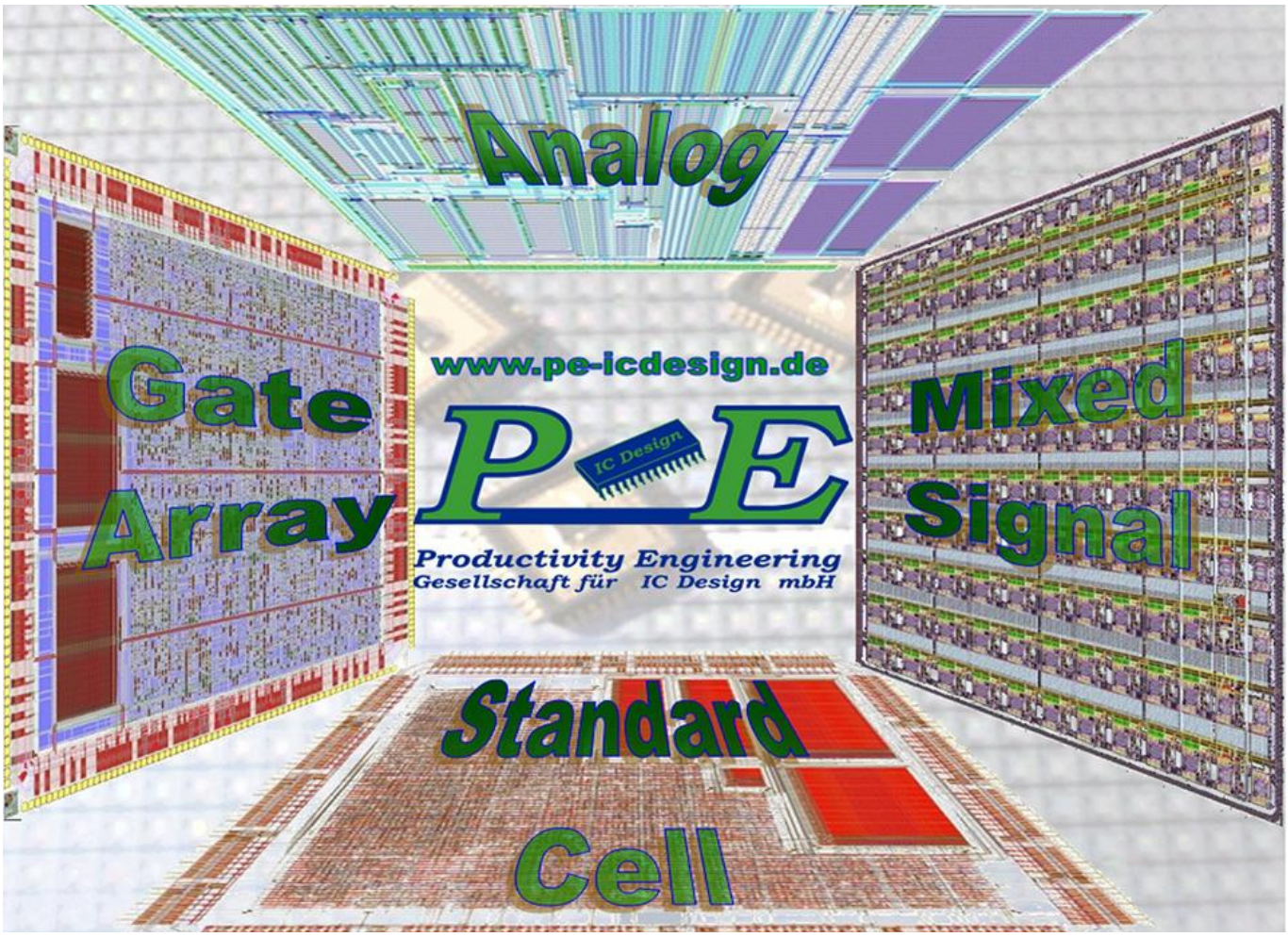
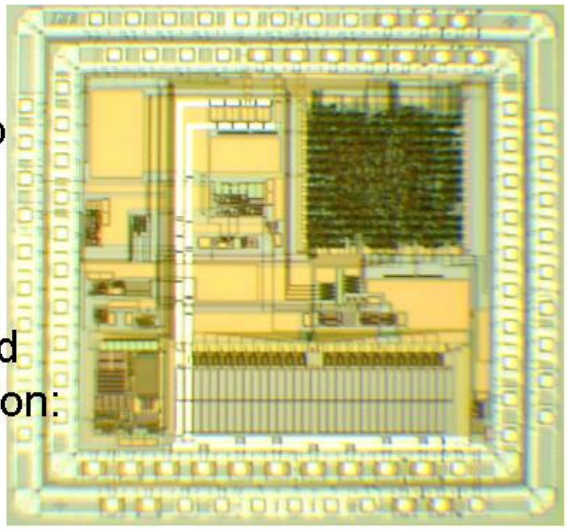
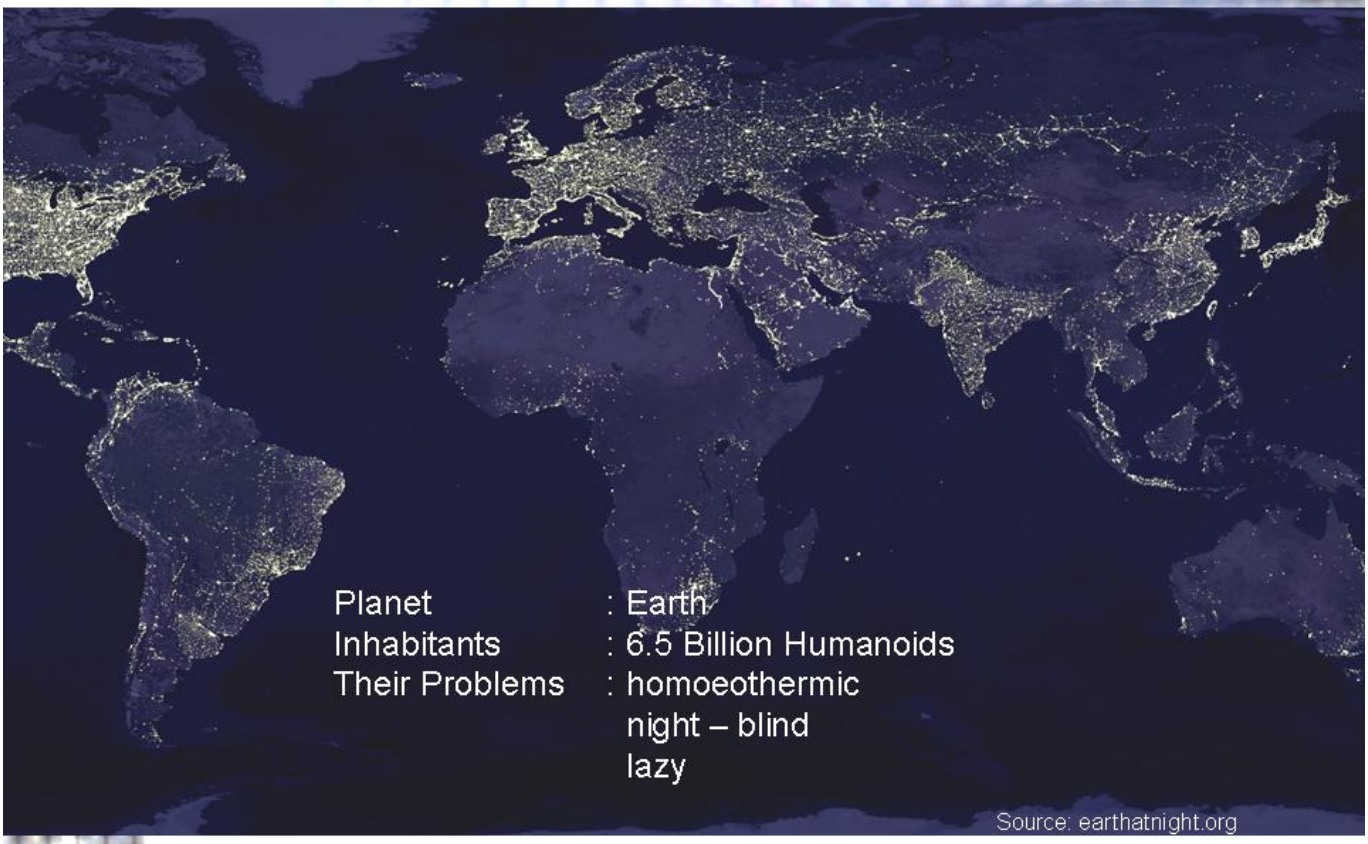


Productivity Engineering Gesellschaft für IC Design mbH



- 13 Employees
- 32 in the PE company group
- Mixed Signal ASIC Design
- Headquarters in Dresden
- founded in 2005
- parent company 11 years old
- strategic competence direction:
  - smart power
  - smart RFID
  - capacitive sensor signal conditioning

Power supply efficiency by current and voltage sensing

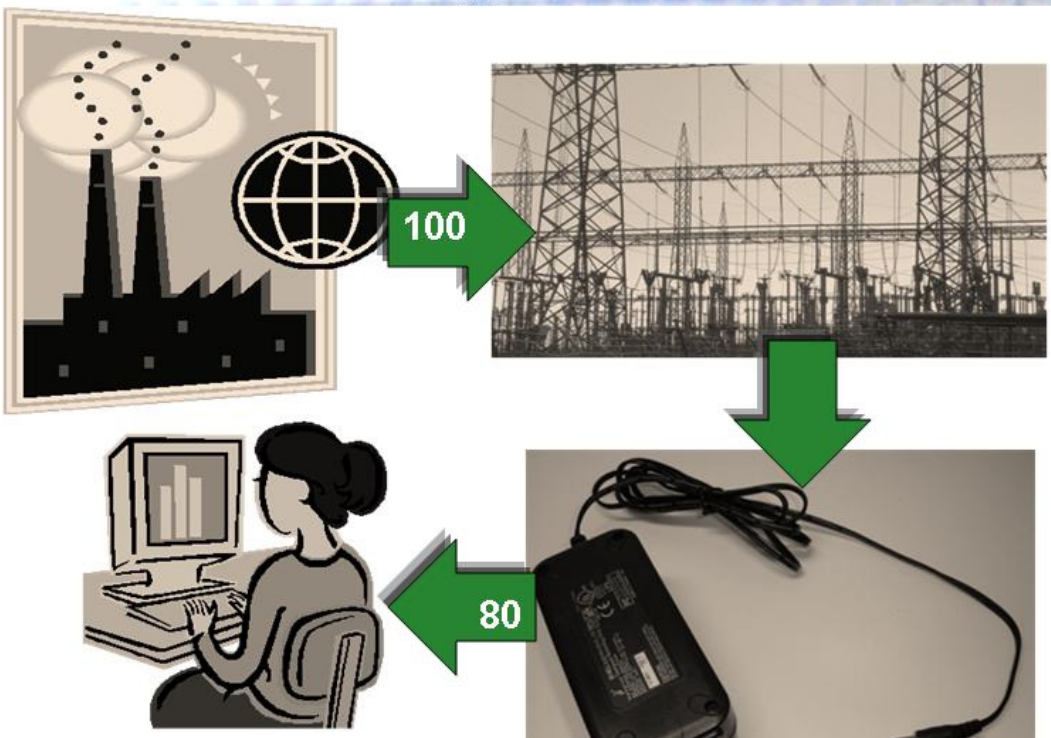


Power supply efficiency by current and voltage sensing

- Today's highly automated world is connected through wires and wireless data communication.
- This is accomplished by a diverse mixture of communication standards.
- They require energy to operate, provided e.g. by switched mode power supplies.
- They operate much more efficiently if their reactive power consumption can be minimized.
- By accurate current and voltage sensing and intelligent data processing the reactive power can be reduced.

Power supply efficiency by current and voltage sensing

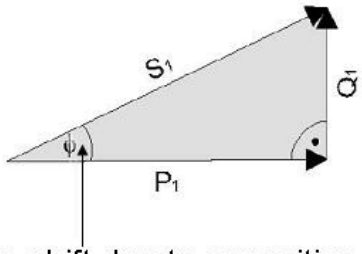
Energy loss?



End application with SMPS
(switched mode power supply)

Power supply efficiency by current and voltage sensing

Reminder : The power triangle



$$\lambda = \frac{P_1}{S_1} = \frac{U \cdot I \cdot \cos\,\phi}{U \cdot I} = \cos\,\phi$$

phase shift due to capacitive or inductive loads (e.g. SMPS !)

BUT

Due to these effects we see a feedback into and thus from the power supplier network and the problem multiplies:

$$\lambda = \frac{\sum_{h=1}^{\infty} U_h \cdot I_h \cdot \cos\,\phi_h}{\sqrt{\sum_{h=1}^{\infty} U_h^2 \sum_{h=1}^{\infty} I_h^2}}$$

apparent power S
is the vector sum of
real power P
and
reactive power Q

Power Factor = λ

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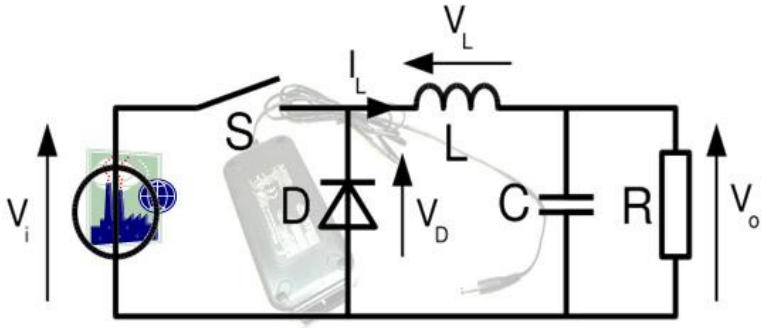
Power supply efficiency by current and voltage sensing

The classic SMPS solution

- Output voltage controlled by a switching MOSFET (S) transistor
- load (R) draws periodically current from the power net
- during opened switch (S), load receives current from the stored energy of the coil
- because of the current peaks on the power net, reactive power is generated



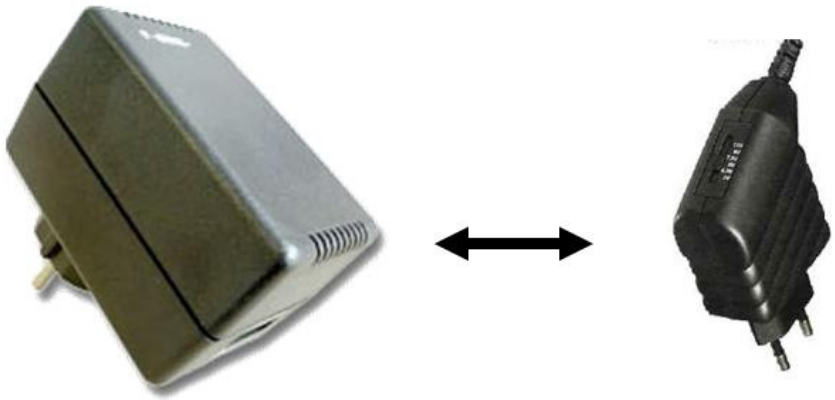
Power supply efficiency by current and voltage sensing

Why use SMPS anyway?

Modern switched mode power supplies:

- need remarkable less material (copper, steel)
- are considerably smaller and lighter (mobility)
- consume less stand-by current
- have a higher efficiency factor
- generate less heat

… compared to classic transformers.

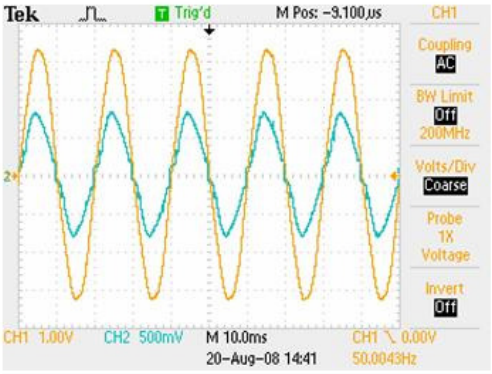


Power supply efficiency by current and voltage sensing

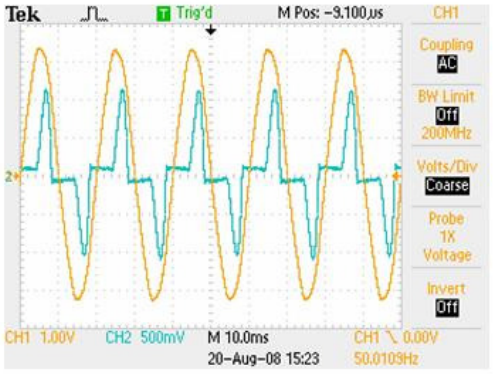
The classic SMPS

- current drawing on input in shape of short impulses (loading of the buffer capacity if voltage over capacity falls below mains voltage)
- this causes deformation and shift of the input sine wave and generation of unwanted harmonics, which lead to electromagnetic disturbance (EMS)
- problem for energy provider to deliver enough energy in constant quality to consumers
- with PFC, the SMPS looks like a quasi-ohmic load to the power net

180watt SMPS with PFC

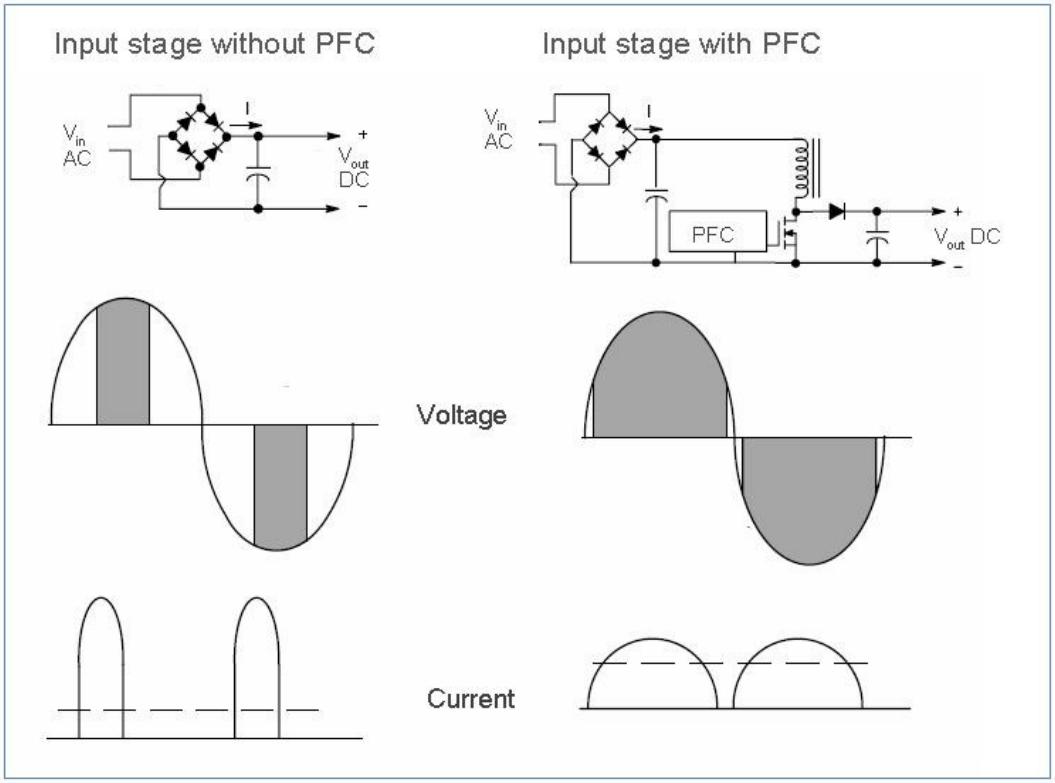


180watt SMPS without PFC



Power supply efficiency by current and voltage sensing

PFC principle



Power supply efficiency by current and voltage sensing
Effect of PFC?

The ZVEI organization (Zentralverband Elektrotechnik- und Elektronikindustrie) calculates the worldwide saving potential if an average **power factor of 0,95** for all applications could be forced:

= 48TWh per year

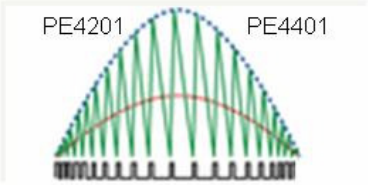
= energy consumption of 13,6M households

= 19 million tons of CO_2

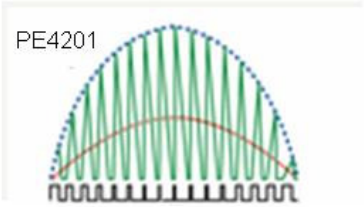
= 4 nuclear power plants

Power supply efficiency by current and voltage sensing
PFC Modes

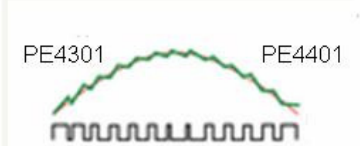
CRM (critical conduction mode)
- variable frequency depending on ratio input/output voltage
- convenient circuitry (zero-crossing)



DCM (discontinuous conduction mode)
- fixed frequency with pulse pause
- fit for applications with a need for synchronization

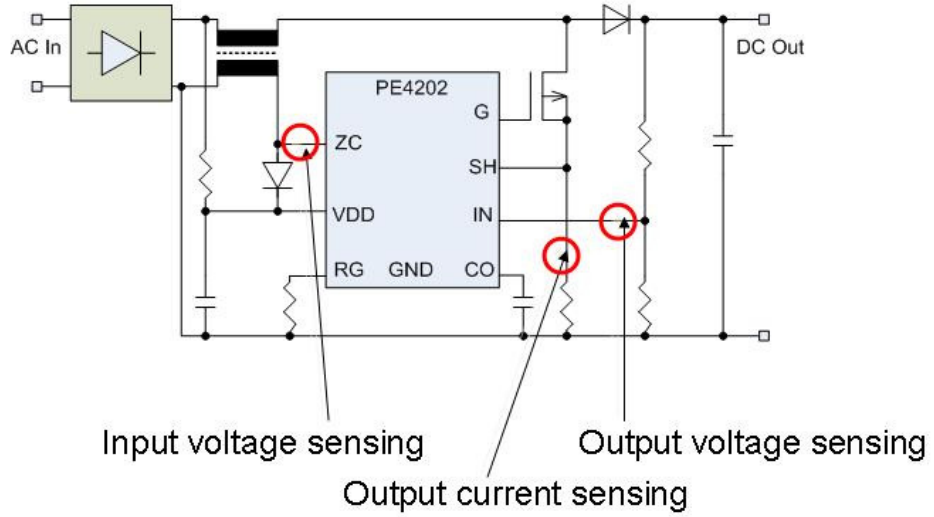


CCM (continuous conduction mode)
- higher effort for determination of the switching time
- cost effective BOM, due to lower switching currents (specification of external components)



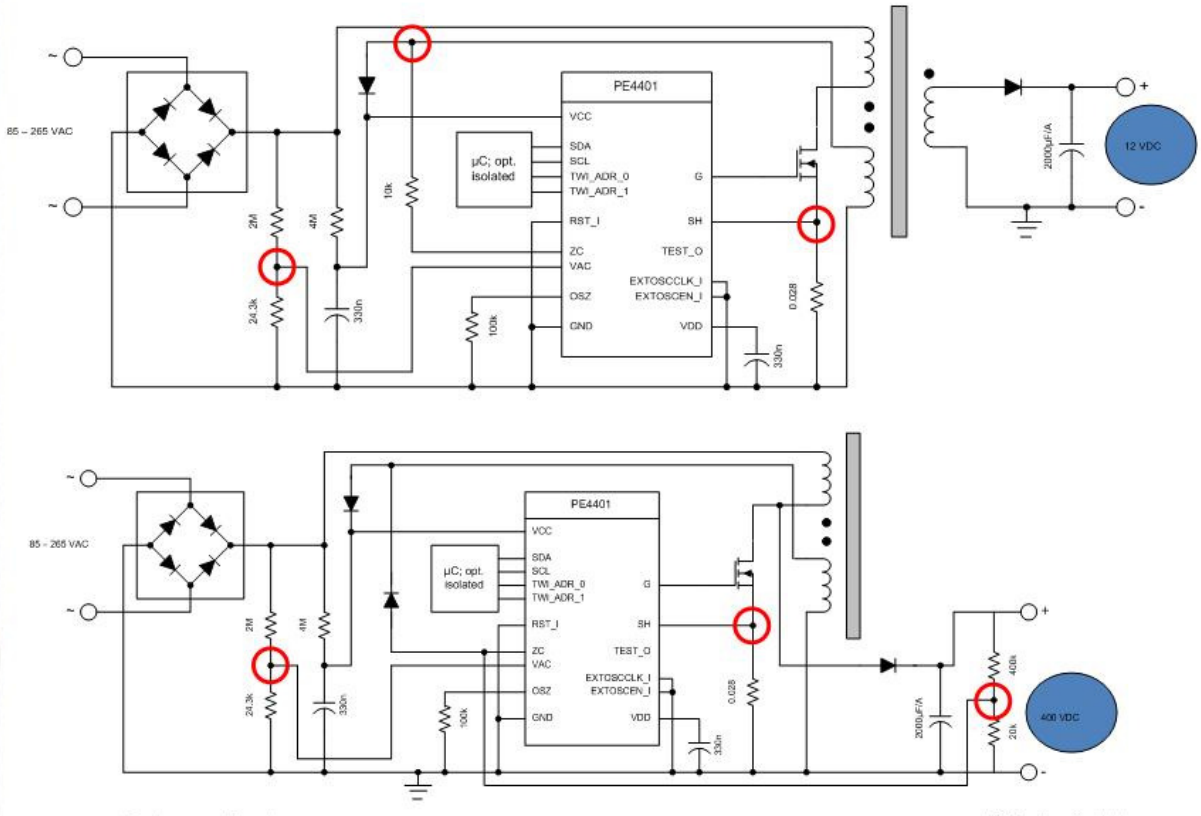
Power supply efficiency by current and voltage sensing

Accurate Threshold level detection circuitry

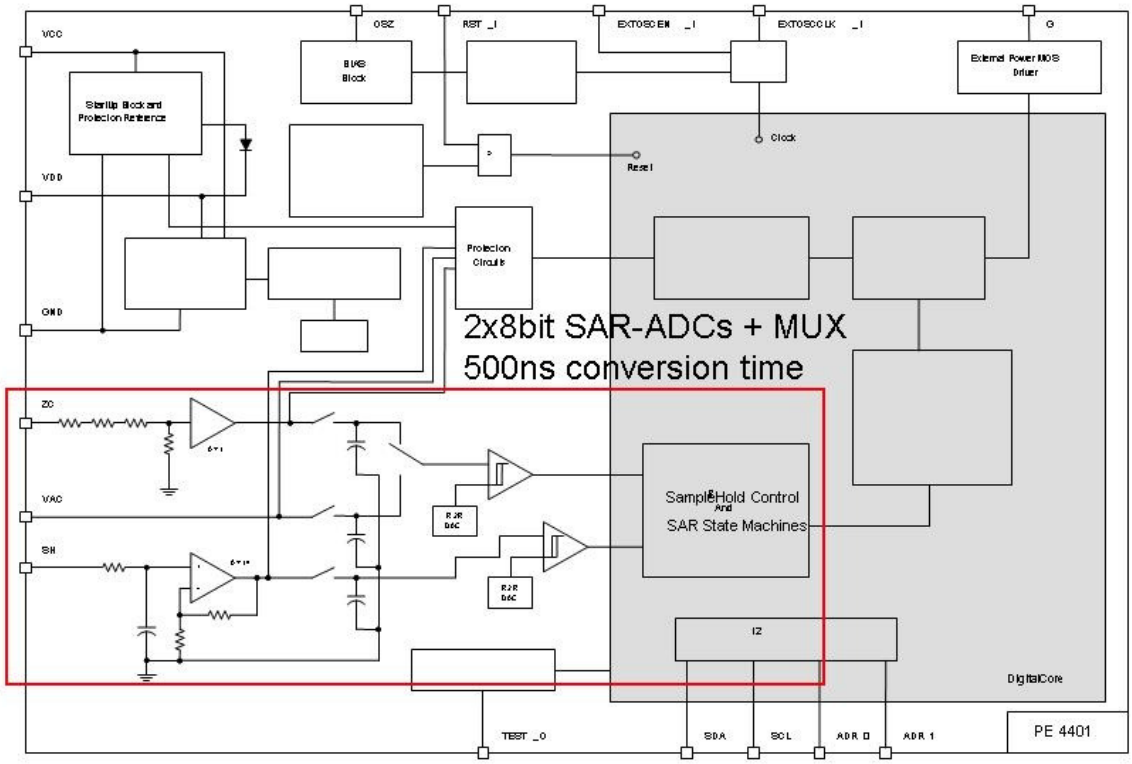


Power supply efficiency by current and voltage sensing

Future Perspective: PWM-PFC IC



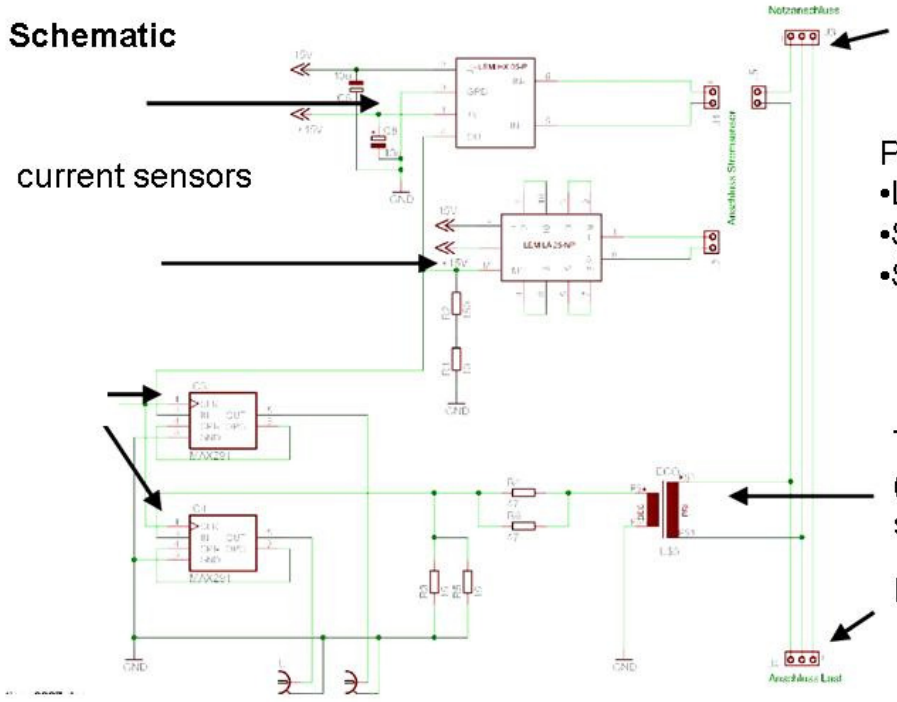
Power supply efficiency by current and voltage sensing



Power supply efficiency by current and voltage sensing

Measuring the „beast“ itself

Schematic



current sensors

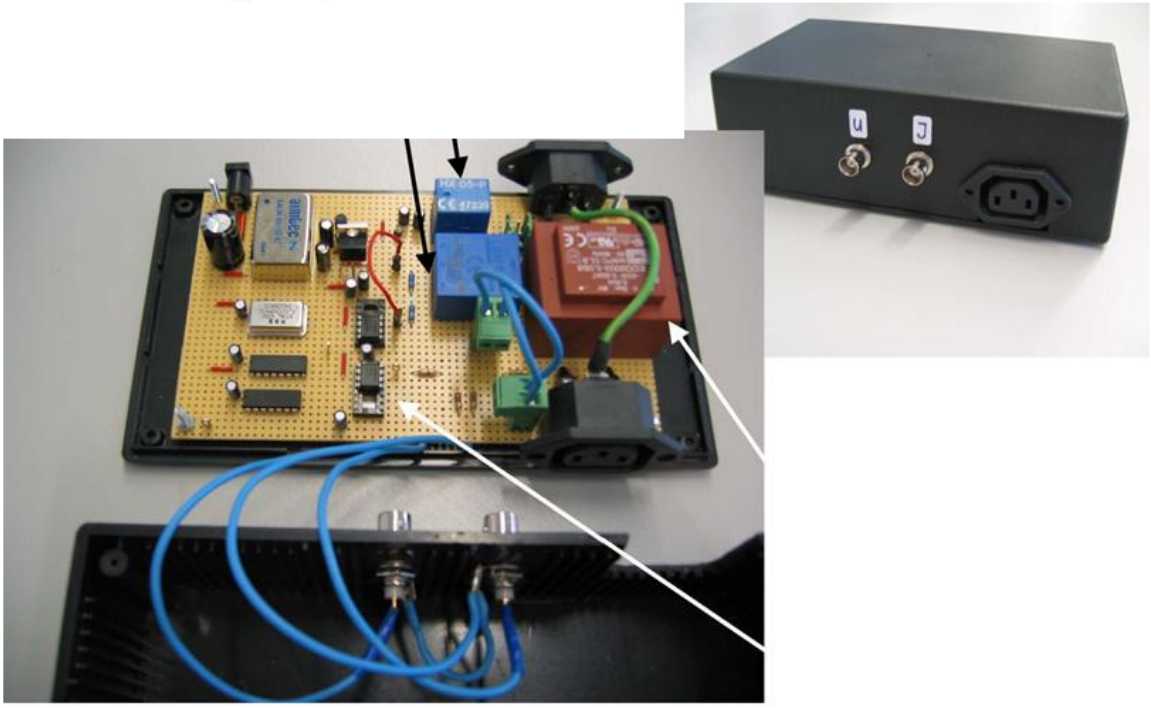
Mains power

Problems:
- Linearity
- Saturation
- Sensitivity

Transformer (voltage sensor)

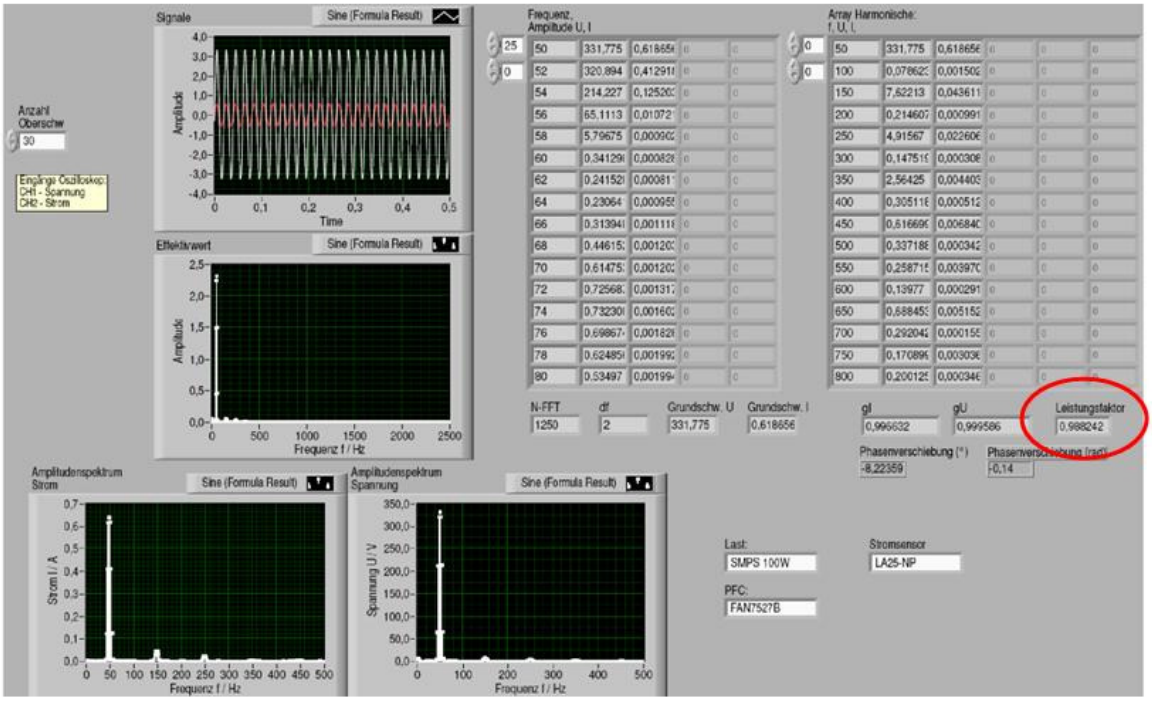
Load

Measuring the „beast“ itself - Hardware



Power supply efficiency by current and voltage sensing

Measuring the „beast“ itself – Labview Software



Power supply efficiency by current and voltage sensing

More details

❖ **Documentation**	Feature Sheets, Data Sheets, Application Notes, UserGuide, Reference PCB Design at www.powerfactorcorrection.de www.leistungsfaktorkorrektur.de
❖ **Samples**	PE4201/PE4301
❖ **Evaluation-Board**	PE4201/PE4301
❖ **Application Support**	pfc@pe-icdesign.de