

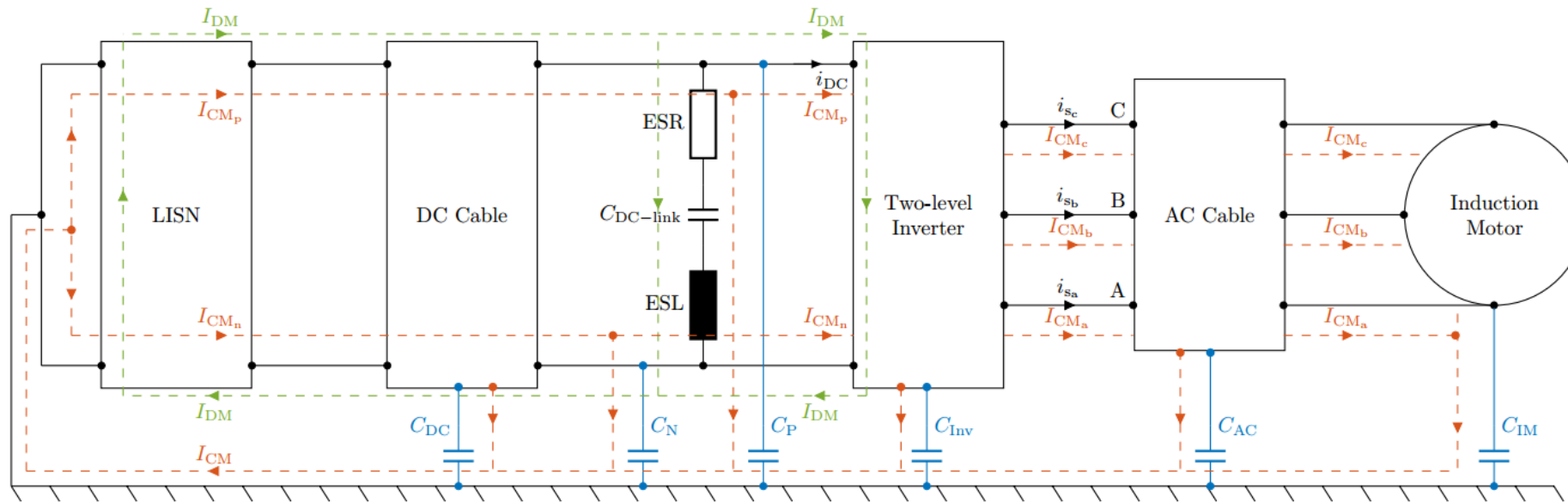
# Advanced EMI Prediction in 3-Phase Motor Drive Systems: A Unified Approach for CM and DM Noise Modeling

Abdelmoumin Allioua, Vefa Karakasli and Gerd Griepentrog  
Technical University of Darmstadt

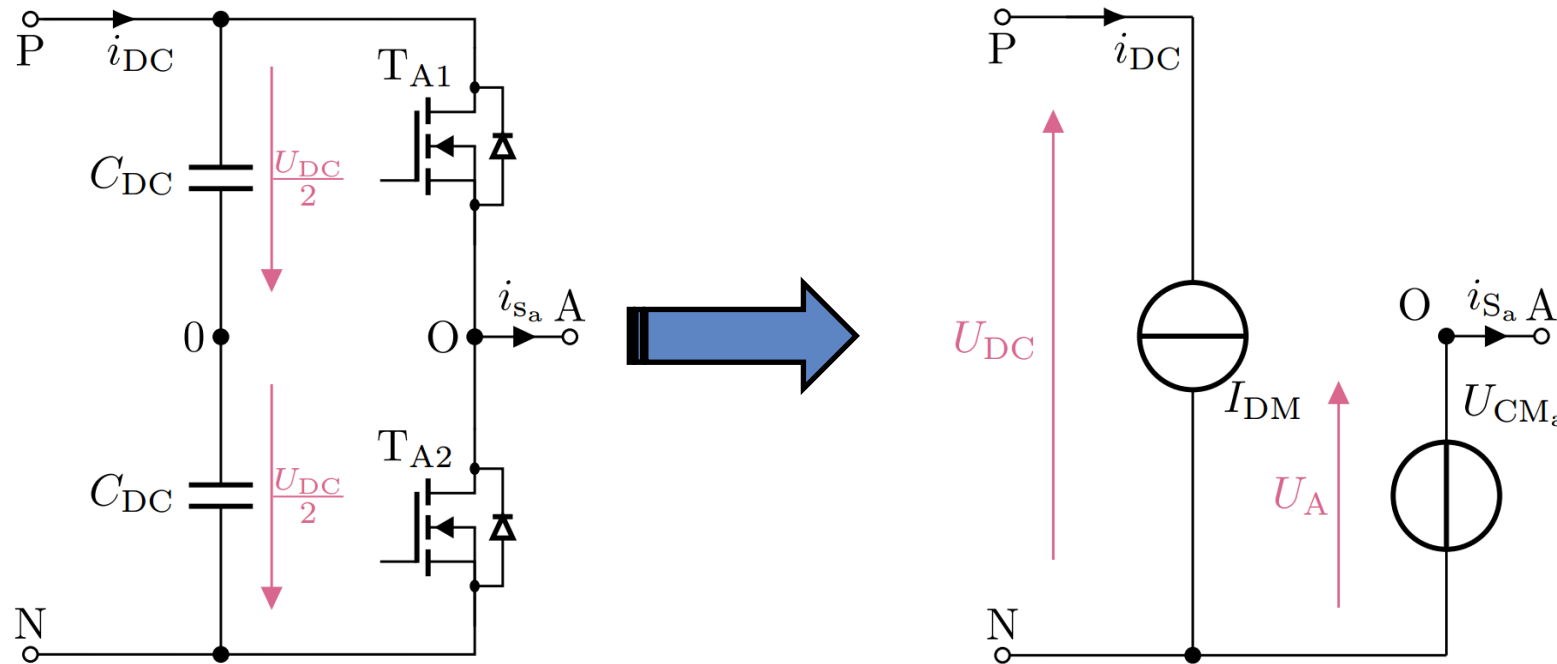
# Content

- **Motivation and Research Challenge**
- **Conventional vs. Proposed Unified EMI Models**
- **Performance Analysis**

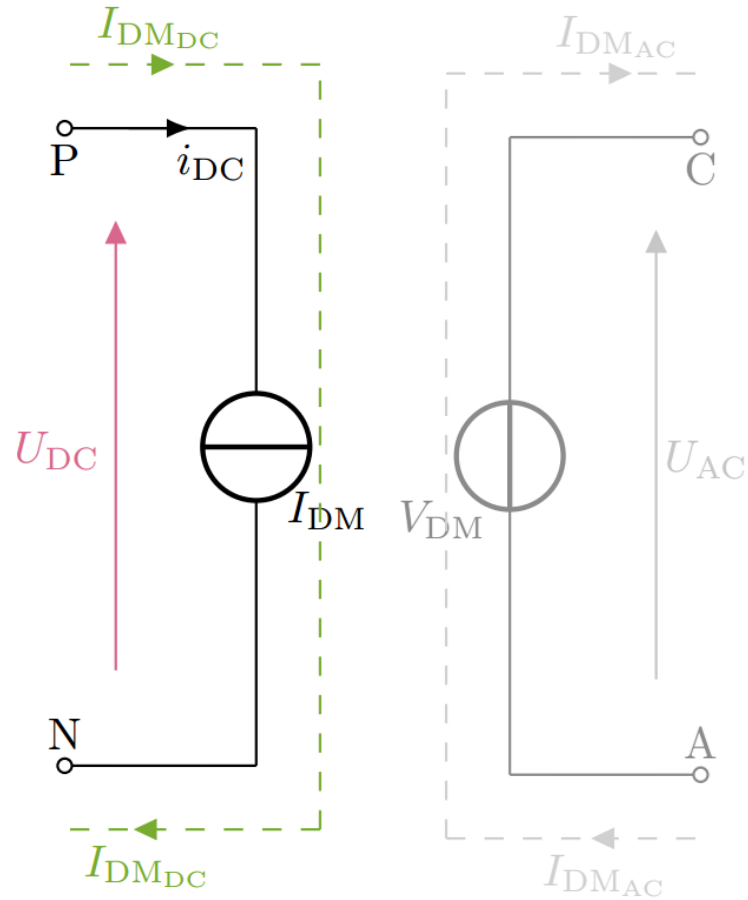
# AC Motor Drive Model - Noise Path



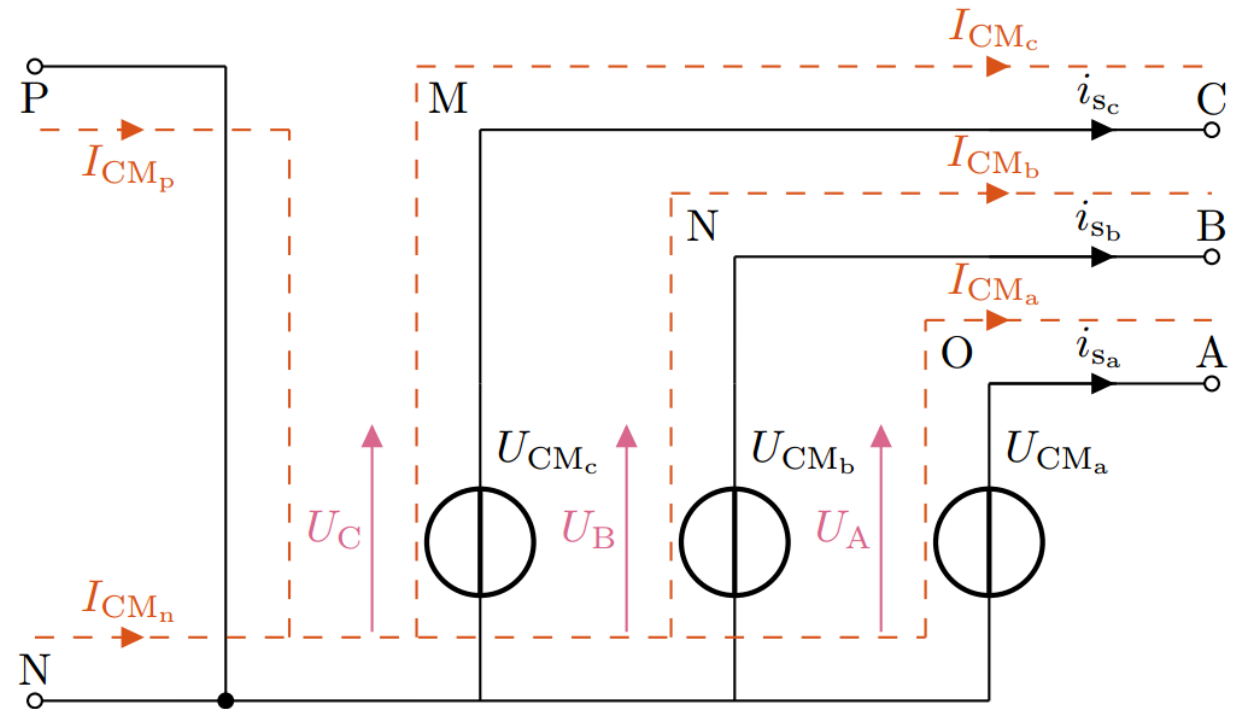
# Simplified FD-EMI Model



# Separate DM and CM Noise Models

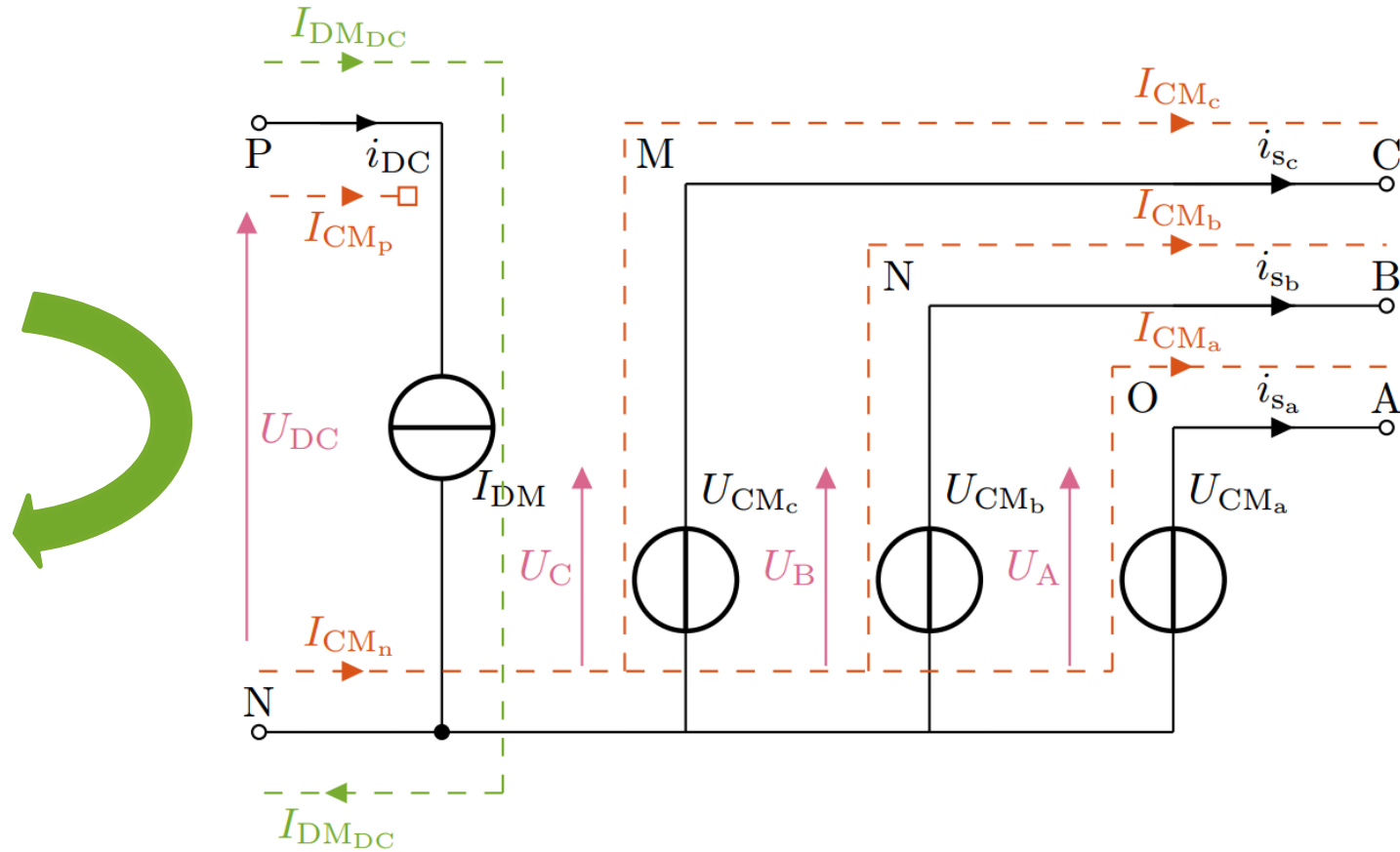


$$I_{DM} = S_a \cdot i_{S_a} + S_b \cdot i_{S_b} + S_c \cdot i_{S_c}$$

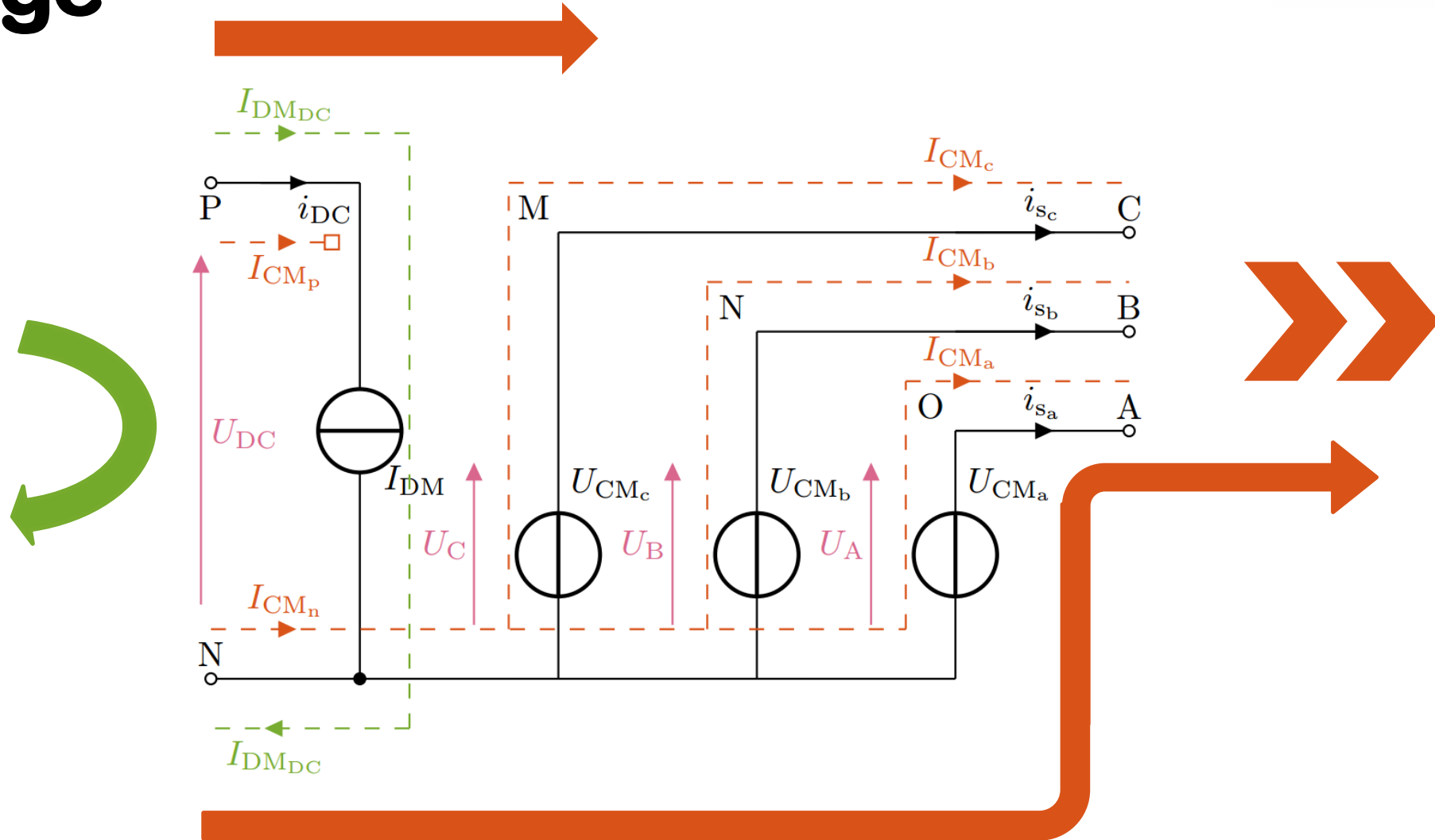


$$U_{CM} = \frac{U_{CM_a} + U_{CM_b} + U_{CM_c}}{3}$$

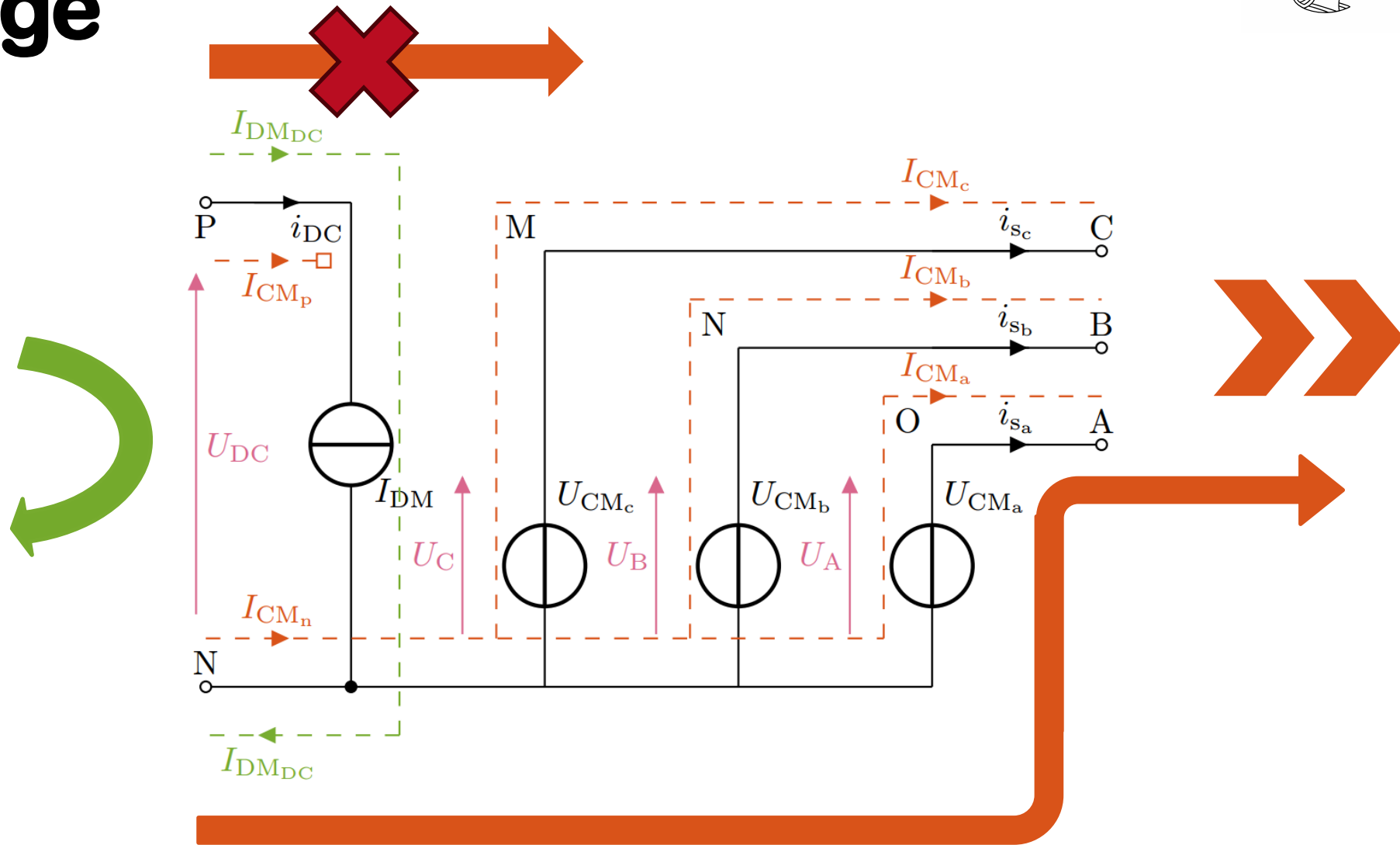
# Challenge



# Challenge

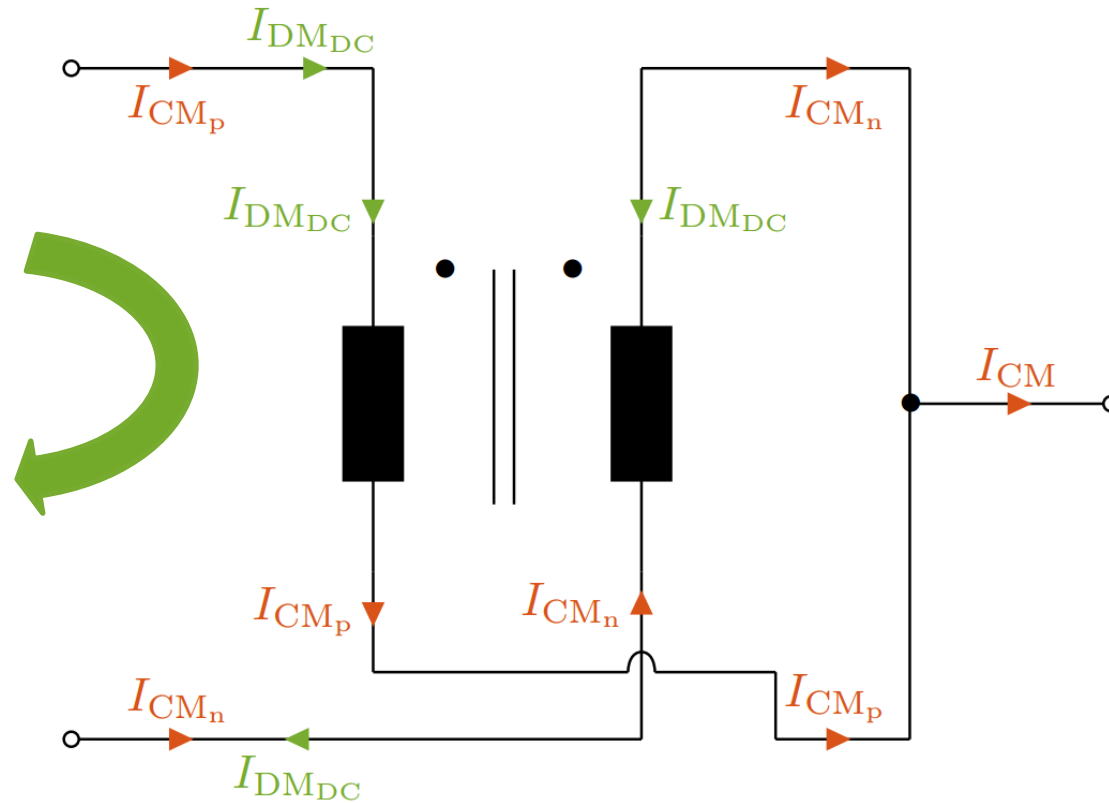


# Challenge

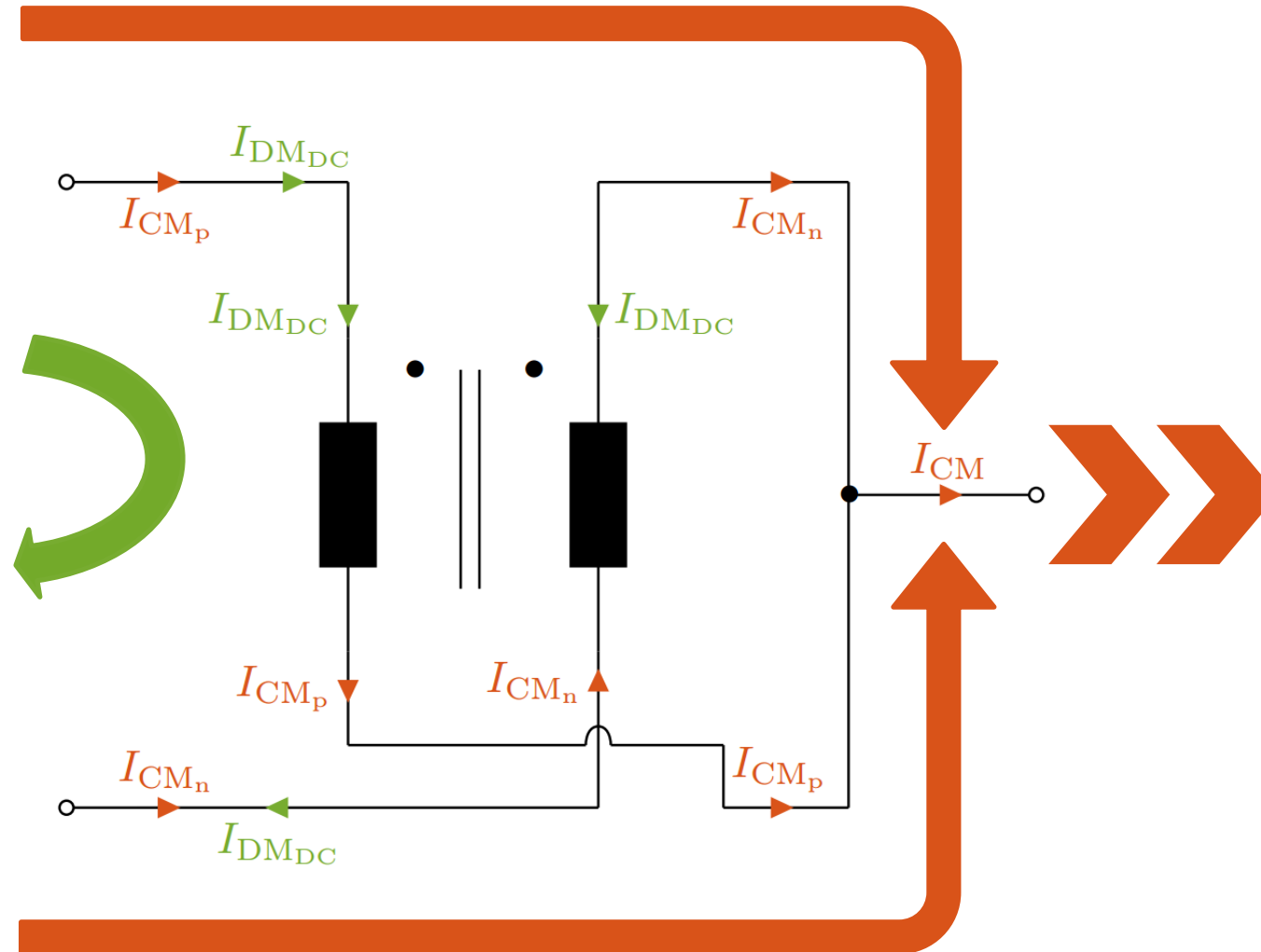




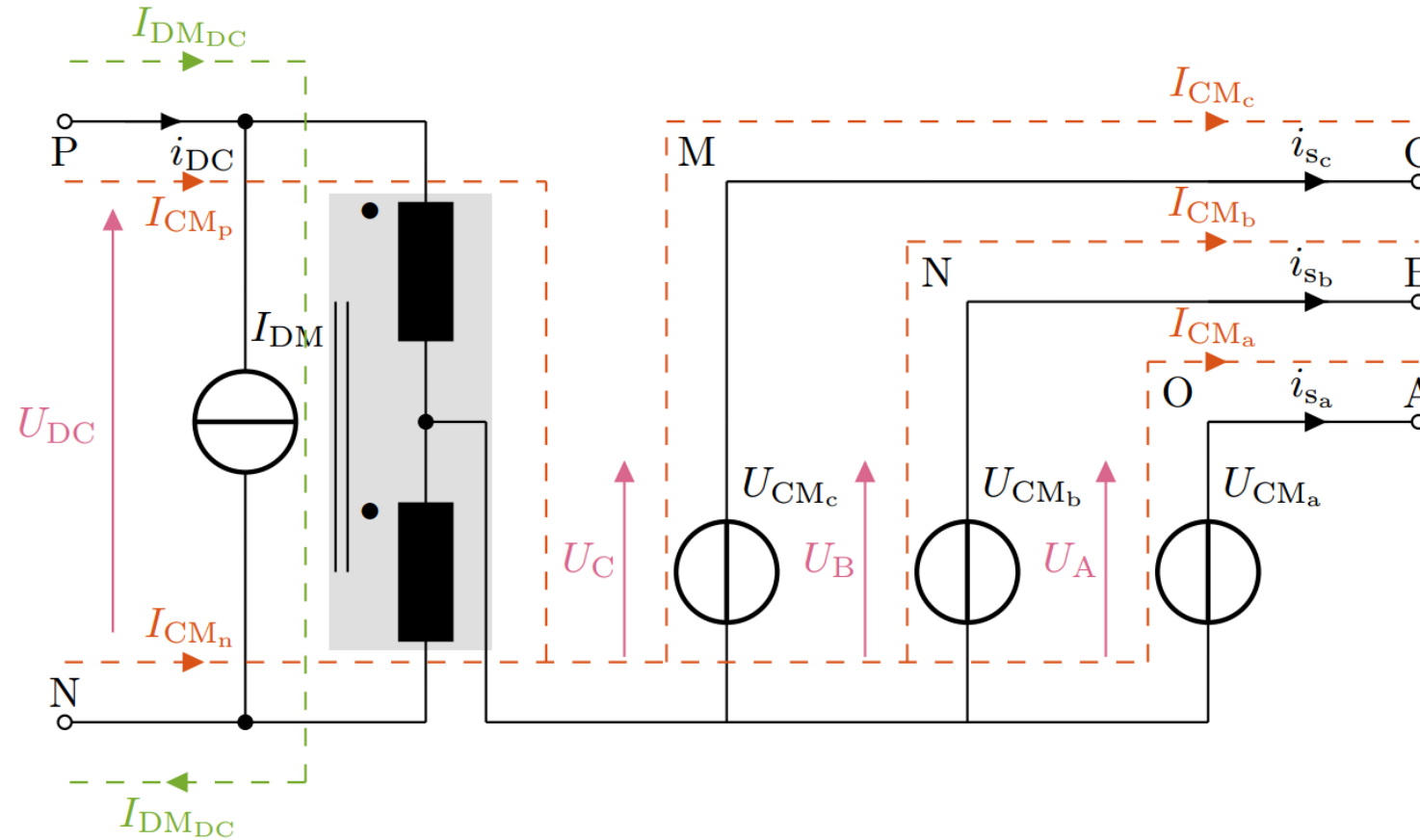
# Ideal Transformer Concept



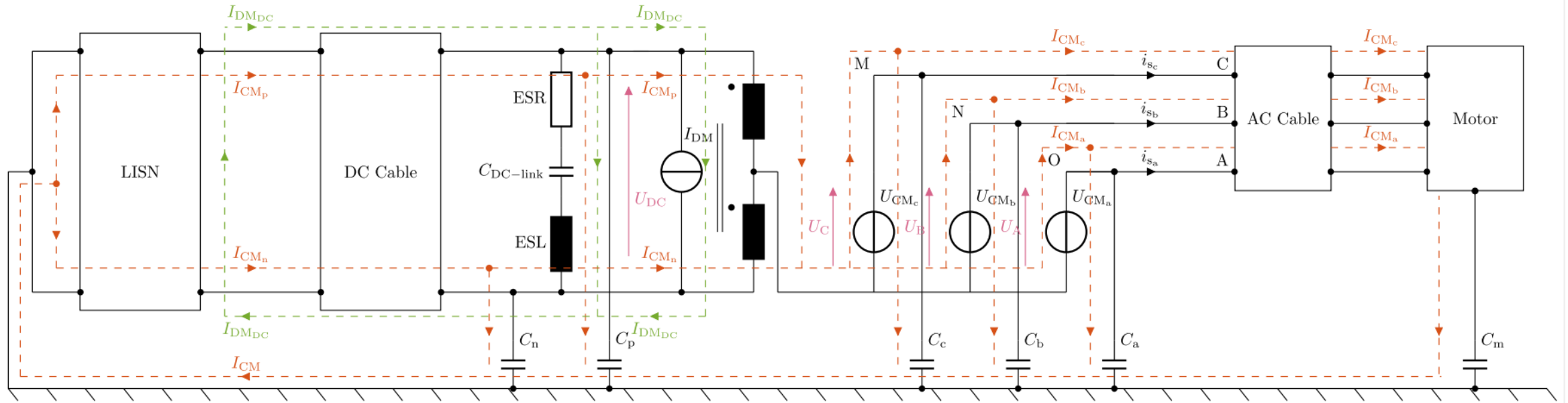
# Ideal Transformer Concept



# Unified Model



# Unified Full-Model

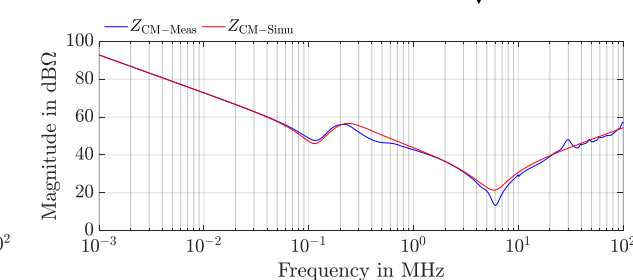
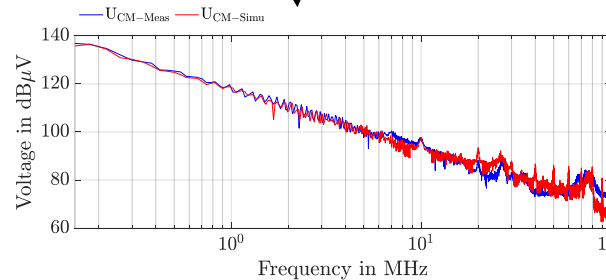
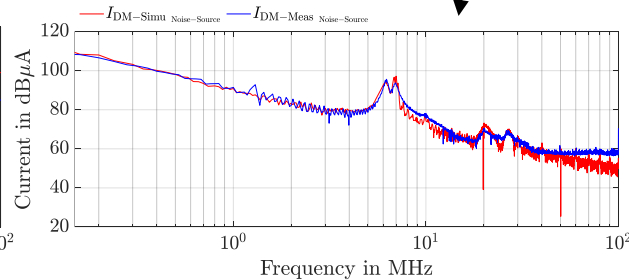
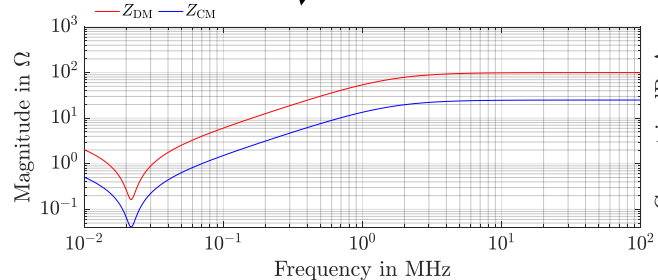
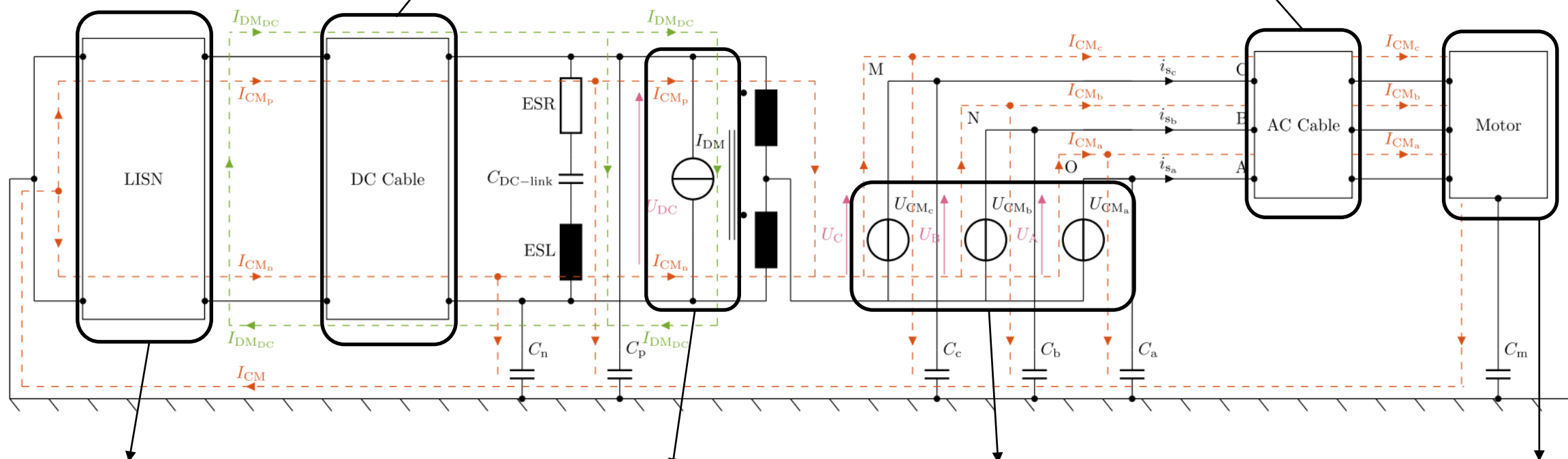
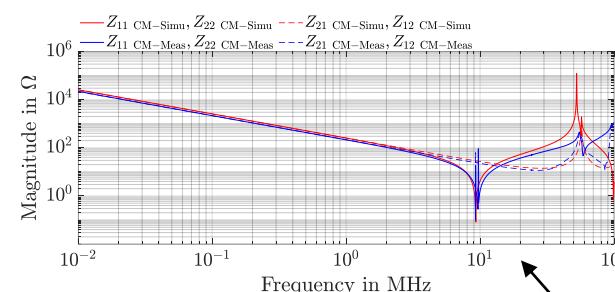
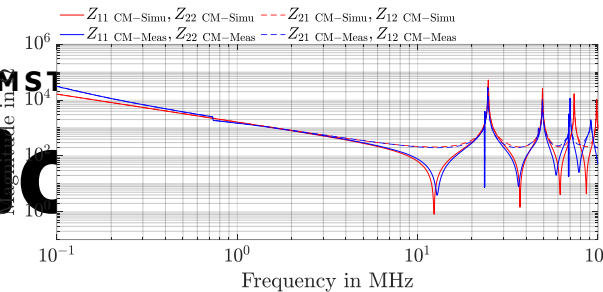


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# Unified Full-MC



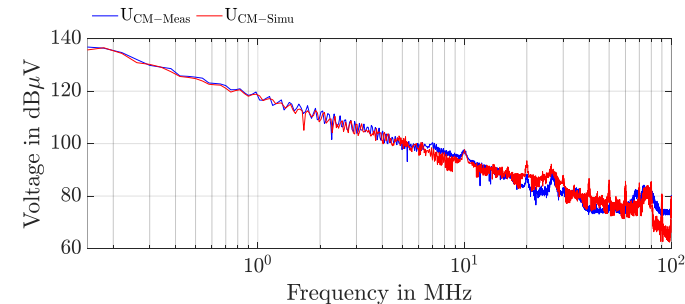
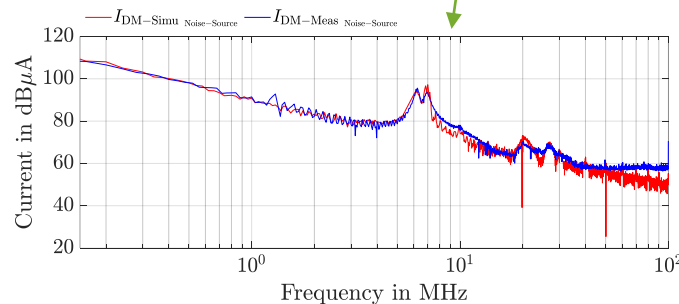
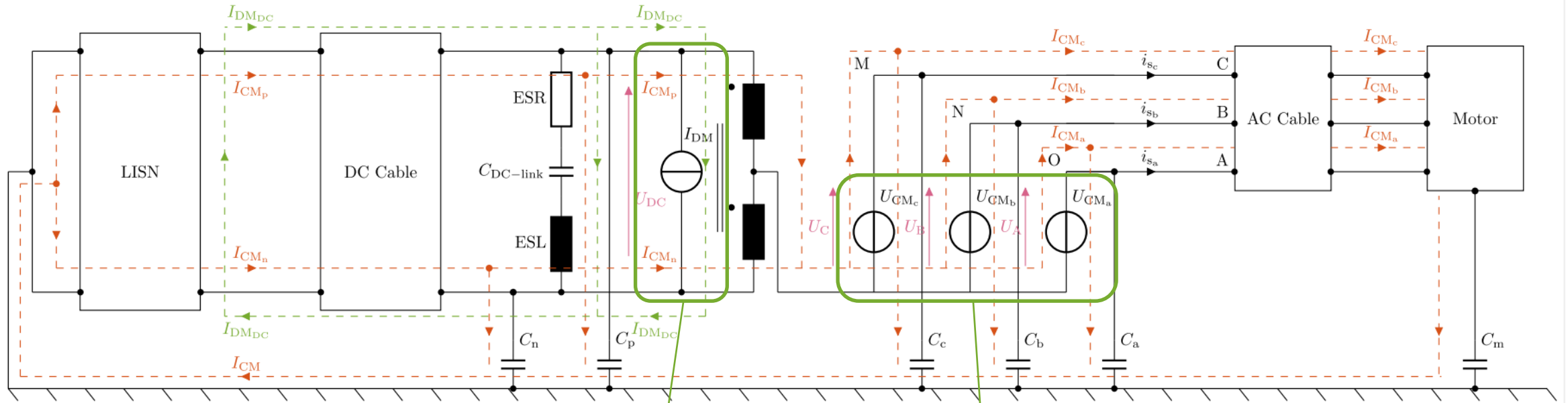
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# Unified Full-Model

[3] V. Karakaşlı, A. Jamal, G. Griepentrog and O. Safdarzadeh, "Common-Mode Voltage in Three-Level T-Type Inverter: Modeling, Analysis, and Compensation," 2024 IEEE APEC, Long Beach, CA, USA.

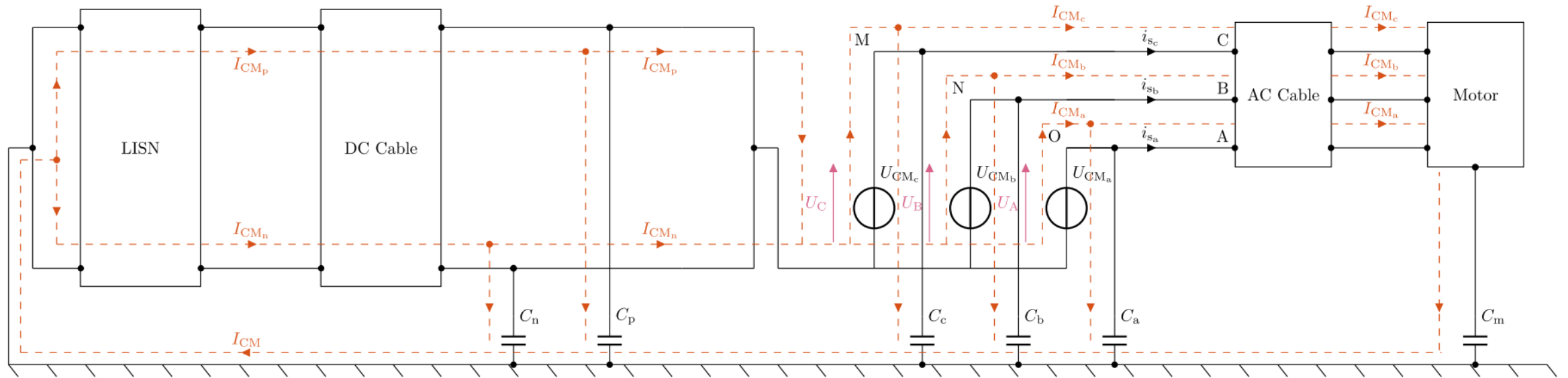
[4] V. Karakaşlı, A. Allioua and G. Griepentrog, "Common-Mode EMI Noise Modeling of Three-Level T-Type Inverter for Adjustable Speed Drive Systems," EPE'22 ECCE Europe, Hanover, Germany



# Performance Analysis

# Conventional vs. Unified EMI Model

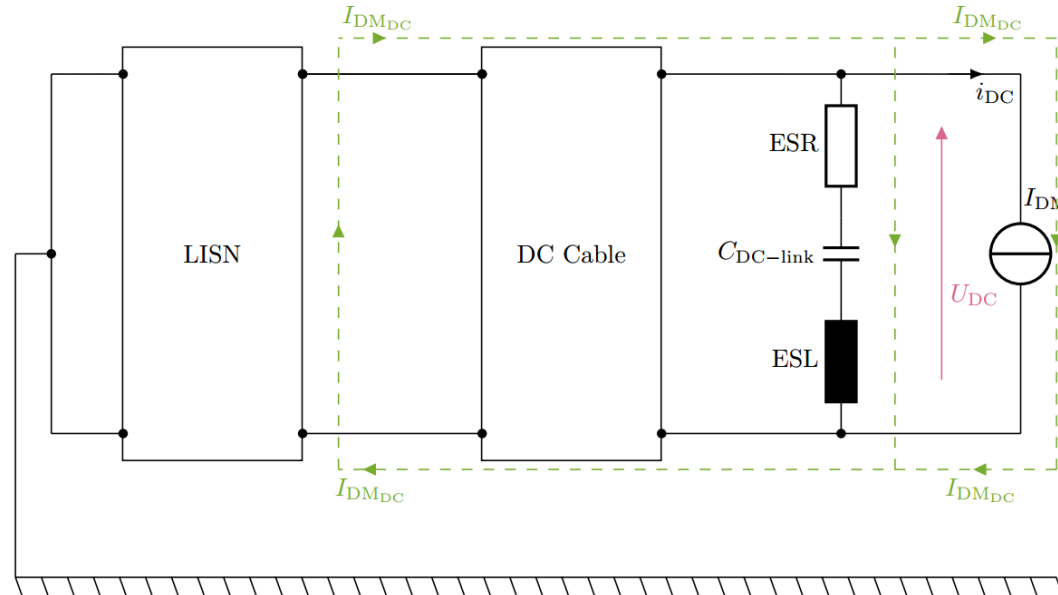
## Conventional CM





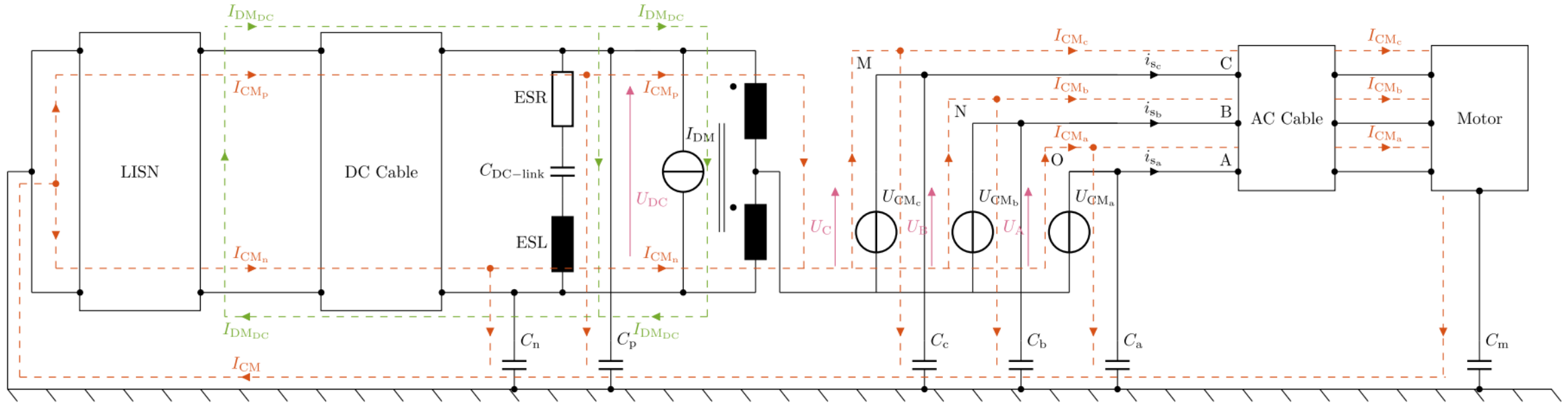
# Conventional vs. Unified EMI Model

## Conventional DM



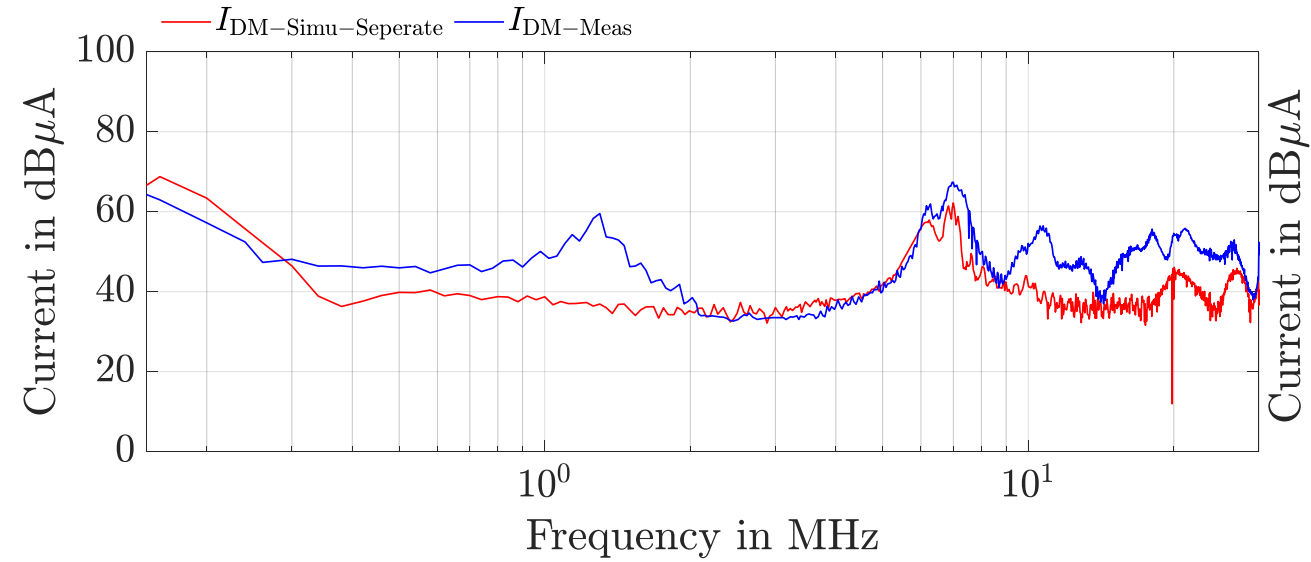
# Conventional vs. Unified EMI Model

## Unified EMI Model

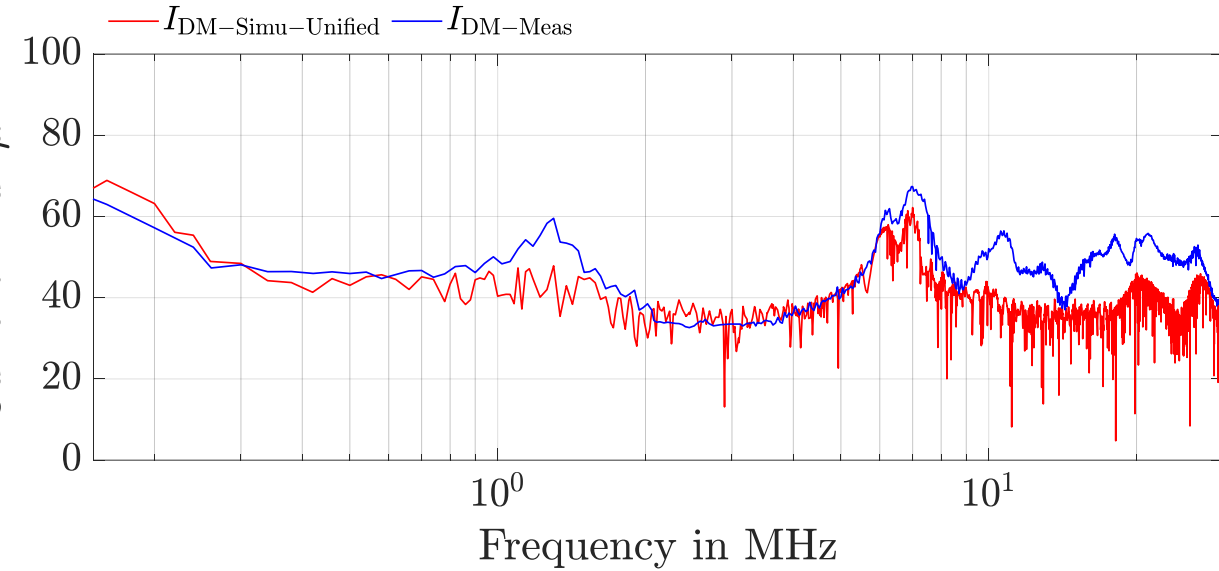


# DM Validation

## Conventional

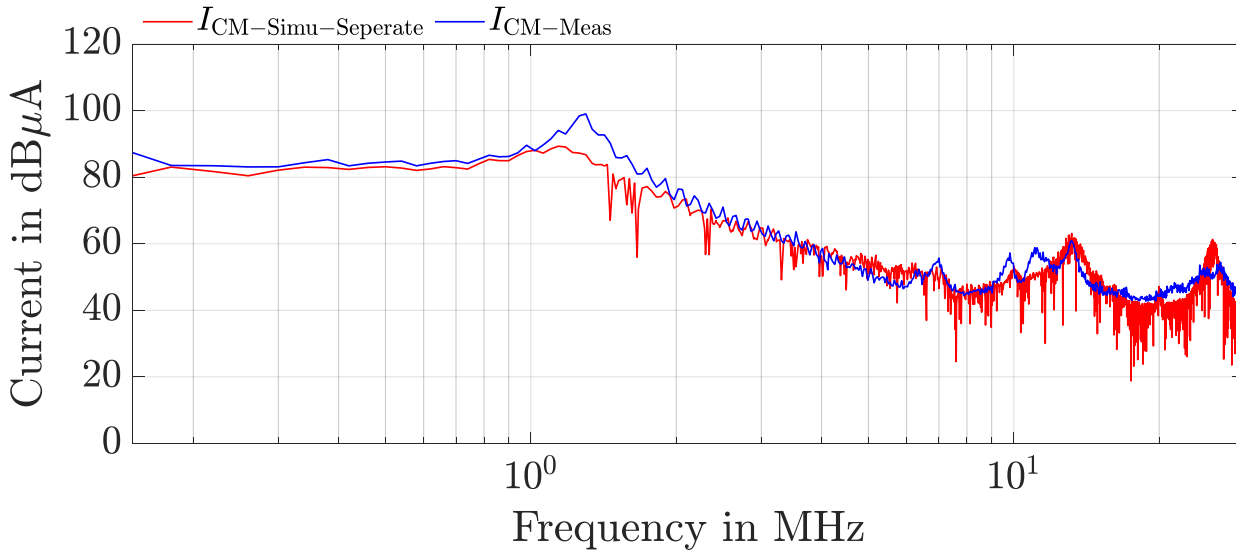


## Unified

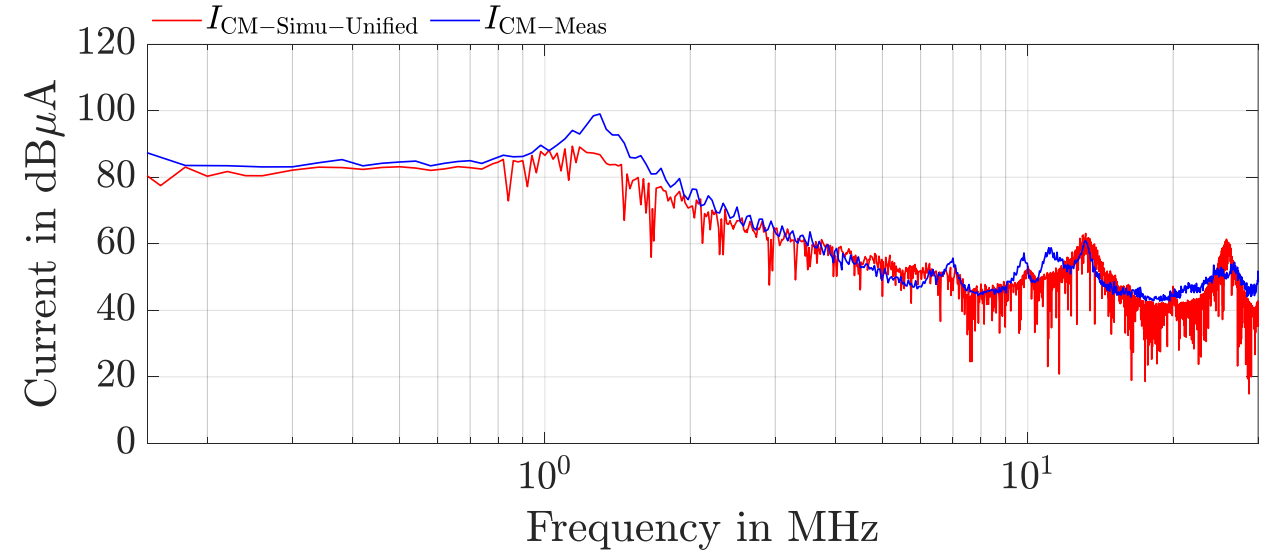


# CM Validation

## Conventional



## Unified



# Summary

- **Unified Model: Integrates DM, CM, and MM effect.**
- **Utility: Total EMI noise modeling, enhances EMI filters design.**
- **Future Expansions:**
  - **Includes AC side DM interactions for complete EMI analysis.**
  - **Extract the MM contribution separately.**

