Master's Thesis Engineering Technology 2024 - 2025

EMI Effects of Reduced DC-Link Capacitance in On-Board Chargers

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1. INTRODUCTION

The **rapid electrification of transport** and the **global energy transition** are driving demand for **compact, efficient,** and **reliable power electronics** in **Electric Vehicles (EVs).** The **On-Board Charger (OBC)** is key in **converting AC grid power** to **DC** for charging the battery. The DC-link capacitor plays a **key role** in **stabilising voltage** and **reducing ripple**, but changes in its value may also **influence Electromagnetic Interference (EMI)** and **thermal performance**.

2. PROBLEM STATEMENT

This study **examines** the **relative impact** of **reducing DC-link capacitance** in an existing OBC prototype. **Measurements** under **non-ideal** but **representative conditions** assessed **changes** in **component volume, voltage and current waveforms, EMI,** and **thermal behaviour.** The aim was not to achieve a fully standard-compliant assessment, but rather to identify the key **trends** and **trade-offs** associated with capacitance reduction.

3. OBJECTIVES

- Perform **measurements** under **non-ideal** but **representative conditions** to capture **conducted emissions** over a broad **frequency range**.
- **Evaluate** different **volumes** of electrolytic **capacitors** for electrical, thermal and EMI behavior.
- Use **high-quality** calibrated **equipment** and stable supply.
- **Analyze data** to map **trade-offs** between capacitance, EMI, electrical and thermal performance.

4. METHODS

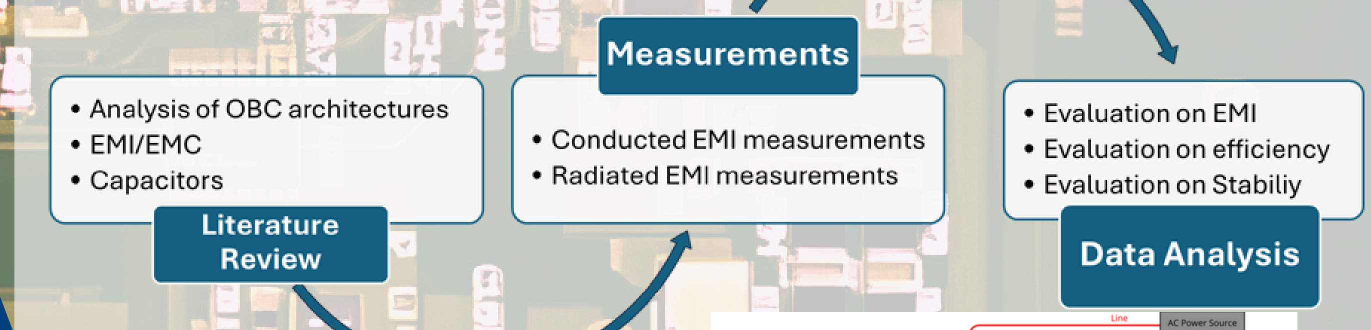

Fig. 1 : Assembled OBC prototype (PCB with DC-link capacitors)

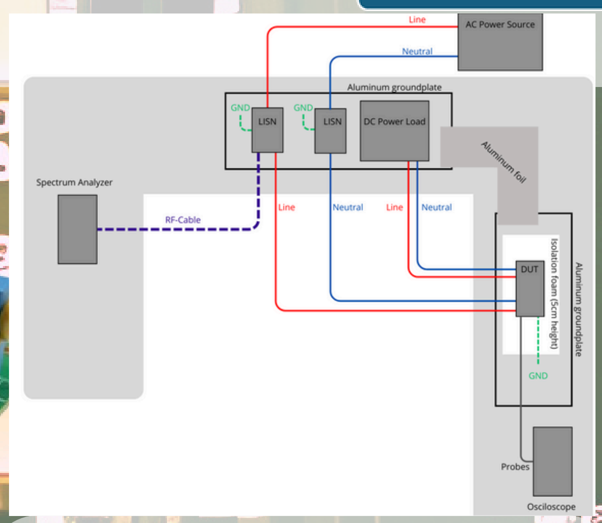

Fig. 2 : Layout of the conducted emission test setup

5. RESULTS

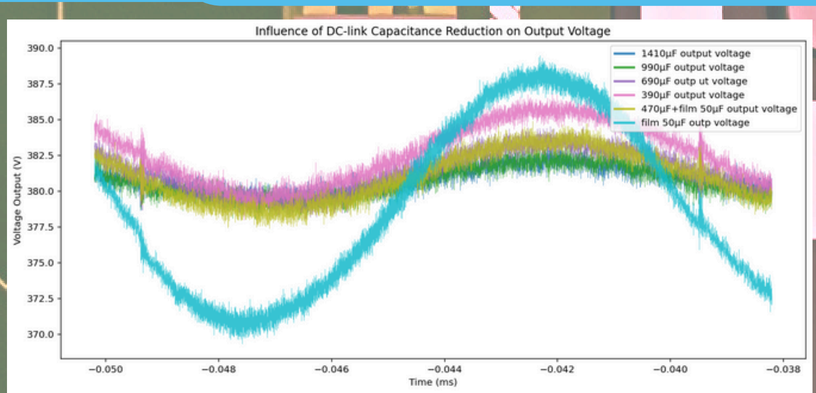

Fig. 3 : Influence of DC-link Capacitance Reduction on Output Voltage

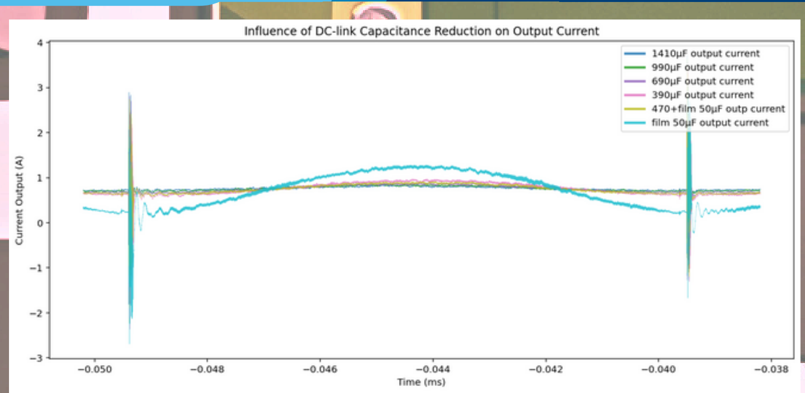

Fig. 4 : Influence of DC-link Capacitance Reduction on Output Current

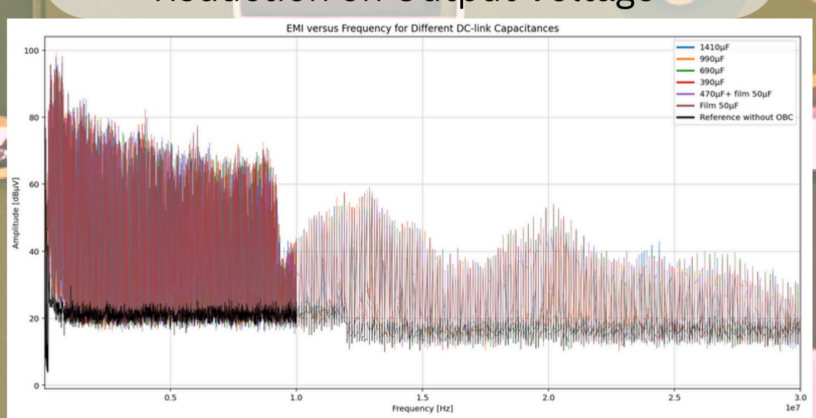

Fig. 5 : Influence of DC-Link Capacitance Reduction on EMI

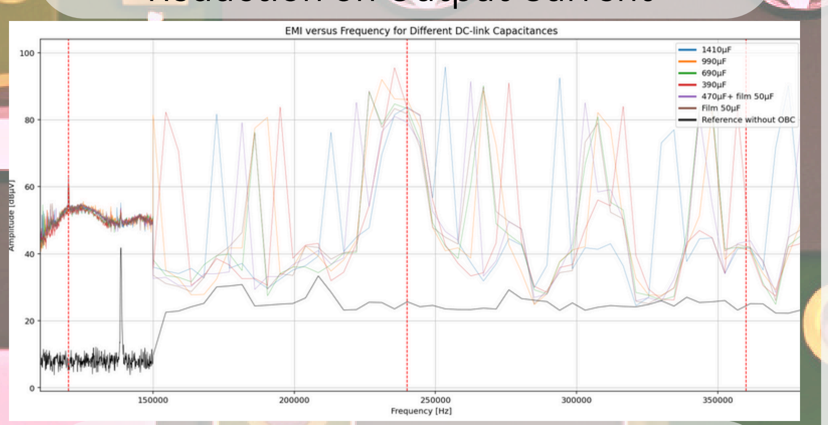

Fig. 6 : Influence of DC-Link Capacitance Reduction on EMI (Zoomed)

Reducing capacitance increases output **voltage ripple** and **noise,** as seen in Figure 3, with the effect strongest at 390 μF and 50 μF film only.

Output current is **less affected** in **steady-state,** but **reduced capacitance** amplifies **oscillations** at **zero-crossings**. As seen in Figure 4, **below 390 μF** and especially with a **50 μF film capacitor,** strong **spikes** and **high frequency distortions** appear due to **switching dynamics.**

No **peaks** are observed in the **reference measurement**, as the OBC was not connected to the Line Impedance Stabilization Network (LISN). **Connecting** the **OBC** to the **LISN** introduces **broadband noise** and **switching peaks.**
Capacitance reduction shows only **minor EMI differences** Figure 5. Figure 6 shows that **EMI disturbances start** to **appear after reaching** the **switching frequency** of **120 kHz**.

6. CONCLUSION

The analysis shows that a **minimum DC-link capacitance** of **690 μF** is **required** to ensure **stable voltage** and **current profiles**. At this capacitance, a total volume **reduction** of **46 %** of the **DC-link capacitor** is **achieved**. **EMI measurements** revealed **broadband noise** and **harmonic peaks**, though the **results** were strongly **affected** by **external measurement** factors and are **therefore not fully conclusive** for defining strict **capacitance limits**. **Thermal analysis** indicated **negligible impact** on the **semiconductors** due to effective water cooling, but at **390 μF** a clear **temperature rise** occurred in the **coupled inductor** as a result of **increased current ripple**. The **capacitors** themselves experienced **no thermal stress**.

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