Motor Technology and Electrical Application Criteria for EC Motors

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Presentation Outline

01 ebm-papst

02 Applications

03 Motor Topologies

04 EC motor: Electronics & Drive topology

05 Electrical environmental requirements to EC-motors

Engineering a better life

We combine sustainable and intelligent products to create plug-and-play solutions

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Engineering a better life

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Sustainable Solutions

Pioneer Spirit

Intelligent Technology

Customized Solutions
Plug & Play

=

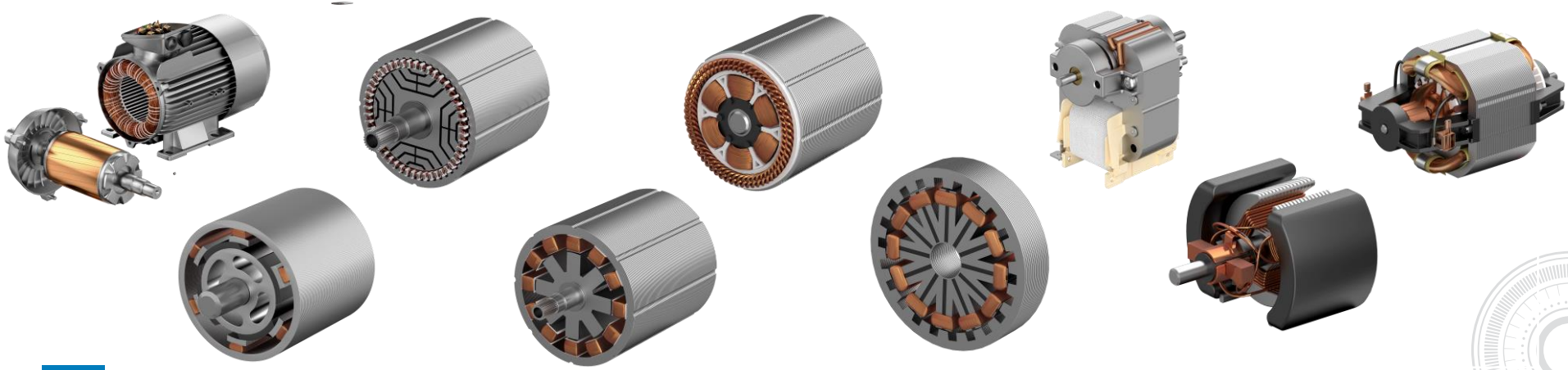
ebmpapst


AIR TECHNOLOGY
HEATING TECHNOLOGY
Air Conditioning & Commercial Ventilation
Refrigeration
Transportation
Indirect & Digital Sales
Natural & Synthetic Gas Technologies
Cleanroom
Residential Ventilation
Renewable Energies
Biomass
Industry & ICT
Heat Pumps
Efficient system solutions for our markets

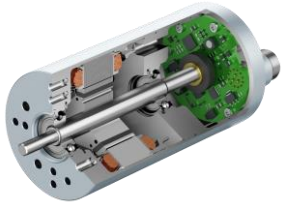
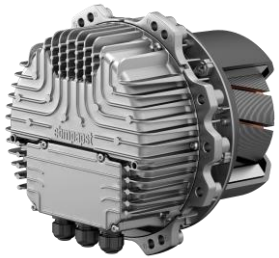
Motor Types and Types of construction

important & relevant Motor topologies / Torque generation principles

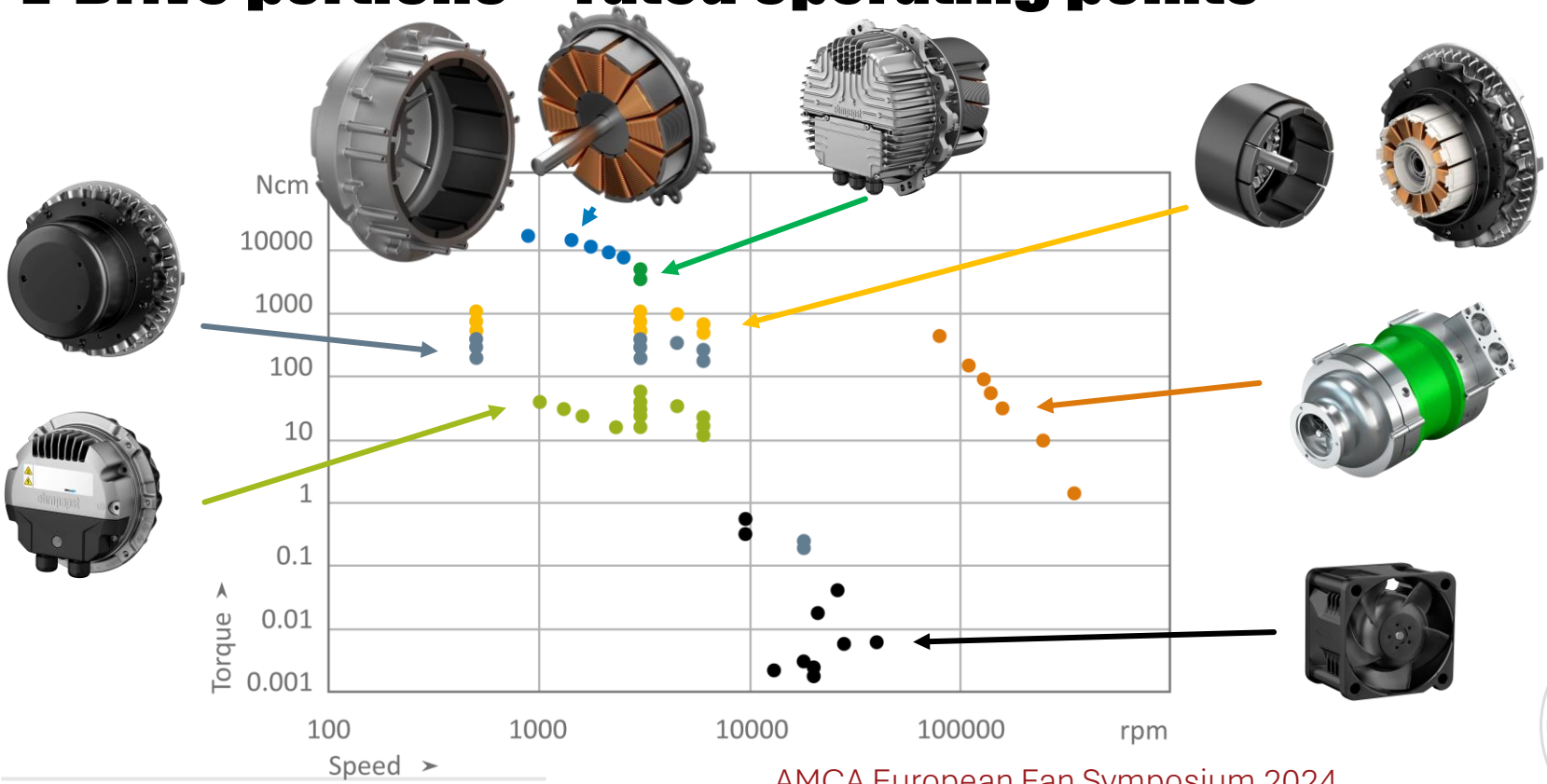
Induction machine (IM, ASM)	**Permanent magnet synchronous machine** (PMSM)	**Synchronous reluctance machine** (SRM)	**Switched reluctance machine** (SRM)	**Electric excited synchronous machine** (EESM)	**Flux switching machine**	**Shaded pole machine**	**DC machine** (with brushes)	**Universal machine** (with brushes)
Lorentz Force	Force on PM	Force on Iron	Force on Iron	Lorentz Force	Force on PM	Lorentz Force	Force on PM	Lorentz Force



Geometrical Motor Designs

	Inner rotor	External rotor	Dual rotor	Diagonal rotor	Disk rotor
Magn. flow direction	Radial	Radial	Radial	Diagonal	Axial
					

E-Drive portfolio – rated operating points

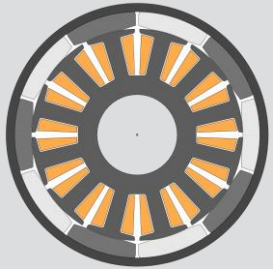


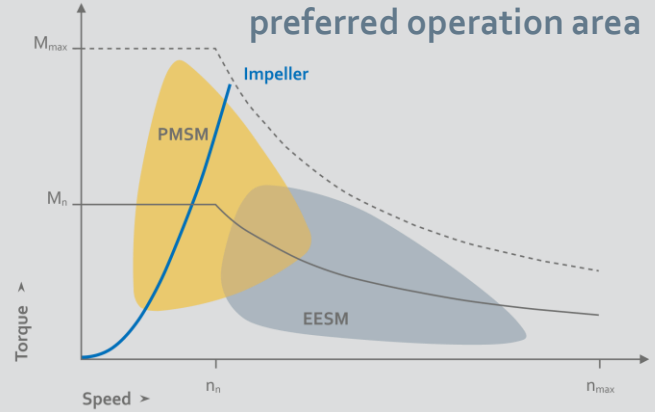
Motor Topology I

Electric Excited Synchronous Machine (EESM)

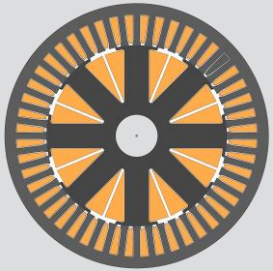
Moving coils instead of permanent magnets

PMSM





EESM



Conclusion

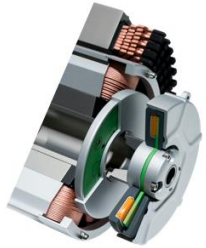
EESM not suitable for fan application because of load profile

Additional efforts for energy transfer into rotor

BMW (1)

ZF (2)

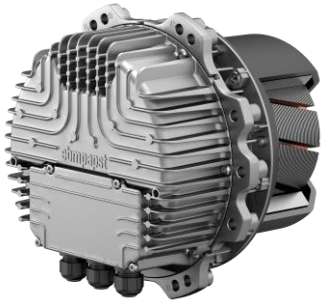
Mahle (3)

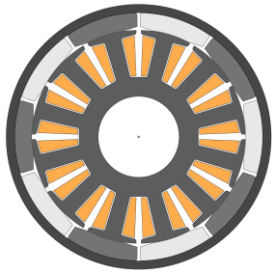


(1) BMW changes its electric motor concept with the iX3
(2) ZF makes magnet-free electric motor uniquely compact and competitive
(3) MAHLE develops highly efficient magnet-free electric motor - MAHLE Newsroom

Motor Topology II

Axial Flux Machine





		Axial Flux E-Drive	ebm-papst M3G200HF
Motor Type		PMSM	PMSM
Flux direction		Axial Flux	Radial Flux
Motor Topology		pancake motor	external rotor motor
Power	kW	8	8
Speed	rpm	1800	1800
Performance & Cooling		comparable	comparable
Volume	l	51	16
Diameter	mm	526	250-340
Length	mm	213	320
Weight	kg	68	42
Magnet Material		Rare Earth magnets	Ferrite magnets

EC motor: Electronics & Drive topology

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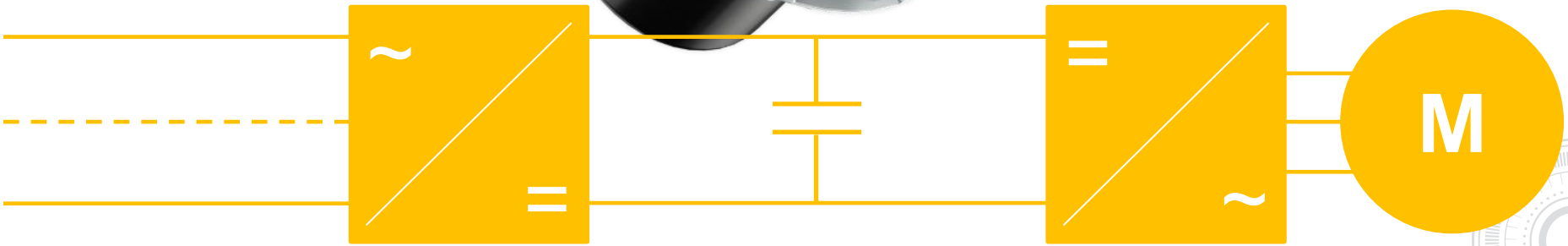
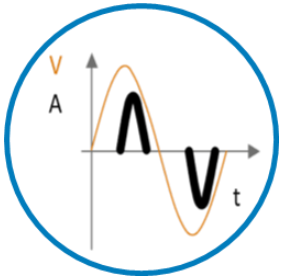
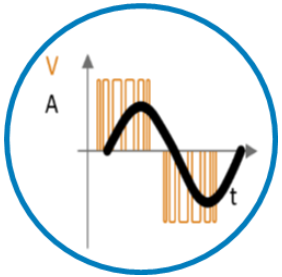
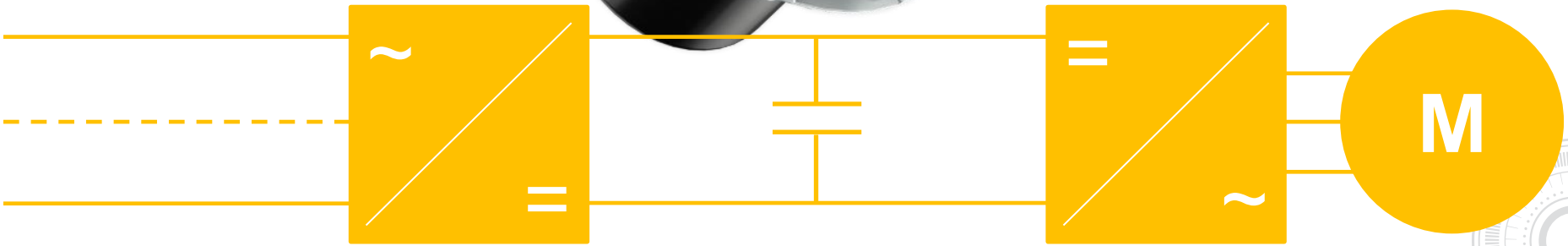


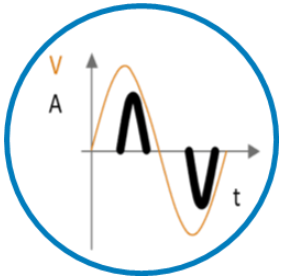
EC motor: Electronics & Drive topology



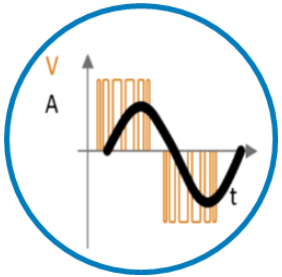




EC motor: Electronics & Drive topology



controls
&
protection



EMC
input filter

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=

=
~

M

EC motor: Electronics & Drive topology

+ compact drive unit
+ excellent drive efficiency
+ easy to use: plug & play
+ extra low noise
+ variable speed ability
+ closed loop control functions
+ motor protection integrated

- fits into electrical environment?
- Interactions with the power supply?
- leakage currents?
- current harmonics?
- EMC: emissions and protection?

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Electrical environmental requirements to EC-motors

- Voltage dips
- energy supply performance
- EMC requirements & current harmonics
- static and dynamic over voltages
- leakage current limitations

Electrical environmental requirements to EC-motors

Voltage dips

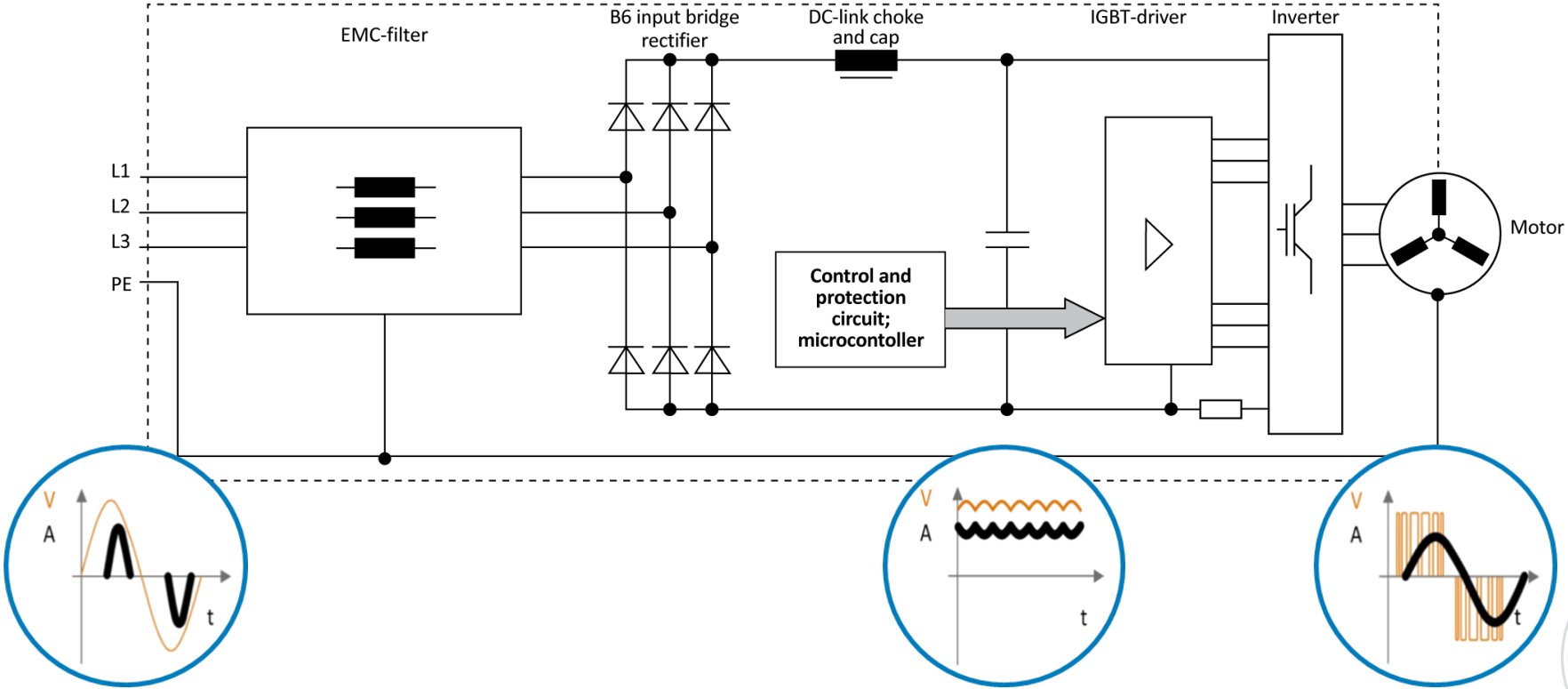
energy supply performance

EMC requirements & current harmonics

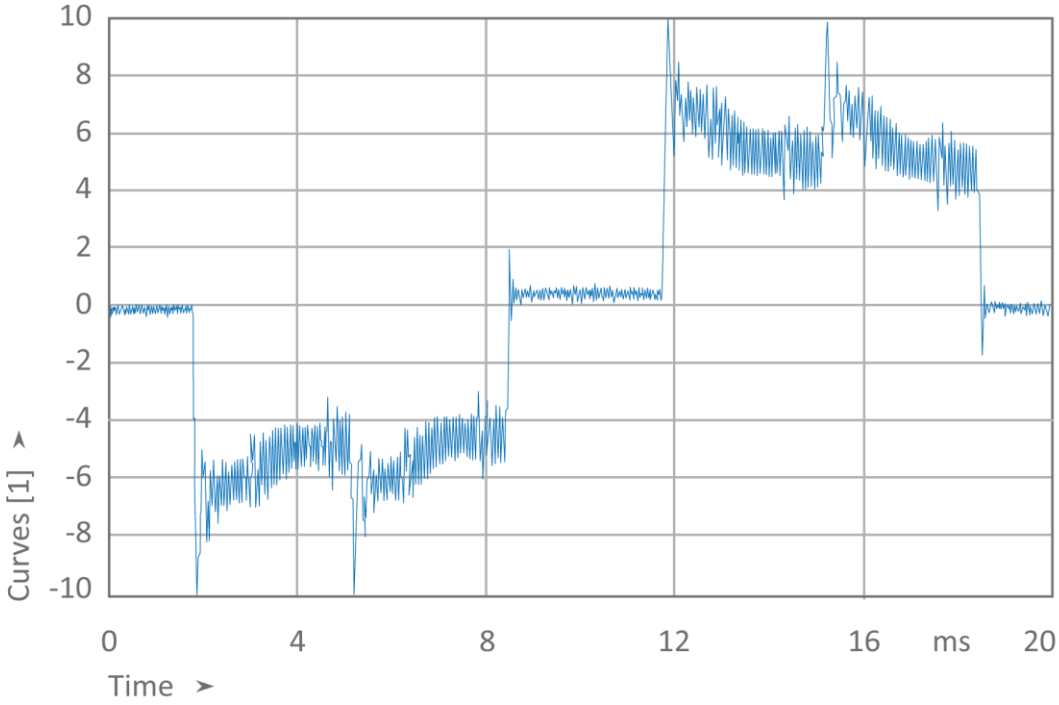
static and dynamic overvoltages

leakage current limitations

Electronics for EC-motors



EMC and current harmonics

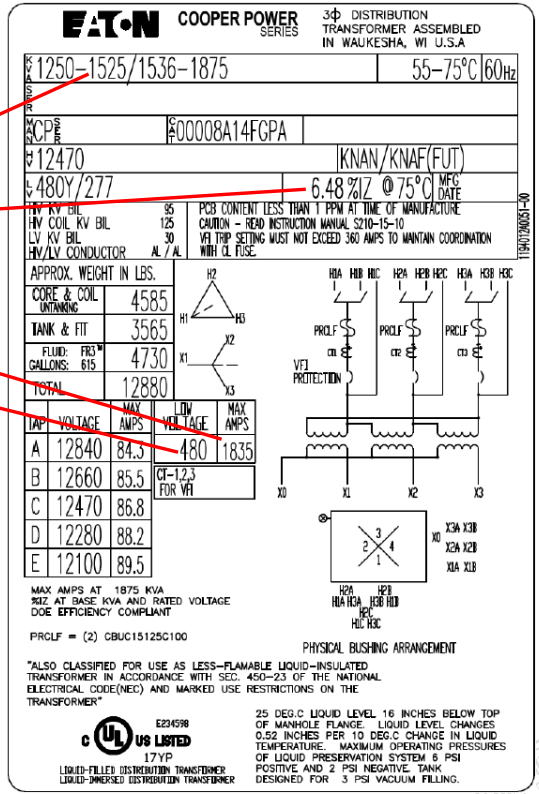


U1	400 V / 50 Hz
I1	4.6 A rms
	10 A peak
P1	2.97 kW
Q1	1.20 k VA
S1	3.20 k VA
LF	0.93
THD(I)	34 %

Energy supply – Rating sufficient?

Example:
Transformer data;
rating plate

$S_{\text{Transformer,nom}} = 1525\ kVA$
$V_{SC} = 6{,}48\%$
$I_{Trafo,nom} = 1835A$
$V_{Trafo,nom} = 480V$



$S_{\text{Transformer,nom}} \approx 1.5$ MVA

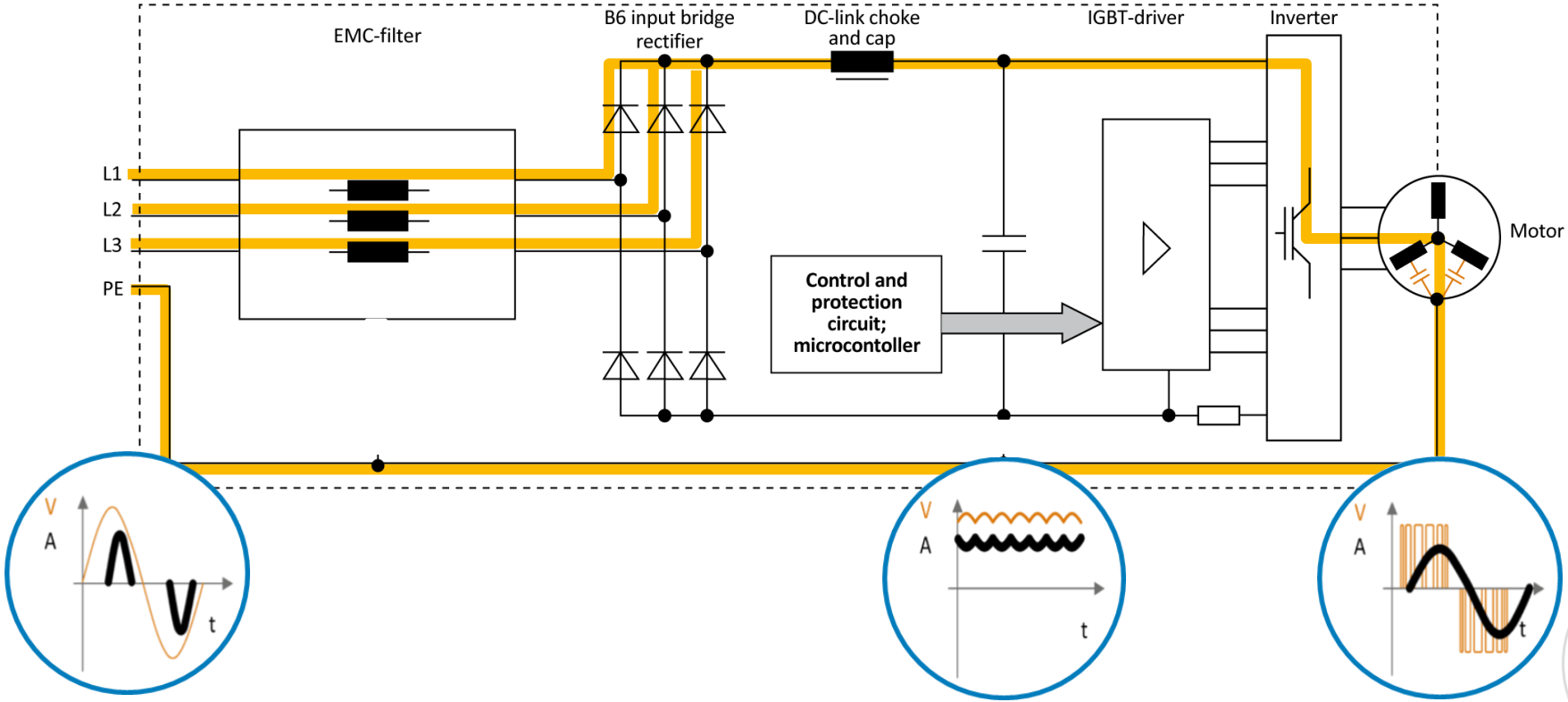
$$S_{\text{Transormer,SC}} = \frac{\sqrt{3} \times I_{\text{Trafo,nom}} \times U_{\text{nom}}}{6.48\ \%} = 23.5 \text{ MVA}$$

$$S_{\text{Fan,max}} \leq \frac{S_{\text{Transformer,SC}}}{250} \approx 100 \text{ kVA}$$

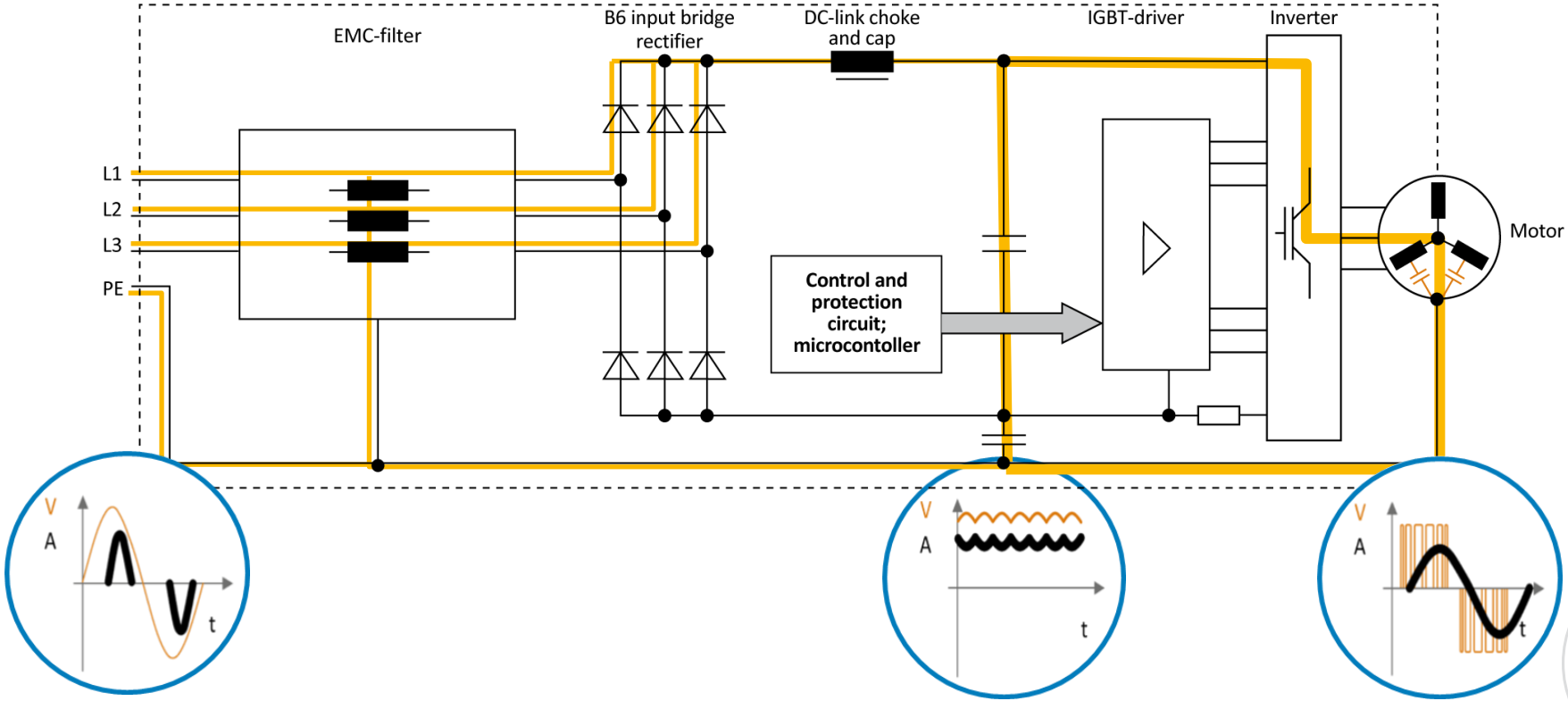
Electrical environmental requirements to EC-motors

- Voltage dips
- energy supply performance
- EMC requirements & current harmonics
- static and dynamic over voltages
- **leakage current limitations**

EC-motors: Why leakage currents ?



EC-motors: leakage currents



Electrical environmental requirements to EC-motors

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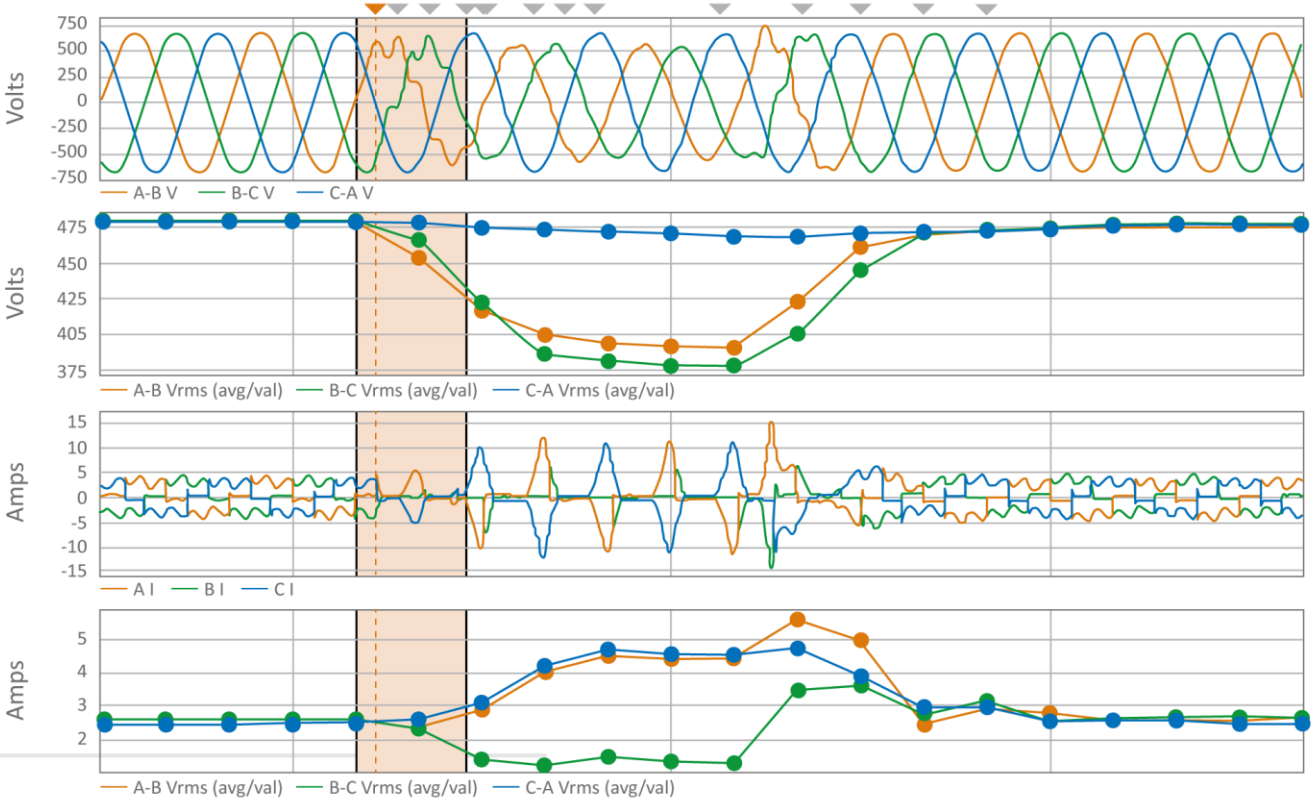
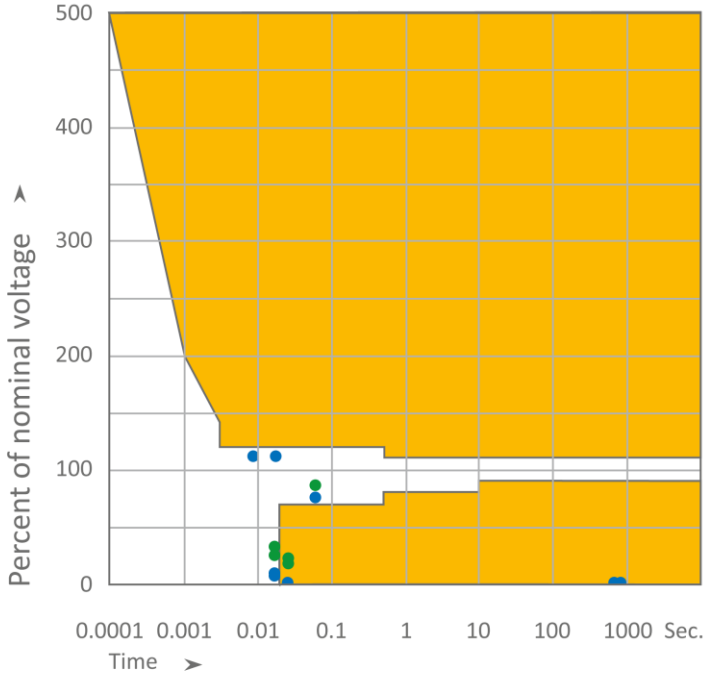
Voltage dips and power supply voltage interruptions

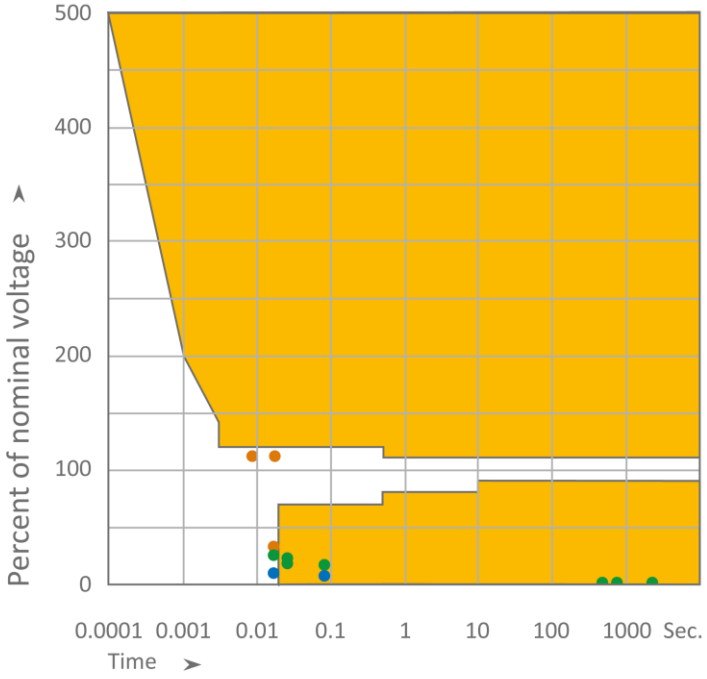
Mains voltage dips (in a 3-phase power supply) and effects to the current draw



Voltage dips in the power supply voltage

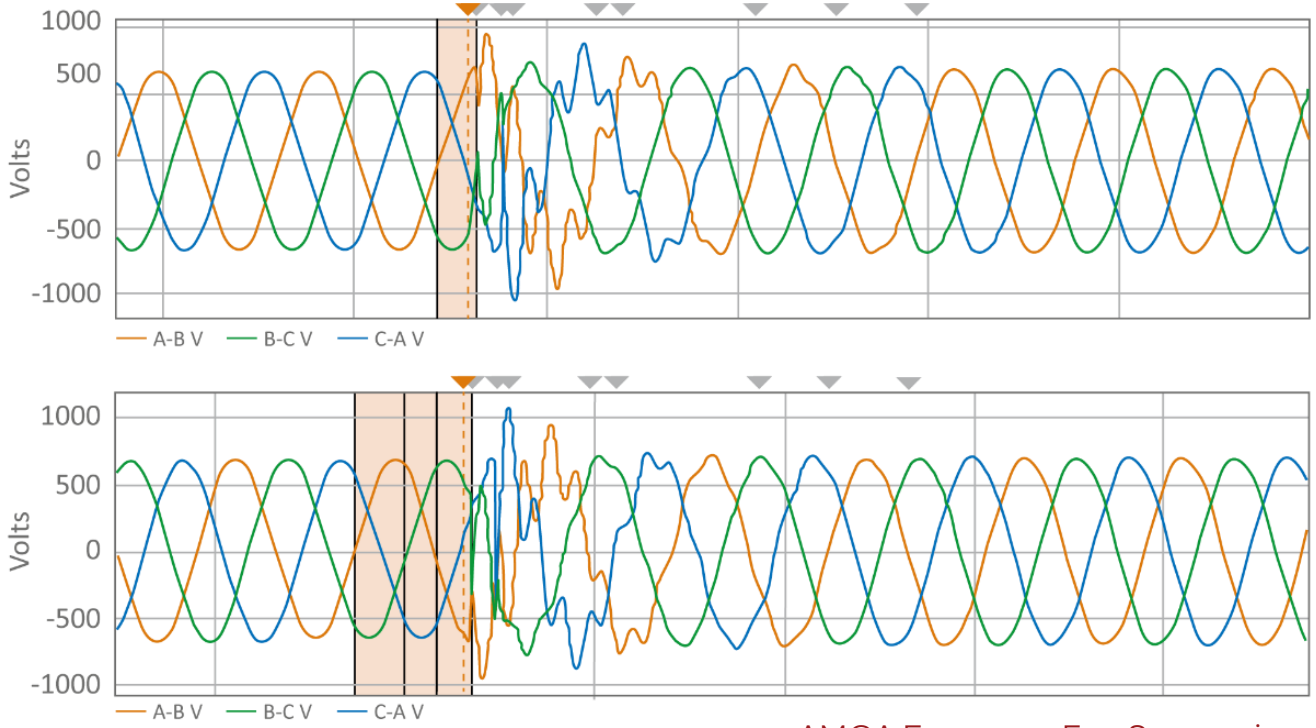
Real measured voltage dips in comparision CBEMA curve





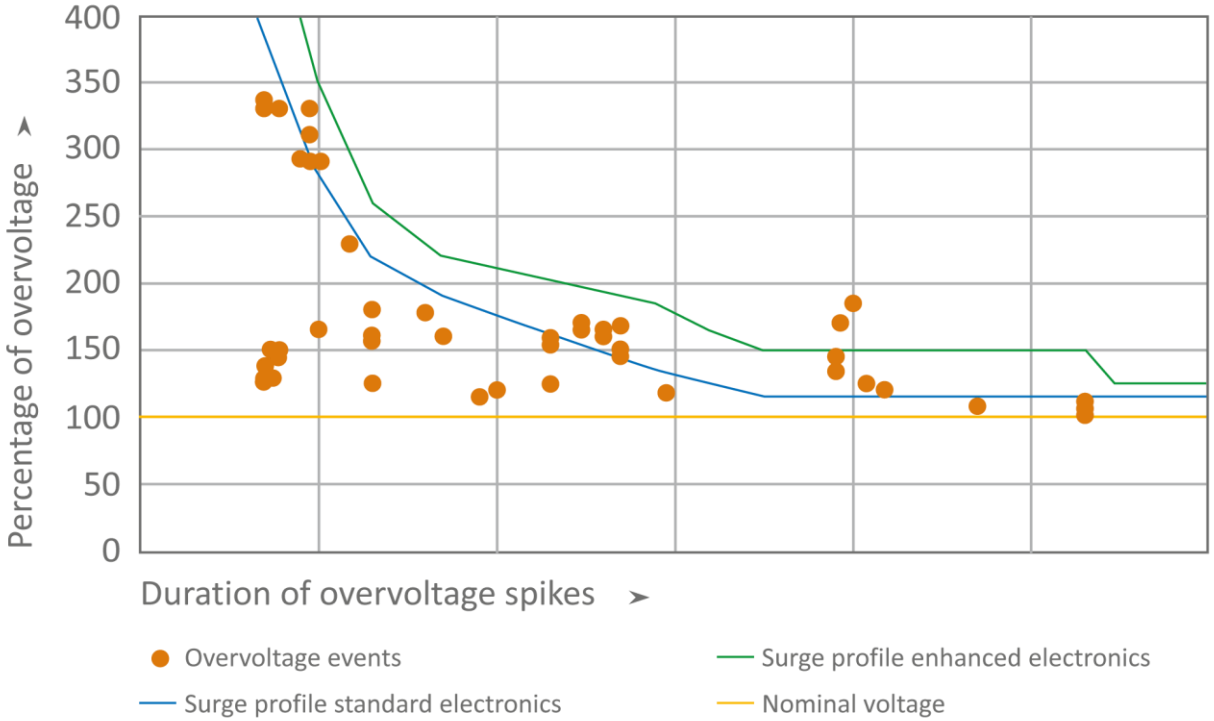
Static and dynamic overvoltages

Dynamic overvoltages due to high load switching in weak power supply grids



Static and dynamic overvoltages

Real measured overvoltage spikes in comparision to surge capability limits



Summary & Conclusions

- EC external rotor motors enable **compact, highly efficient and low-noise plug & play solutions** in ventilation and air conditioning technology
- EC motors can be operated just as **reliably and robustly as AC motors** if the operating conditions and electrical parameters of the power supply are fully known

Thank you!

Do you have any questions?
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