4. FACHTAGUNG E-MOTOREN UND TRANSFORMATOREN
28. JANUARY, 2015

PASSIVE FILTERS BETWEEN MOTOR AND FREQUENCY INVERTER

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AGENDA

INPUT FILTER

OUTPUT FILTER

DESIGN & TESTING

SUMMARY

THE COMPANY MANAGEMENT

Wolfgang Reichelt
Dr. Dennis Kampen
Jens Scheffelmeier
Michael Hundhammer
Jörg Reichelt
Udo L. Thiel
Reinhard Kleinschmidt
Lars Ullenboom
Veit Brämer

DRIVE SYSTEMS YESTERDAY

Not efficient, but sinusoidal current and voltage waveforms

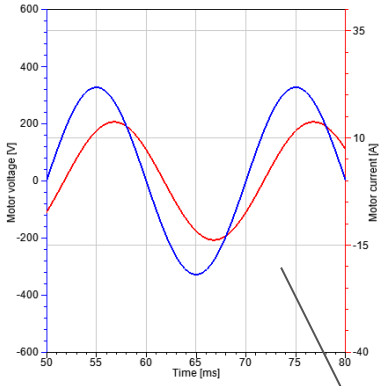


foto:fh-trier.de

grid

motor

DRIVE SYSTEMS TODAY
PRINCIPAL WAVE FORMS

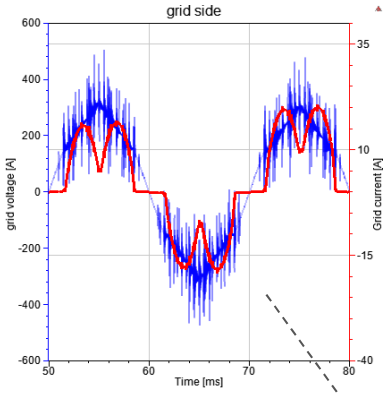
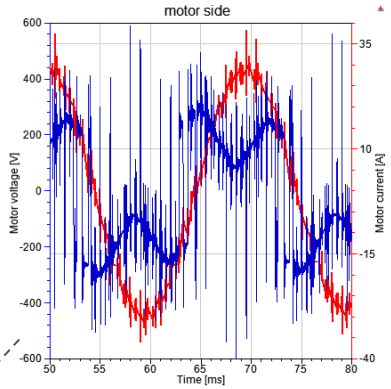


foto:motor-talk.de



Nonlinear currents and voltages
→faults of other equipment

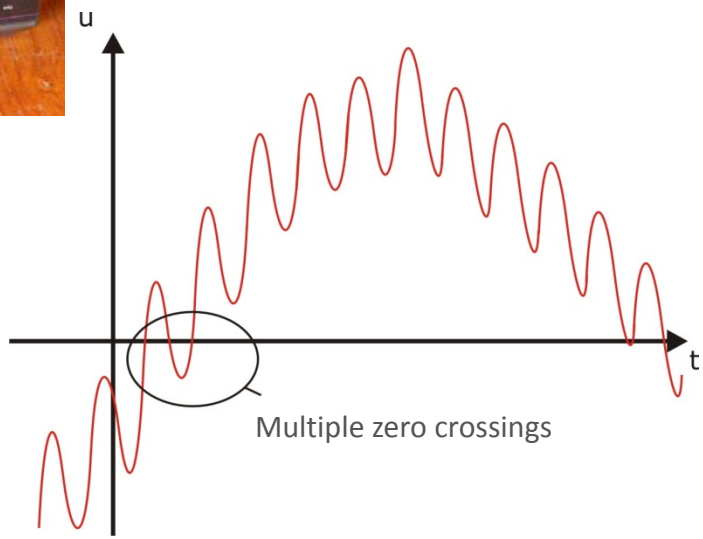
PWM voltage
→ motor faults

grid

inverter

motor

HARMONICS
IMPACT ON THE POWER QUALITY, LINE TRIGGERED CLOCKS



messtechnik-special 05/2004 | installati

In Coburg gehen die Uhren anders

Einen wichtigen Beitrag zur Sicherung der Spannungs-Qualität im Niederspannungsnetz liefert die moderne Messtechnik. Ohne sie könnte weder eine Aussage über die Qualität der Spannung, also über deren einzelne Merkmale, gemacht, noch die Ursache für Störungen gefunden werden.
Dieser Beitrag soll dem Leser einen kleinen Einblick in die Komplexität der Thematik „Sicherung der Spannungs-Qualität" gewähren. Ein Thema, das erst am Anfang seiner Bedeutung für die Elektrizitätswirtschaft steht.

Von Jürgen Blum und Bernhard Kübrich

auch, dass Ihre Waschmaschinen während des Waschvorganges vorzeitig gestoppt oder nach dem Waschvorgang wieder von vorne begonnen haben. Ein weiteres Beispiel mit unangenehmen Nebenwirkungen: Drehteller von Microwellen-Geräten drehten sich sehr unregelmäßig schnell.
Wir entschieden uns, im Ortsnetz zunächst eine Standardanalyse der Spannungsqualität nach DIN EN 50160 „Merkmale der Spannung in öffentlichen Elektrizitätsver-

» Seite 78

Eine Erfassung der Spannungsqualität in den von den Städtischen Werken Über-

nen machen, was sie wollen!" lauteten viele Aussagen der Bewohner in

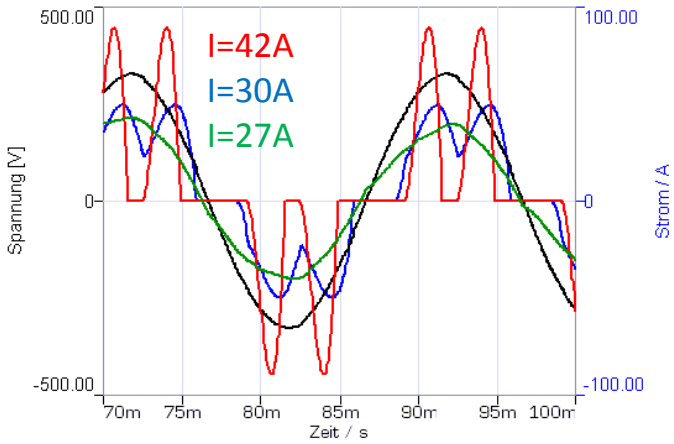
HARMONIC FILTERS OVERVIEW

no filter

with 4% uk line reactor

with harmonic filter

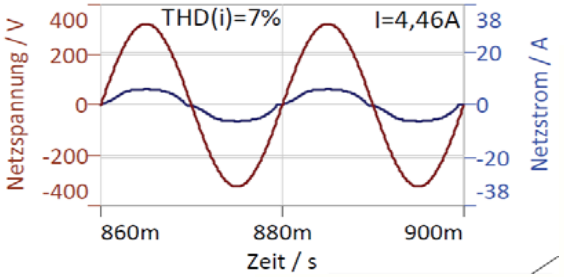
Line currents @ 20kW load

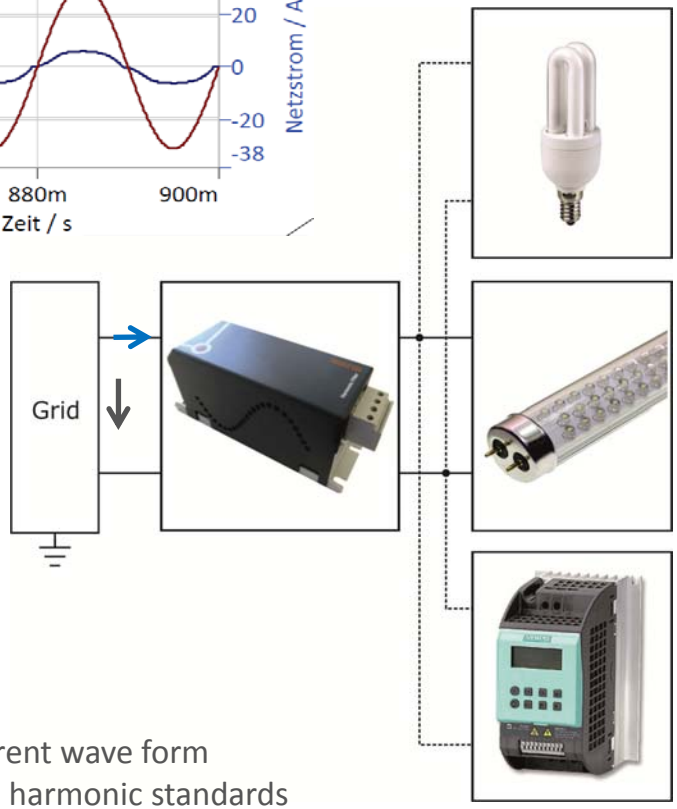


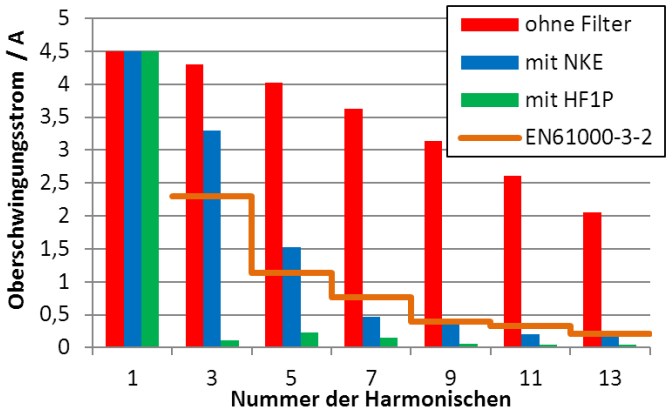
THD(i)=97% no filter
THD(i)=34% with 4% uk reactor
THD(i)=7% with harmonic filter

With a 4%uk inductor the harmonics can be reduced, but often this damping is not enough and a harmonic filter is required.

HARMONIC FILTER FOR B2
HF1P

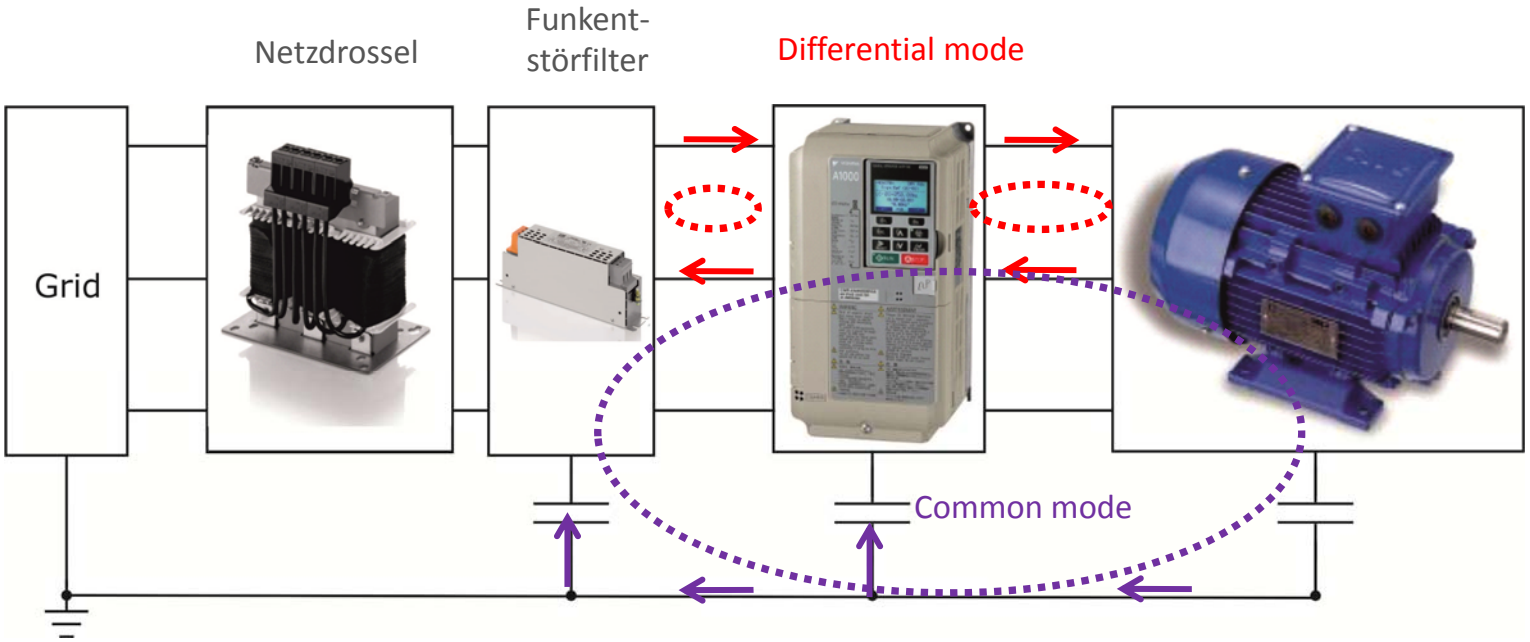






- Sinussoidal current wave form
- Comply with all harmonic standards
- Unburden of neutral conductors
- Application: office buildings, parking buildings, industry with a lot of single phase inverters

DISTRIBUTION OF DISTURBANCES
CONDUCTED EMISSIONS 150KHZ TO 30MHZ



The grid can be safely protected against disturbances of all frequencies with a line inductor or a harmonic filter and in addition an EMI-filter.

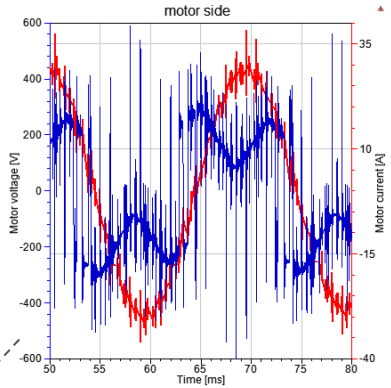
TESTING IN-HOUSE
EMI

Absorber hall

Free field measuring

DRIVE SYSTEMS WITH GRID SIDE FILTERS
MOTOR STILL UNPROTECTED

foto:motor-talk.de



PWM voltage
→ motor faults

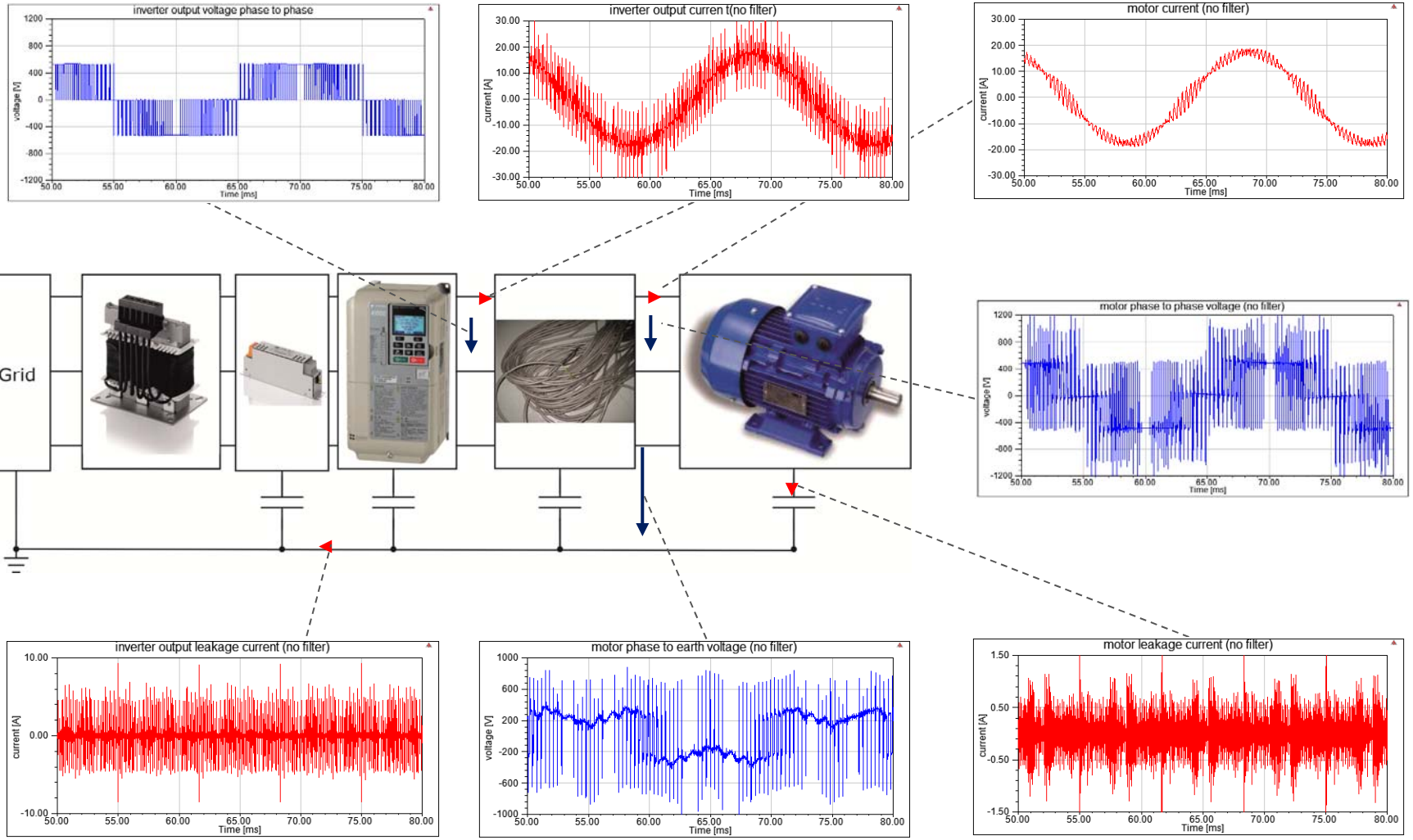
Grid is safe!

grid

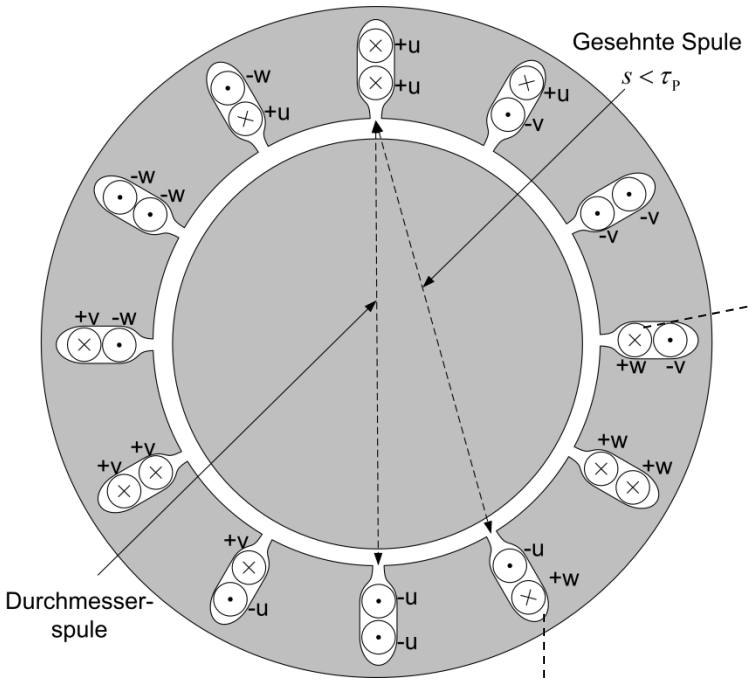
inverter

motor

MOTOR FILTERS
WAVE FORMS WITHOUT FILTER

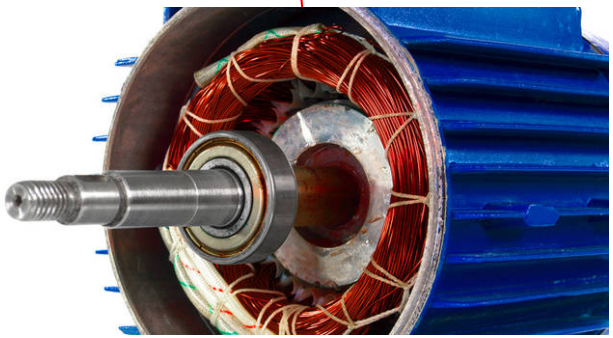


LIFE TIME OF MOTORS
POSSIBLE PLACES OF ISOLATION FAULTS IN MOTORS



Picture: Prof. Parspour, IEW University of Stuttgart

Differential mode
between phases
or
within one phase

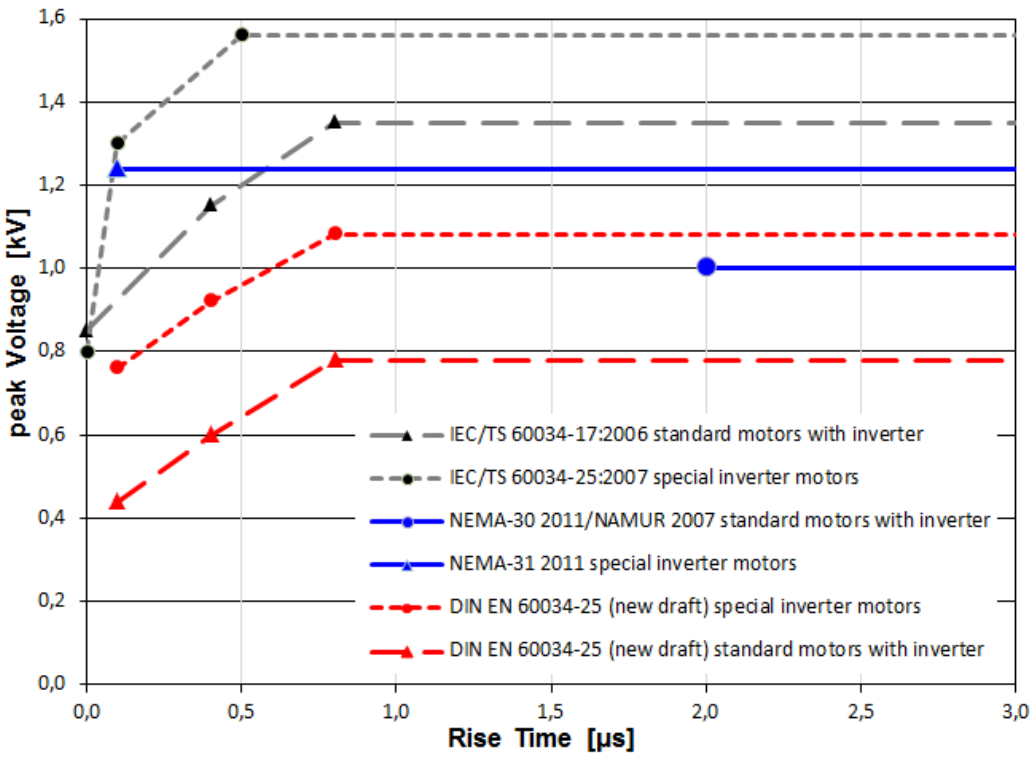


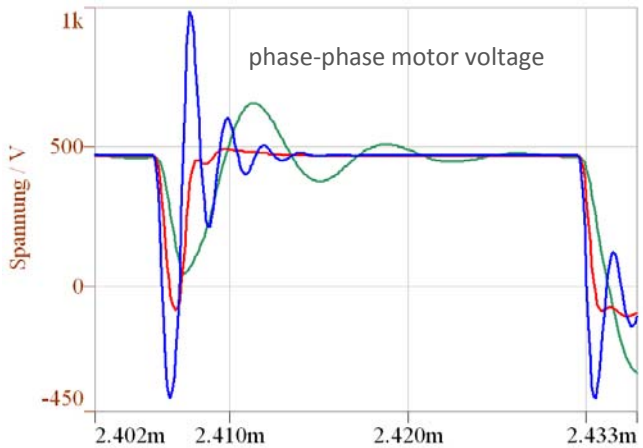
Common mode phase to earth

LIFE TIME OF MOTORS

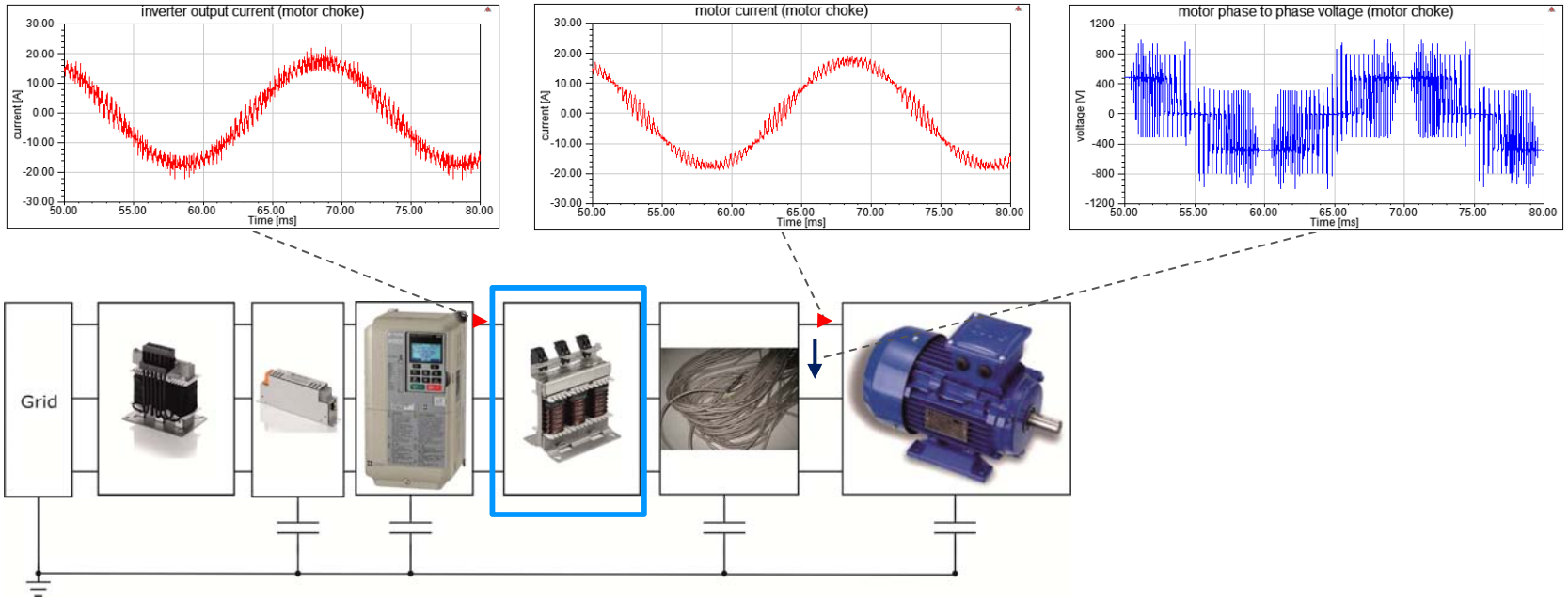
STANDARDS LIMITING DU/DT AND PEAK VOLTAGES AT MOTOR TERMINALS

Limit comparison for 400V motors



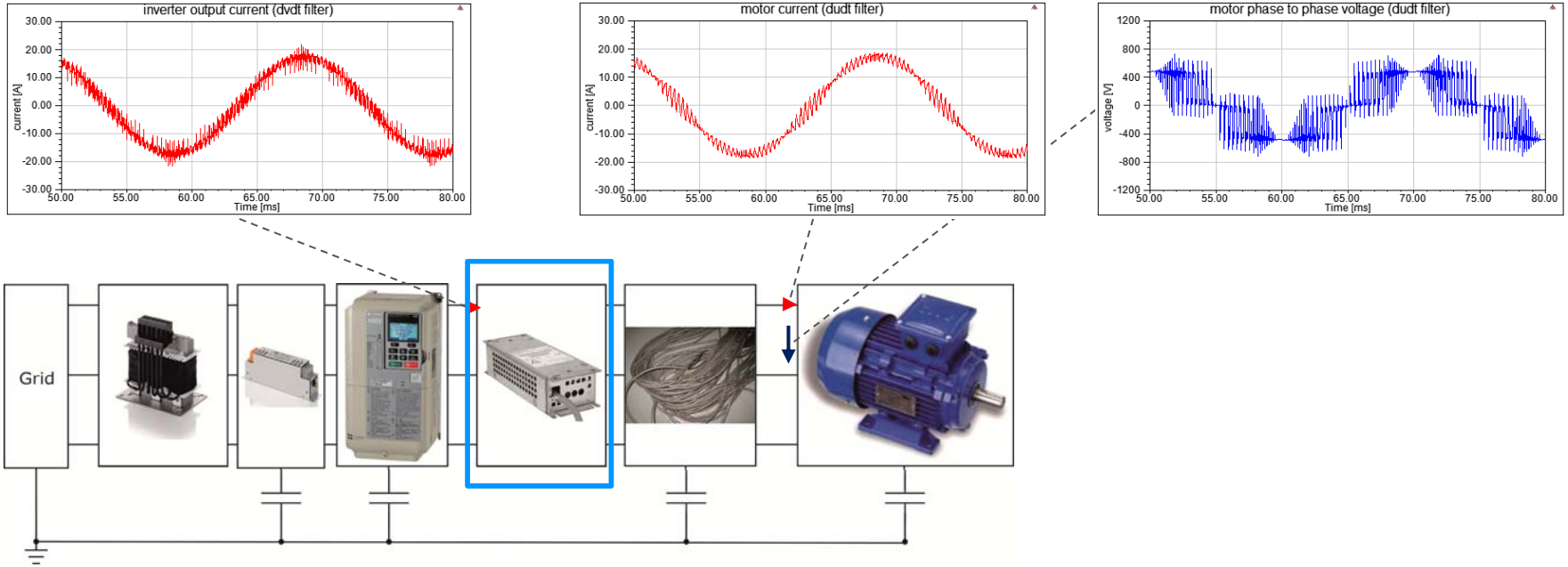


DIFFERENTIAL MODE MOTOR FILTERS
MOTOR CHOKE MR3

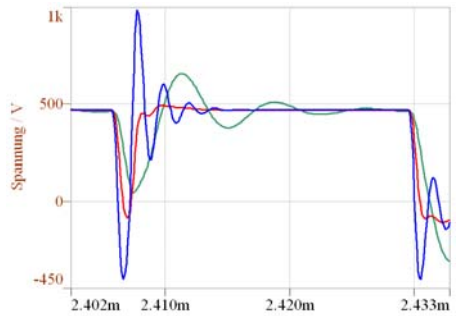


Reduction of differential mode dv/dt <500V/µs
→ prevention of motor insulation faults
→ reduction inverter output current peaks

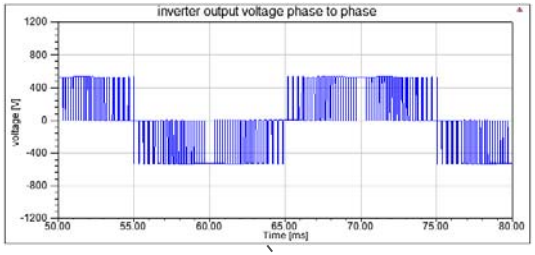
DIFFERENTIAL MODE MOTOR FILTERS
DV/DT FILTERS

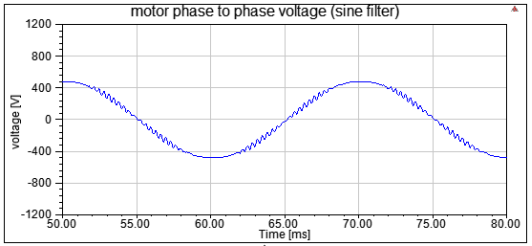


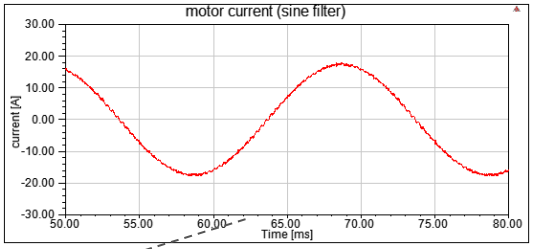
In comparison to motor chokes stronger and saver reduction of differential mode dv/dt and motor peak voltage
→ Nearly complete elimination of cable reflection with high ohmic damping
→ for older motors with lower peak voltage vs. rise time requirements

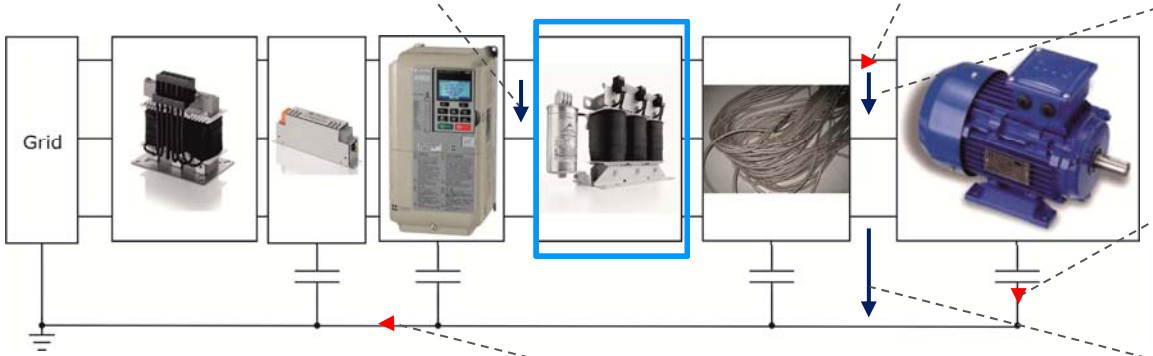


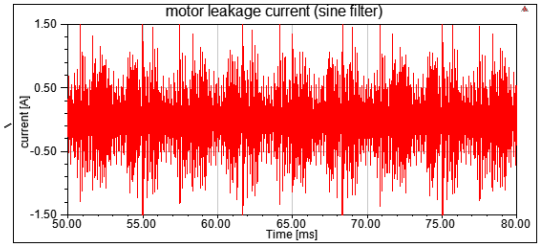
DIFFERENTIAL MODE MOTOR FILTERS
SINE FILTER SFB





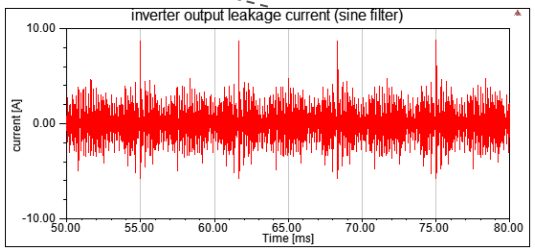


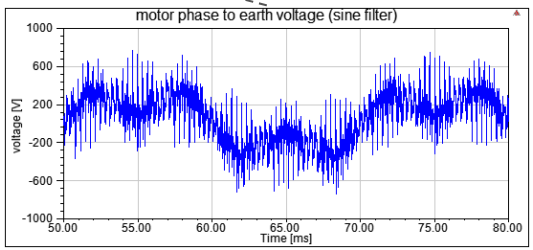




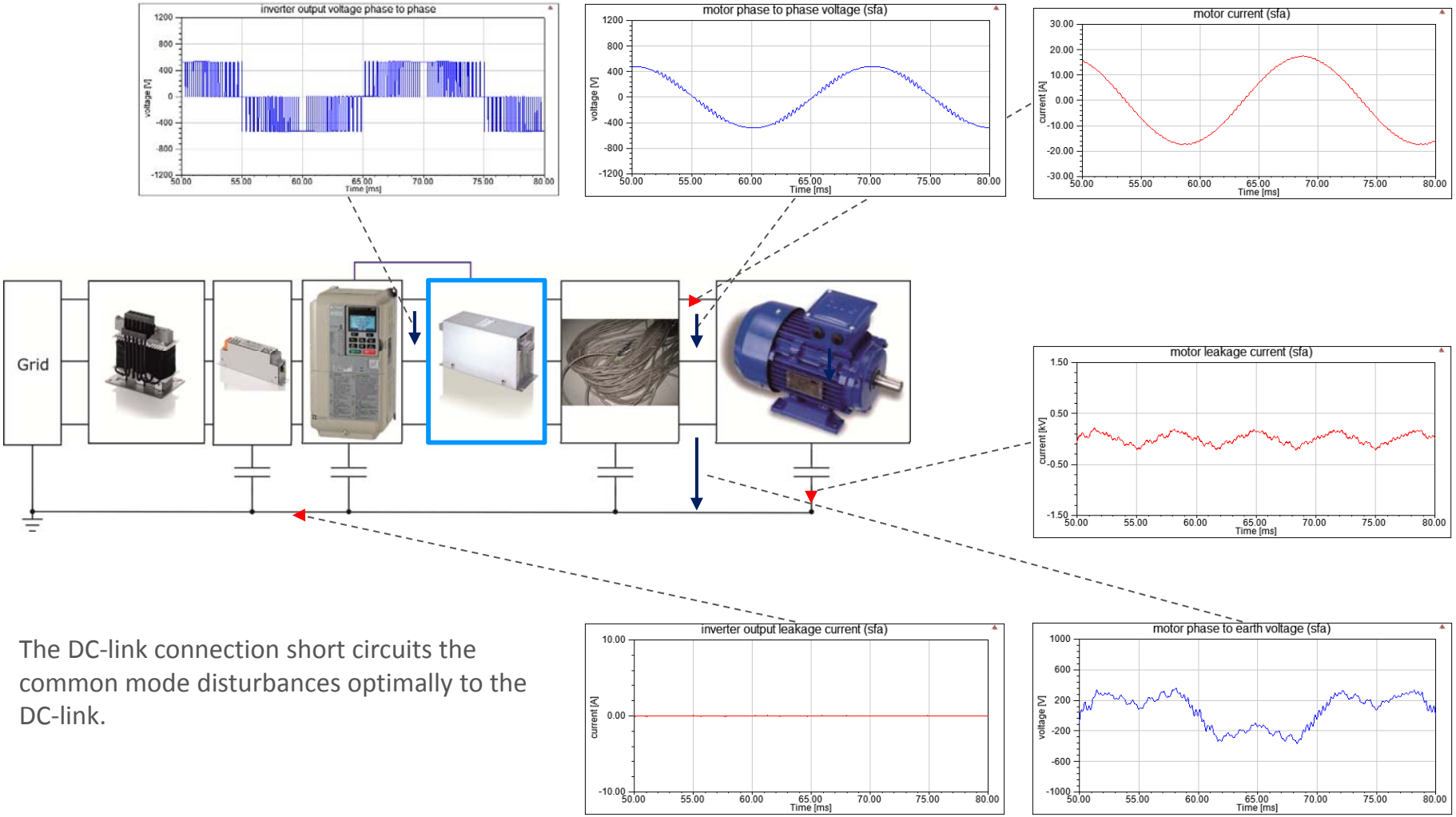
Generates nearly pure sinusoidal differential mode motor voltages and motor currents

→ long motor cables are possible, no HF losses in motor





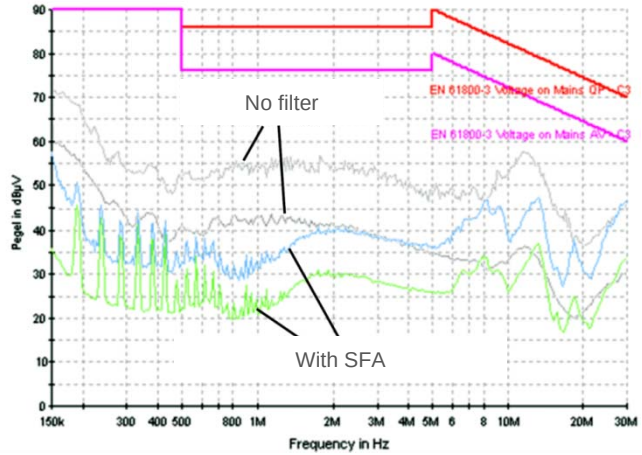
COMMON MODE MOTOR FILTERS
ALLPOLE SINE FILTER - SFA



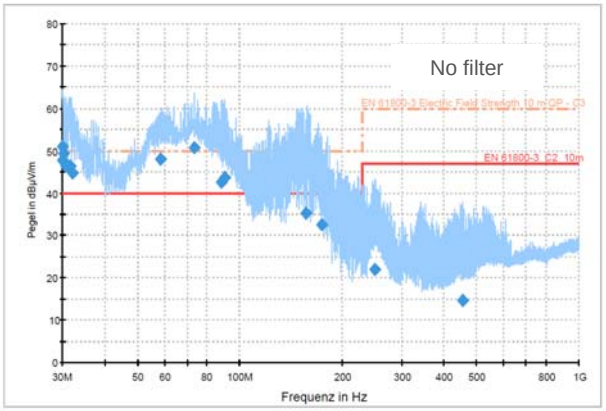
The DC-link connection short circuits the common mode disturbances optimally to the DC-link.

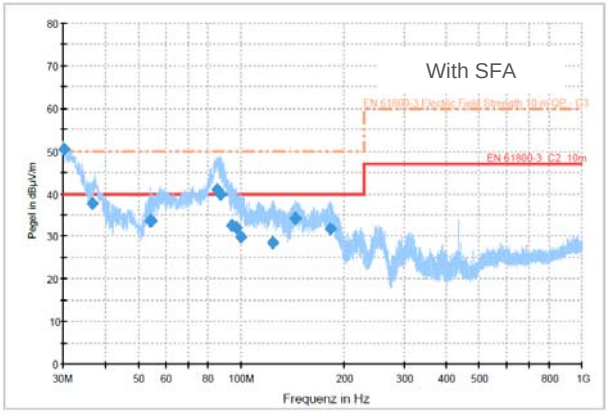
COMMON MODE MOTOR FILTERS
ADDITIONAL BENEFITS OF ALLPOLE SINE FILTER - SFA

Line conducted emissions



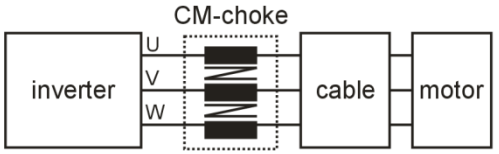
radiated emissions

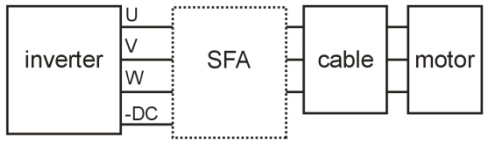




EVALUATION OF BEARING CURRENTS
ABSTRACT OF THE EVALUATION

Cooperate evaluation with institut for electrical engineering
University of Hannover



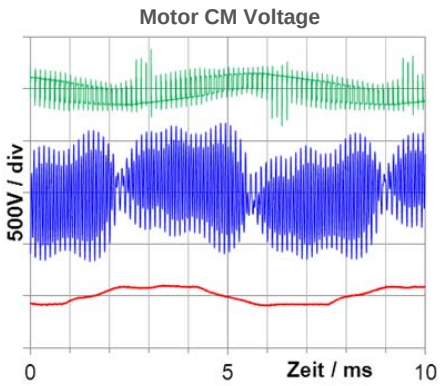


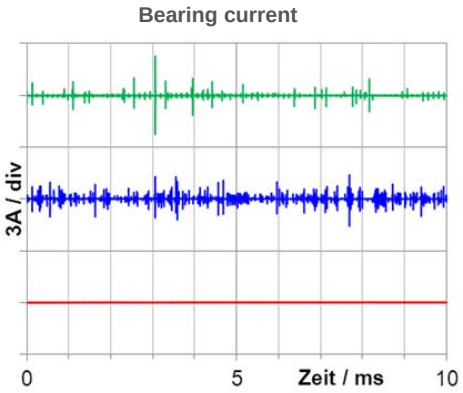
No filter

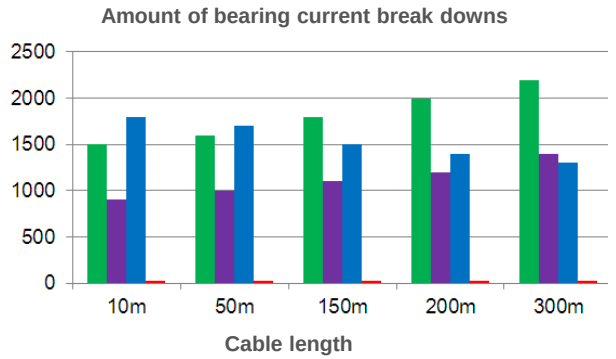
With CM-choke motor side

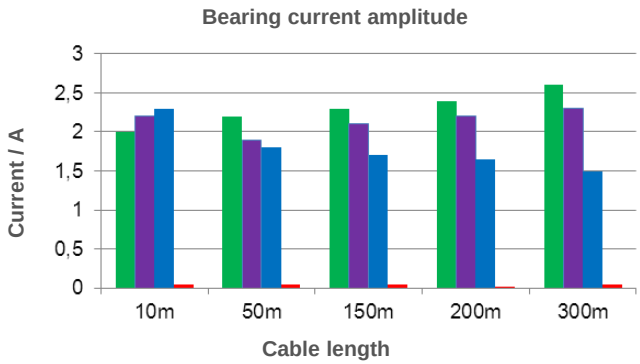
With CM-choke inverter side

With SFA allpole sine filter



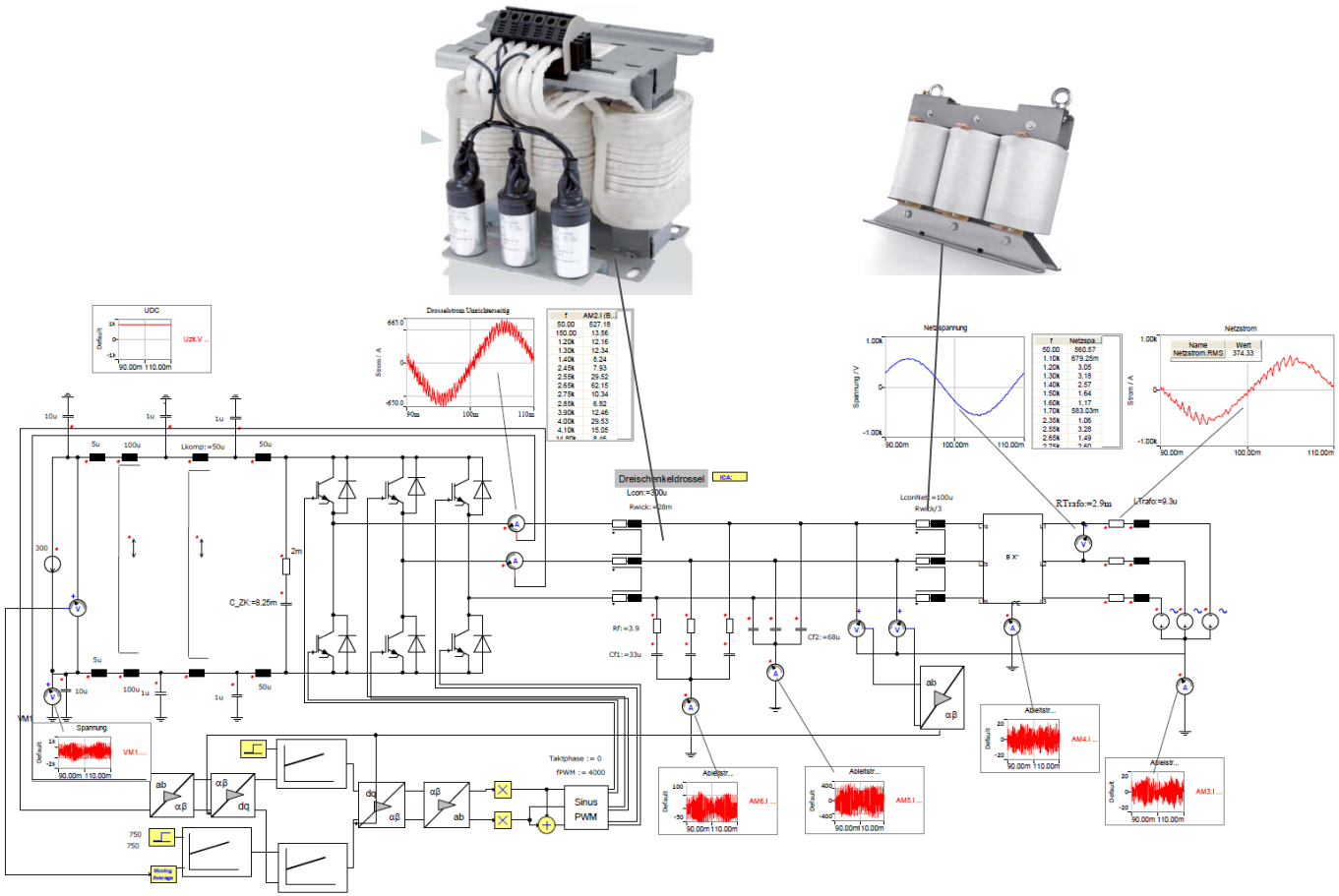






Only SFA eliminates bearing currents!

DESIGN: COMPLETE SYSTEMS WITH SIMPLORER
GET L, C, CURRENT,…

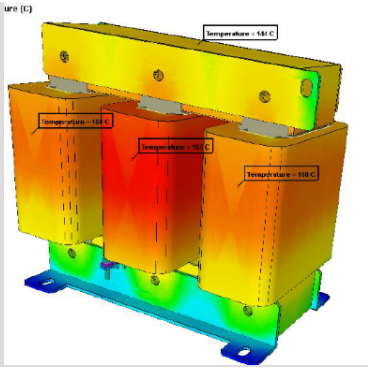


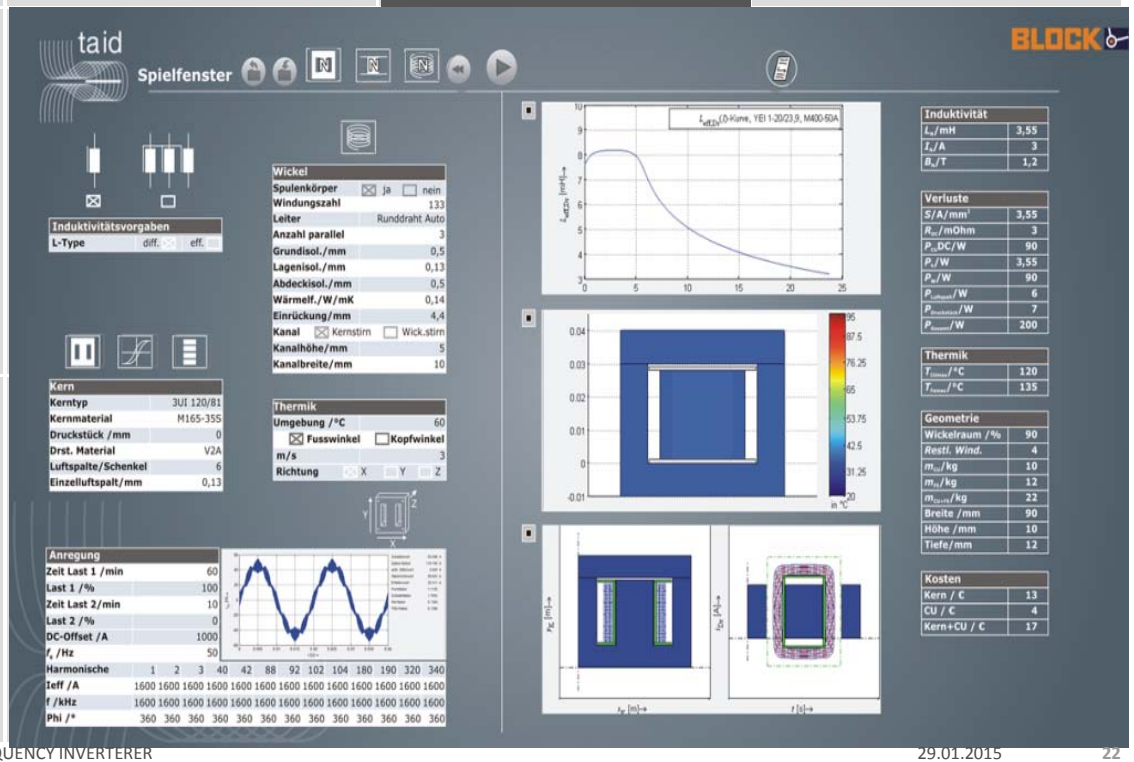
models for AFE, 2- und 3-level-inverter, different PWM strategies

INDUCTOR CALCULATION SOFTWARE
DESIGN THE CHOKE

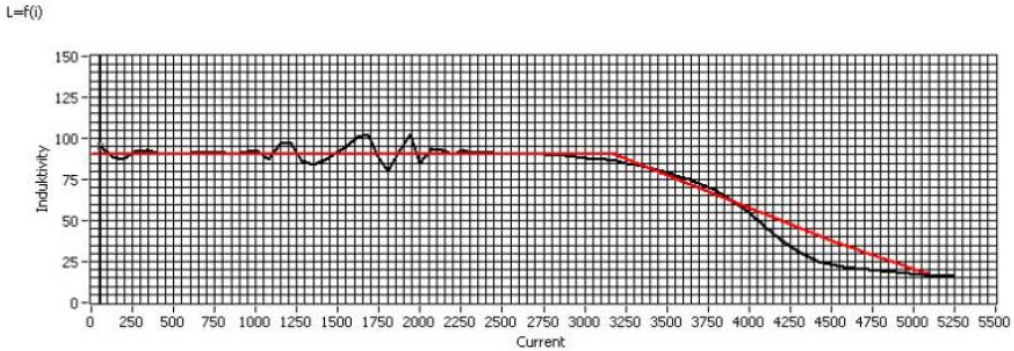
FEM -
for special projects

TaID- own calculation programm





TESTING IN-HOUSE
INDUCTANCE, IMPEDANCE, THERMAL



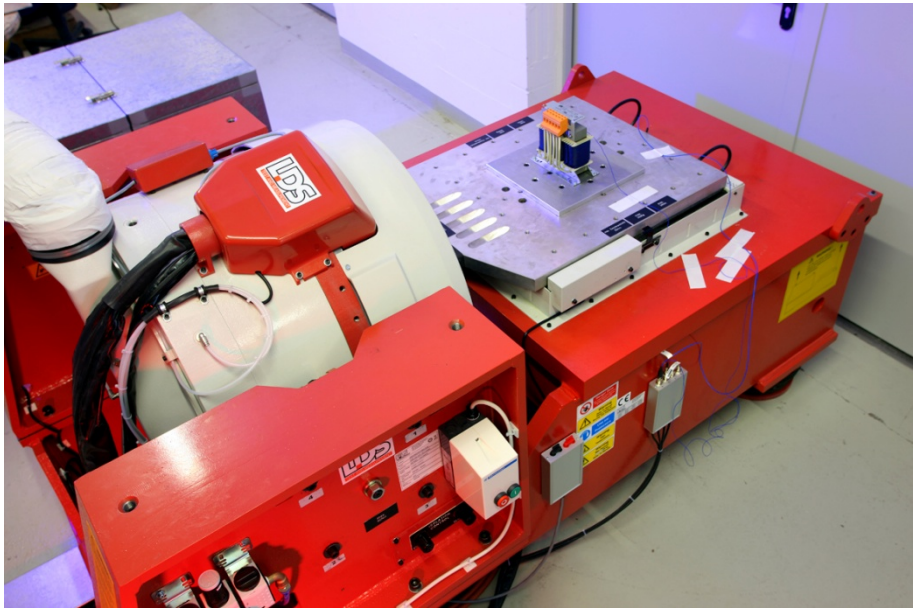
Inductance measurement up to 12.000A

YOKOGAWA/ZIMMER
Power measurement

Parasitics, acoustics

1MVA load

TESTING IN-HOUSE
MECHANIC / AGING



Shaker
150g / 350kg / 3000Hz / 2m/s

Climatic chambers

SUMMARY
WHERE TO USE WHAT?

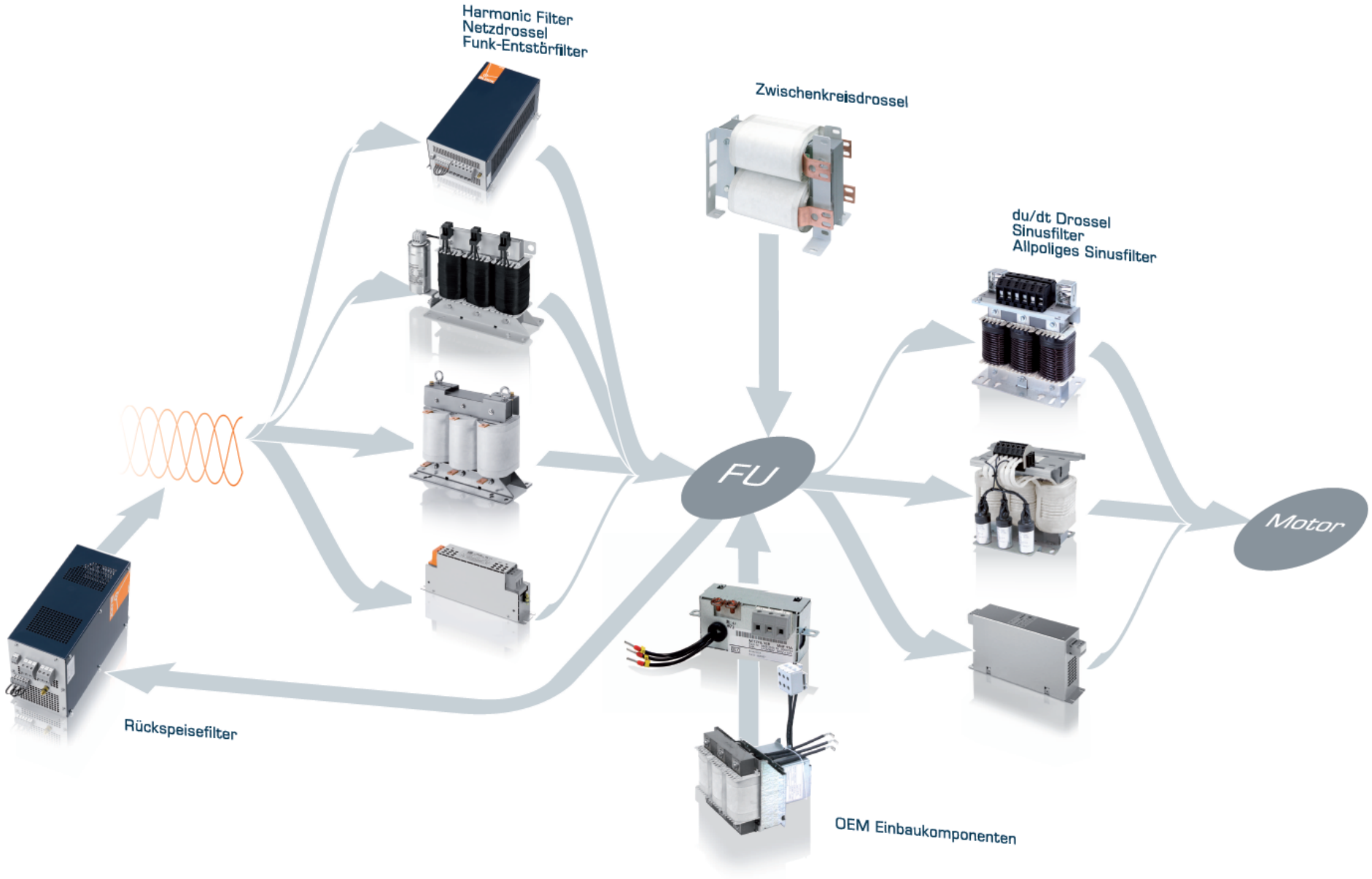
		EMI-standards			Grid	RCD	lifetime of motors				inverter	
	Improvement	conducted EMI	radiated EMI	line harmonics	line reactive power	leakage currents	motor isolation	bearing currents	motor audible noise	motor losses	input inrush current	output chargings currents, inverter losses
EMI-Filter	HLD, HLE, HFD…	XXX	X			XX						
Harmonic filter	LR3, LR1 line chokes			XX	XX						XX	
	HF1K, HFM, HF1P			XXX	XXX						XXX	
Motor filter	MR3 motor choke	X					X					XX
	SFB sine filter	X					XX		XX	XXX		XXX
	SFA allpole	XX	X			XX	XXX	XXX	XXX	XXX		XXX

X-beneficial impact

XX-high beneficial impact

XXX- very high beneficial impact

SUMMARY


Harmonic Filter
Netzdrossel
Funk-Entstörfilter
Zwischenkreisdrossel
du/dt Drossel
Sinusfilter
Allpoliges Sinusfilter
FU
Motor
Rückspeisefilter
OEM Einbaukomponenten

WISHLIST FOR SUPPLIERS

CU/Al:

- Less specific resistance
- Self-isolated >500V and <10µm isolation (mechanical stress and 200°C resistant for 30 years)
- Ideally rounded down edges of foils
- HF-Litz wires >100.000 x 0,05mm
- Delivery same day 1kg-10to

Electrical steel:

- Easy to stamp and assemble
- Minimum losses 2kHz-20kHz
- Zero magnetostriction
- Delivery same day 1kg-10to

Isolation material:

- Breakdown voltage >50kV/mm
- Thermal conductivity >2W/mK
- High resin absorptive capacity
- High partial discharge resistance
- High mechanical robustness
- Temp. Class N
- Delivery same day 1kg-10to
- nonflammable/nontoxic

Lower price!

VIELEN DANK!

THANK YOU!

HABEN SIE FRAGEN?

DO YOU HAVE QUESTIONS?

DR.-ING. D. KAMPEN

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