

Proposed Master thesis

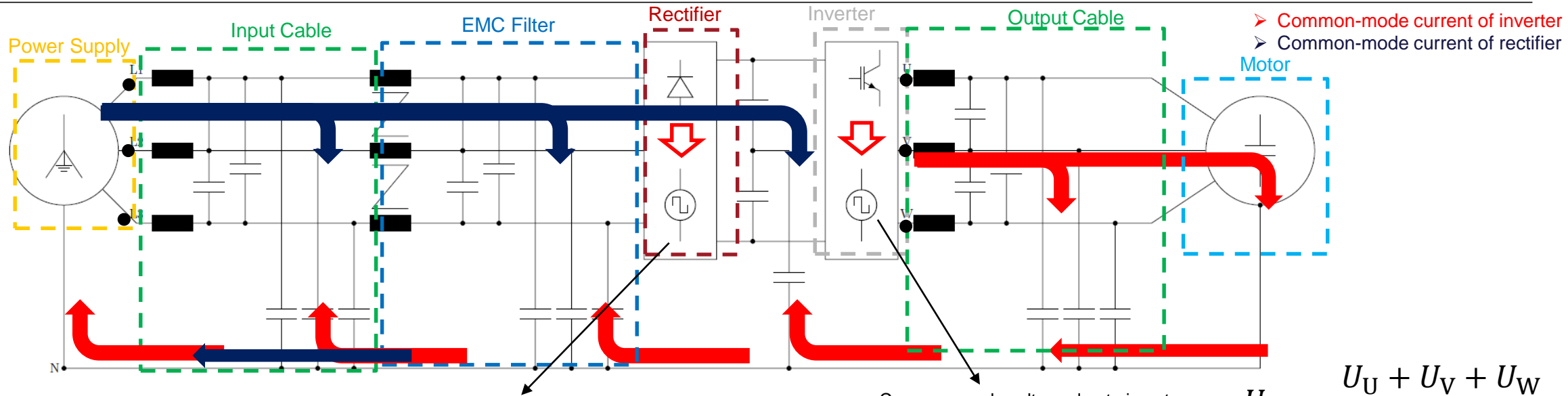
Andrea Zingariello, M.Sc

TU Darmstadt



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Electric motors and common-mode currents



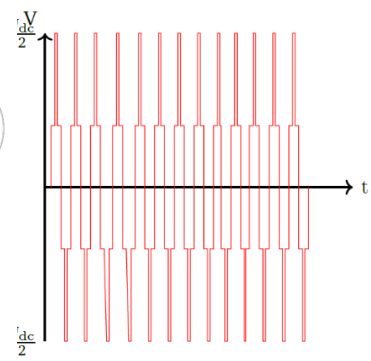
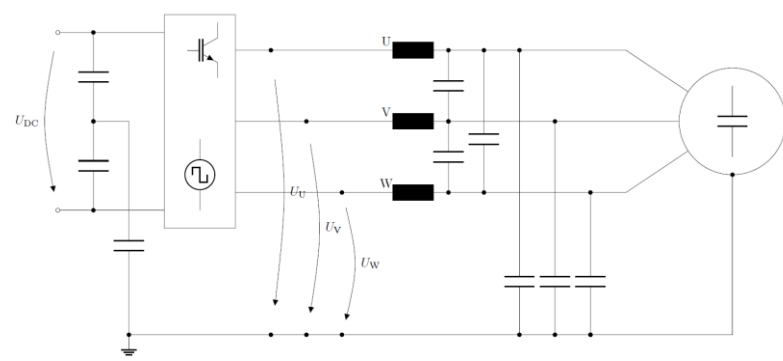
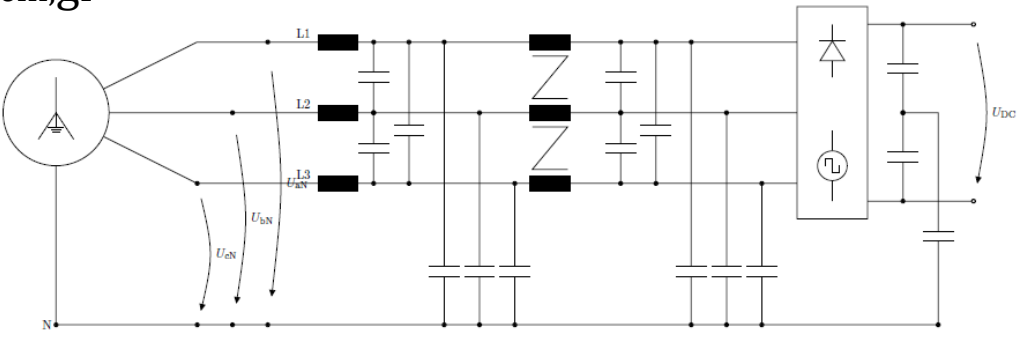
- Common-mode current of inverter
- Common-mode current of rectifier

$$U_{cm,gl} = \min(U_{aN}, U_{bN}, U_{cN})$$

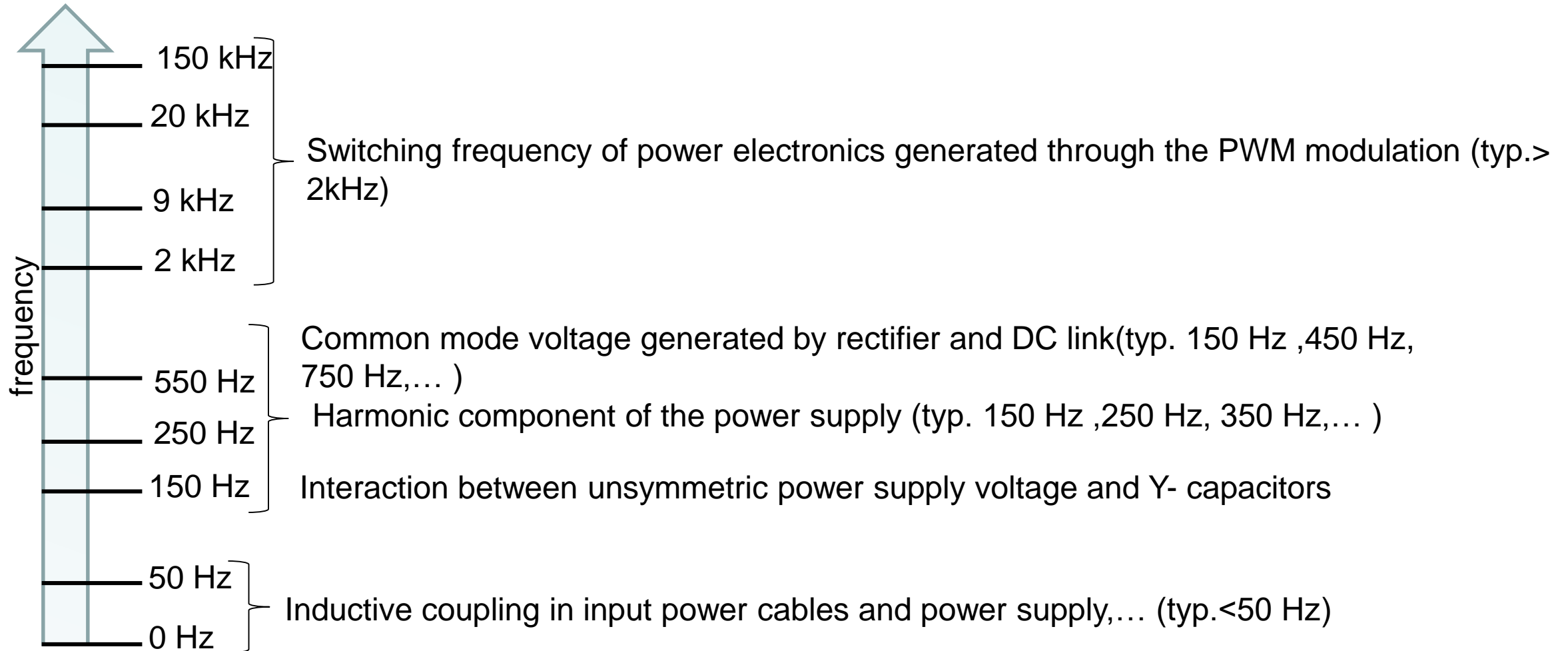
Common-mode voltage rectifier

Common-mode voltage due to inverter

$$U_{cm} = \frac{U_U + U_V + U_W}{3}$$

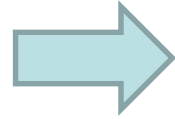


Frequency components of the common mode currents

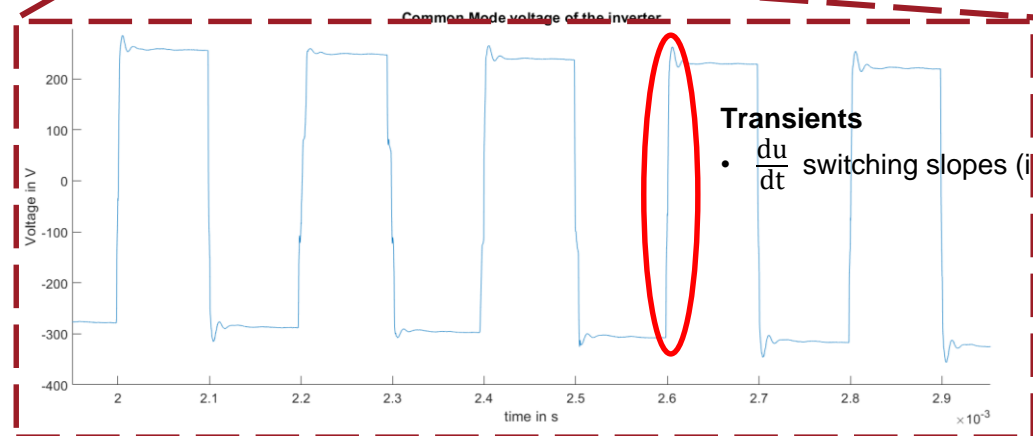
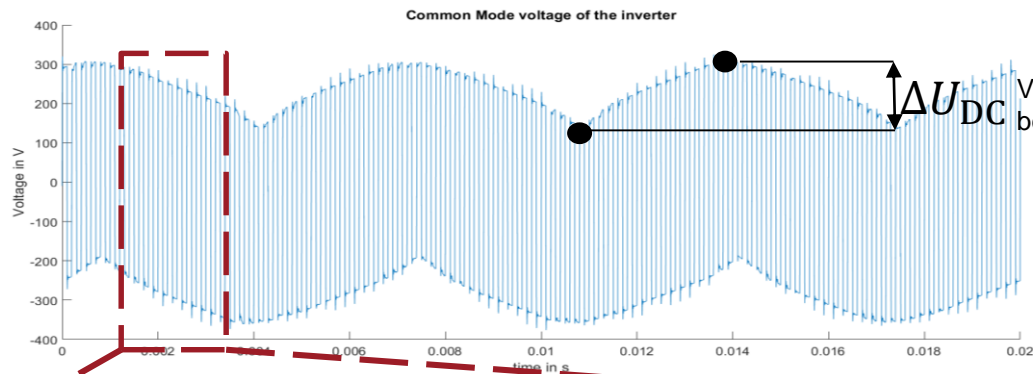


Common-mode (CM) voltage of the inverter

$$U_{cm} = \frac{U_U + U_V + U_W}{3}$$

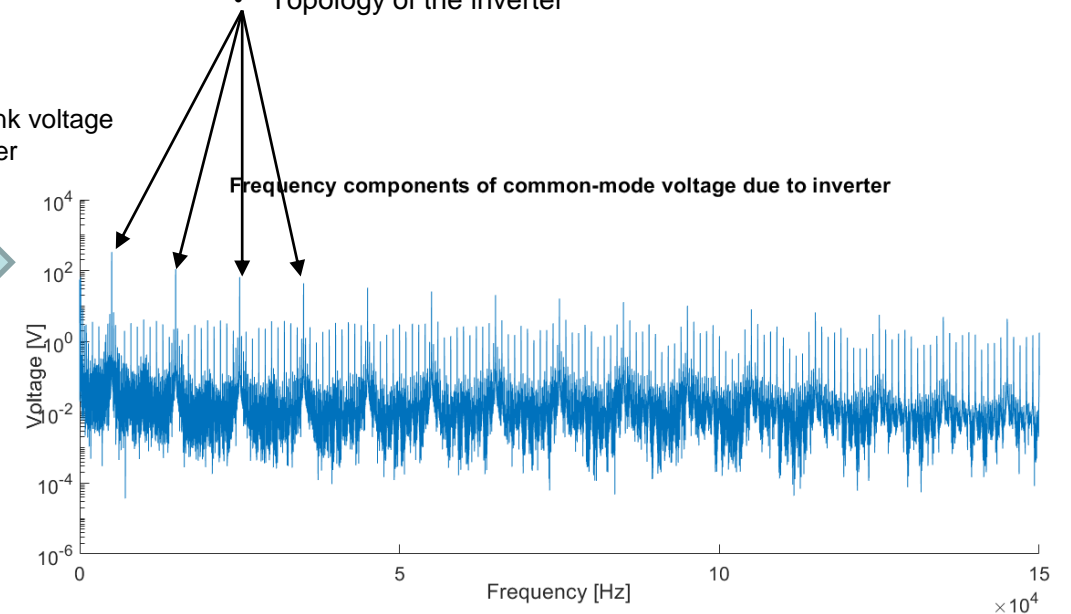


▪ The CM voltage is a staircase function with step $\pm \frac{1}{3} U_{DC}$ (U_{DC} = DC Link voltage)



Fundamental wave and harmonics

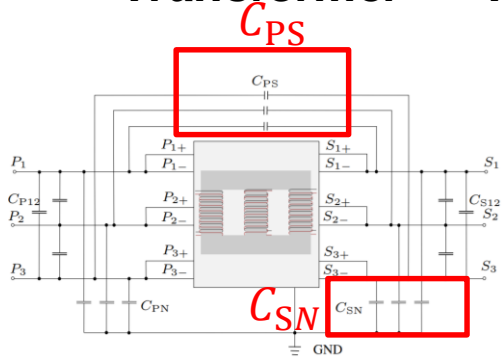
- Switching frequency (f_s) and harmonics ($3 \cdot f_s, 5 \cdot f_s$, etc)
- Modulation technique
- Topology of the inverter



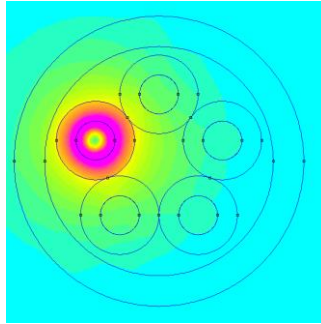
- Inverter adds common-mode voltage components at the switching frequency and its harmonics
- The kind of modulation also influences the frequency components

Propagation Paths

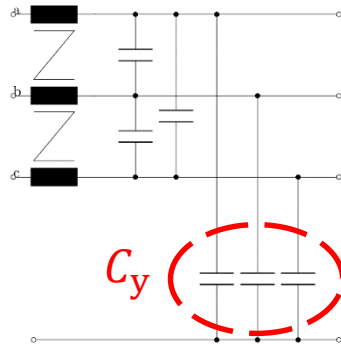
Transformer



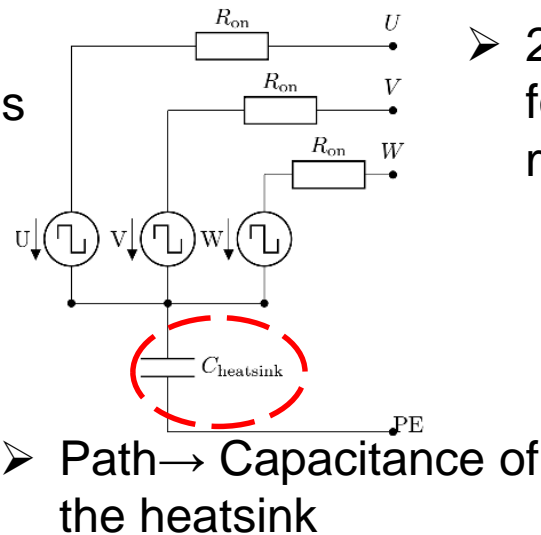
Input Cable



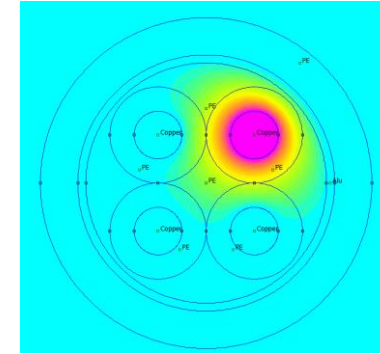
EMC Filter



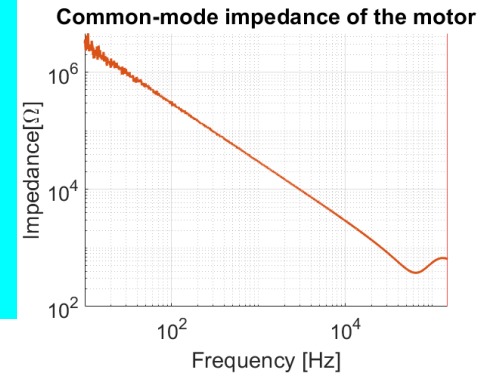
Converter



Output Cable



Motor



Induction motor
↓
Capacitive
behaviour for the
common-mode

- C_{ps} provides a coupling path for the common-mode between primary and secondary
- C_{ps} provides a coupling path for the common-mode between secondary side and ground

- 2 possible paths for the common-mode
 - PE wire
 - N wire

- C_y capacitances provides a path for the common-mode

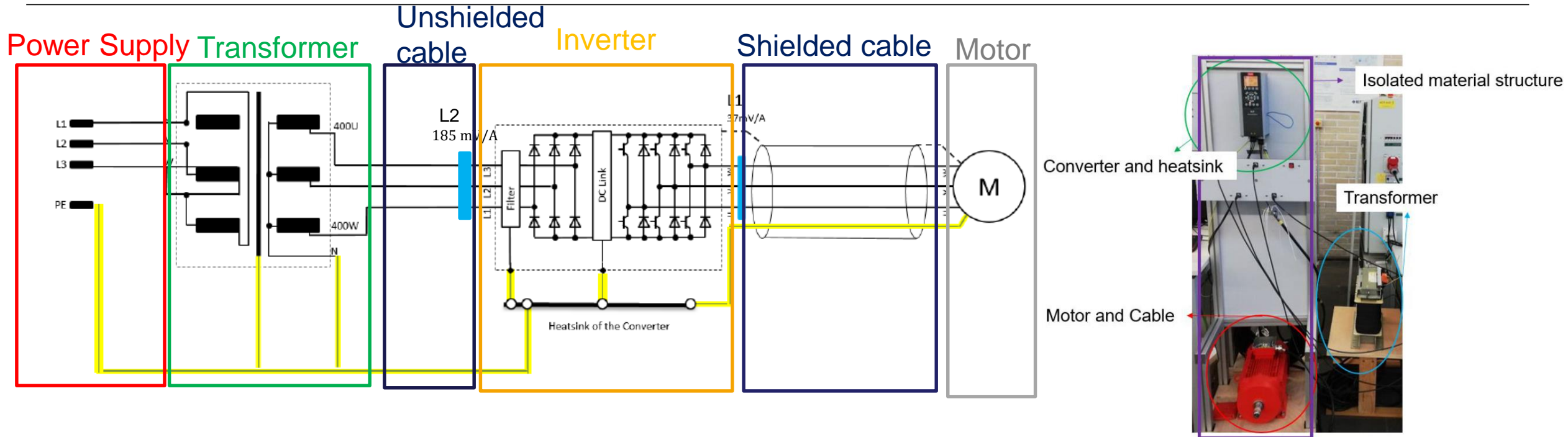
- 2 possible paths for the common-mode current:
 - PE wire
 - Shield

- Path → Capacitance of the heatsink



REFERENCE SYSTEM

Reference system



- The system is isolated → The whole common-mode current flows through the PE of the cable and the shield of the cable



PROPOSED MASTERTHESIS

Development of active zero PWM for reduction of the leakage current

Task

- Development of active zero state pulse width modulation
- Implementation of the active zero state in the system and testing

Requisites:

- Knowledge of Matlab and Simulink
- PLECS knowledge is a plus
- Experience in control of drives

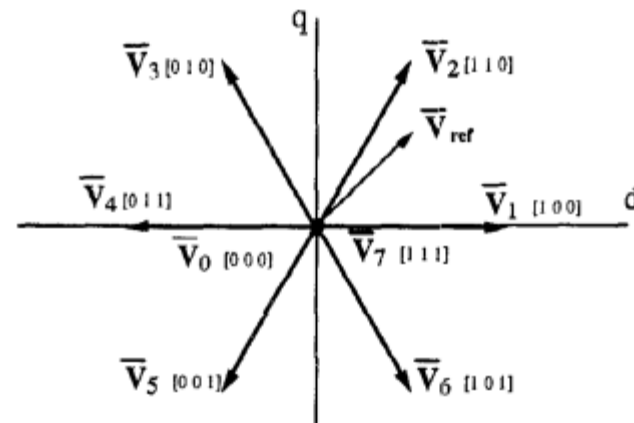


Fig. 5 Space vectors on the d q plane

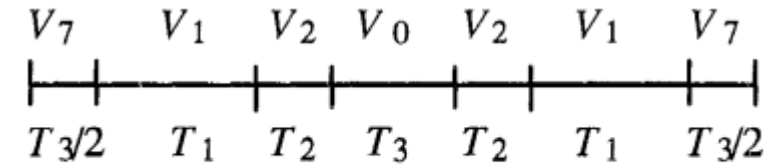


Fig. 6 Switching pattern for typical space vector modulation

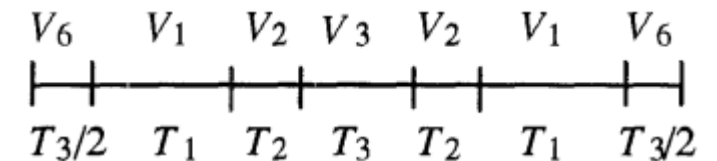


Fig. 7 Switching pattern for the first space vector modulation without the zero state