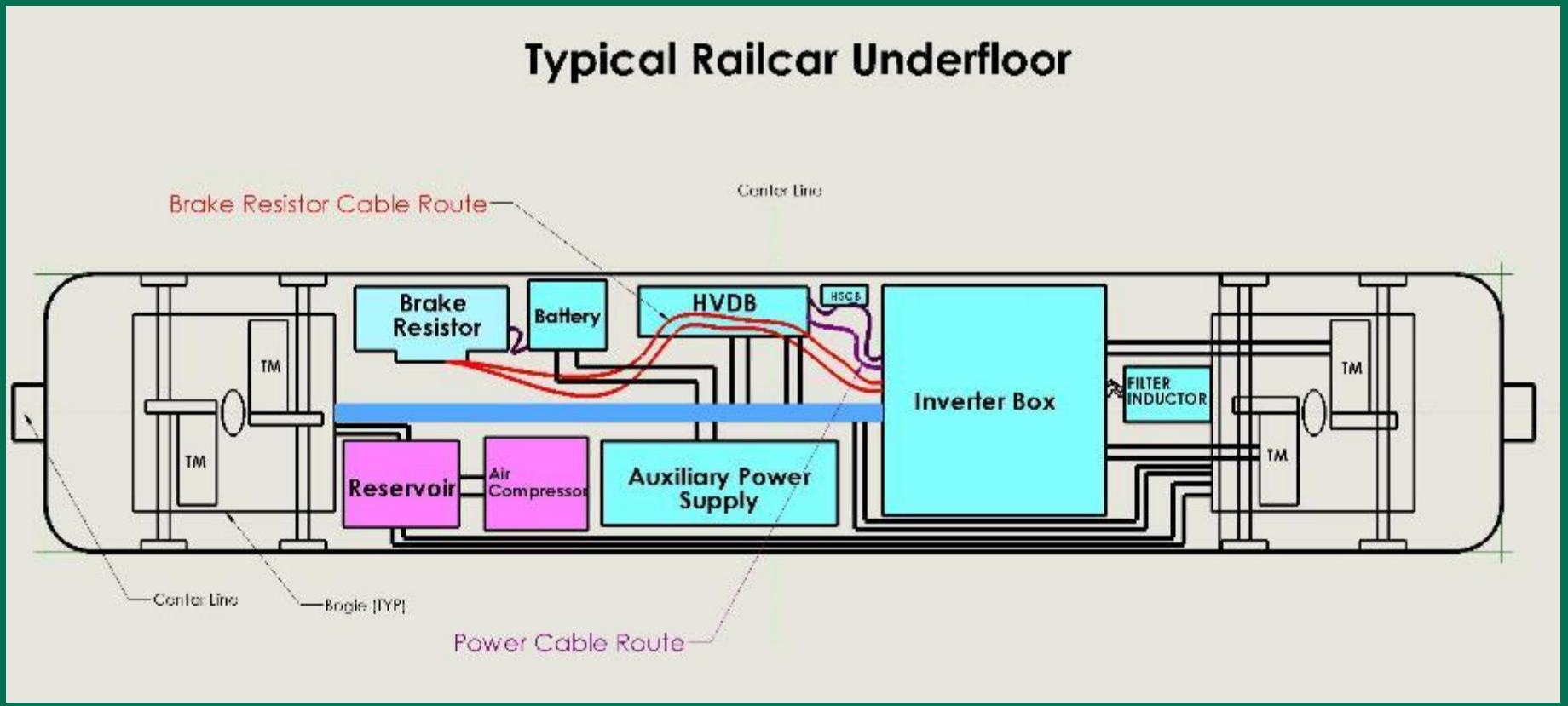
# Inductive Interference (IE)

- Railcar Propulsion or Aux currents cause time-varying magnetic flux in the rail-axle loop under the railcar
- Induces rail-to-rail voltage under the railcar




- **If** railcar currents have **enough** harmonic content in the track circuit sensitive frequency range and the **leakage flux** from high-current conductors is high, IE can cause a **False Clear**, a safety hazard

# Dense Undercar Equipment



# Undercar Equipment in the Test Lab

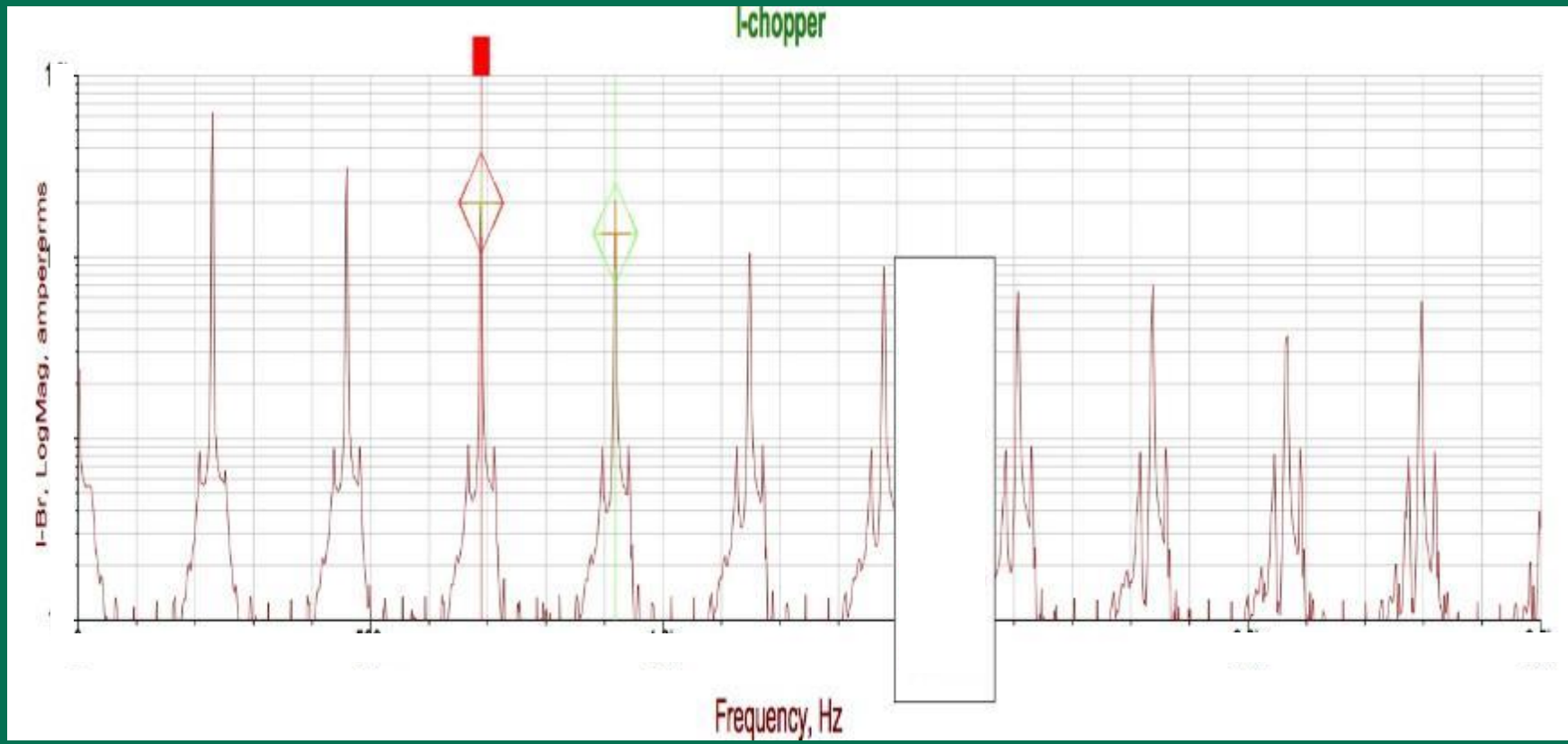
Inverter Box

Brake Resistor (BR)

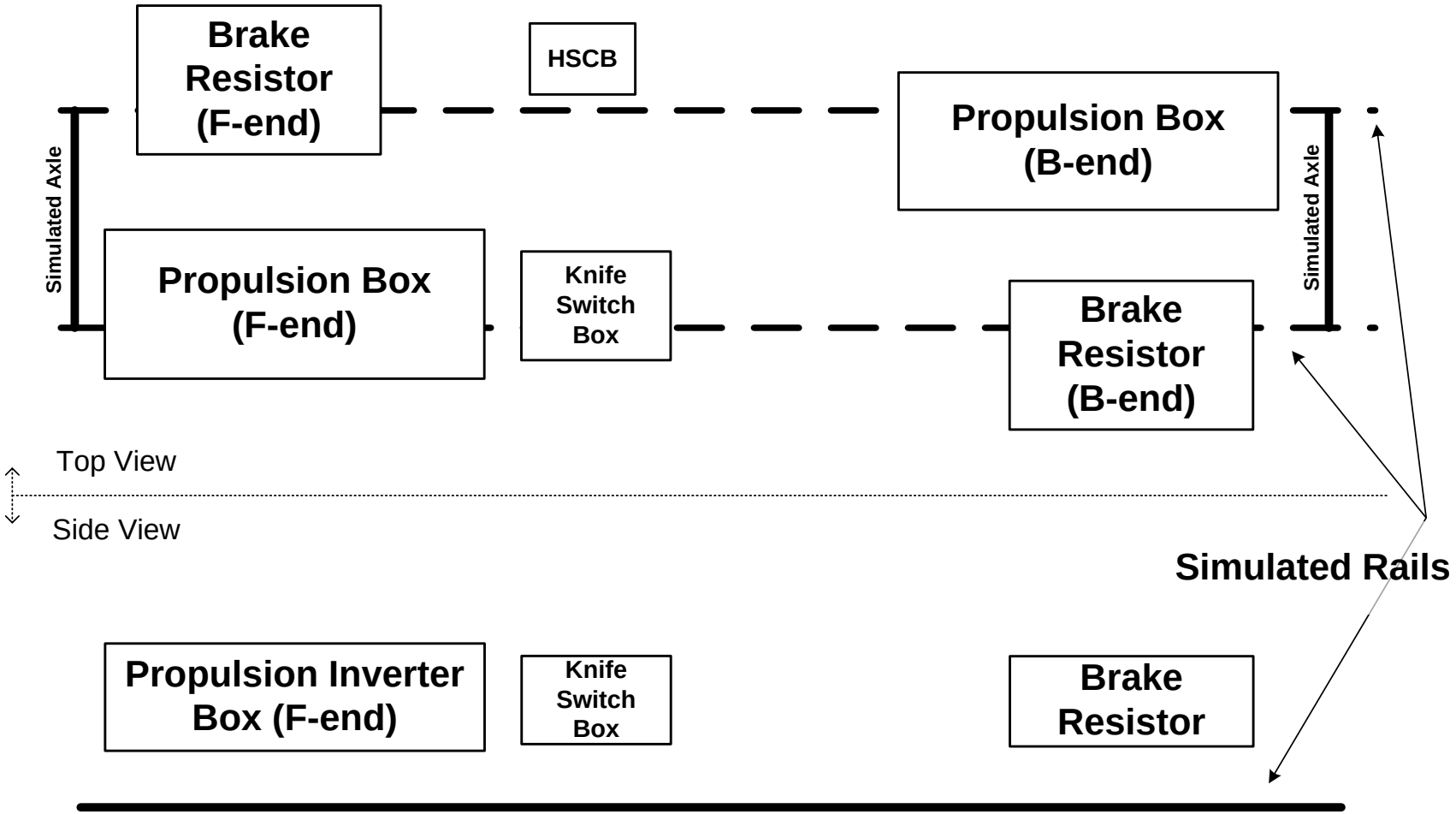
Simulated Running Rails

Cables at BR terminals

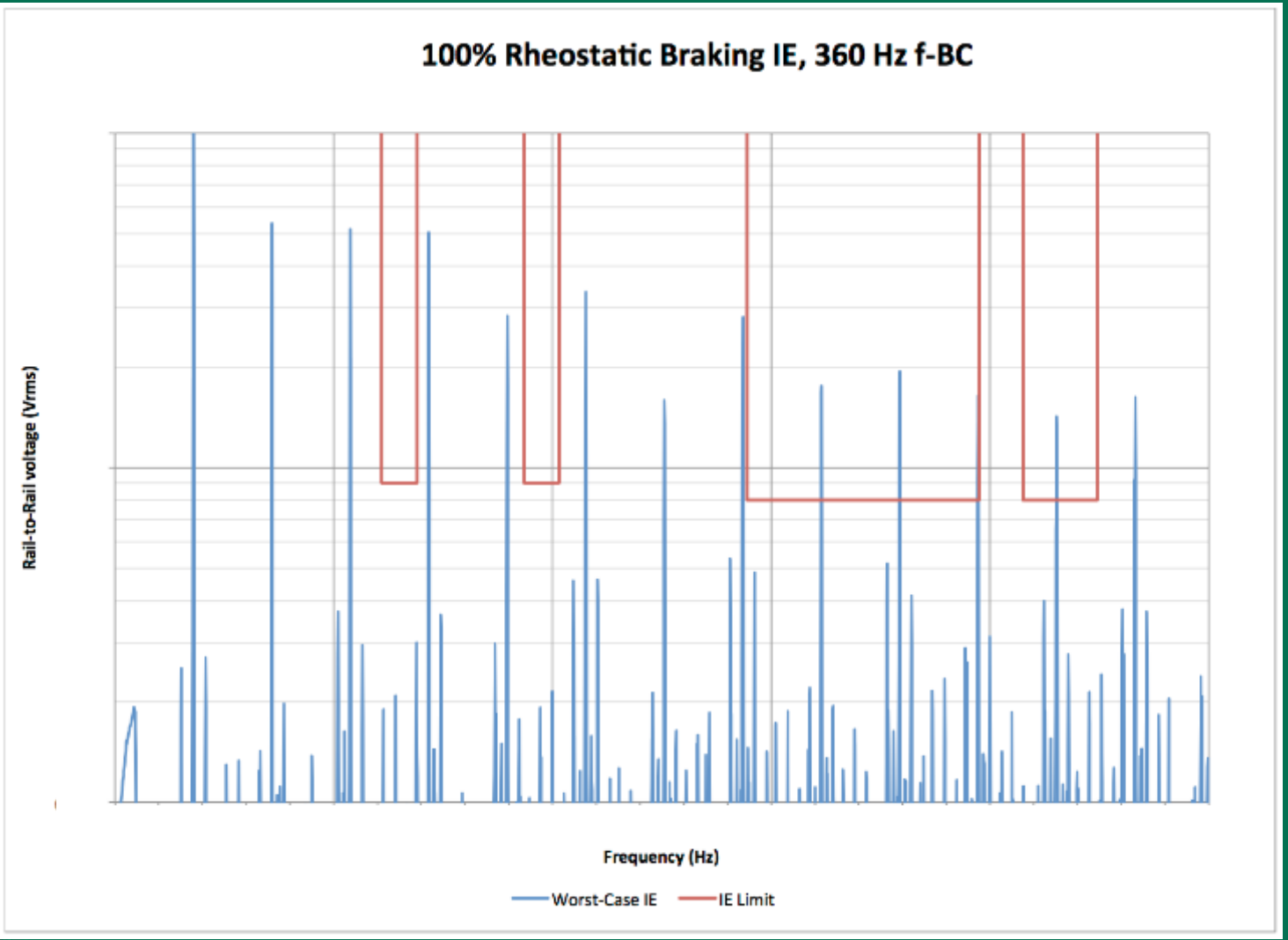
# Spectrum of Dynamic Brake Current



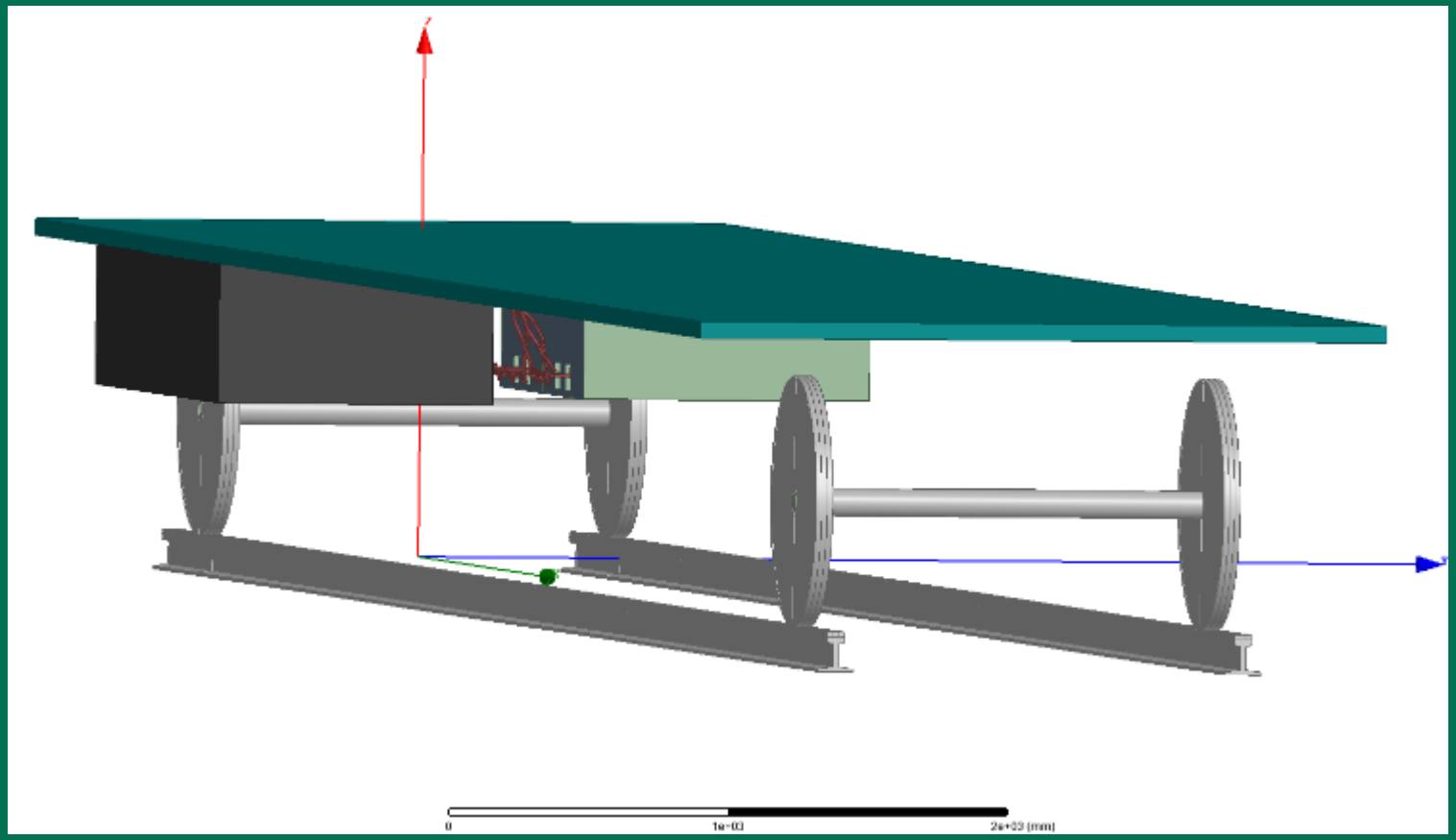
# Lab Inductive Emission Test Setup

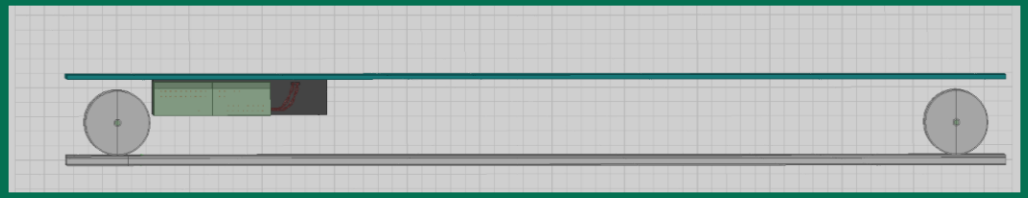


# Resulting Interference

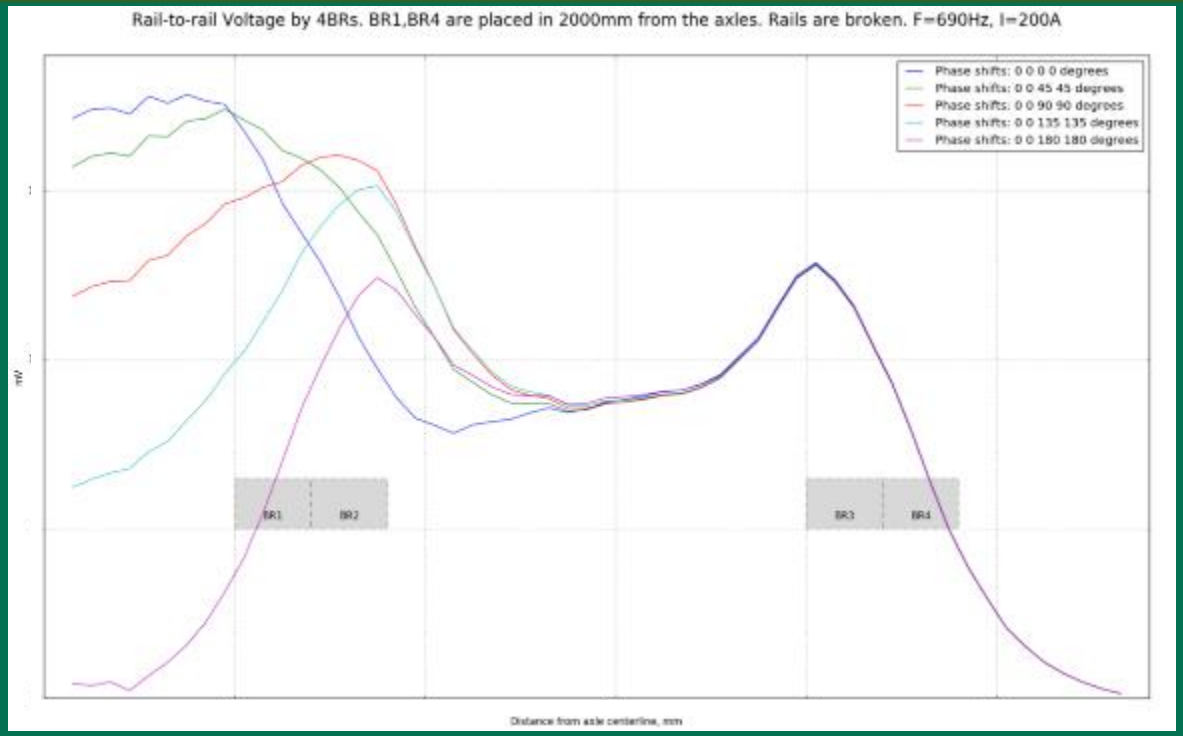


# EMF Model



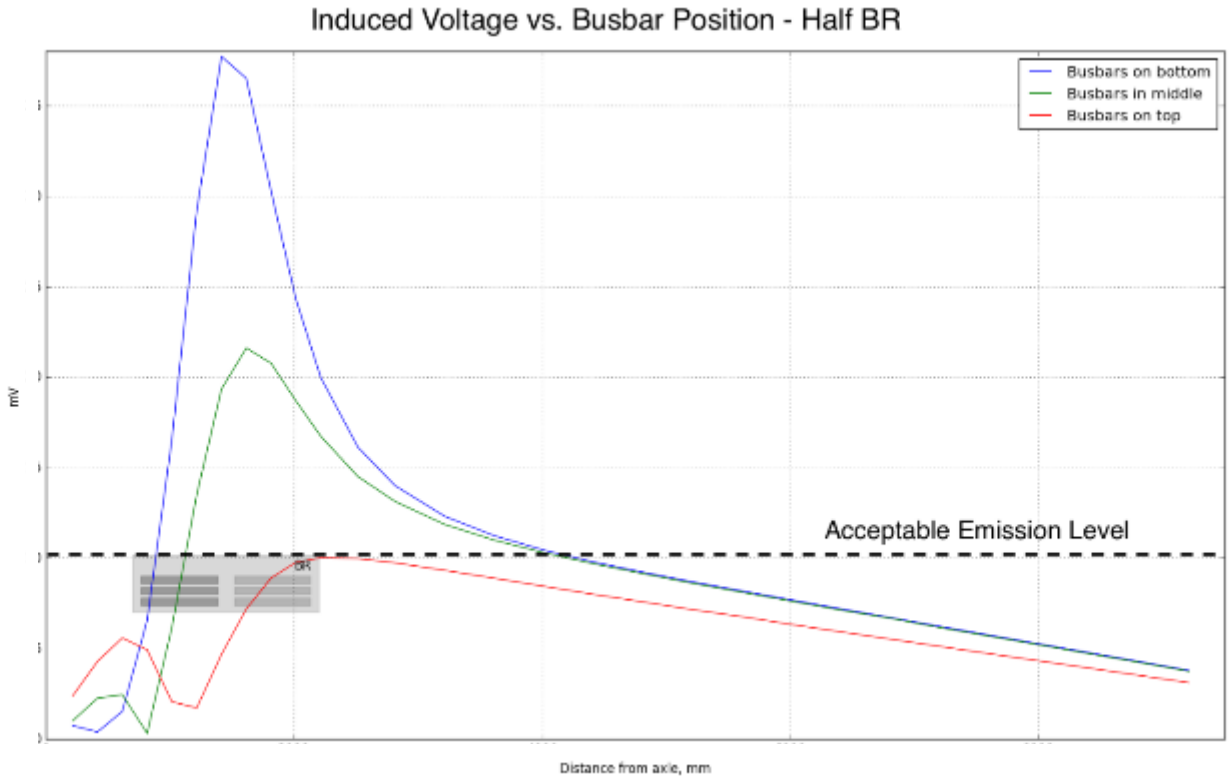
# Full Car EMF vs Brake Resistor Phase Several Variations




- Numerical simulation allows quick evaluation of alternative mitigations
- Phase offset between Front end and Back end Brake Resistors (BR) can keep 4 BR IE at 2 BR IE levels

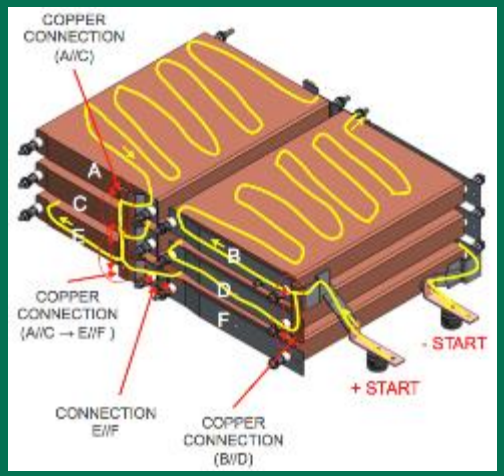
# EMF from Resistor – Bad Case

**With original busbar, emissions from each half-resistor are almost 4x the acceptable level!**



# Brake Resistor Rearrangement


BR terminals and cable fanout




BR Busbar Rearrangement

Swapping Polarity of BR connections

Many possible Mitigations

Shield Material

# Different Approaches to Solve the Problem

- **Traditional way**

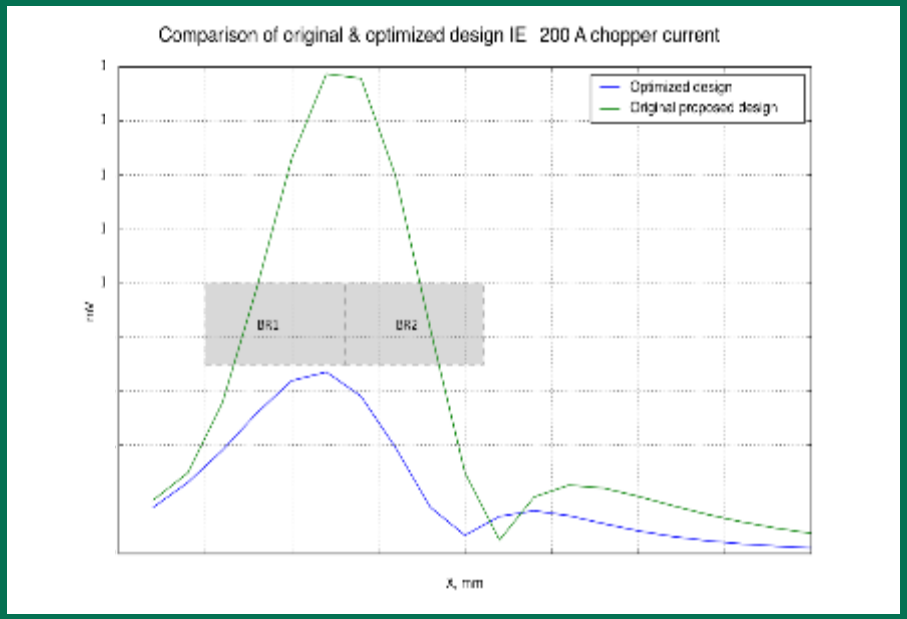
  Build it and test it.  Then do it again.

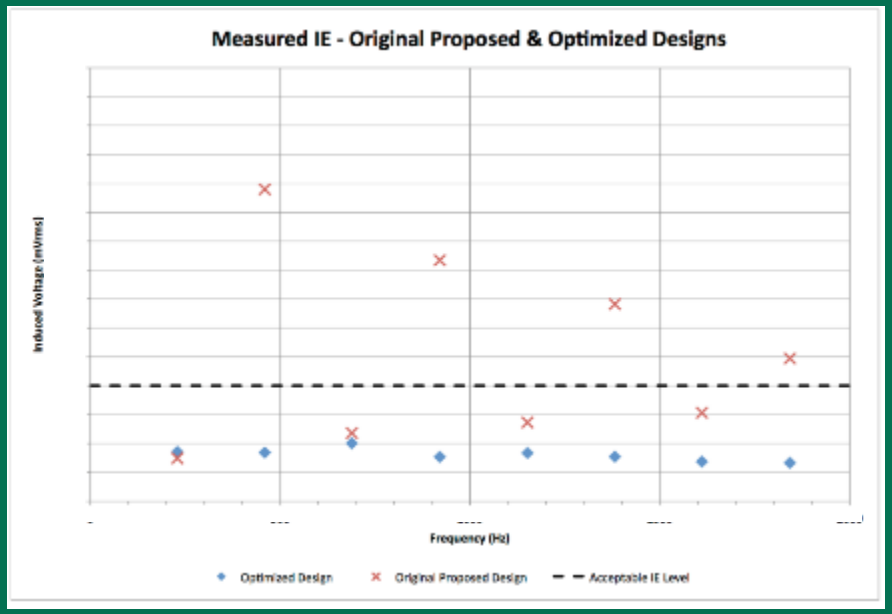
- **Better way**

  Model it.  Then model it again and again.

  Then build it and test it.

# Results: Before and After Change




About 3x Simulated Reduction

3-5x Improvement in Measured Results

# Conclusion

- Powerful modeling tools enable faster better design solutions
- Save time and money