



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**



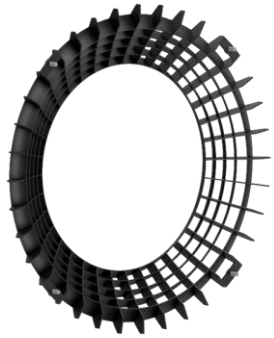
Engineering a better life

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



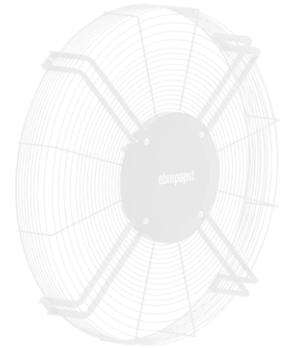
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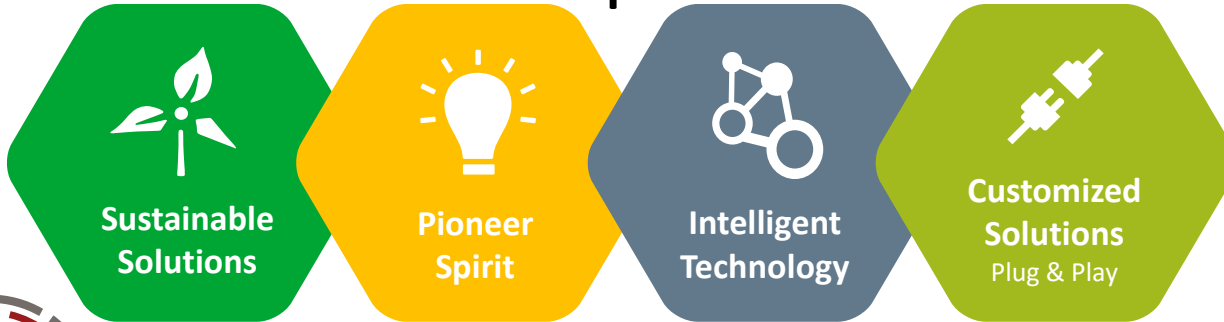


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AIR TECHNOLOGY

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)
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Lorentz Force Force on PM Force on Iron Force on Iron Lorentz Force Force on PM Lorentz Force Force on PM Lorentz Force



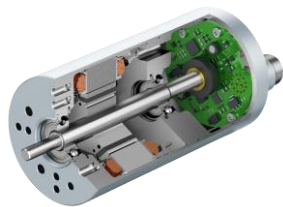


Geometrical Motor Designs

Magn.
flow
direction

Inner rotor

Radial



External rotor

Radial



Dual rotor

Radial



Diagonal rotor

Diagonal



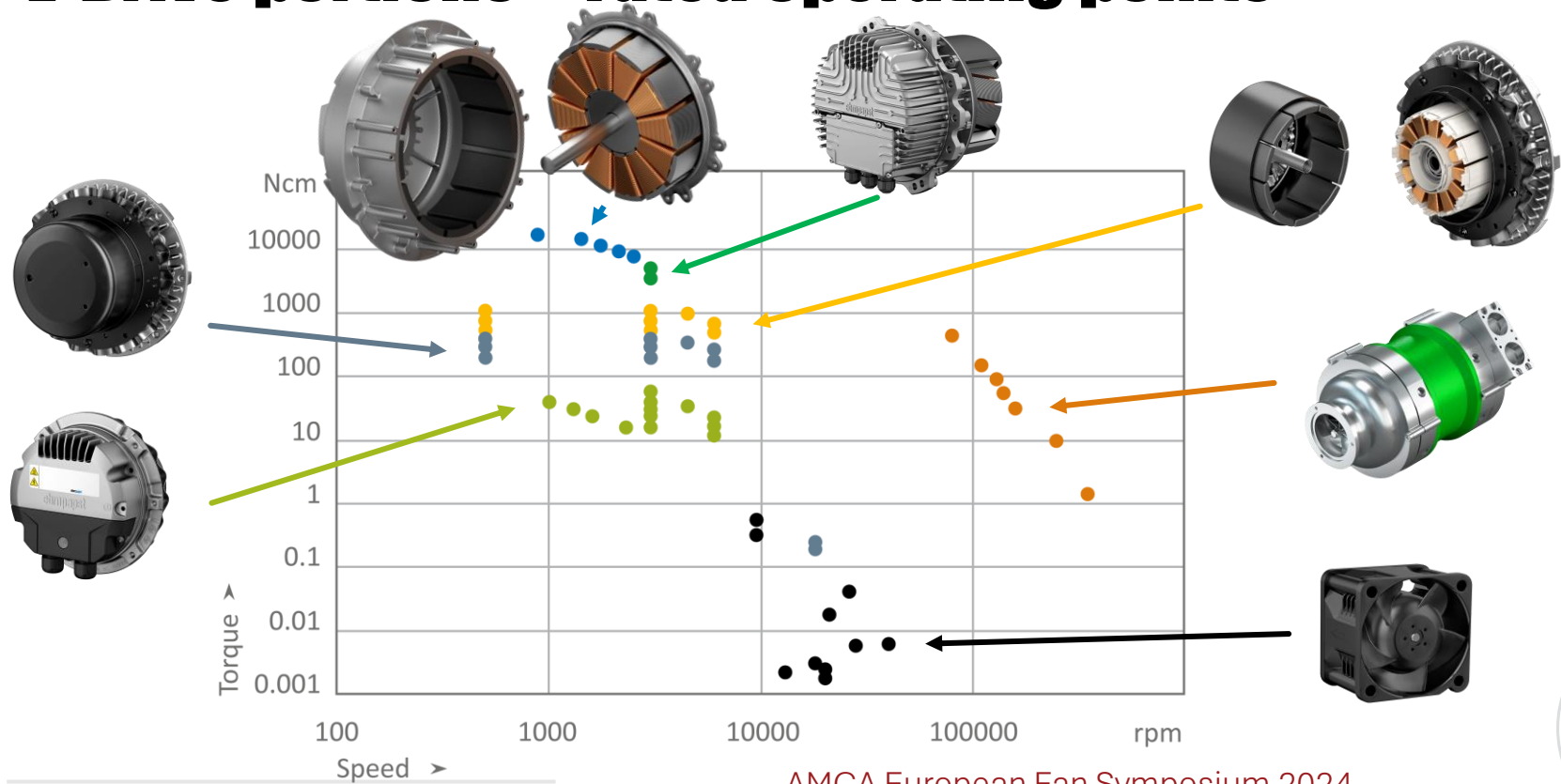
Disk rotor

Axial





E-Drive portfolio – rated operating points

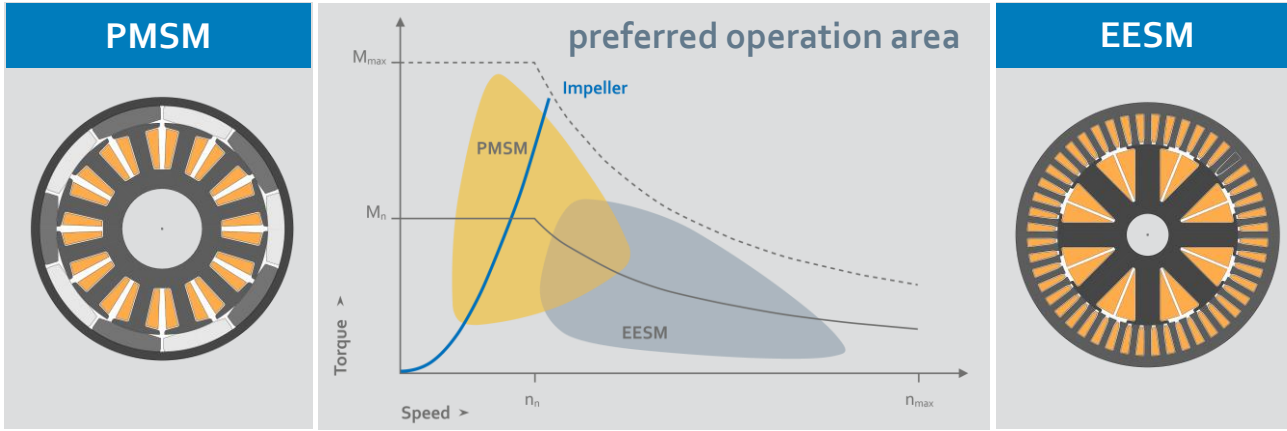




Motor Topology I

Electric Excited Synchronous Machine (EESM)

Moving coils instead of permanent magnets



Conclusion
 EESM not suitable for fan application because of load profile
 Additional efforts for energy transfer into rotor

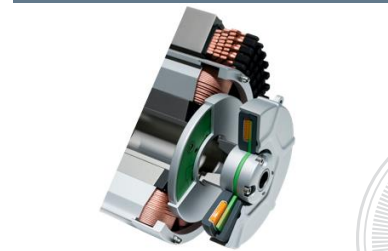
BMW (1)



ZF (2)



Mahle (3)



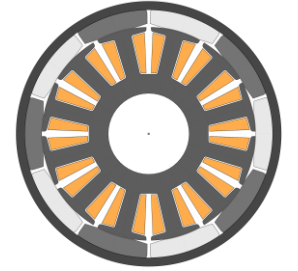
(1) BMW changes its electric motor concept with the iX3
 (2) ZF makes magnet-free electric motor uniquely compact and competitive
 (3) MAHLE develops highly efficient magnet-free electric motor - MAHLE Newsroom





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



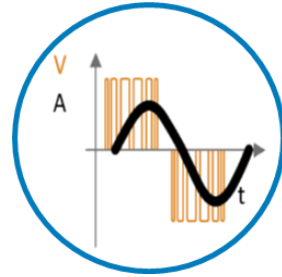
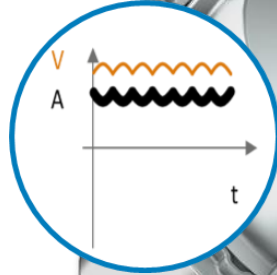
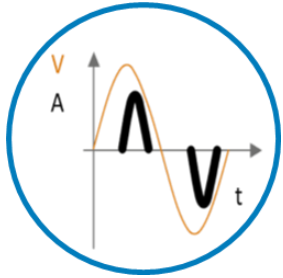


EC motor: Electronics & Drive topology



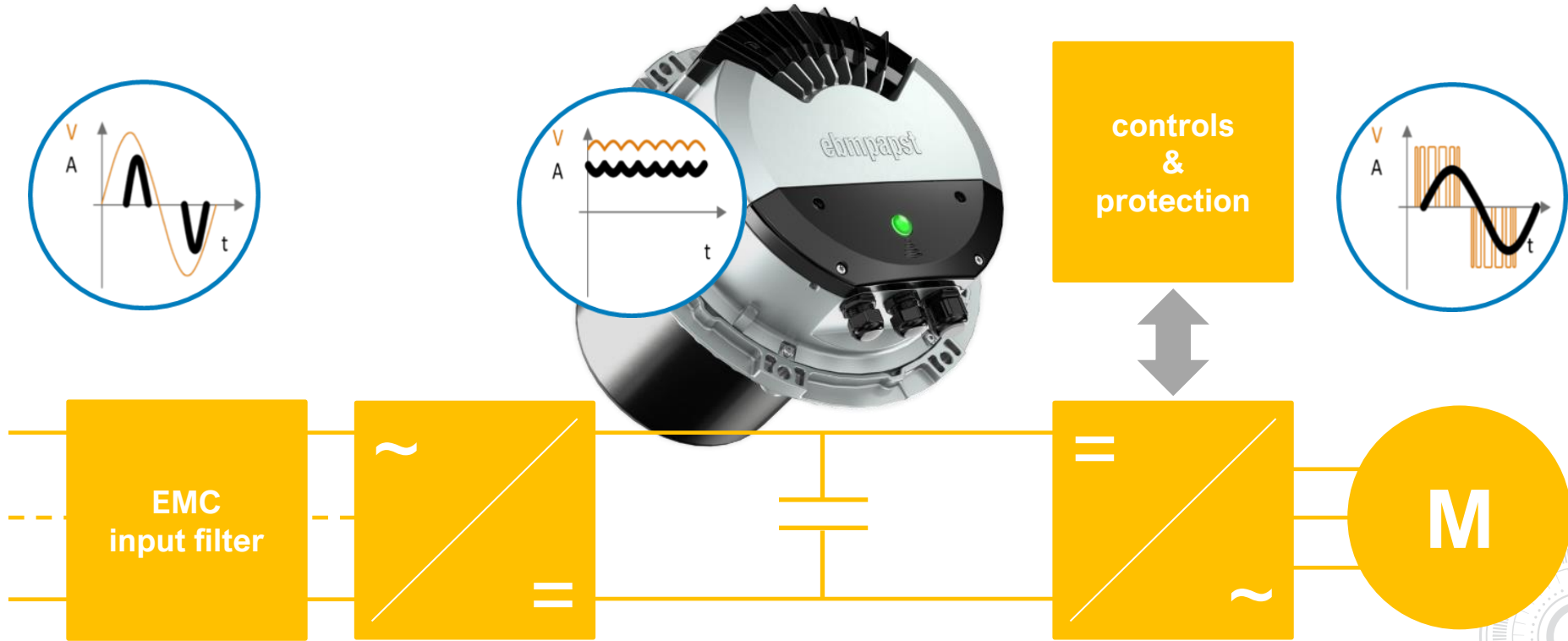


EC motor: Electronics & Drive topology





EC motor: Electronics & Drive topology





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

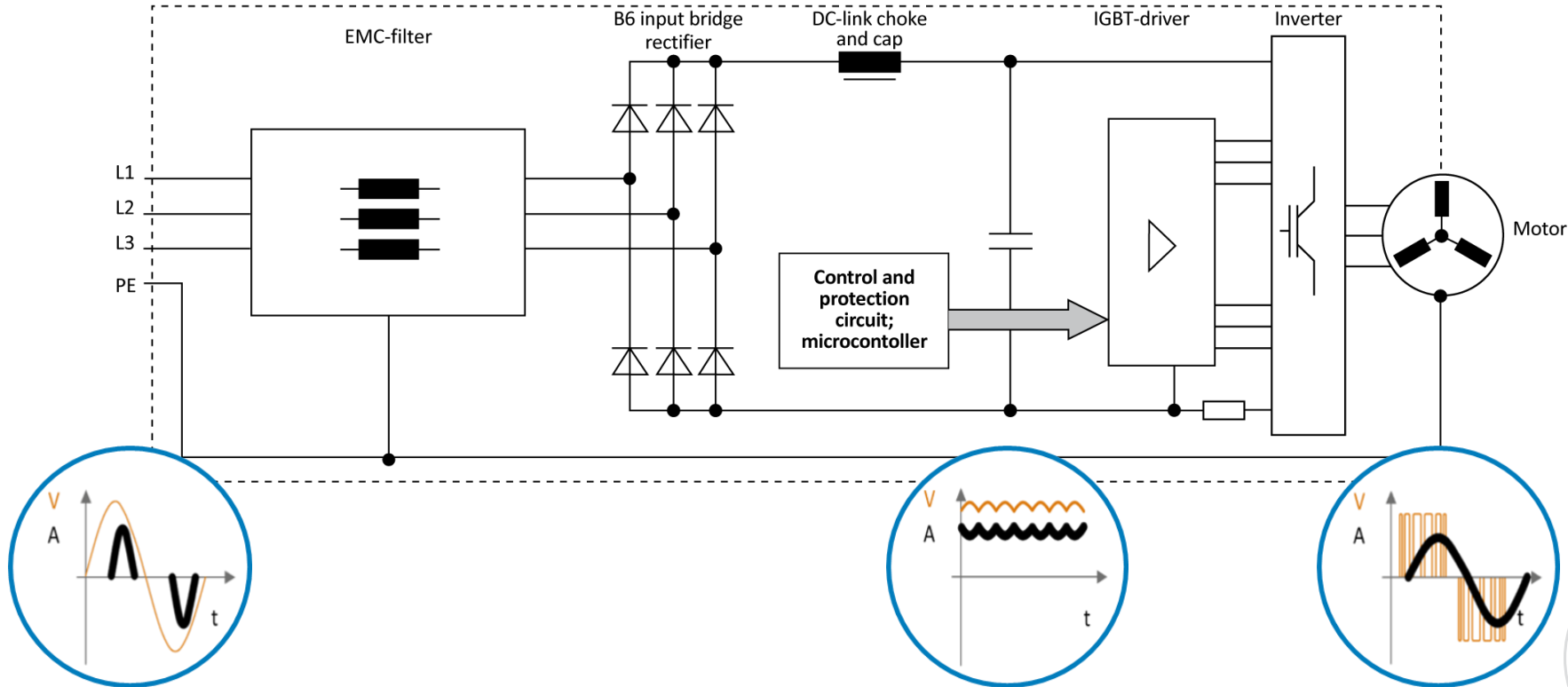


leakage current limitations



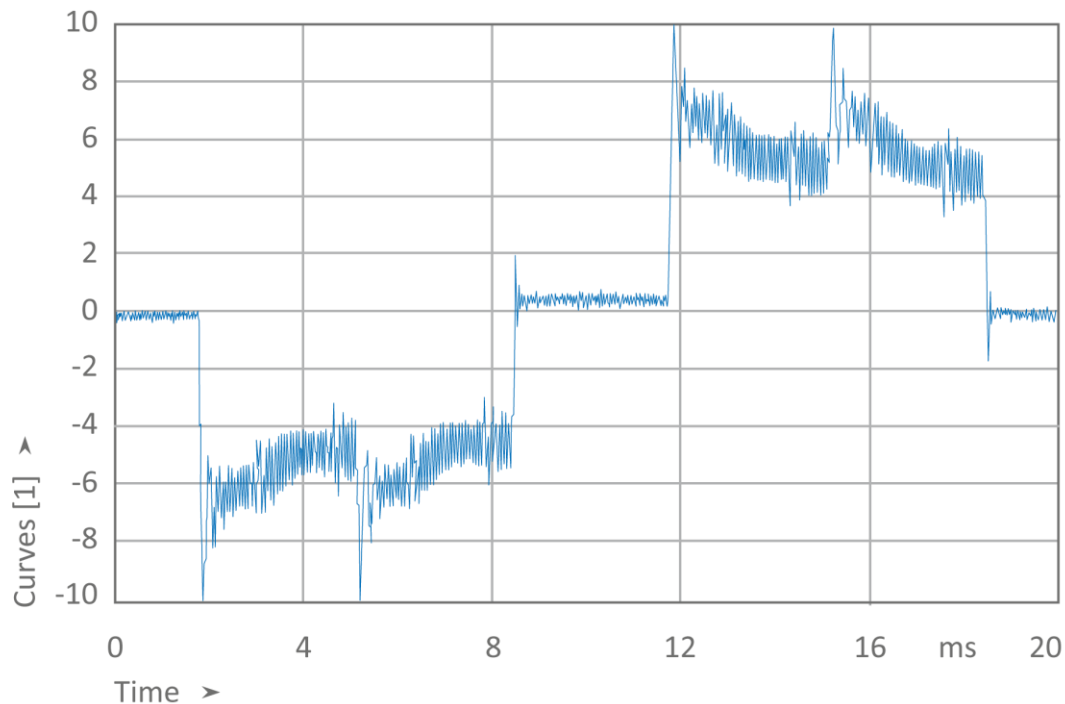


Electronics for EC-motors





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

$$S_{\text{Transformer, nom}} = 1525 \text{ kVA}$$

$$V_{SC} = 6,48\%$$

$$I_{\text{Trafo, nom}} = 1835 \text{ A}$$

$$V_{\text{Trafo, nom}} = 480 \text{ V}$$

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

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

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

EATON COOPER POWER SERIES 3Φ DISTRIBUTION TRANSFORMER ASSEMBLED IN WAUKESHA, WI U.S.A.

1250-1525/1536-1875 55-75°C 60Hz

MODEL NO. 12470 SERIAL NO. 00008A14FGPA

VOLTS: 480Y/277 KVAR: 1525

IMPEDANCE: 6.48% @ 75°C

PCB CONTENT LESS THAN 1 PPM AT TIME OF MANUFACTURE
CAUTION - READ INSTRUCTION MANUAL S210-15-10
VFI TRIP SETTING MUST NOT EXCEED 360 AMPS TO MAINTAIN COORDINATION WITH CL FUSE.

WINDING	VOLTAGE	MAX. AMPS	LOW VOLTAGE	MAX. AMPS
A	12840	84.3	480	1835
B	12660	85.5		
C	12470	86.8		
D	12280	88.2		
E	12100	89.5		

APPROX. WEIGHT IN LBS.
CORE & COIL UNTANKING: 4585
TANK & FIT: 3565
FLUID: FR3 GALLONS: 615
TOTAL: 12880

MAX AMPS AT 1875 KVA
RET. AT BASE KVA AND RATED VOLTAGE
DOE EFFICIENCY COMPLIANT

PRCLF = (2) CBUC15125C100


PHYSICAL BUSHING ARRANGEMENT

ALSO CLASSIFIED FOR USE AS LESS-FLAMMABLE LIQUID-INSULATED TRANSFORMER IN ACCORDANCE WITH SEC. 450-23 OF THE NATIONAL ELECTRICAL CODE (NEC) AND MARKED USE RESTRICTIONS ON THE TRANSFORMER

25 DEG.C LIQUID LEVEL 16 INCHES BELOW TOP OF MANHOLE FLANGE. LIQUID LEVEL CHANGES 0.52 INCHES PER 10 DEG.C CHANGE IN LIQUID TEMPERATURE. MAXIMUM OPERATING PRESSURES OF LIQUID PRESERVATION SYSTEM 4 PSI POSITIVE AND 2 PSI NEGATIVE. TANK DESIGNED FOR 3 PSI VACUUM FILLING.




Electrical environmental requirements to EC-motors



Voltage dips



energy supply performance



EMC requirements & current harmonics



static and dynamic over voltages

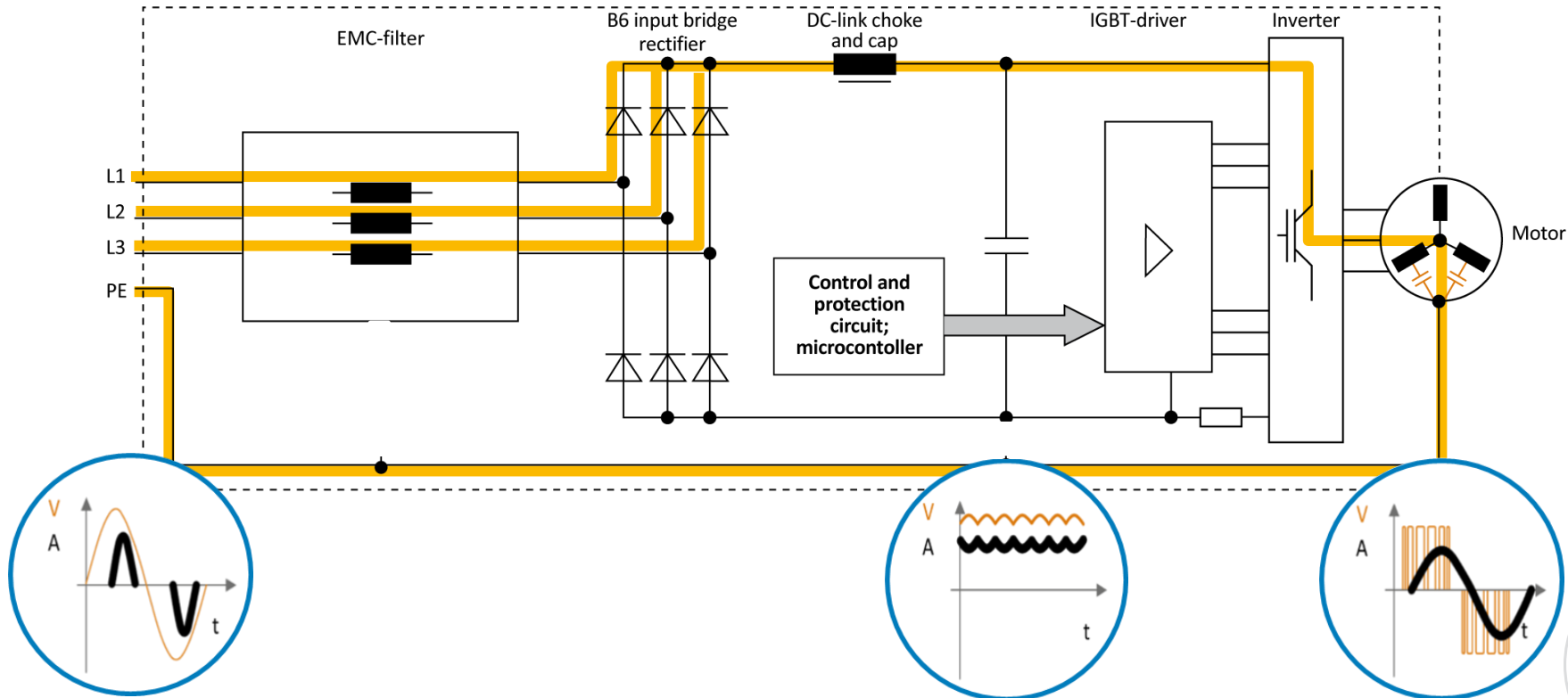


leakage current limitations



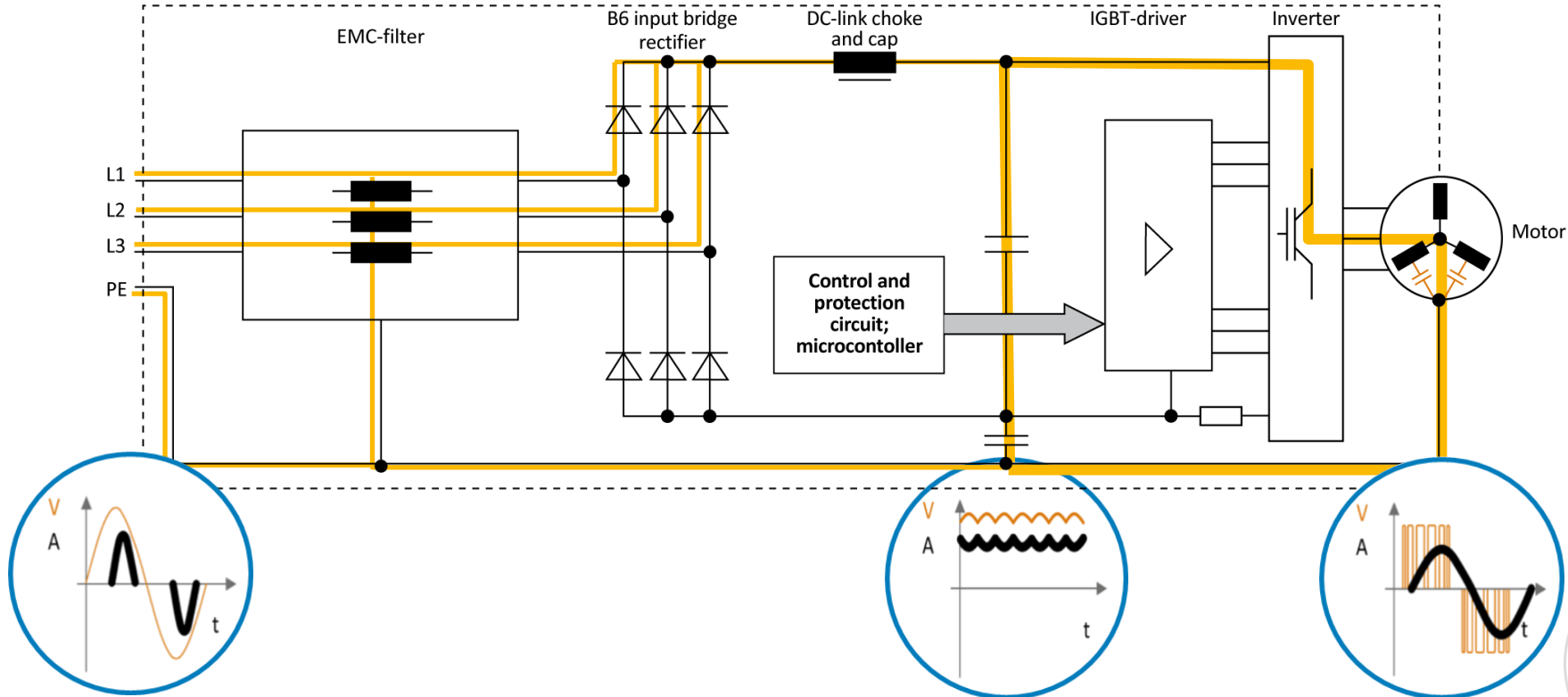


EC-motors: Why leakage currents ?





EC-motors: leakage currents





Electrical environmental requirements to EC-motors



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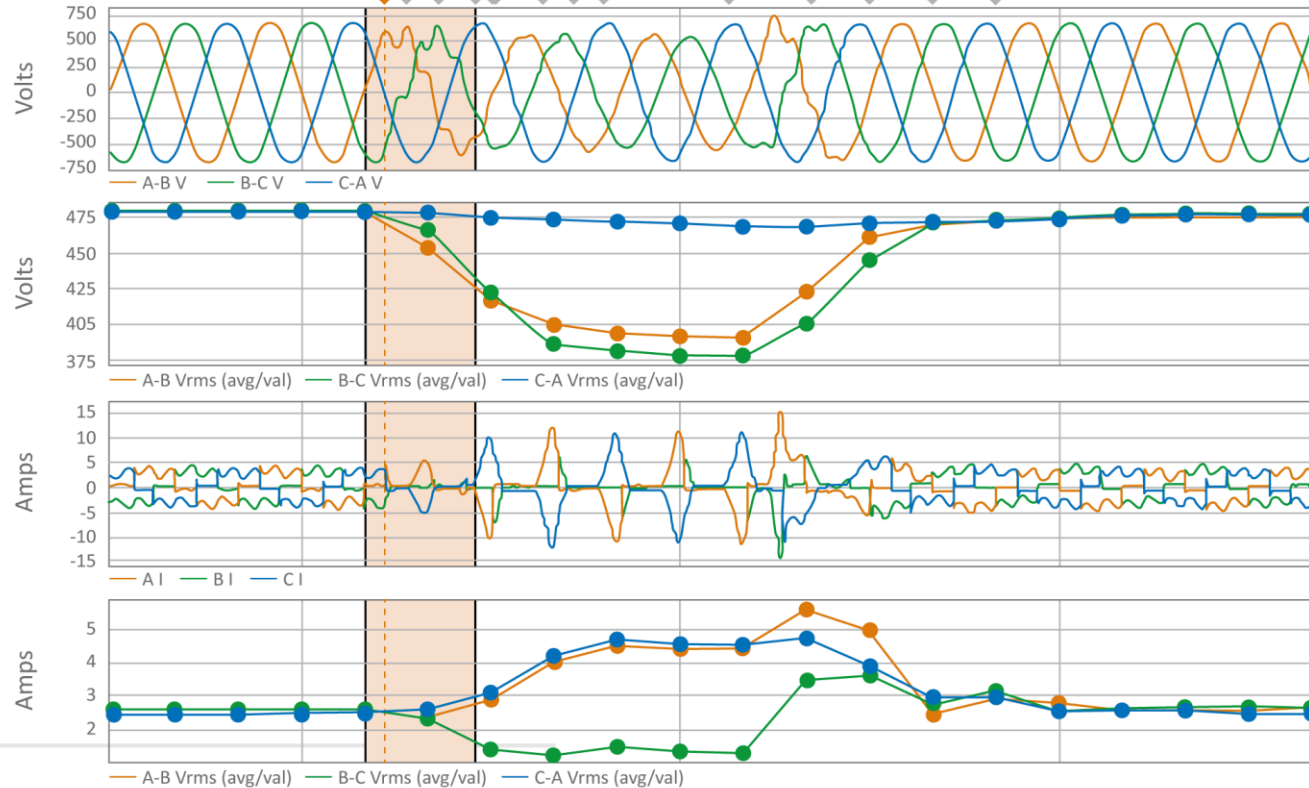
leakage current limitations





Voltage dips and power supply voltage interruptions

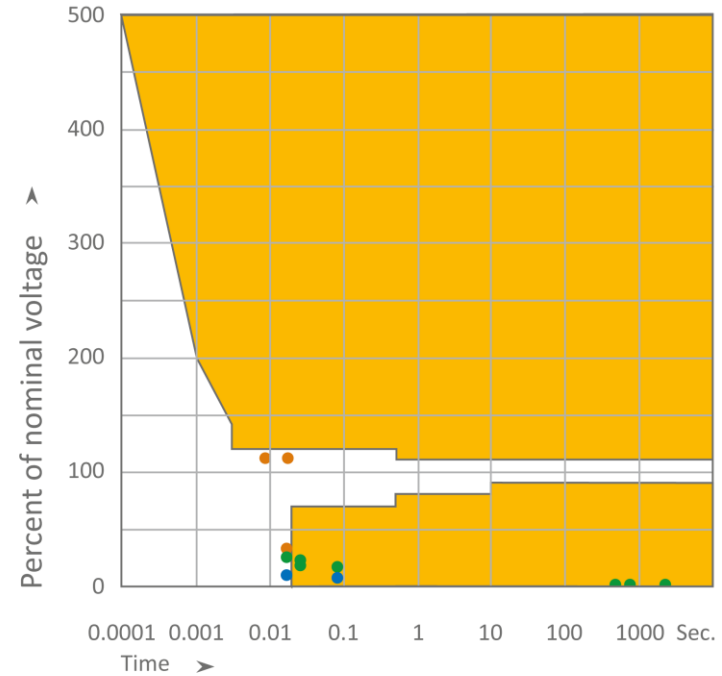
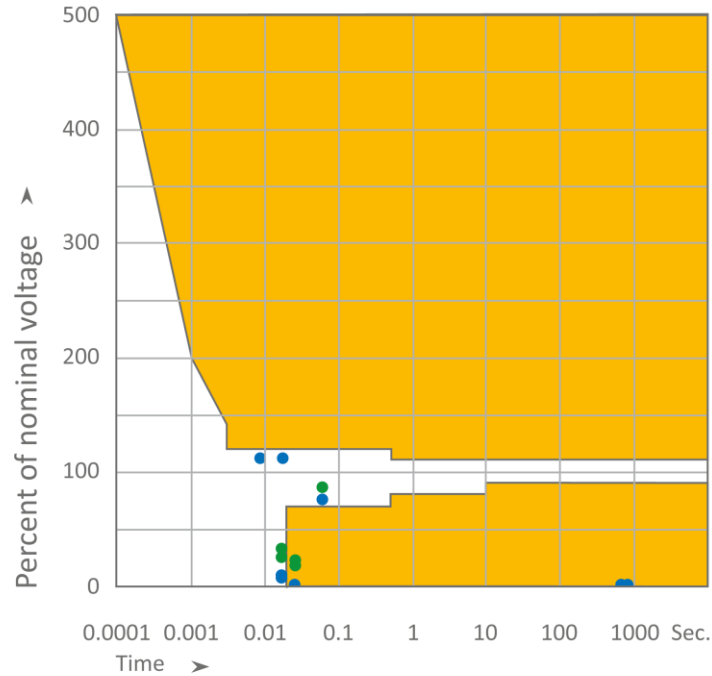
Mains voltage dips (in a 3-phase power supply) and effects to the current draw





Voltage dips in the power supply voltage

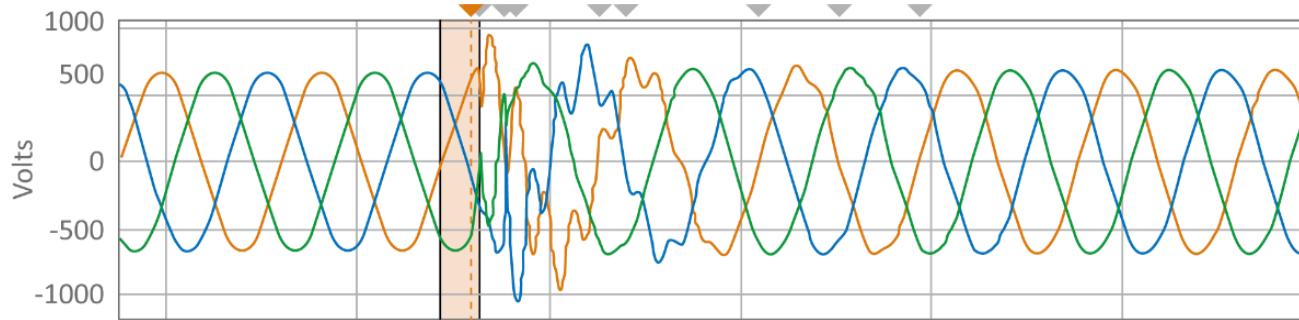
Real measured voltage dips in comparison CBEMA curve



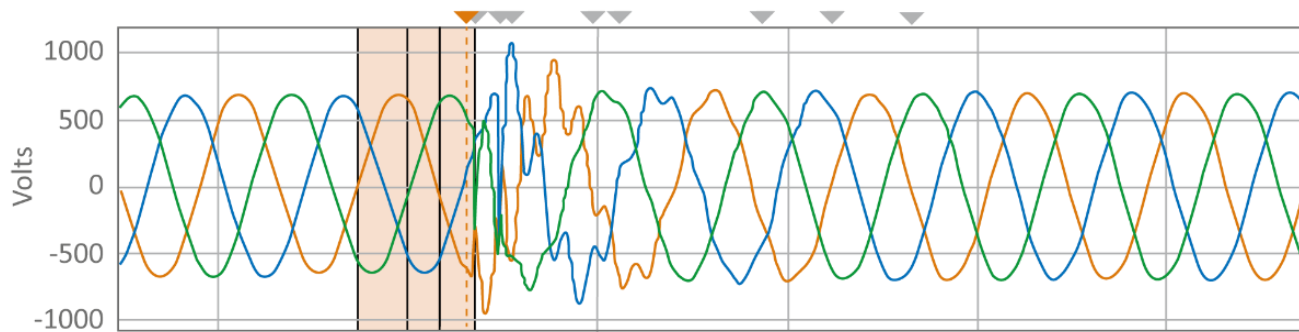


Static and dynamic overvoltages

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



— A-B-V — B-C-V — C-A-V



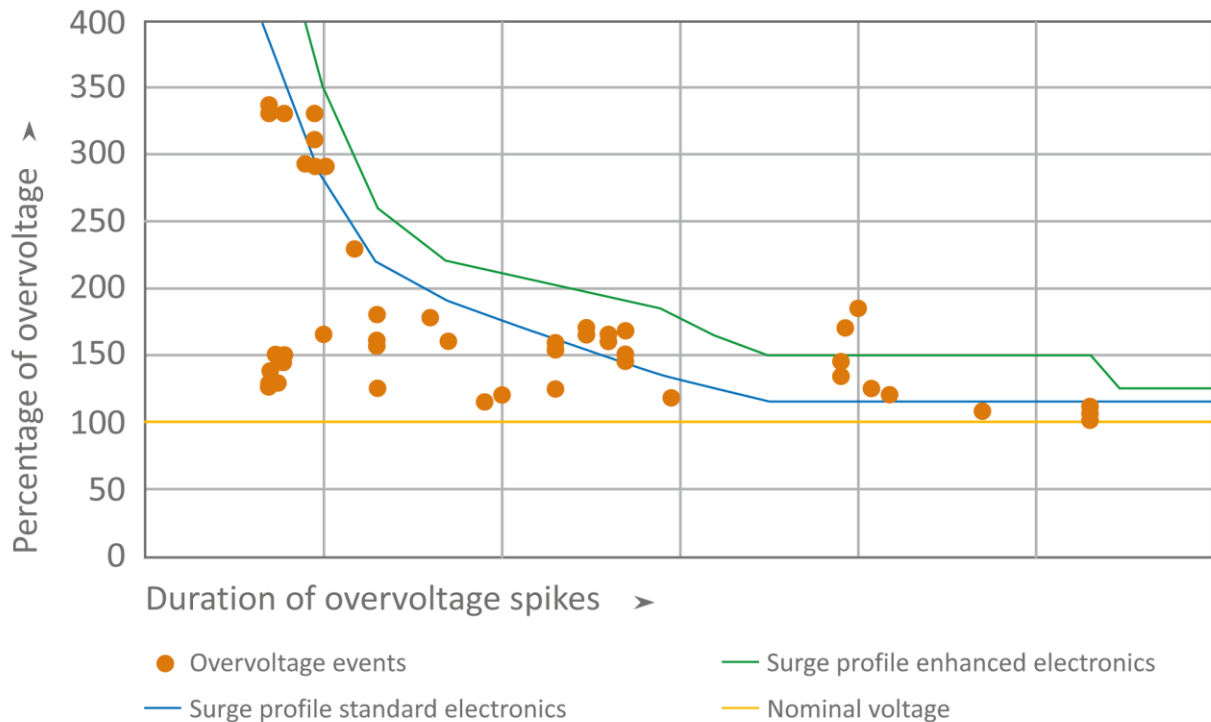
— A-B-V — B-C-V — C-A-V





Static and dynamic overvoltages

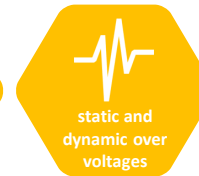
Real measured overvoltage spikes in comparison to surge capability limits





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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