White Paper

EMA3D® Cable Helps EV Project Mitigate EMC Risk

Introduction

Among projects under development at Lightning eMotors, one of the more exciting is the Mobile Battery Vehicle Charger (MBVC). It has the capability to relocate to almost any area and bring enough on-board battery storage to charge up to five electric vehicles (EVs). Three concerns drove a desire for early electromagnetic compatibility (EMC) analysis: 1) The DC/DC converter selection was ideal in terms of cost and performance, but came with potential concerns about electromagnetic noise based on CISPR 25 testing; 2) Knowledge that high voltage/high power systems of this kind have been known to cause self-compatibility issues on other EVs, with interference to CAN lines sometimes rendering a system inoperable; 3) The need to avoid impact to schedules if an EMC problem was discovered on a physical prototype, requiring extensive on-site troubleshooting and potentially costly re-designs.

EMA was brought in to use EMA3D Cable® to analyze the MBVC system and determine potential threats and mitigations.

- Using CAD provided by Lightning eMotors, a simplified model was created for EMC simulation
- Cable harness parameters were selected to capture the potential noise level of the threat (shielded HV cable carrying high frequency noise from the DC/DC converter) and immunity concerns of the victim (co-routed or nearby low voltage CAN lines). The stimulus on the threat cable was chosen to replicate the levels found in component level CISPR 25 testing
- These steps took ~48 hours of work by a single Staff Scientist, new to EMA3D Cable®, to develop

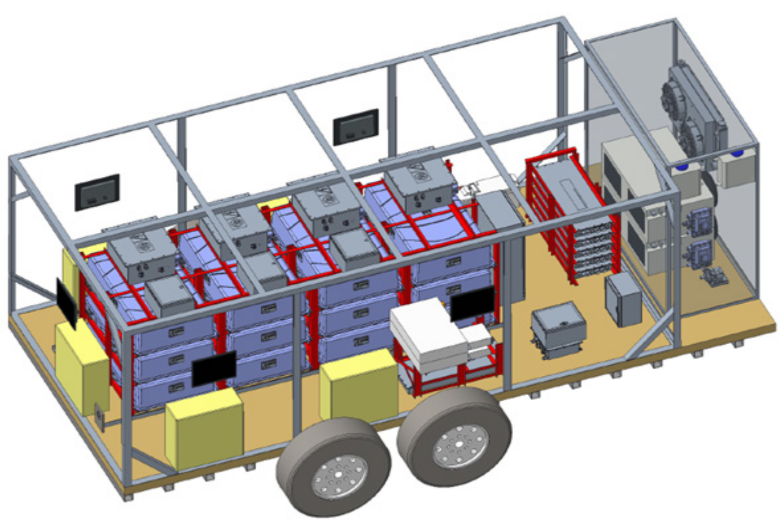


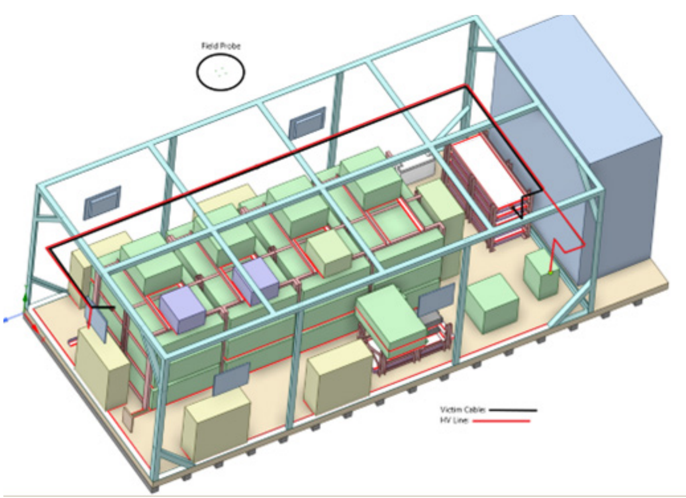
Figure 1. Trailer shown with enclosure skeleton, minus enclosure covers

Using realistic threat/victim parameters and close co-routing of the cables, EMA confirmed that there is a real threat to the CAN network of the MBVC if HV and LV cables are routed carelessly, with voltages up to 22 dB above the interference threshold in the 100 kHz – 100 MHz range appearing on the twisted CAN lines.

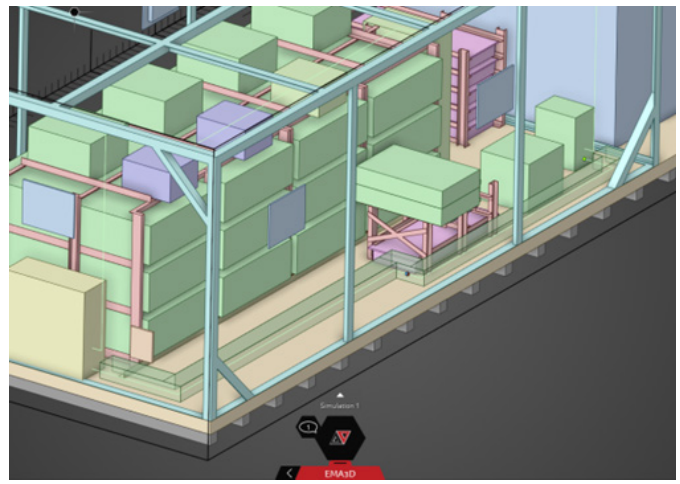
Knowing that a threat existed, EMA quickly iterated through possible solutions:

- Separating the threat and victim cables by routing HV near the floor and CAN near the ceiling—reduced the noise but not enough
- Routing CAN along the ceiling with a well-bonded metal cable tray for support, offering potential shielding between CAN and HV—reduced the noise but not enough
- Routing HV cable through and under an aluminum floor panel—made noise worse due to antenna effects where the cable passed through the hole in the floor
- Routing HV cable under an aluminum floor panel using a through-bulkhead connector—eliminated noise but HV connector not a cost-effective solution
- Limiting the distance of parallel routing between the HV and CAN lines—reduced noise but not in case where HV and CAN lines terminated on the same electronics box

The final iteration needed was routing the HV cables through a metal tunnel on the aluminum floor of the MBCV. In this configuration CAN lines could be routed as close to the HV cables as needed, and as long as they remained outside of the HV tunnel the high frequency noise remained below the interference threshold.



Using available CAD and less than two months of calendar time (~120 hours of total staff time), EMA was able to use EMA3D Cable® to determine that there was a real threat to the MBCV development project. We were able to quickly iterate through multiple design solution options to arrive at one that was low-cost and relatively easy to implement, all while working in parallel with the normal design and production schedule. This avoided a potentially severe cost and schedule impact during the prototype phase. It also allowed the project to proceed with using the original DC/DC converter choice, even if that unit presented some EMC challenges.



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