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NSF Engineering Research Center

Advancing Sustainability through Powered Infrastructure for Roadway Electrification

Nanocrystalline opportunities in wireless charging systems

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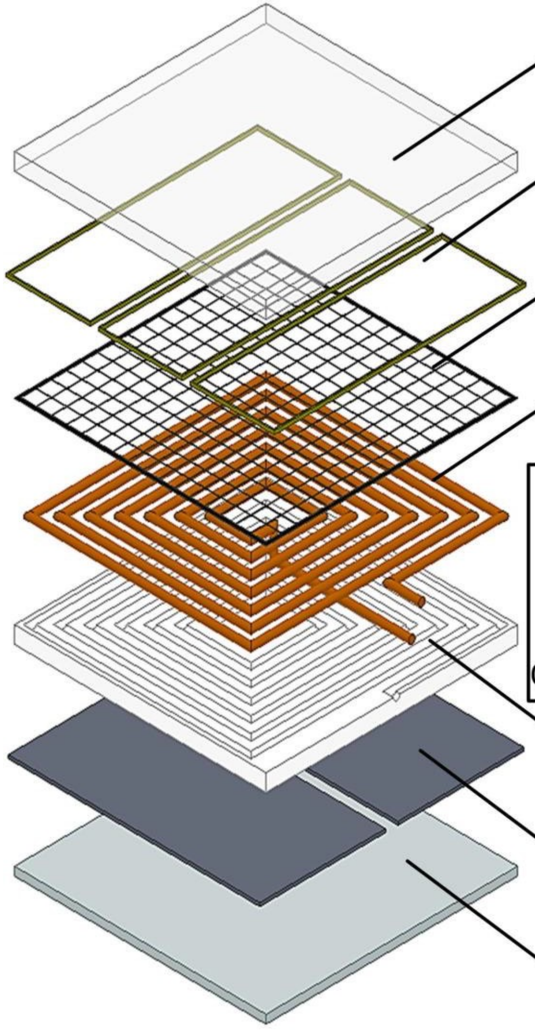
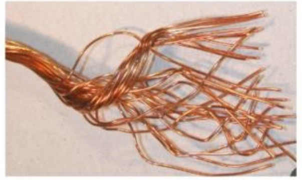
Challenges with wireless charging

- A wireless charging system can be thought of as a dual active bridge with a loosely coupled transformer and resonant network on both the primary and secondary windings
  - Coupling varies between 0.1 to 0.3
- Wireless charging coils create 3D magnetic fields
  - Improperly placed nanocrystalline cores will create high eddy current losses
- Vehicle OEMs want smallest possible footprint, low weight, and low cost





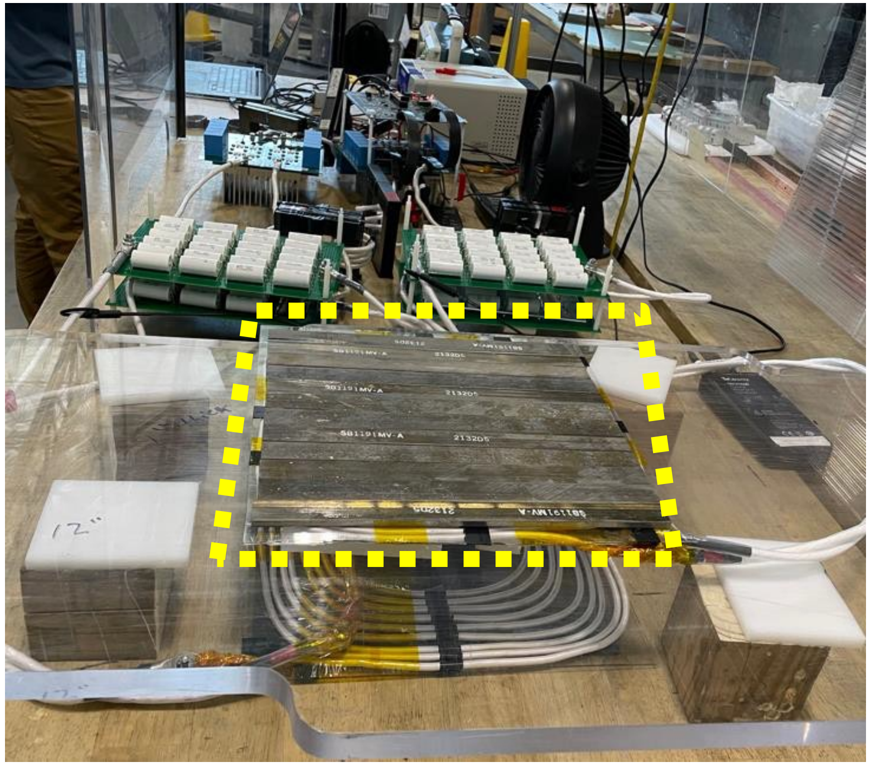
Close-up of litz wire structure

Feasibility study of nanocrystalline cores in WPT

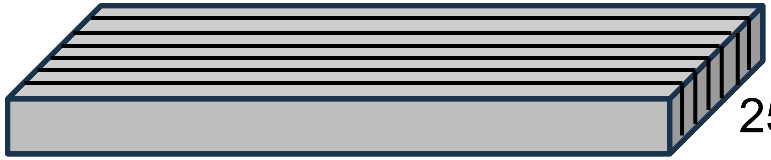
- Developed a 7kW prototype wireless charging system with a nanocrystalline cores and compared it to ferrite

- Key takeaways:
  - Nanocrystalline cores can outperform ferrite solutions (higher efficiency and coupling)
  - The 2D field restriction makes designing compact coils challenging compared to ferrite cores, especially when operating under misaligned conditions

- Project funded by CBMM

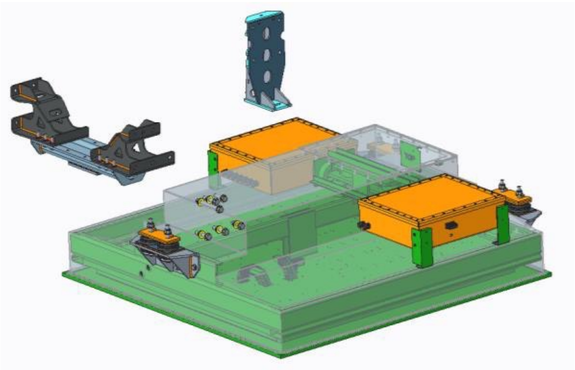


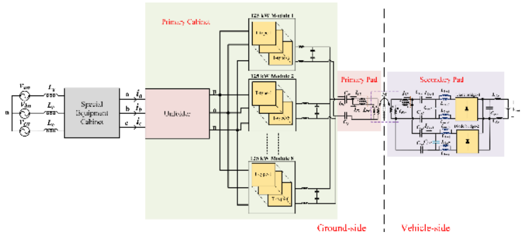
Nanocrystalline bar-shaped structure

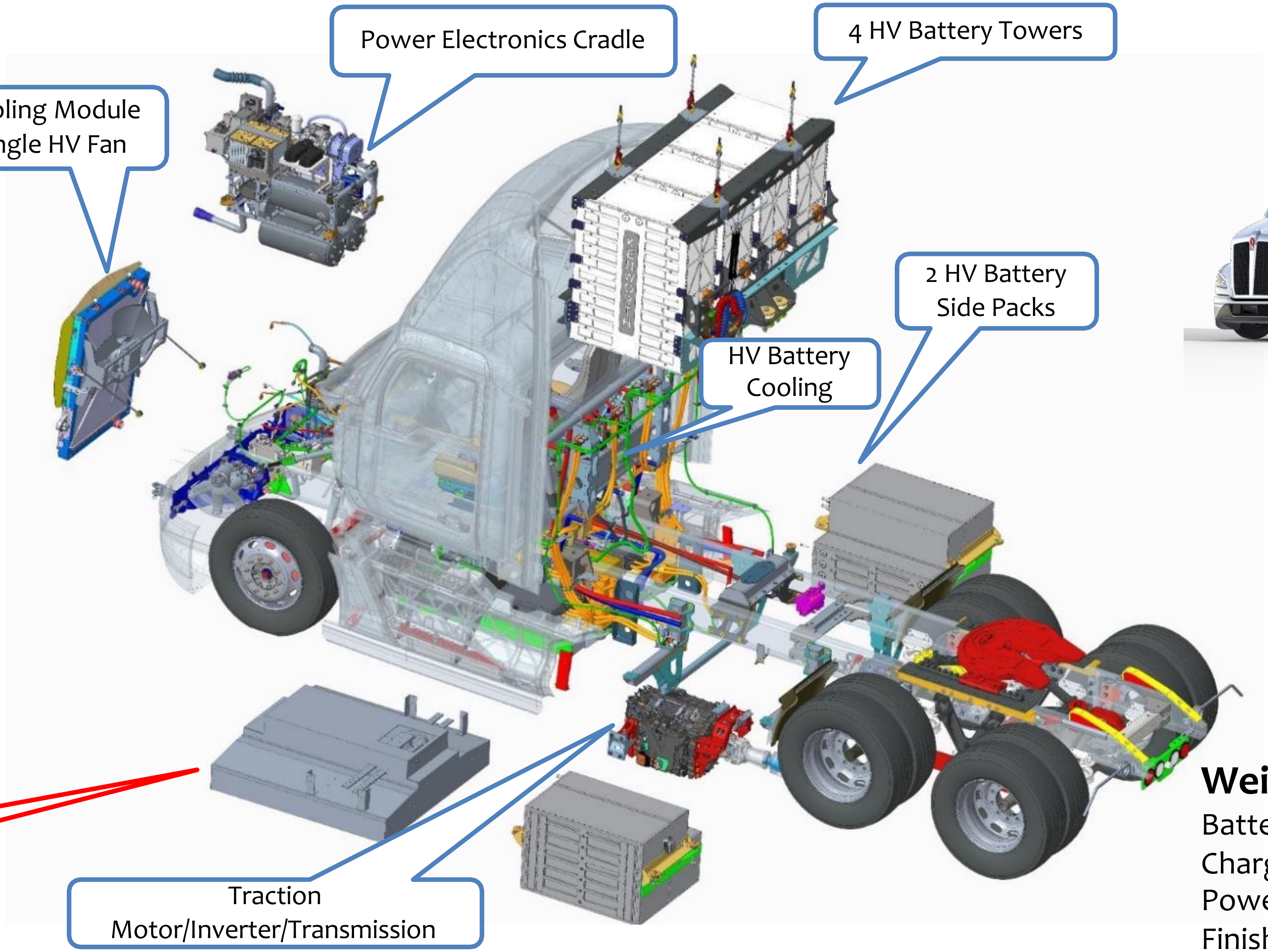


WPT for HD vehicles

Project Falcon: DOE VTO ELT262: Long-Range Battery Electric Vehicle with Megawatt Wireless Charging





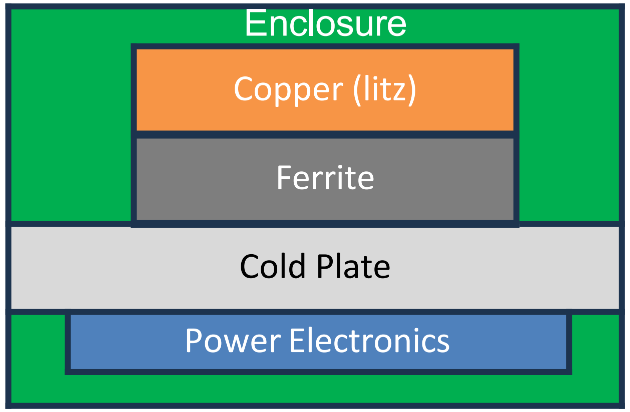


Weights

Batteries – 12,000lbs
Charge plate – 2,500lbs
Power Electronics Cradle - 770lbs
Finish Chassis – 25 to 27Klbs

Challenges in high power wireless charging

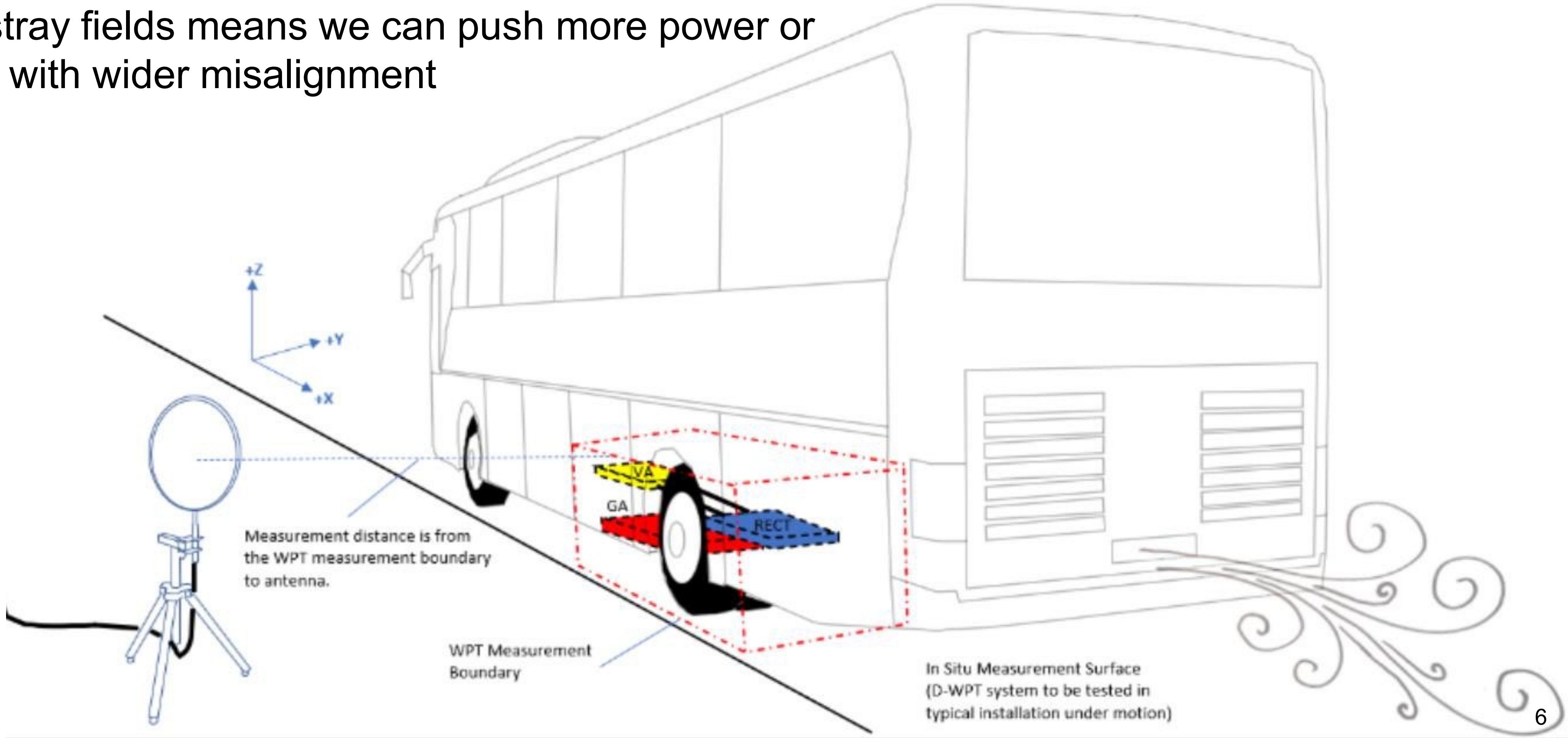
- High power wireless charging coils can consume a lot of ferrite
  - 1MW wireless charging system requires 200-350kg of ferrite cores
- Cooling is challenging!
  - Impractical to get liquid cooling to the windings
  - Ferrite has low thermal conductivity
- Nanocrystalline cores can help:
  - Reduce core volume and weight
  - Act as a better material to transfer heat



Shielding

- B-field limited to 15uT at the edge of the vehicle
  - Use nanocrystalline ribbons as a cost effective way to absorb stray fields at the side of the vehicle
  - Lower stray fields means we can push more power or operate with wider misalignment

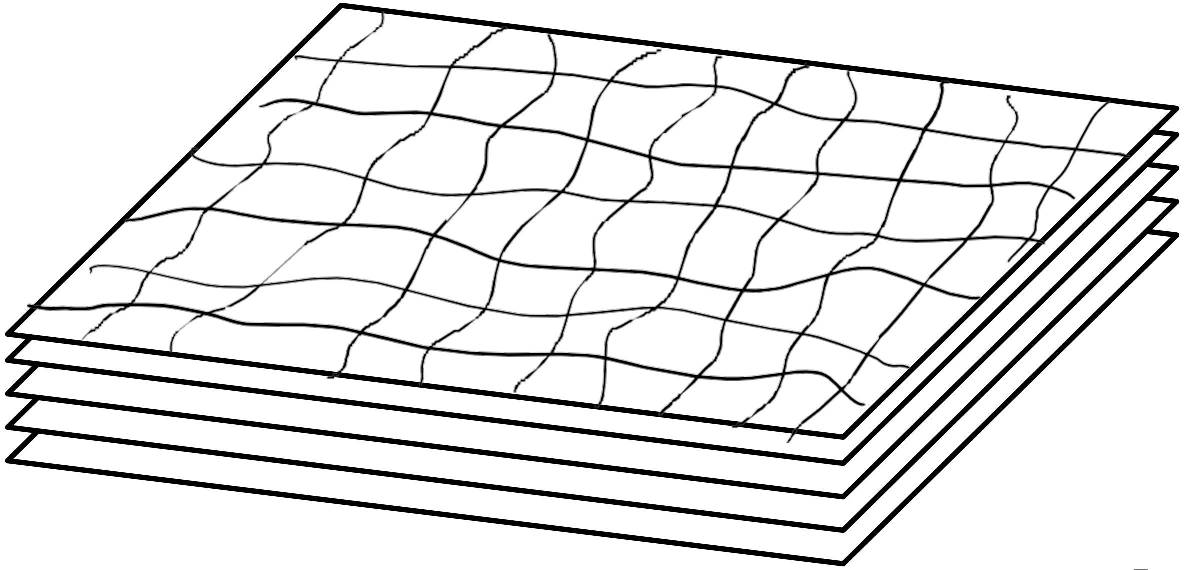
SAE J2954/2



Fractured ribbon structures

- A fractured ribbon structure can would reduce in-plane performance but also reduce eddy current losses due to 3D fields

- Can potentially simplify the manufacturing process



What WPT researchers need

- Premade nanocrystalline block cores that we can purchase
  - I can currently purchase the following ferrite shapes with ease:
    - 10mm x 10mm x 2mm
    - 25mm x 25mm x 5mm
    - 50mm x 50mm x 5mm
    - 100mm x 100mm x 5mm
    - And many more
  - Gives researchers flexibility to explore design options
  - If we had similar products available for nanocrystalline cores then we can develop designs with ease

- Researchers will help manufactures determine what the optimal shapes should be

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