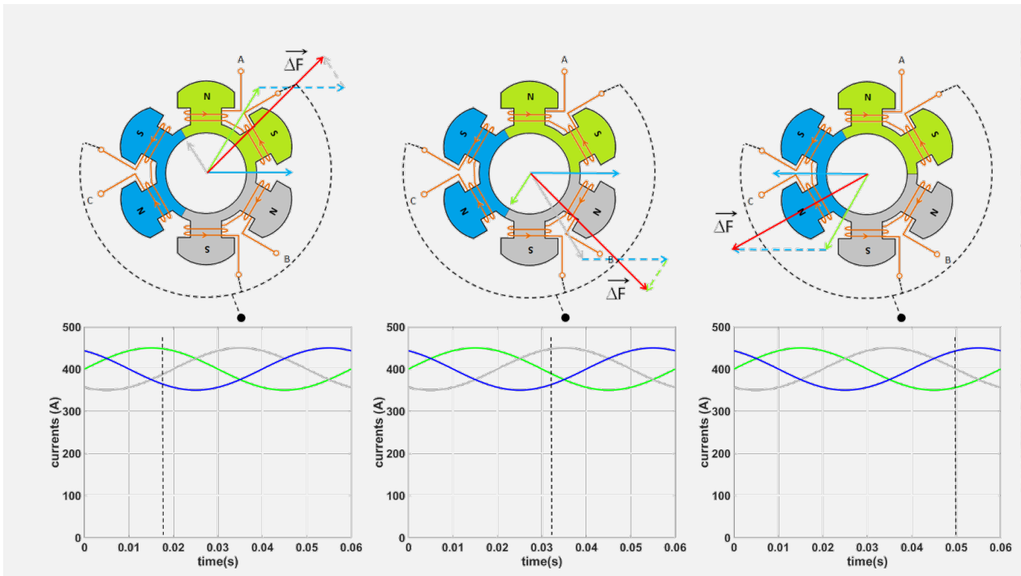
A salient pole rotor winding model for fast switching current control

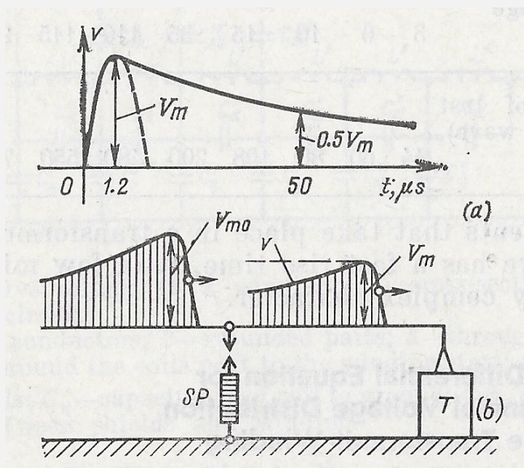
HydroFlex

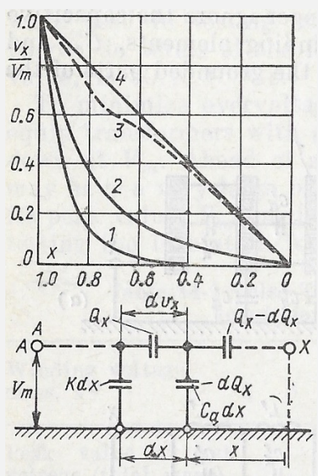
WHY?

Fast switching power electronics devices applied to the highly inductive field winding can produce unbearable stress for the winding insulation due to over-voltages or/and uneven voltage distribution. This needs to be assessed in advance.

Current control and electric stress of the insulation are related







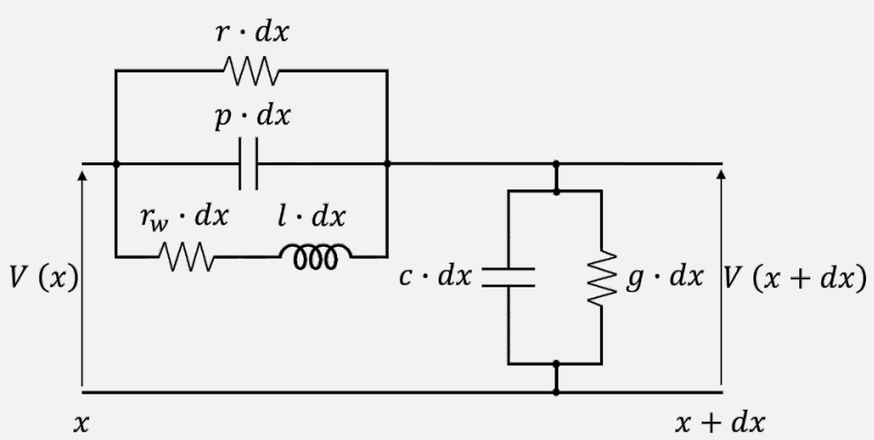
I.Smolensky, *Electrical machines*, MIR Publisher, vol.1, p. 171

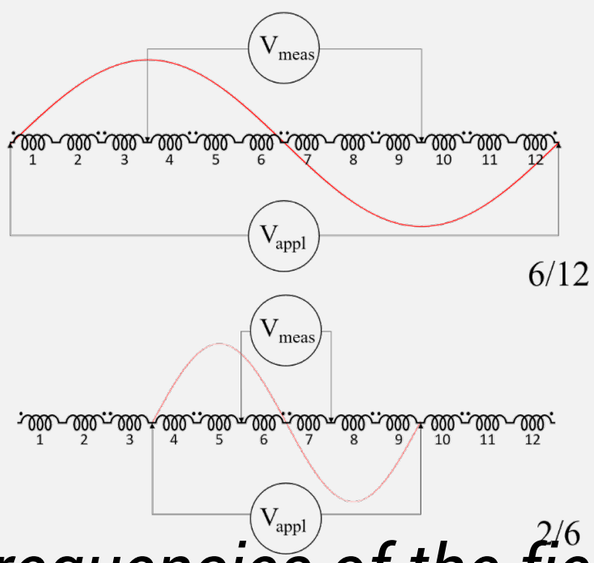
$$\left.\frac{\Delta V_m}{\Delta t}\right|_{light} = \frac{30\ kV}{1.2\ \mu s} = 25\ \frac{kV}{\mu s} \qquad \left.\frac{\Delta V_m}{\Delta t}\right|_{SiC} = 10 \div 50\ \frac{kV}{\mu s}$$

WHAT?

Single Transmission Line Model is simple, well known, is able to reproduce the winding behavior on a wide range of frequency and takes into account the modal dispersion of travelling waves.

Single Transmission Line Model for the field winding



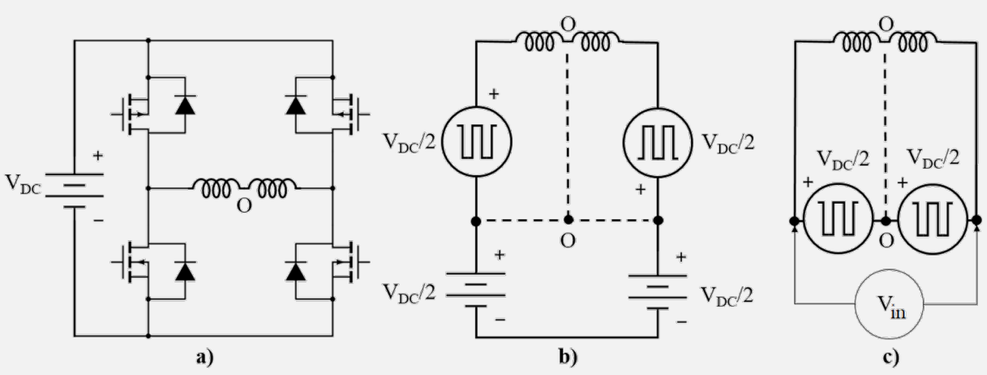


$$\omega_{1,1/2} = \frac{1}{\sqrt{\left(\frac{a/2}{\pi}\right)^2 lc + \frac{l}{p}}} \qquad \omega_{1,1/4} = \frac{1}{\sqrt{\left(\frac{a/4}{\pi}\right)^2 lc + \frac{l}{p}}}$$

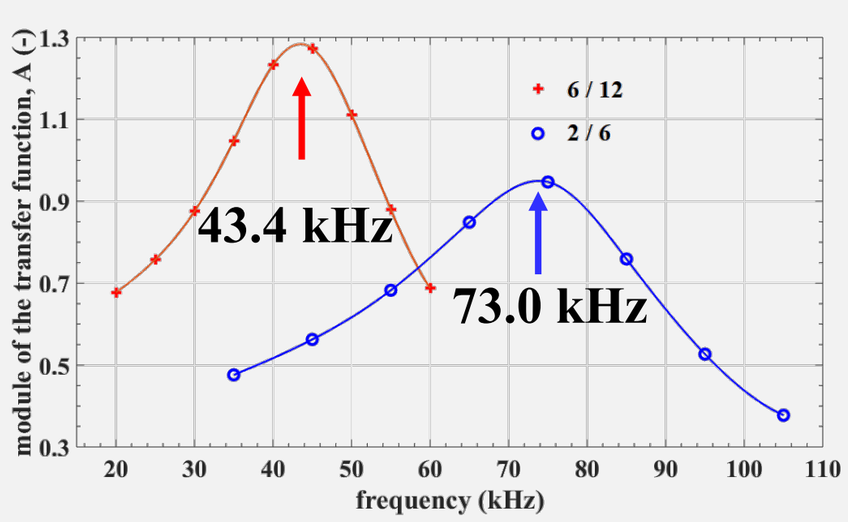
HOW?

The distributed parameters of the model are determined by exciting the fundamental Eigen frequencies of different portions of the field winding by means of a chirping single phase square wave inverter.

Exploring the own resonance frequencies of the field winding



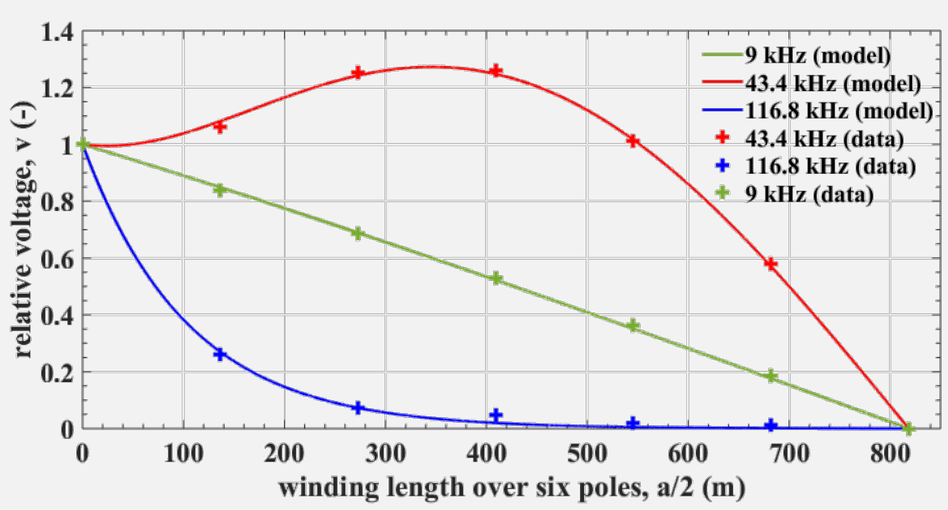
a) supplying circuit
b) equivalent representation
c) dynamic circuit without DC-bias

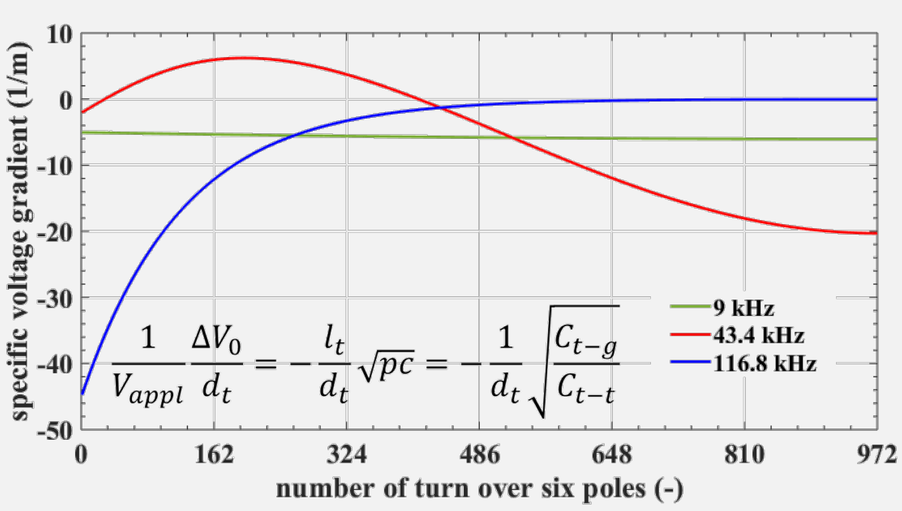


AND?

The obtained model has been experimentally validated and it has proved to fit very well the measured values over a wide range of frequency. From the voltage profiles was possible to gain the specific distribution of the electric field strength along the winding at different frequencies.

An experimentally validated model for assessing the insulation stress





$$\frac{1}{V_{appl}}\frac{\Delta V_0}{d_t} = -\frac{l_t}{d_t}\sqrt{pc} = -\frac{1}{d_t}\sqrt{\frac{C_{t-g}}{C_{t-t}}}$$

Authors: Roberto Felicetti, Johan Abrahamsson, Urban Lundin
Institution: Uppsala University
Date:: 07-05-2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764011.