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# Automotive Electrification: Associated EMC Challenges

## COMMON EMC ISSUES with EVs and TECHNIQUES to RESOLVE

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Applus<sup>+</sup>  
test

# Introduction



**Paul Wolstenholme - EMC Technical Consultant ([paul.wolstenholme@applus.com](mailto:paul.wolstenholme@applus.com))**

- ⊕ Twelve years EMC Experience within the Automotive Sector.
- ⊕ Launched the EMC Technical Consultancy Department within Applus+ in January 2020.
- ⊕ Experienced in component and vehicle-level EMC testing and delivering EMC compliance for vehicle programmes.

Specializing in resolving EMC issues associated with electrified vehicles and high voltage components, I actively encourage and support automotive manufacturers with ensuring greater EMC engagement in the early design stages of both components and new vehicle electrical architectures.

# Automotive Electrification: Common EMC Issues and Techniques to Resolve - Overview



## Overview of the Topics to Cover:

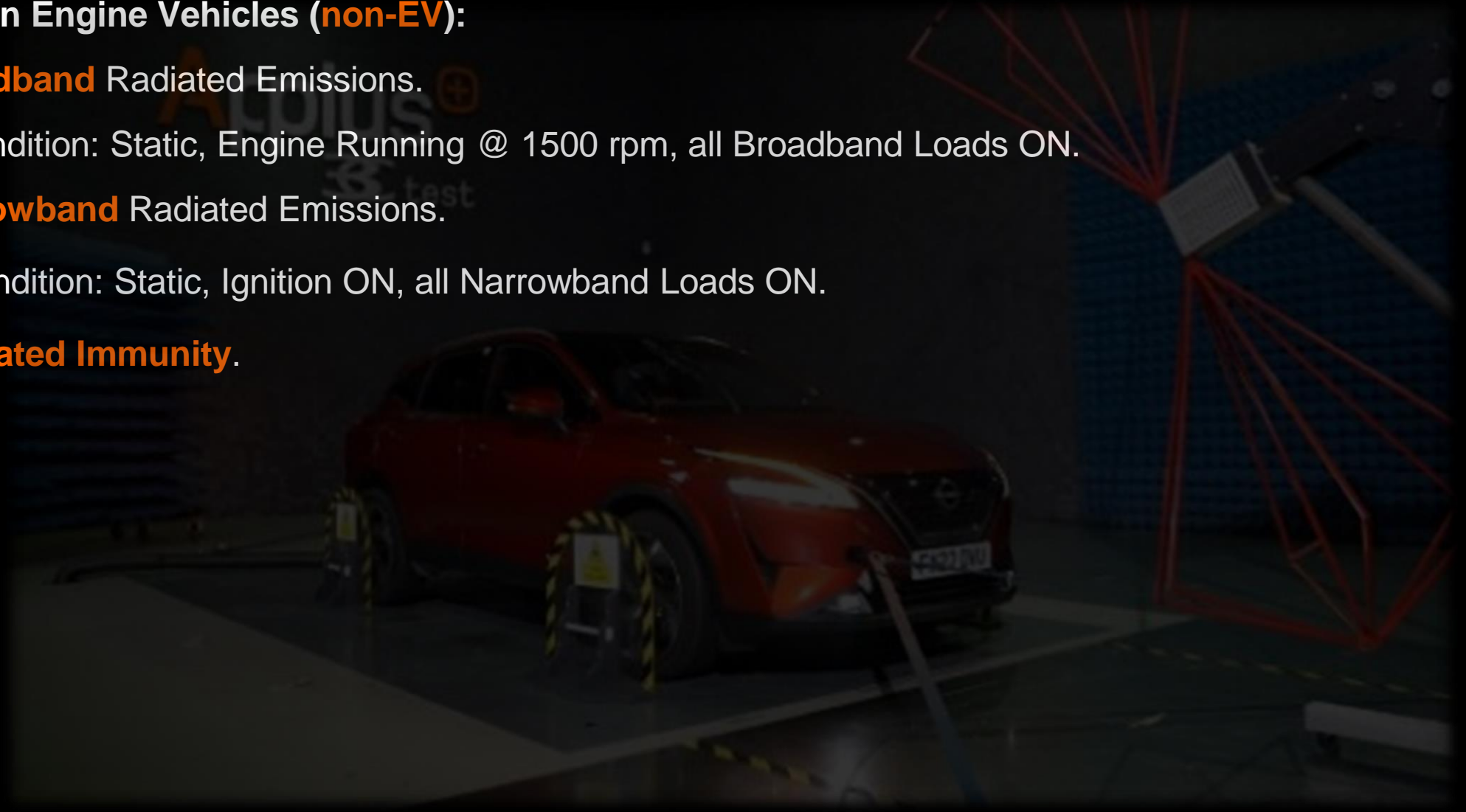
- ⊕ Defining the European EMC Regulatory Test Requirements for Electrified Vehicles.
  - ⊕ Highlighting the Additional Tests Required for Electric / Hybrid Electric Vehicles, Compared to those for a more Traditional Non-Hybrid Internal Combustion Engine (ICE) Vehicle.
- ⊕ Detailing the Common Areas / Tests where Manufacturers tend to Experience Non-Compliances as a result of Electrification.
  - ⊕ Including Examples of the Typical Culprits (Components), Responsible for these Non-Compliances.
- ⊕ Reviewing Various Methods and Techniques to Resolve these Issues, along with Potential Root Causes.
- ⊕ Outlining how these Issues could be Prevented through Employing EMC Best Practices during the Virtual Vehicle Design Phases (CAD).

# Automotive Electrification: Vehicle-Level Certification EMC Test Requirements (non-EV)



## Internal Combustion Engine Vehicles (**non-EV**):

- ⊕ Off-Board **Broadband** Radiated Emissions.
  - ⊕ Vehicle Condition: Static, Engine Running @ 1500 rpm, all Broadband Loads ON.
- ⊕ Off-Board **Narrowband** Radiated Emissions.
  - ⊕ Vehicle Condition: Static, Ignition ON, all Narrowband Loads ON.
- ⊕ Off-Board **Radiated Immunity**.



# Automotive Electrification: Vehicle-Level Certification EMC Test Requirements (EV)



## Electrified Vehicles (e.g., Battery Electric Vehicles, Hybrid Electric Vehicles, etc.):

- ⊕ Off-Board **Broadband** Radiated Emissions.
  - ⊕ Vehicle Conditions: Performed Dynamically (**@ 40 km/h**) and During AC and DC Charging (Charging **Modes 2, 3 and 4** Where Applicable).
- ⊕ Off-Board **Narrowband** Radiated Emissions.
  - ⊕ Vehicle Condition: Ignition ON / EV Drive Ready State, Narrowband Loads ON.
- ⊕ Off-Board **Radiated Immunity**.
- ⊕ Conducted Emissions During **AC** Charging.
- ⊕ Measurements of Harmonics, Fluctuations and Flicker along **AC** Charge Lines.
- ⊕ Immunity to EFT (Electrical Fast Transients) Conducted along **AC** Charge Lines.
- ⊕ Immunity to Surges Conducted along **AC** Charge Lines.

# Automotive Electrification: EMC Certification AC and DC Charging Modes Overview.



**Mode 2:** Portable Charger  
Supplied with the Vehicle.



**Mode 3:** Simulating the Connection to  
an AC Charging Station.



**Mode 4:** Simulating the  
Connection to a DC Charging  
Station.

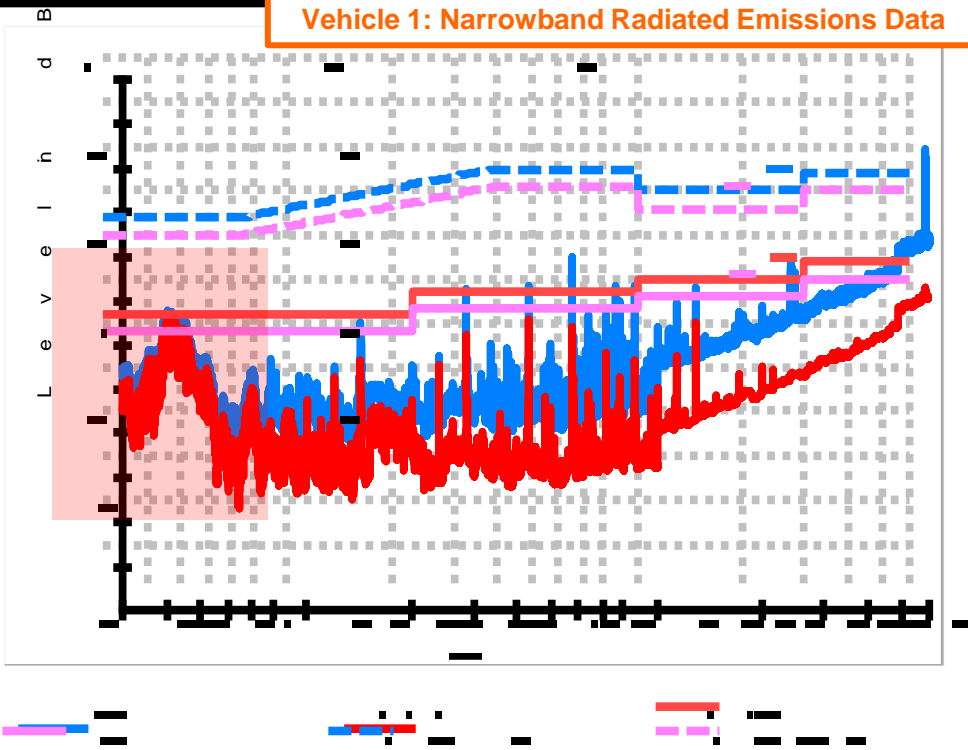
# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, RE NB.



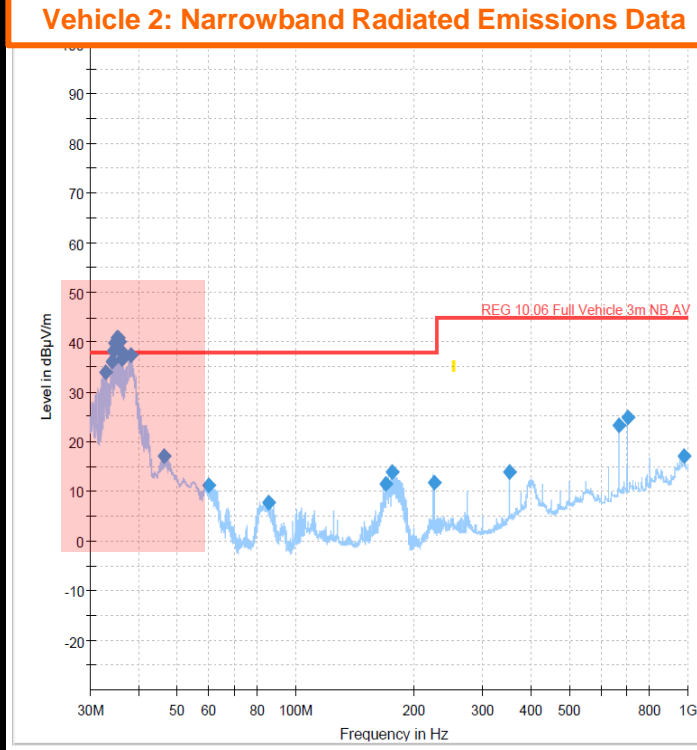
The most common EMC non-compliances experienced during the development of electrified vehicles, and those that are the hardest to resolve, are typically related to off-board radiated emissions and conducted emissions.

## Examples of Off-Board Radiated Emissions Non-Compliances:

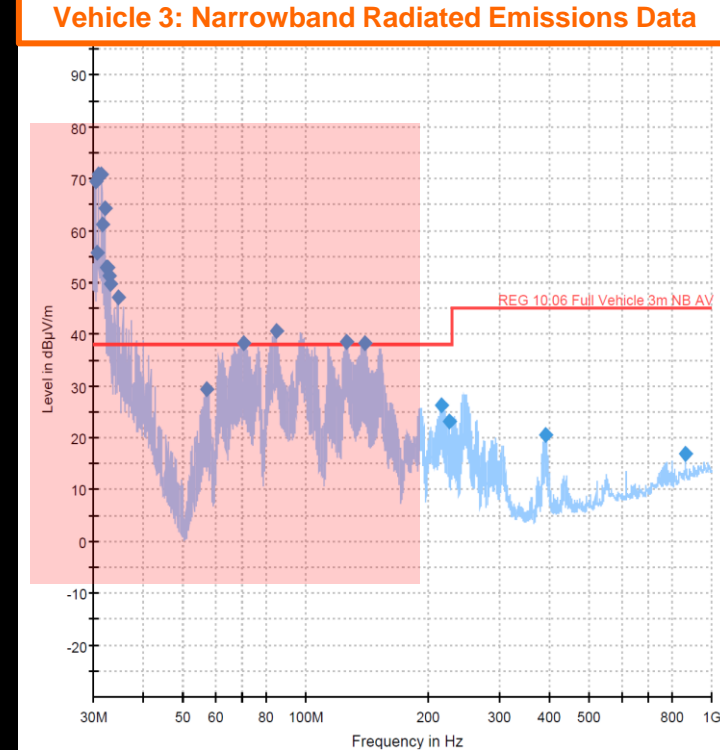
Vehicle 1: Narrowband Radiated Emissions Data



Vehicle 2: Narrowband Radiated Emissions Data



Vehicle 3: Narrowband Radiated Emissions Data



High commonality between each of the non-compliances, and the responsible component in each case is: **HV DCDC**

# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, RE NB.

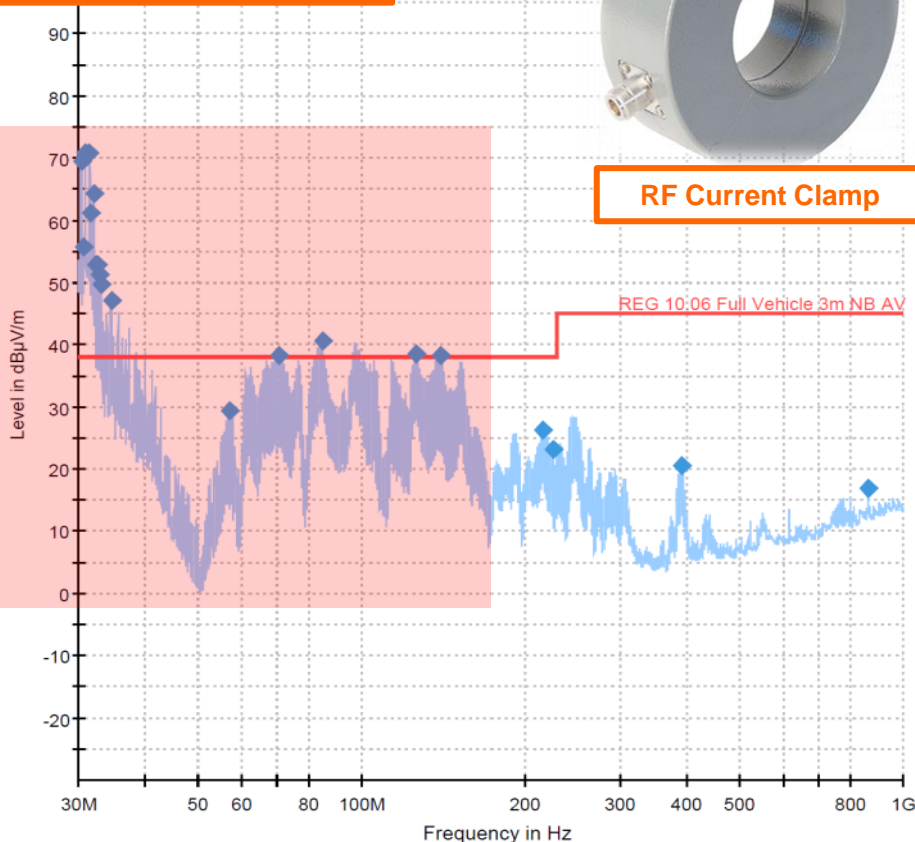


To resolve a non-compliance such as this, once the source has been identified, its critical to understand how the interference is propagating out of the component.

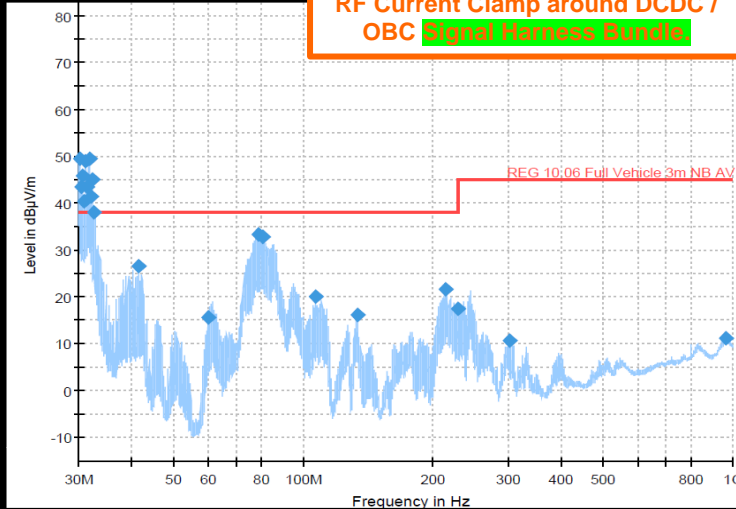
Vehicle 3: Narrowband Radiated Emissions Data



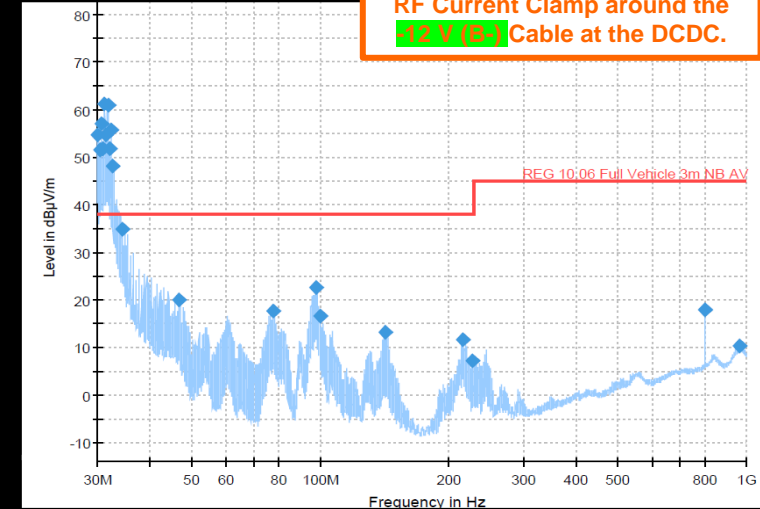
RF Current Clamp



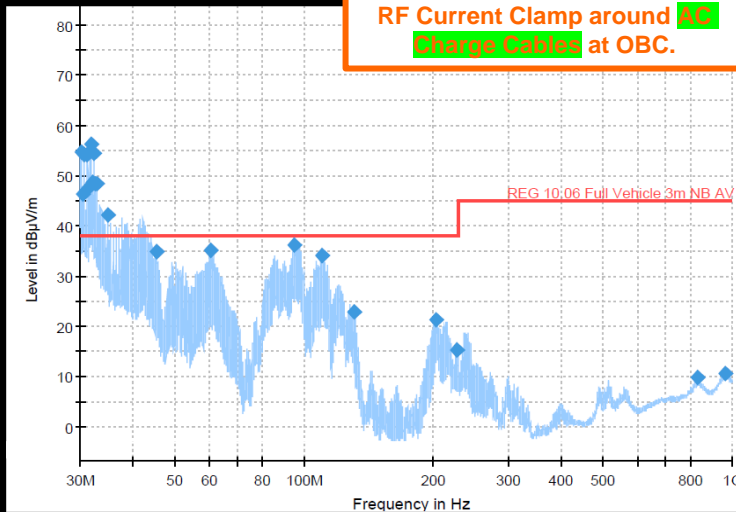
RF Current Clamp around DCDC / OBC Signal Harness Bundle.



RF Current Clamp around the 12 V (B+) Cable at the DCDC.

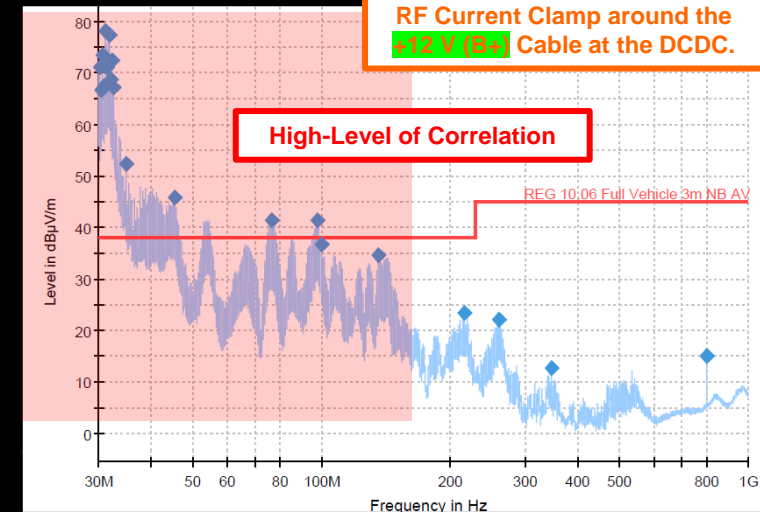


RF Current Clamp around AC Charge Cables at OBC.



RF Current Clamp around the 12 V (B+) Cable at the DCDC.

High-Level of Correlation

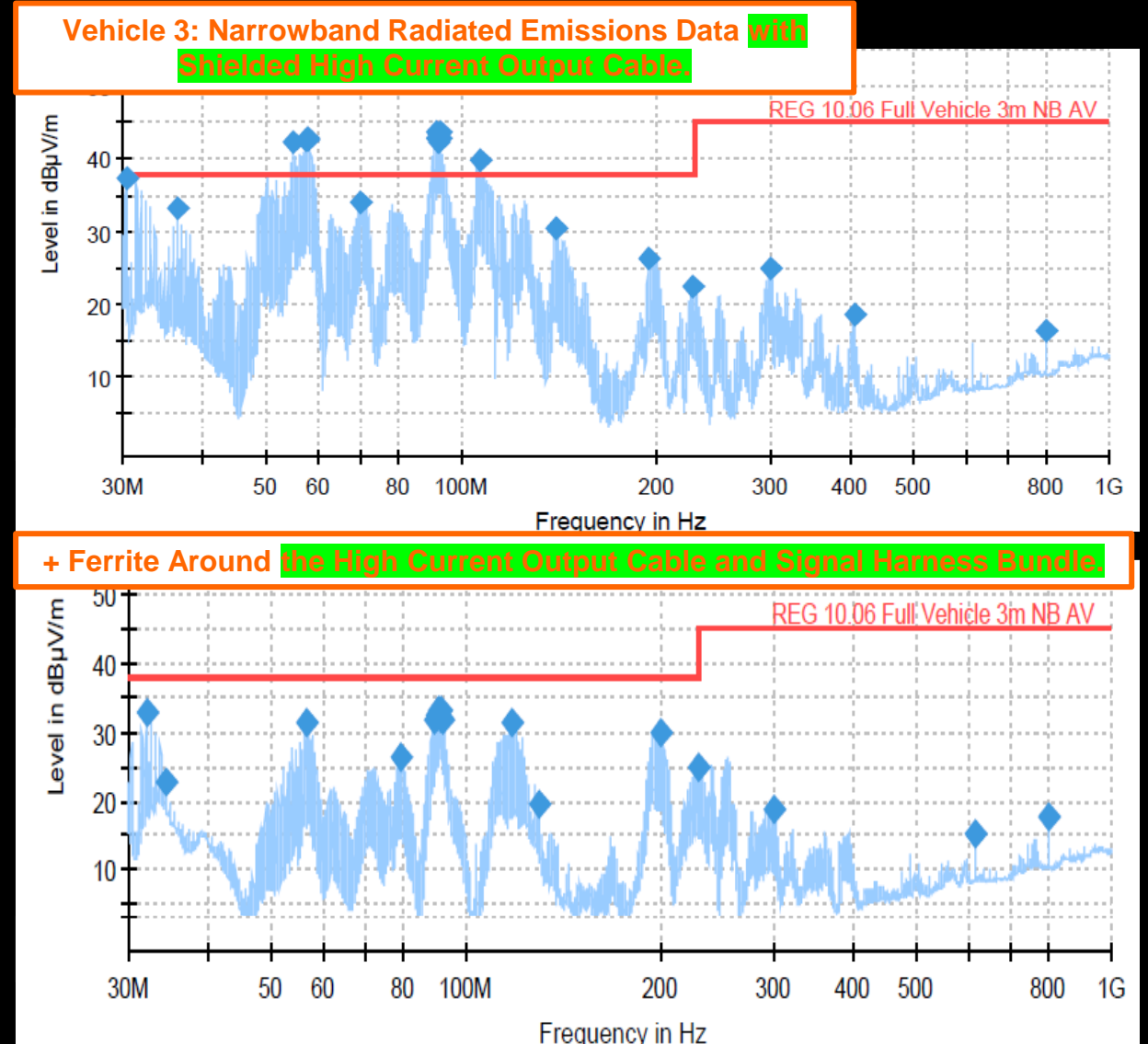
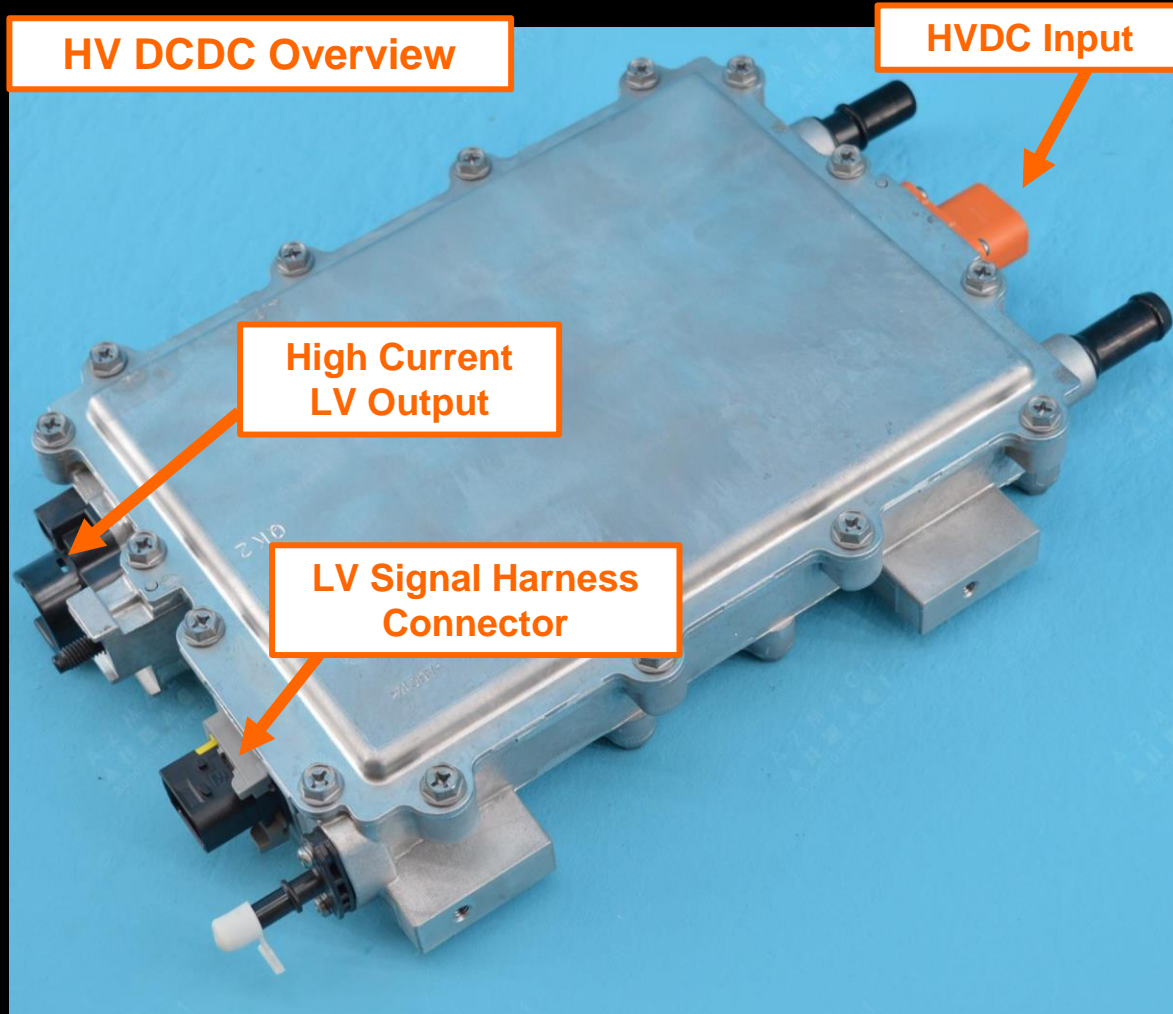




# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, RE NB.



Possible vehicle-level modifications for reducing interference from components such as a HV DCDC is as follows:

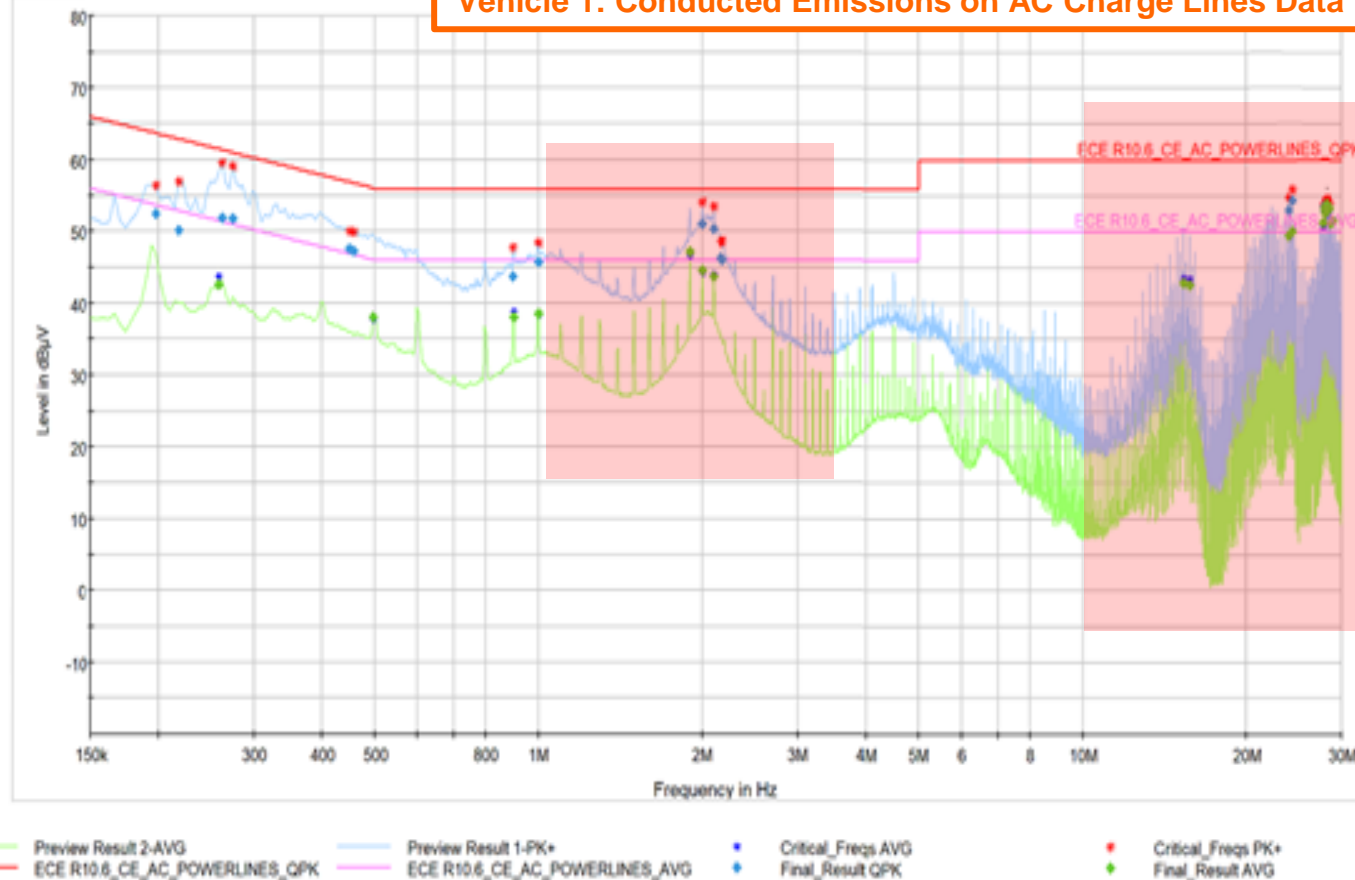


# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, CE.

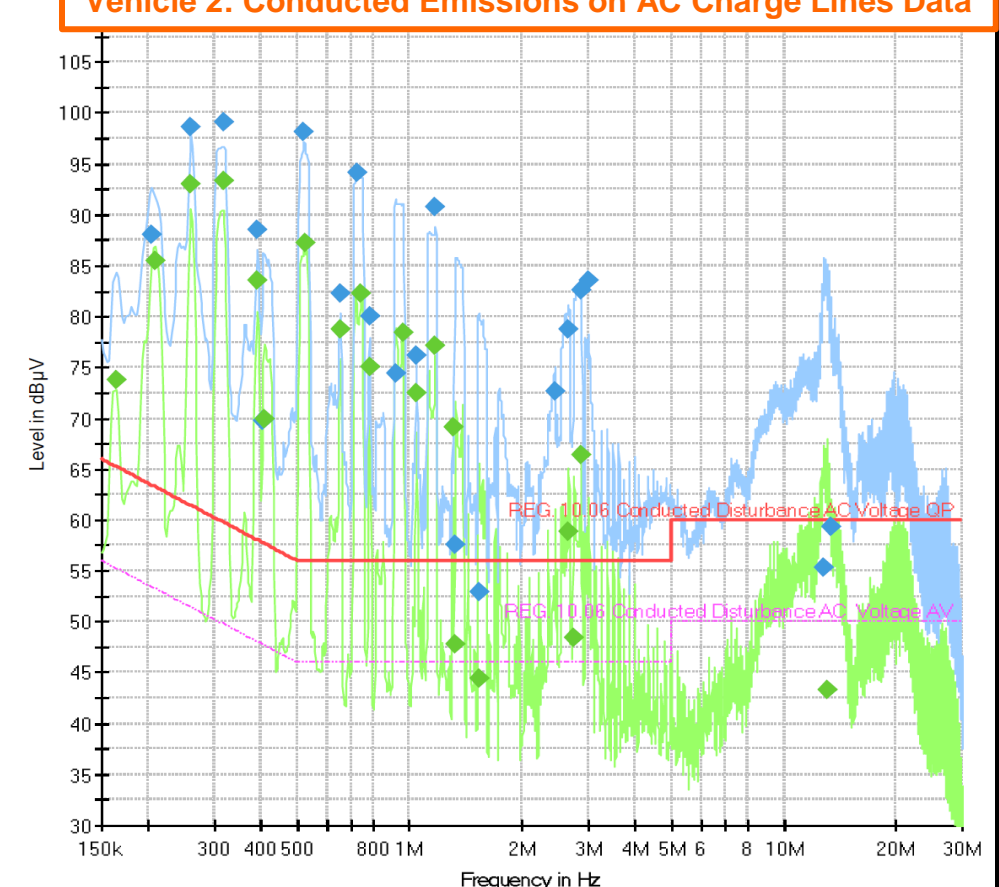


## Examples of Conducted Emissions Non-Compliances:

Vehicle 1: Conducted Emissions on AC Charge Lines Data



Vehicle 2: Conducted Emissions on AC Charge Lines Data



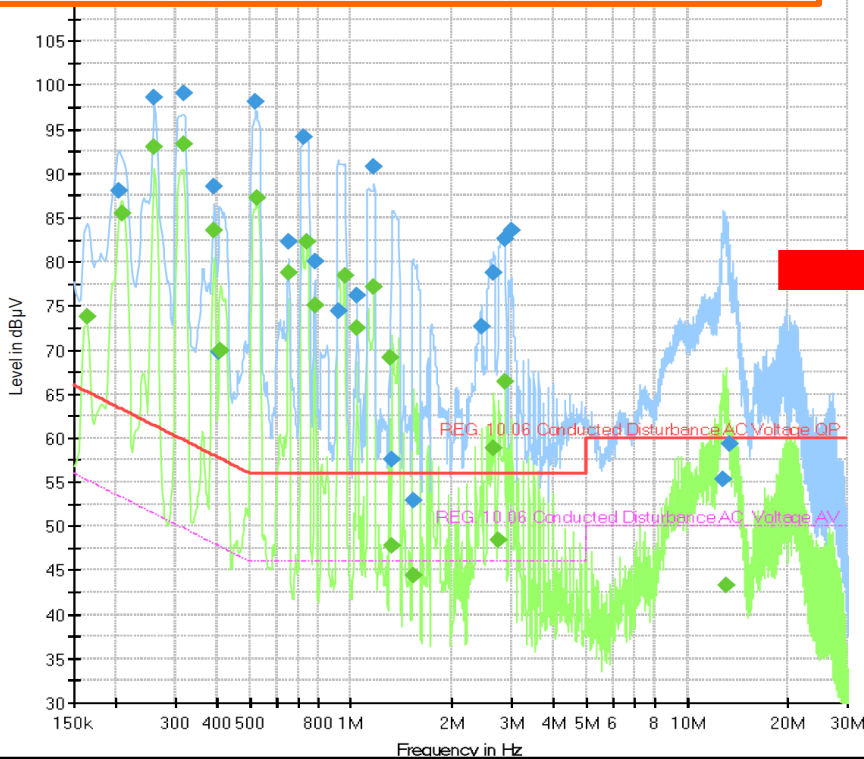
Unsurprisingly, the **OBC (OnBoard Charger)** is typically responsible for conducted emissions on AC charge lines non-compliances.

# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, CE.



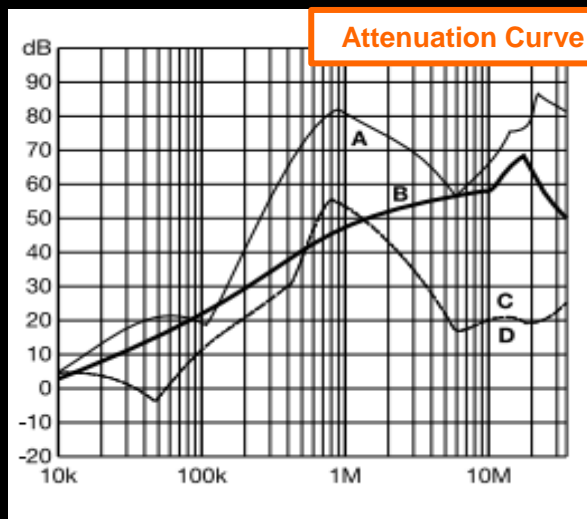
Implementation of an AC Inline Filter is a Good Solution, but Expensive and Challenging to Integrate.

Vehicle 2: Conducted Emissions During AC Charging Data

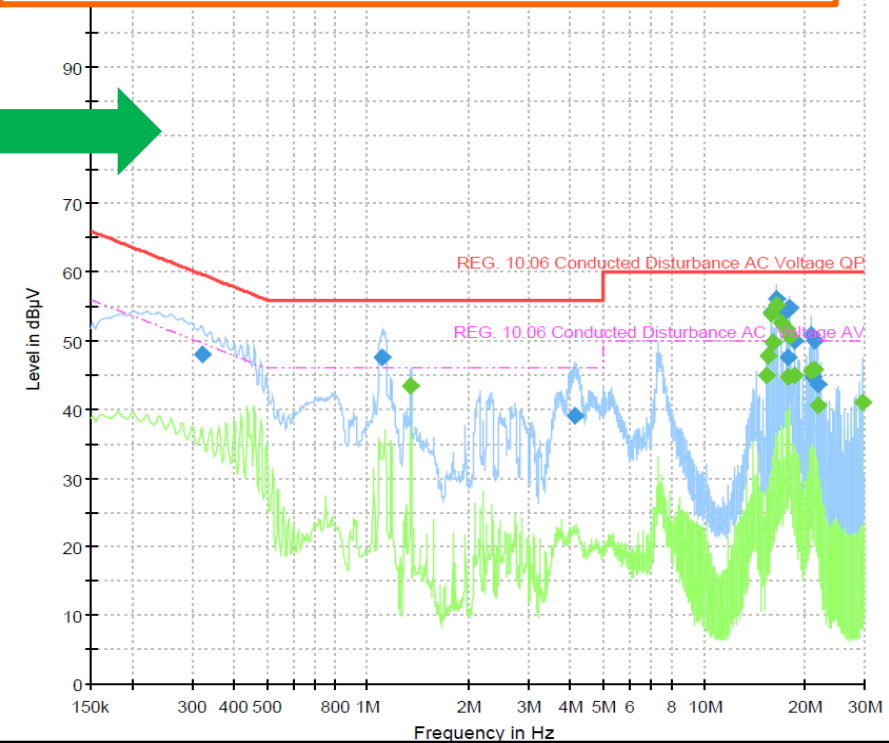


Very High Levels of Interference, Suggesting that very Limited Filtering has been Implemented within the Component.

Example of an "Off-the-Shelf" Commercial AC Inline Filter. *NOTE: Not Automotive Approved*



Vehicle 2: Conducted Emissions During AC Charging Data with Inline AC Filter (Between OBC and Charge Socket)



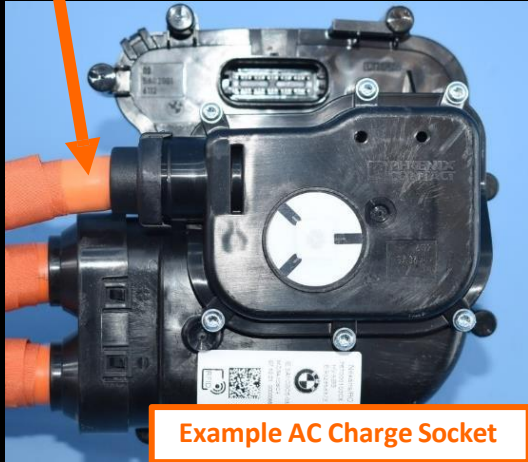
Significant Reduction in Interference Levels - very Close to Achieving Compliance.

# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, CE.



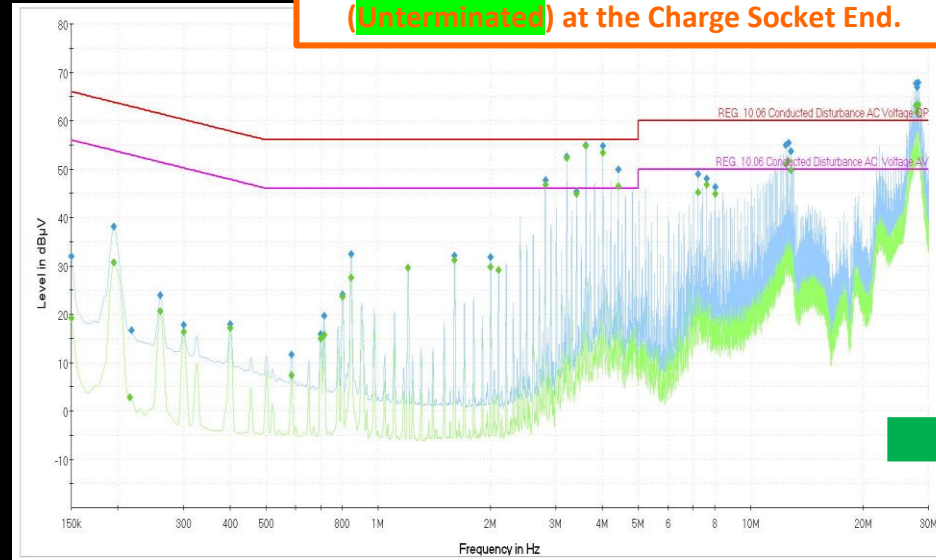
Methods for reducing the higher frequency conducted emissions (1 MHz to 30 MHz) are as follows:

Remove the Insulation and Terminate the Screen of the AC Charge Cable at the Charge Socket End to the Vehicle Body, via a Short Fly Lead.

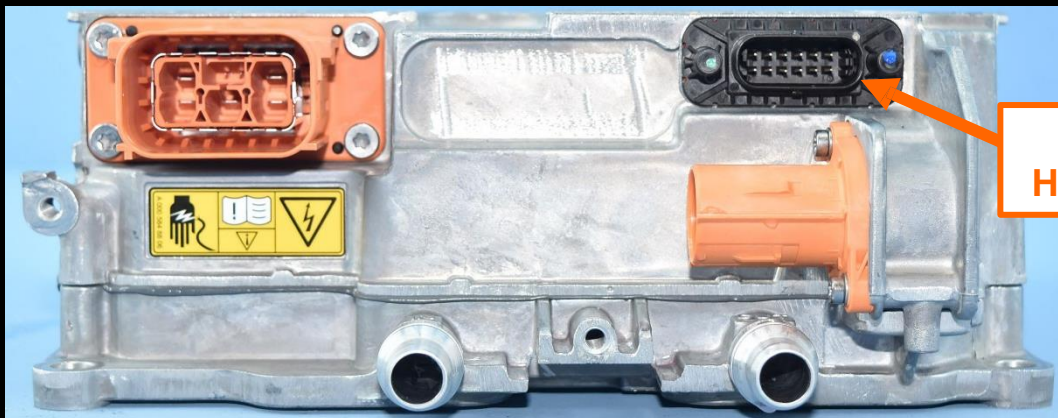
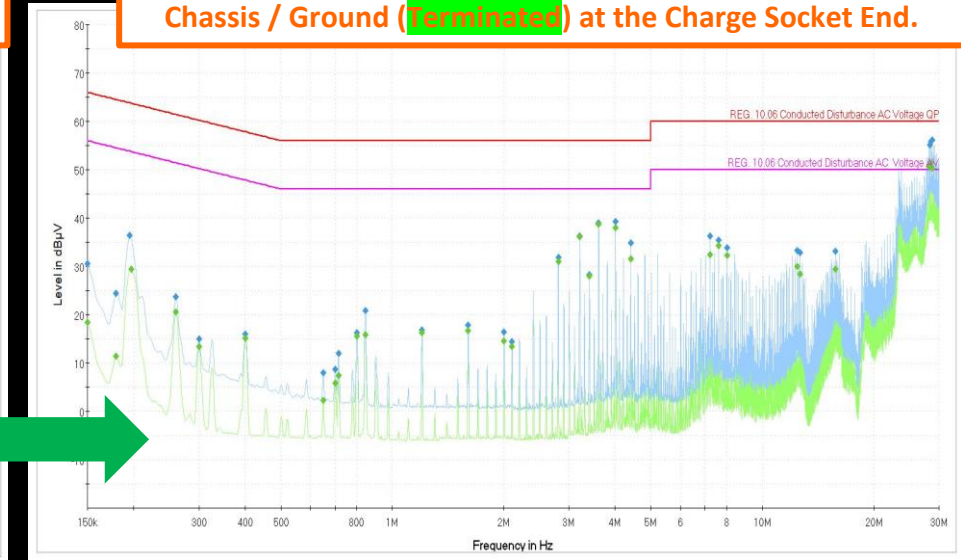


Example AC Charge Socket

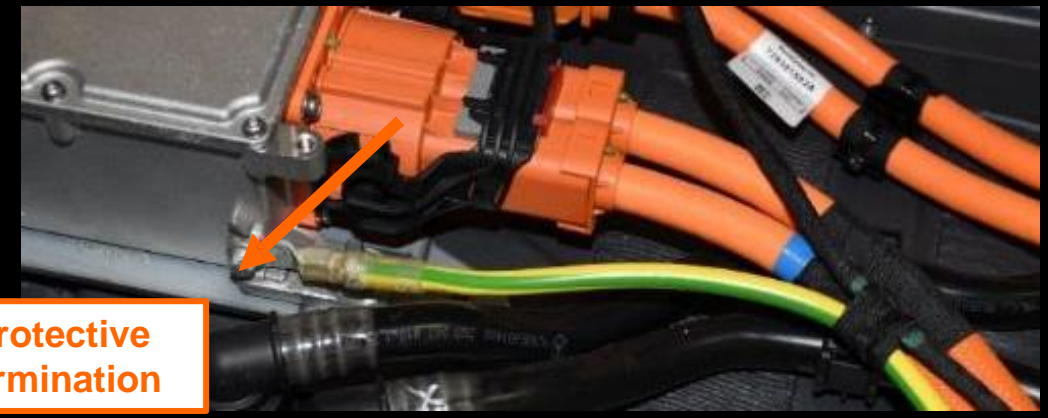
With the AC Charge Cable Screen Open (Unterminated) at the Charge Socket End.



With the AC Charge Cable Screen Connected to the Vehicle Chassis / Ground (Terminated) at the Charge Socket End.



OBC LV Signal Harness Connector

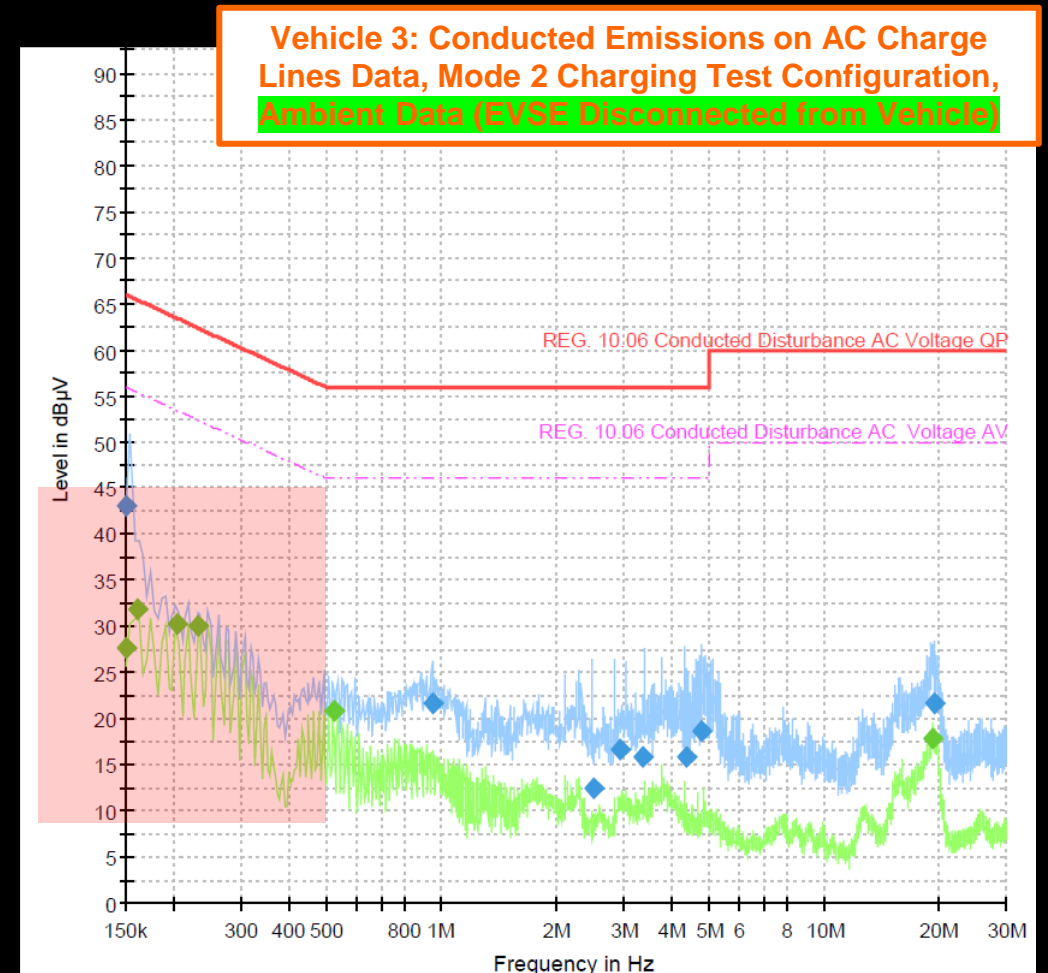
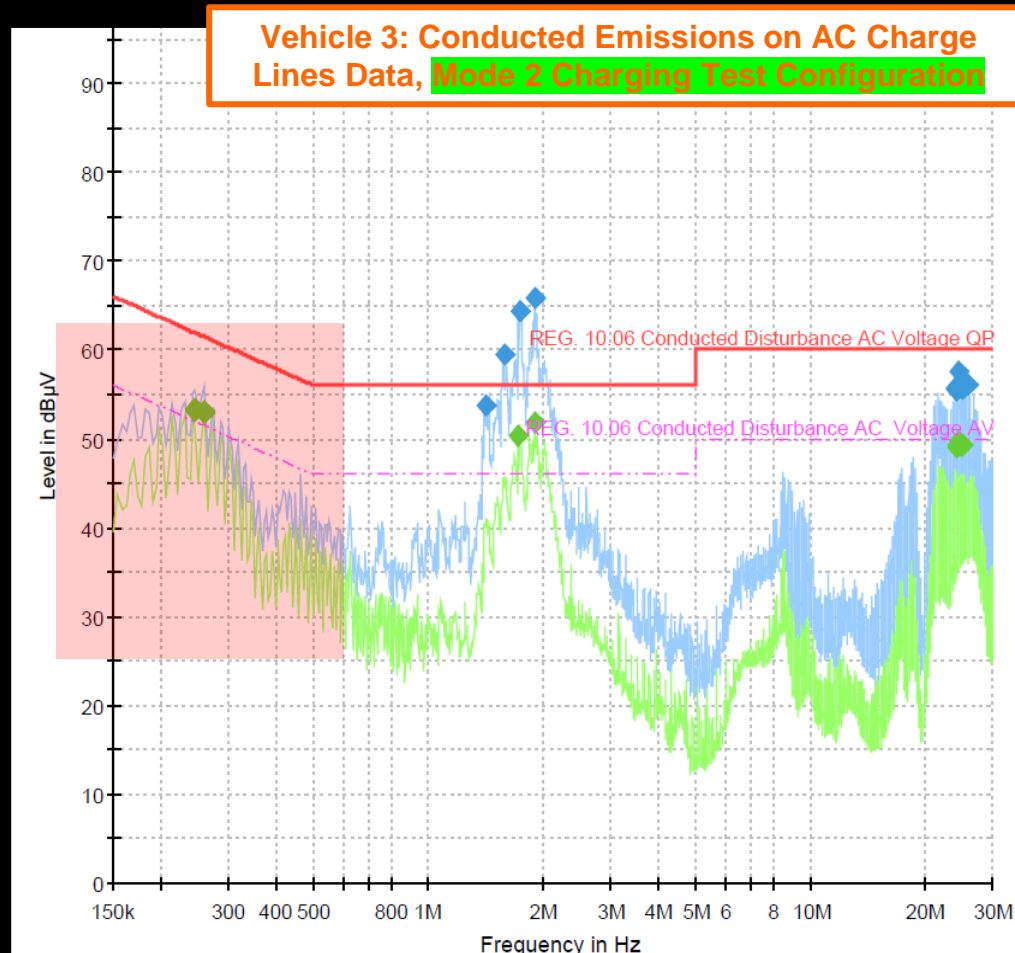


OBC - Protective Earth Termination

# Automotive Electrification: EMC Certification of Electrified Vehicles, Common Issues, CE.



## Concerns Related to **Mode 2** AC Chargers:

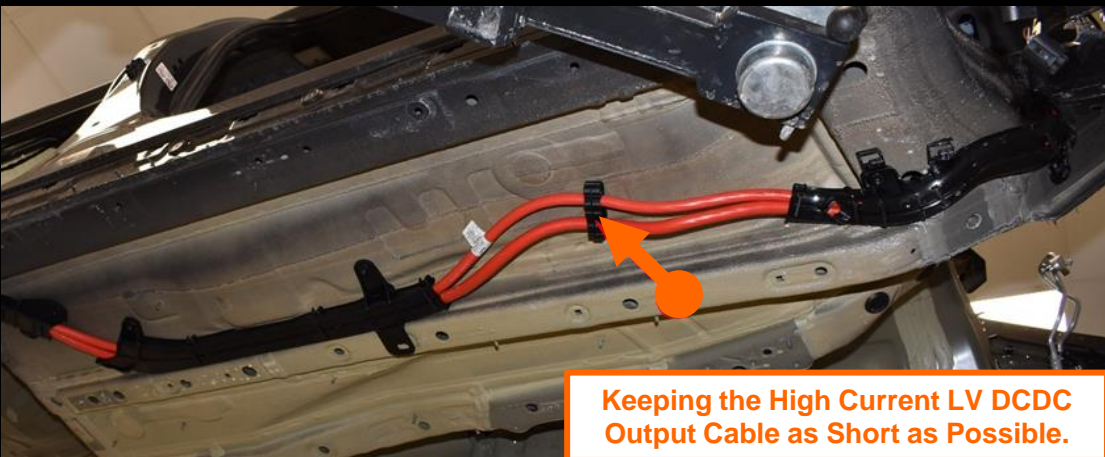


Often Mode 2 AC Chargers are “CE-marked” and **NOT** “E-marked”, leading to issues during vehicle-level testing / approval.

# Automotive Electrification: EMC Certification of Electrified Vehicles, Integration Strategies.



## HV System Integration Strategies for Improving EMC:



Thank you, any Questions?

