LED EVENT 2017

Design en engineering trends voor LED-applicaties

BE WOENSDAG 29 NOVEMBER 2017
TECHNOPOLIS, MECHELEN
NL DONDERDAG 30 NOVEMBER 2017
CONGRESCENTRUM 1931
BRABANTHALLEN, DEN BOSCH

WÜRTH ELEKTRONIK

PFC and EMI filtering

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November 2017

- **EMC Standards**
- **Power Factor Correction**
- **Conducted emissions**
- **Radiated emissions**

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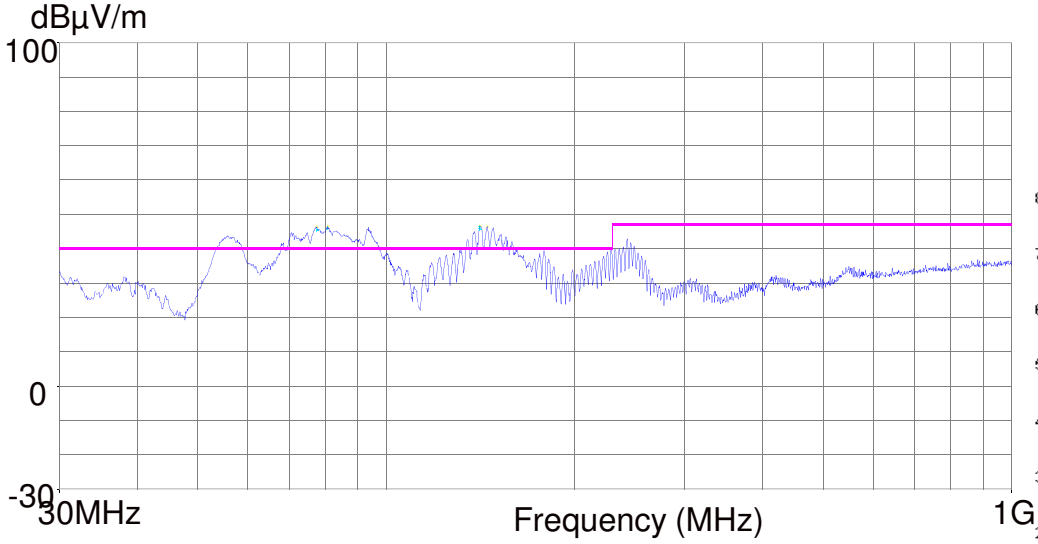
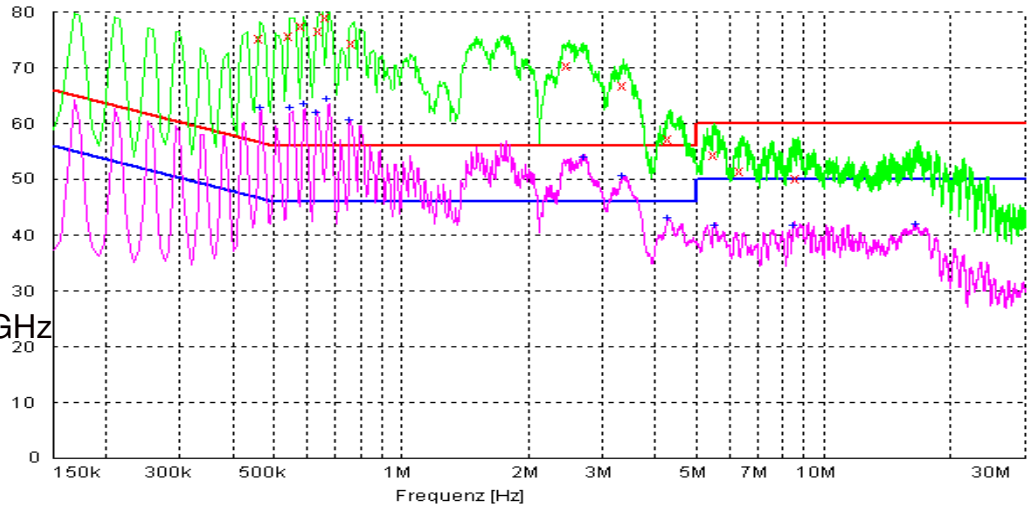
Overview of standard covering SMPS

- *CISPR11, EN55011 for industrial, medical, scientific applications*
- *CISPR13, EN55013 for consumer applications*
- *CISPR14, EN55014 for home appliances, power tools,*
- *CISPR15, EN55015 for lighting equipment*
- *CISPR22, EN55022 for computing applications*





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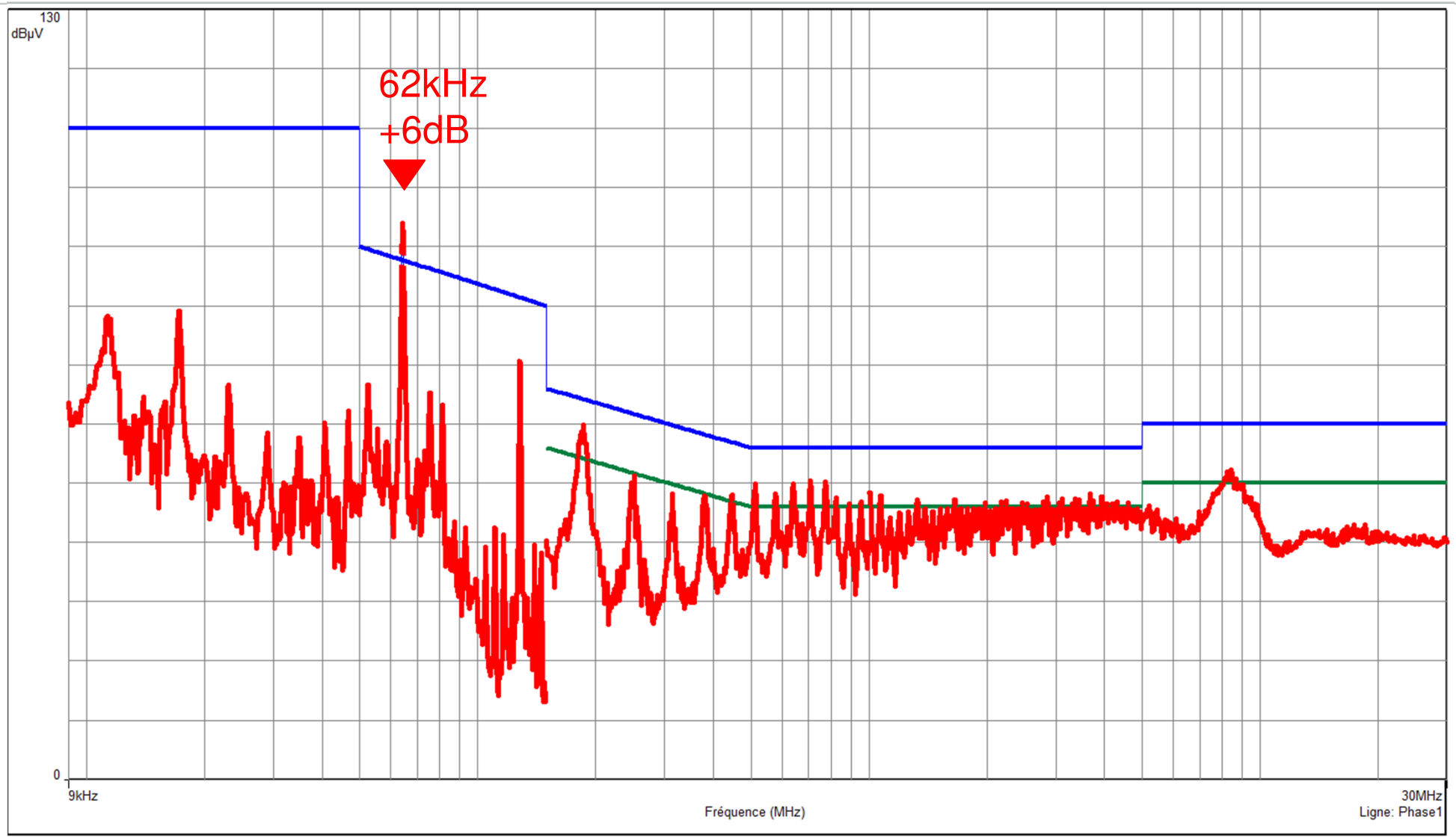
Low Frequency Conducted EMC (CISPR15)



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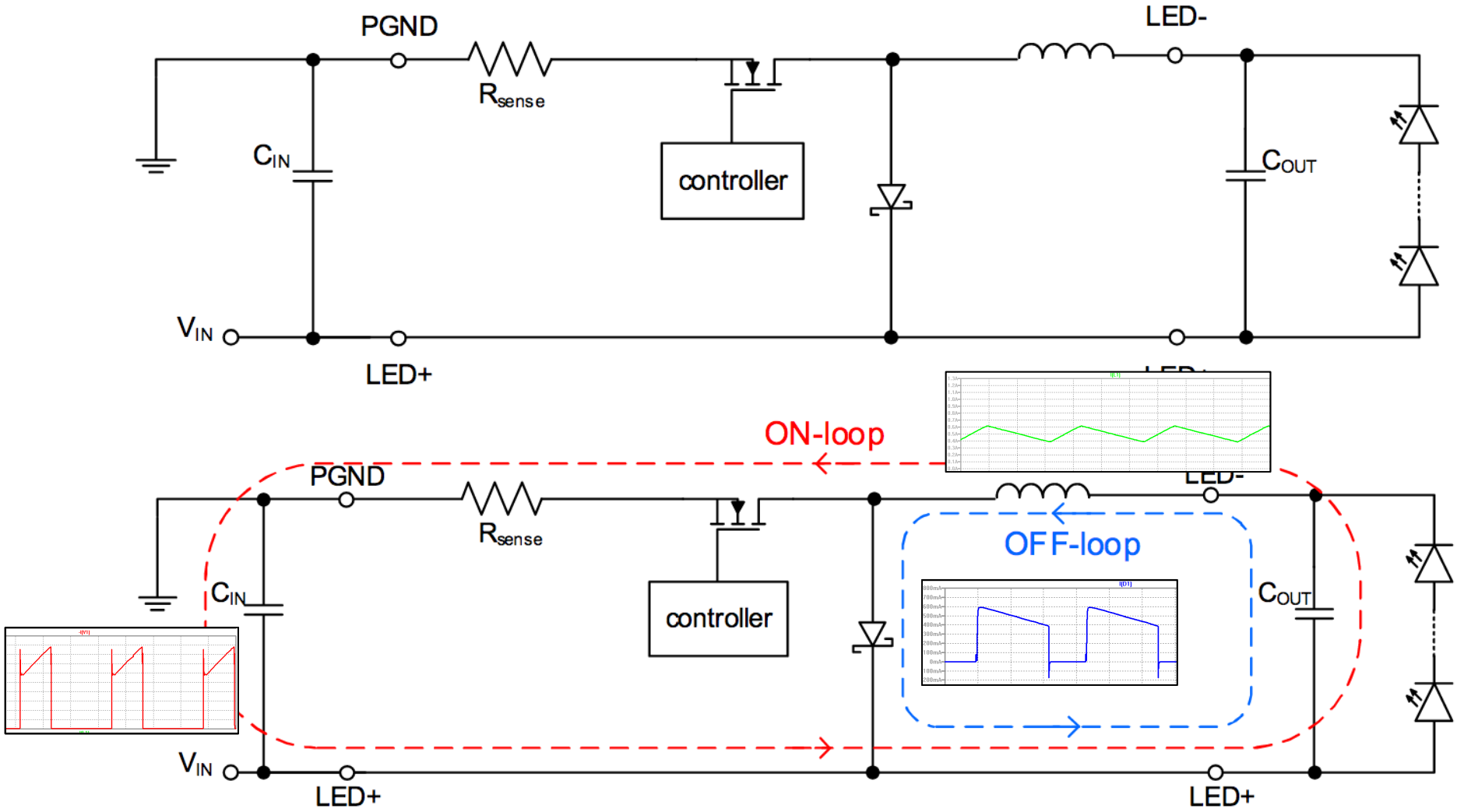
LED Driver



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PFC/ Harmonic standard EN61000-3-2

- To avoid reactive power on power network, a PFC circuit is needed with most switch mode power solutions
- It is required by law
- Used for electrical regulated Loads
  - Switching power supplies
  - Electronic Engine regulation
  - Lighting dimmer

Problems of high peak current

- Peak current of the loads occur at the same time
- occur nearly at the voltage peak

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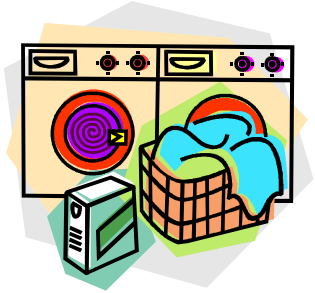
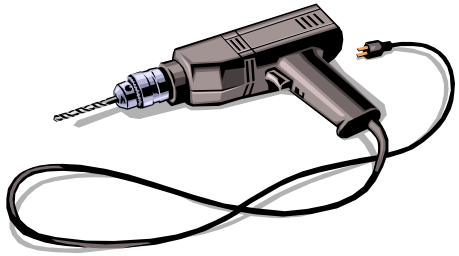
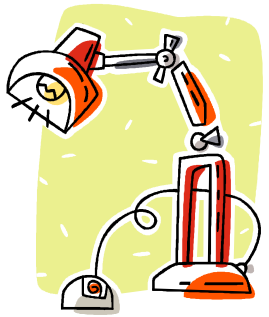
EN61000-3-2 Classes

- Class A
  - 3-phase devices
  - White goods
  - All devices which are not mentioned in other Classes
- Class B
  - Portable Tools
- Class C
  - Lighting equipment
    - PF requirement also for small power
- Class D
  - PC
  - Screen
  - TV- Radio equipment with input power of < 600W







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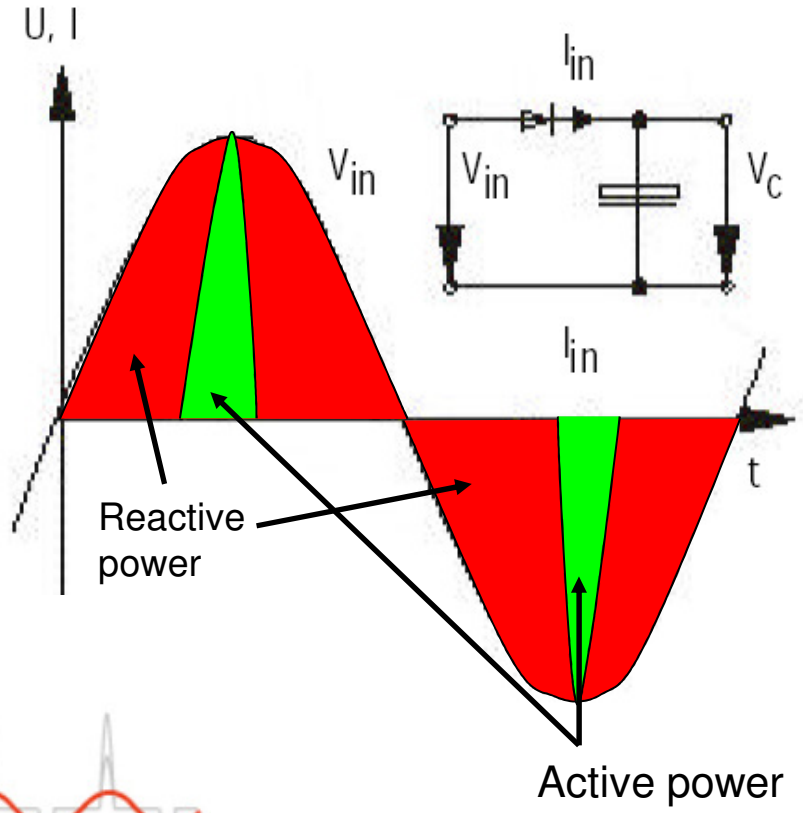
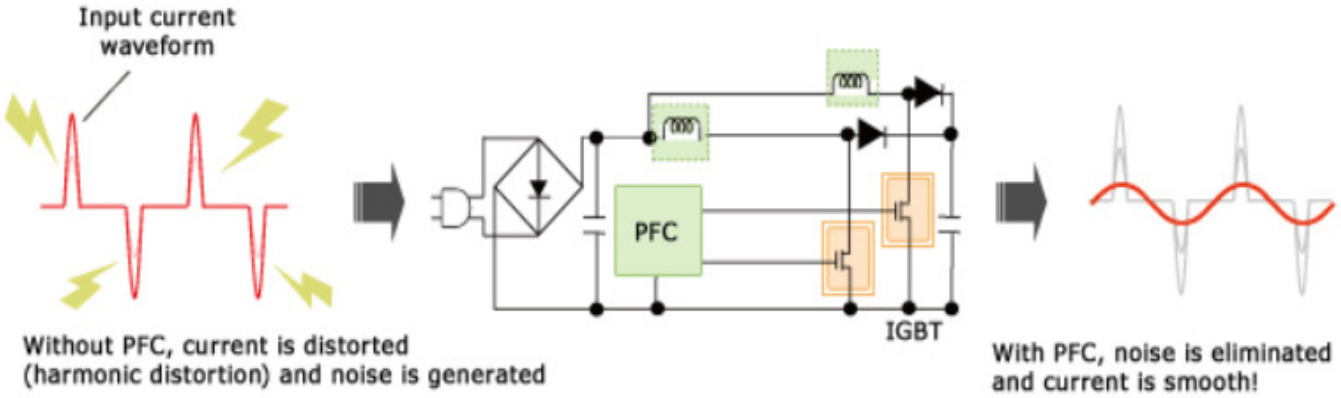
What is PFC and what does a PFC (choke) do?

- **What does PFC mean?**
  PFC means “power factor correction”
- **PFC choke forms the input current**
  in phase to the mains voltage
- **Why PFC?**
  To avoid reactive power
  which have to be provided by energy providers





Source: www.Renesas.eu

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Passive PFC

- **Passive PFC**
  - **Choke and Cap. (Low-Pass-Filter)**

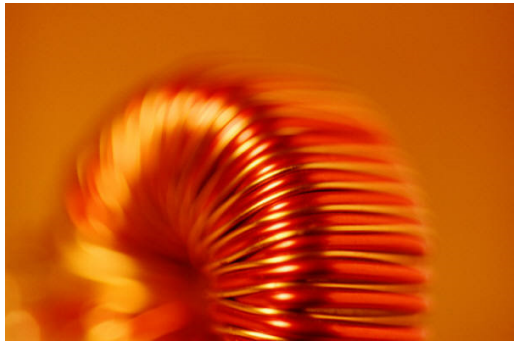
Advantage:

- **Cost effective (Component)**

Disadvantage:

- **Required too much space on PCB**
- **Power Factor between 0,7 -0,8**

typical characteristic on the PCB
→ big toroidal core at the input



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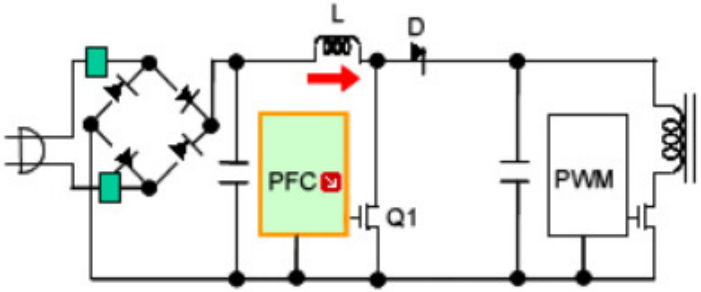
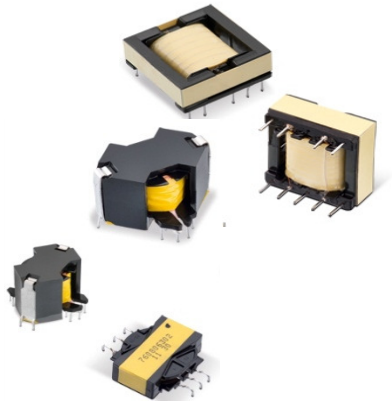
Active PFC



- **Active PFC**
  - **Choke with Bias winding for the IC (not for all a Bias winding)**
  - **Controlled by an IC**

  Advantage:
  - **Required less space on PCB**
  - **Power Factor close to 1**
  - **Universal input regulation**
  - **Better EMI compatibility**

  Disadvantage:
  - **Cost intensive**



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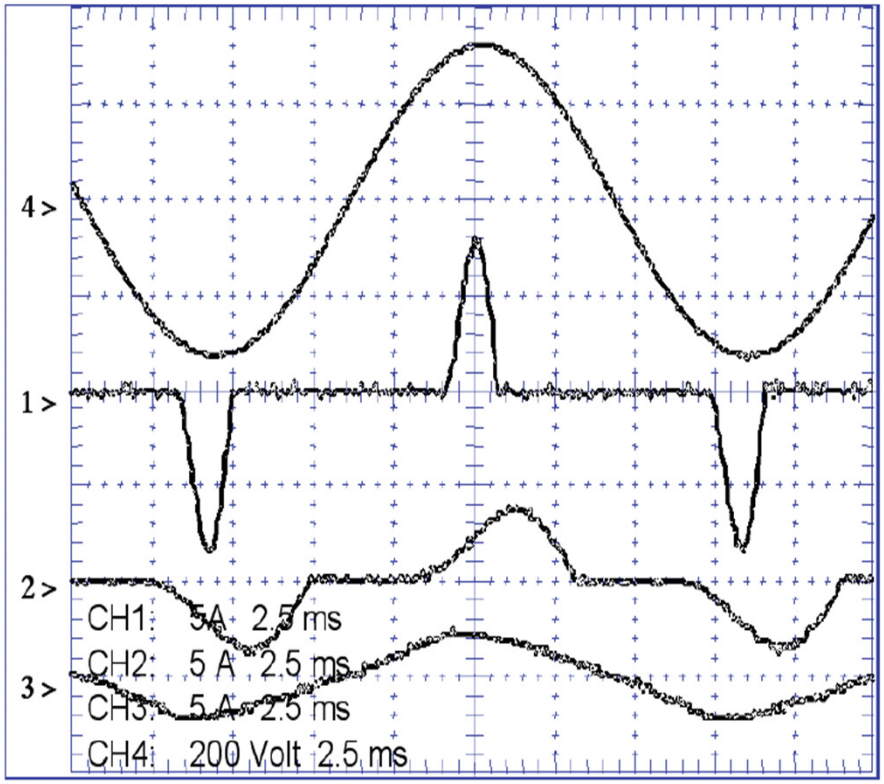
Different PFC Solutions

1. Input current with no PFC
2. Input current with passive PFC
3. Input current with active PFC
4. Input voltage



- **Input Characteristics of PC Power Supplies with PFC Types**
- **(None, Passive and Active)**

Source: www.onsemi.com/pub_link/Collateral/HBD853-D.PDF

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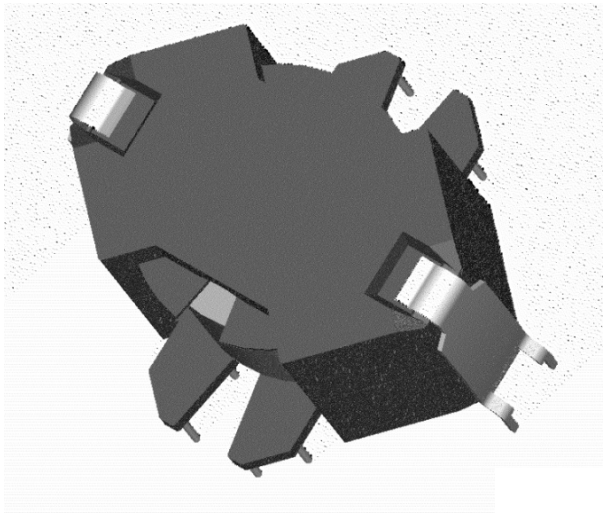
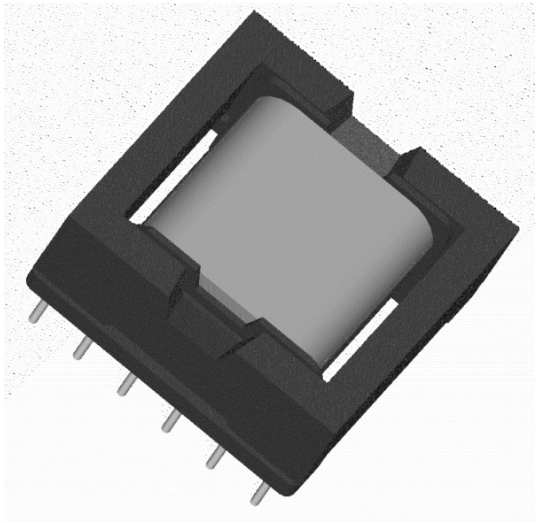
WE Standard PFC parts

- **RM series**
  - **Small footprint**
  - **Good EMC behaviour due to shielded and grounded core**
  - **Low proximity losses due to litz wire**



- **EFD series**
  - **Flat design**
  - **Low proximity losses due to litz wire**



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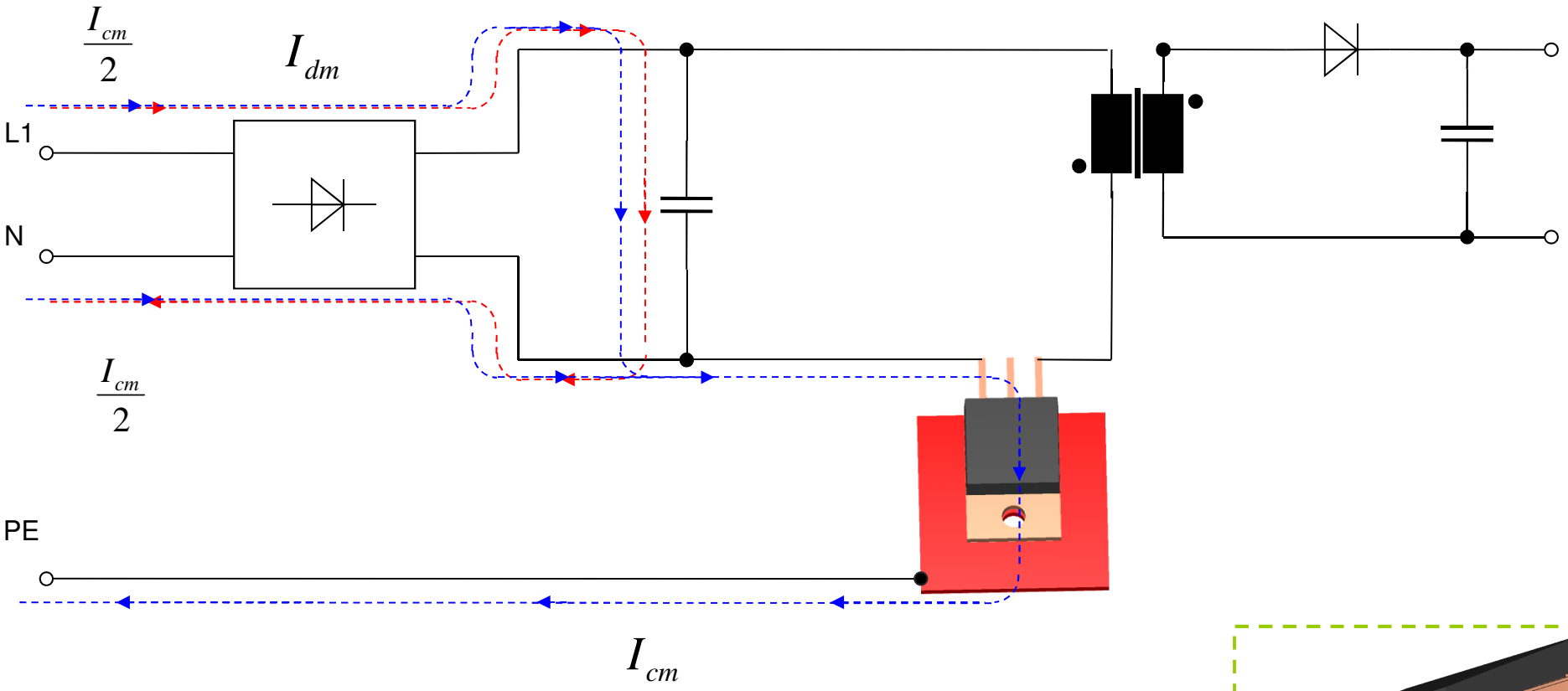
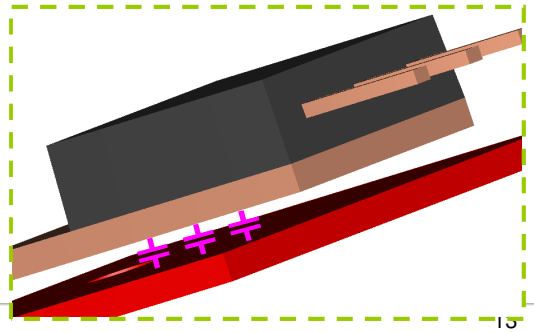
Common Mode noise



→Parasitic capacities

e.g.: collector to cooling element



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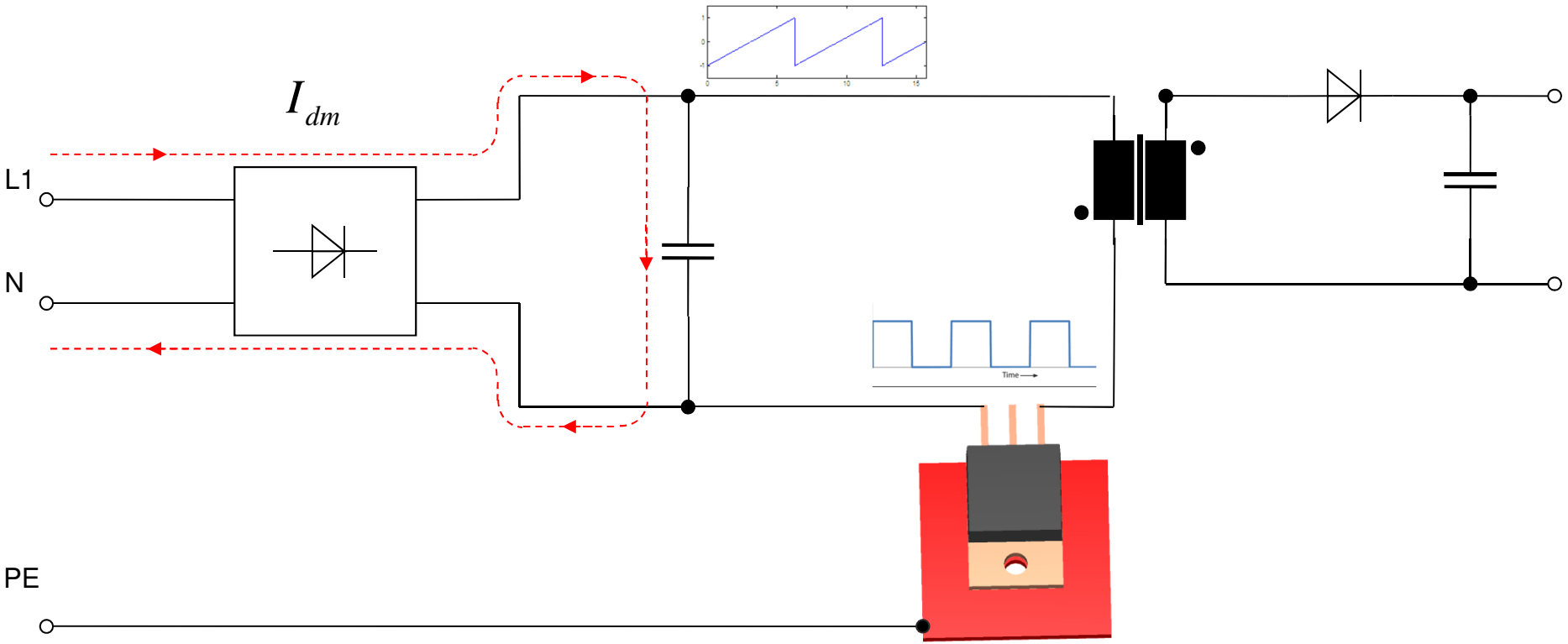
Differential mode calculation example



$I = 2A$

$Duty\ \text{Cycle} = 50\%$

$F_{sw} = 150Khz$

$ESR = 50m\Omega$

Check 55022 ClassB standard @ 150Khz : Allowed 66 dBµV = 2mV

$$I_{Harmonic1} = \frac{2}{\pi\sqrt{2}} = 450mA_{rms} \qquad V_c = I_{Harmonic1} ESR = 23mV$$

$$V_{measured} = \frac{V_C}{2} = 11{,}5mV$$

WARNING!
BAD THINKING AHEAD

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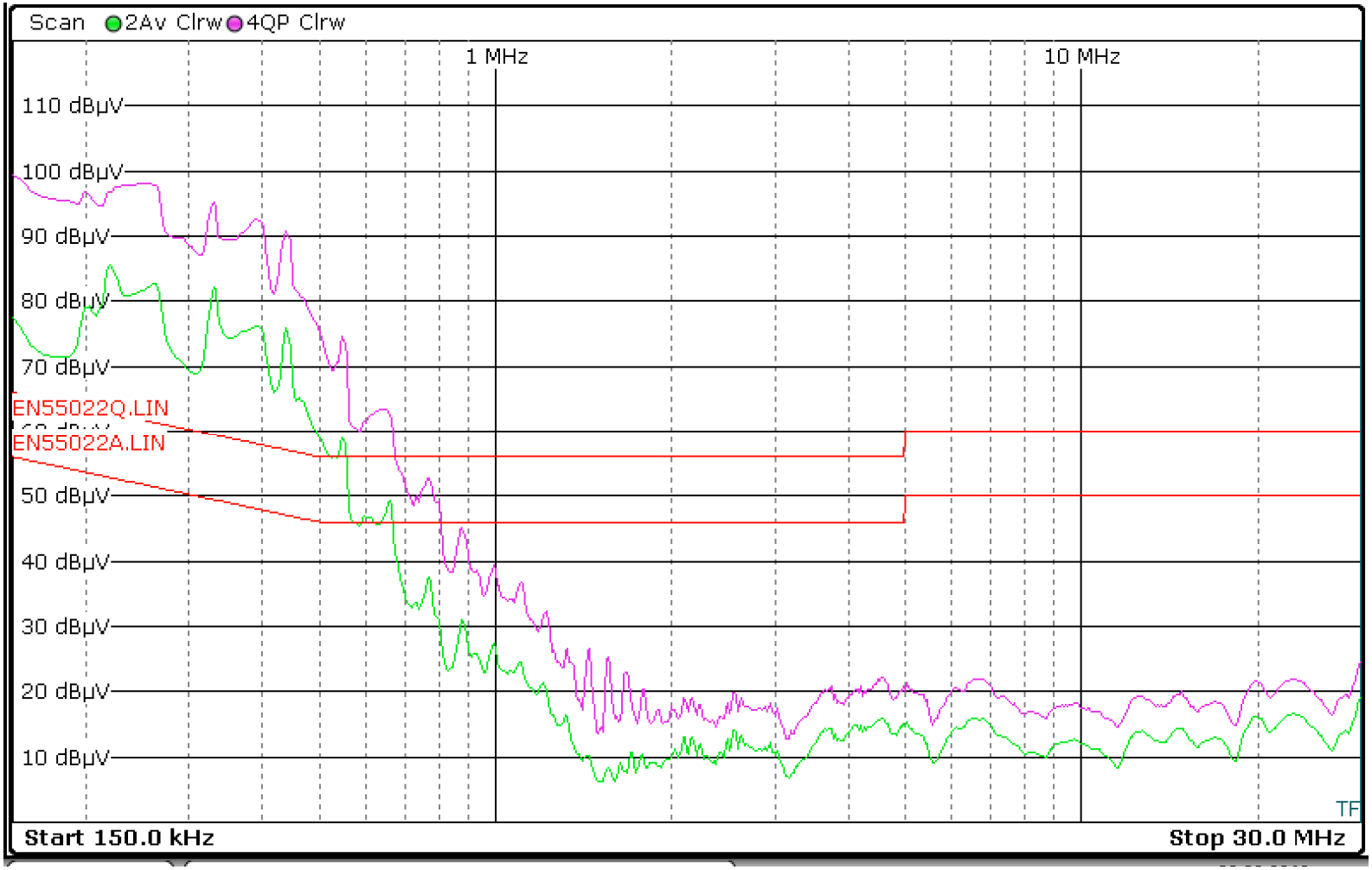
Still noisy



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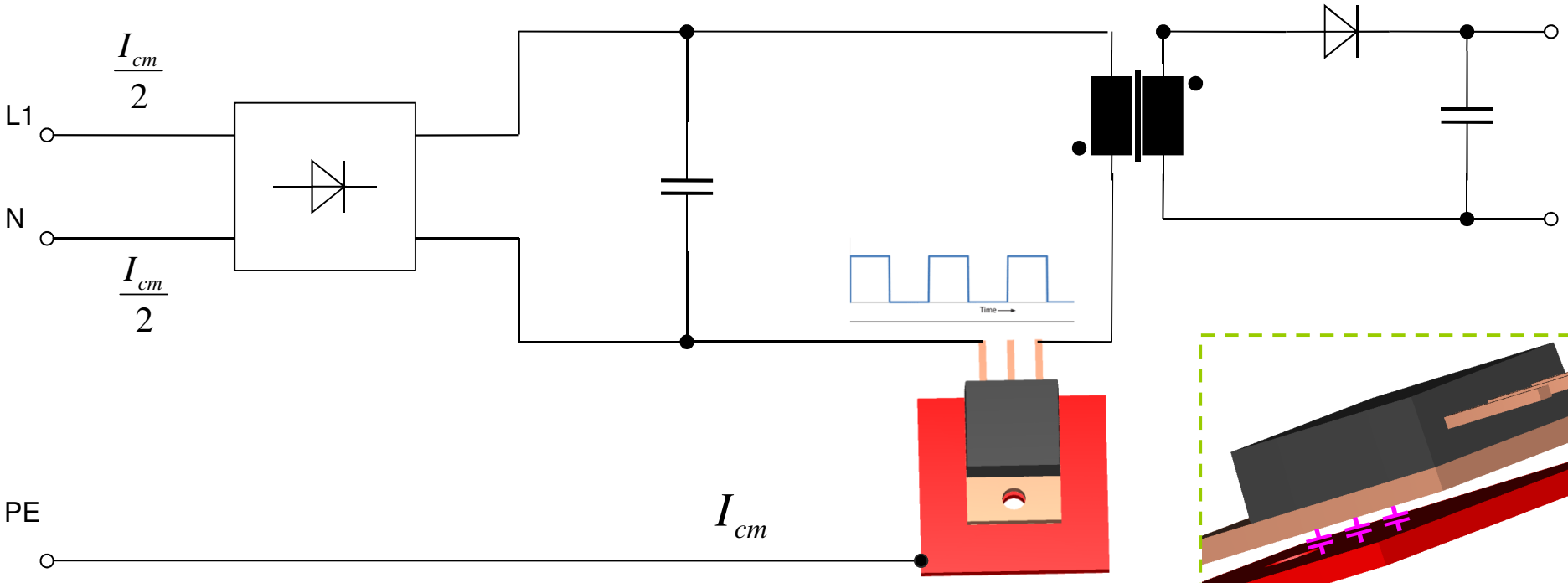
Common mode noise calculation example



$V = 400V$

$Duty\,\text{Cycle} = 50\%$

$F_{sw} = 150Khz$

$C = 50pF$

Check 55022 ClassB standard @ 150Khz : Allowed 66 dBµV = 2mV

$$V_{Harmonic1} = \frac{2}{\pi}\frac{V_{max}}{\sqrt{2}} = 180V_{rms}$$

$$I_{hamonic1} = 2.\pi.f.C.V_{Harmonic1} = 8{,}4mA$$

$$V_{measured} = 25\Omega.I_{cm} = 210mV$$

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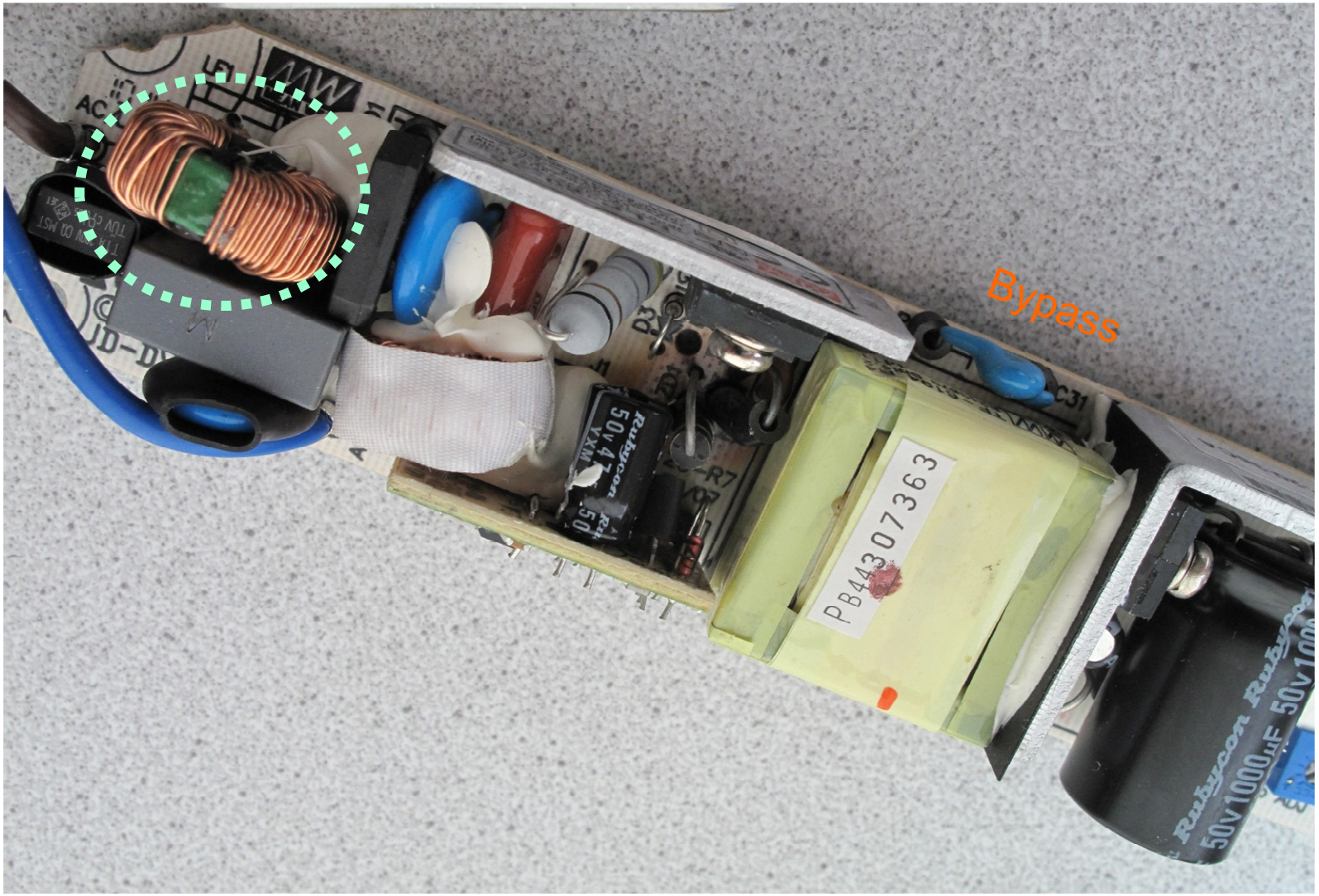
« Block & Bypass » examples



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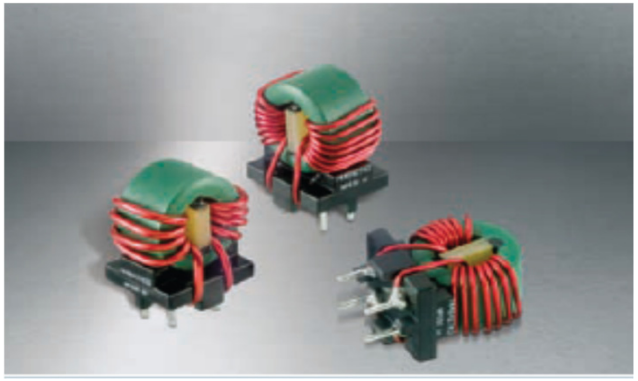
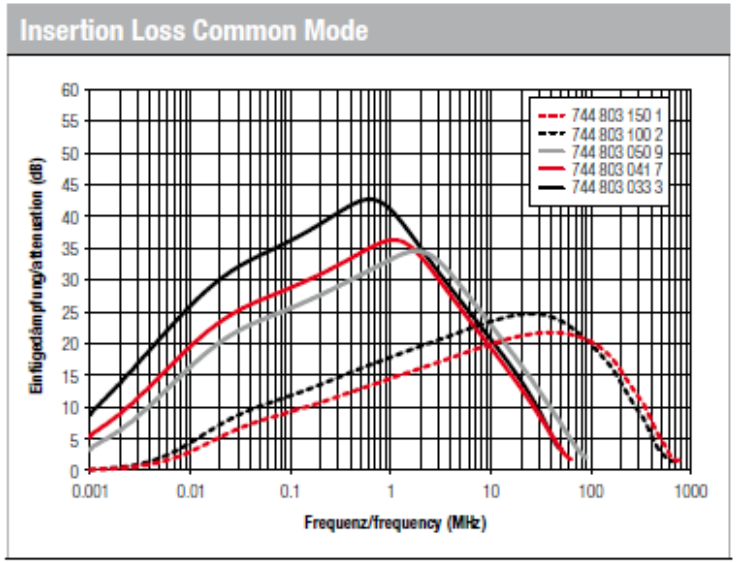
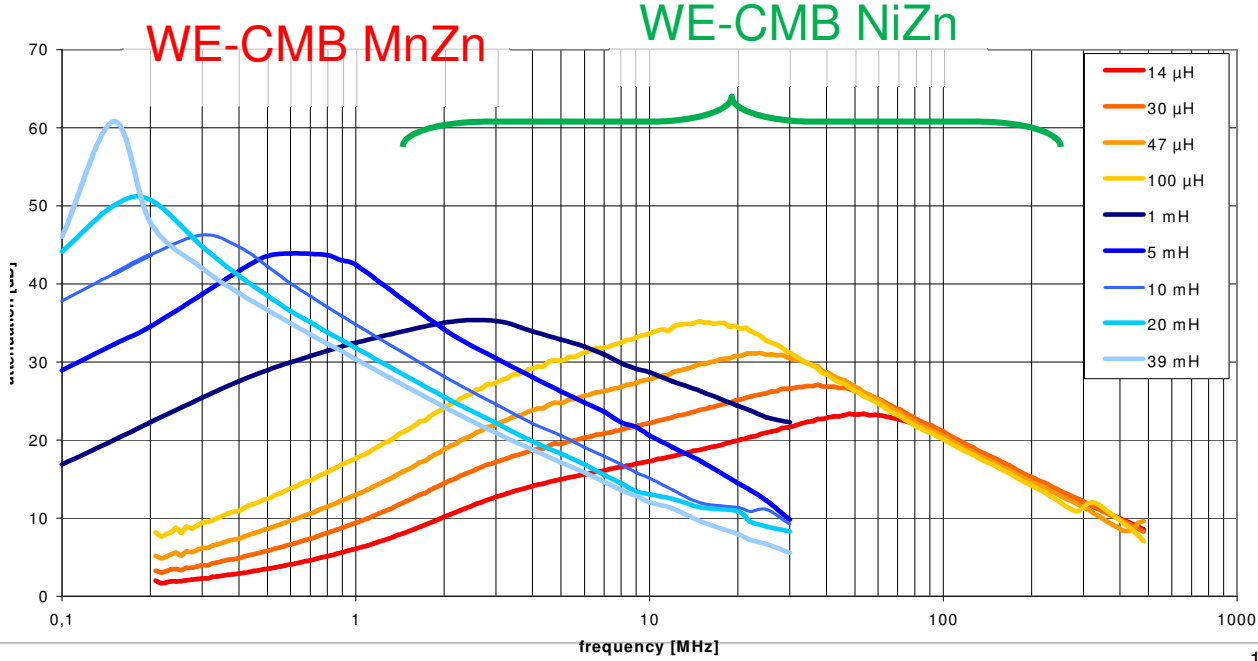
Effective frequency range

CMB NC







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X-Y capacitors

	Safety MLCC	Safety Film
		
Availabe series:	WCAP-CSSA	WCAP-FTX2 WCAP-FTXX
Safety class:	X1/Y2, X2/Y3	X2
Type:	SMT 1808, 1812, 2211	THT boxed
Rated Voltage:	250 V_{AC}	275 V_{AC}, 310 V_{AC}
Dielectric:	NP0, X7R	Polypropylene (PP)
Capacitance Range:	33–2200 pF	0.0056–6.8 µF
Approvals:	TUV (EN 60384-14:2005), File number: R 50268363 cULus, File numbers: E345659, E331896	ENEC 10 by VDE cULus, File number: E345659 CQC, File number: 13001104051
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