

## FUSS-EMV: The EMC-Authority

- Analysis
- Measurements
- Consulting
- Development and Fabrication of EMI-Filters



- Who is FUSS EMV?
- Harmonics
- Frequency Range
  - Low Frequencies
  - High Frequencies
- Ways of Filtering
  - Passive Filters
  - Active Filters

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## New Head Office 2010, Berlin-Adlershof



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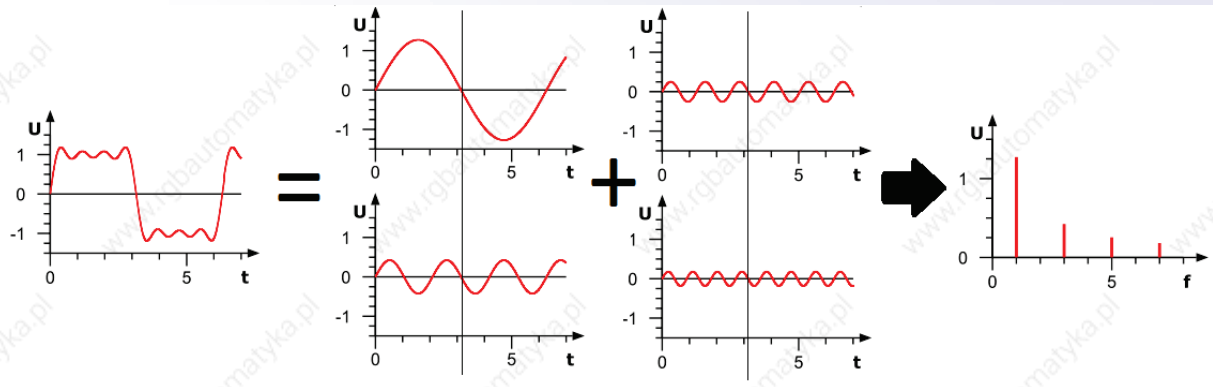
## Numbers on FUSS

Locations	Office and Lab: Berlin Manufacturing: Berlin and Prenzlau
Founded	In <b>1908</b> by Ing. Max Fuss, Inventor of electromechanical voltage controller for generators
Sales in Mio €	1998: 0,48 2008: 2,4 2010: <b>5,8</b>
Volume	<b>30.000</b> filters per year for power electronic applications <b>1200</b> customer specific products
Employees	68
Committees	VDE: National Committee on Standards DKE 623 ZVEI: Workgroup Power Quality
R&D Projects	TU Berlin, Fraunhofer Institute

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# Harmonics

Harmonics are generated by devices with non-linear characteristics. Today's most widespread producers of harmonics are power electronics, especially rectifiers using capacitive smoothing.



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# Harmonics

- Harmonics cause reactive power, the so called "Distortion Power"
- Harmonics can also cause overcurrents, even in the neutral conductor
- Harmonics can cause iron losses and thermal overloads in transformers
- Harmonics have a rotating field and therefore influence the operating performance of motors
- Harmonics can influence power switches and cause accidental shut-downs

The percentage of harmonics is represented by the Total Harmonic Distortion THD

$$THD_U = \frac{\sqrt{U^2 - U_1^2}}{U_1} = \sqrt{\sum_{v=2}^{50} \left(\frac{U_v}{U_1}\right)^2}$$

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## Low Frequencies 50 Hz – 2.5 kHz

IEC 61000-3-12, IEC 61000-3-2, EN 50160, D-A-CH-CZ

Solution: Harmonic Filters

Filtertype	THDi
No Filter	140 - 150 %
Line Choke 4% $U_k$	30 - 50 %
DC-Link Choke	30 %
Passive Harmonic Filter 16	16 %
Passive Harmonic Filter 10	10 %
Passive Harmonic Filter 10 plus DC-Link Choke	5 %
Active Filter	1 – 2%

## High Frequencies 150 kHz – 16 GHz

IEC 61000, IEC 61800

Grid-bound interferences: 150 kHz – 30 MHz

Field-bound Interferences: 30 MHz – 16 GHz

Solution: EMI-Filters (14 kHz – 40 MHz)

## In Between: 2.5 kHz – 20 kHz

No real standards, only guidelines, for example the ILA-guideline

Important frequency range because of clock frequencies of frequency-converters (usually 3 kHz – 7 kHz)

Solution: Output-Filters like dU/dt-Filters, Sinusoidal Filters or All Pole Sinefilters (2 kHz - 18 kHz)

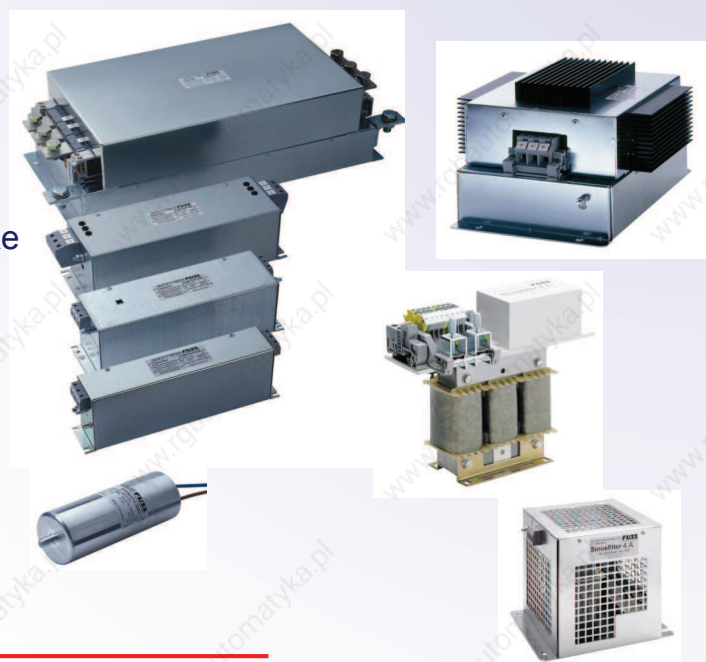
## Passive Filters

### Scheme

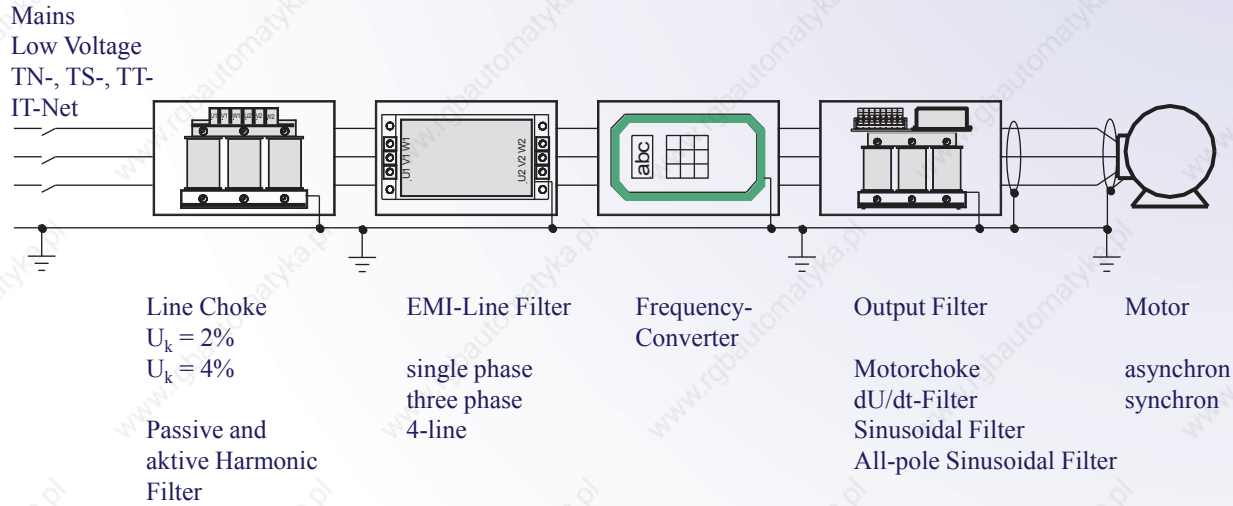
- Inputfilter – Outputfilter
- Harmonic Filter – Sinusoidal Filter
- du/dt – Filter
- Line Choke – Motor Choke

### Challenges:

- Component Design
- Taking Parasitics into account for optimum filter design.
- Parasitics Compensation
- New Topologies

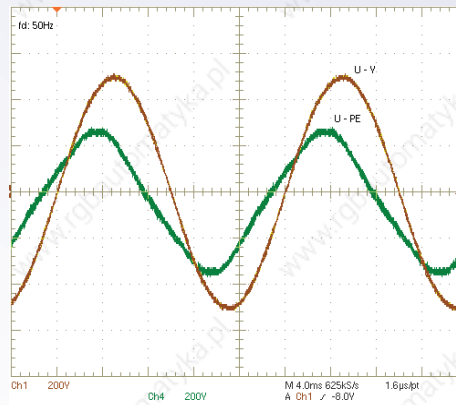
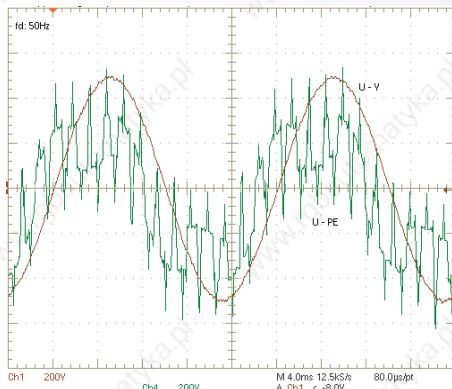
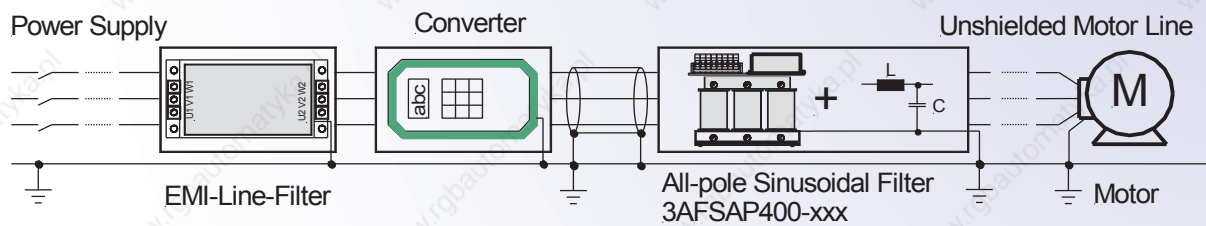


# EM Compatible Drive



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# All-pole Sinusoidal Filters with CM-stage



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# Active Filters

What means active? What is the difference to passive?

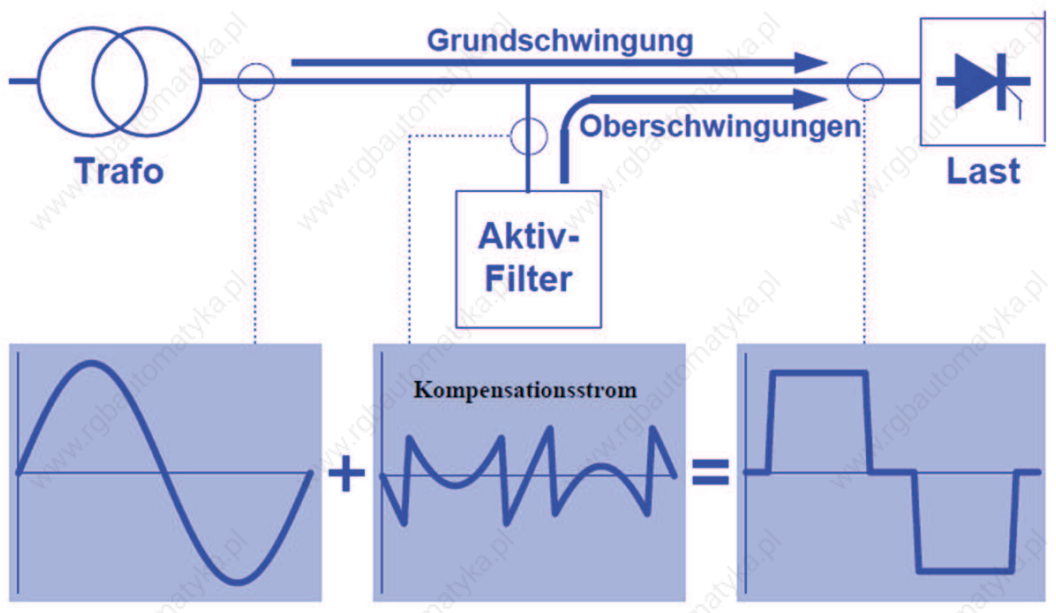
Passive Filters:

- low-pass filter that has to be built for a certain frequency range,
- blocks other frequencies
- different filters for different functions

Active Filters:

- do active measurements and induct a compensating signal
- parameterizable for single harmonics, harmonic ranges, and / or reactive power compensation
- one filter for different functions

# Active Filter Function



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Thank you very much for your attention!  
[www.fuss-emv.com](http://www.fuss-emv.com)

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