Influence of DC & Phase Shift On Power Measurement of WHM

Presentation in KEPCO (Korea Electric Power Corporation)

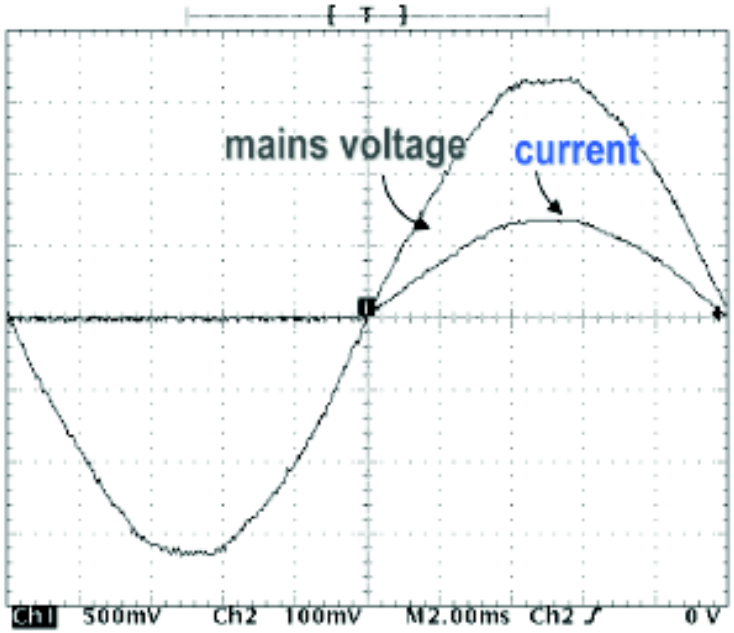
J&D SMART SENSING

Consumption of domestic appliances

Current load profiles for:

Hair dryer

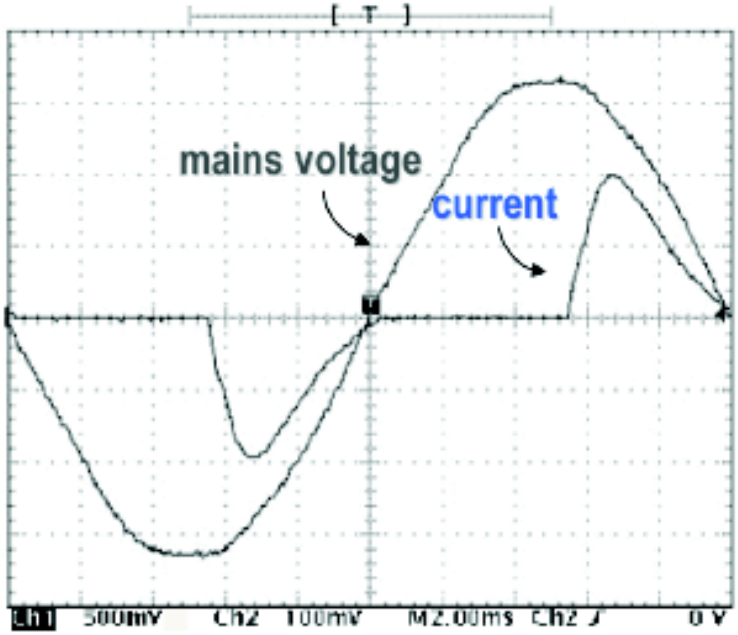
(power regulator using rectifying diode)



The current wave form has a 50Hz in-phase contribution (cos φ = 1), a larger DC-component is present also ($I_{DC} \neq 0$)

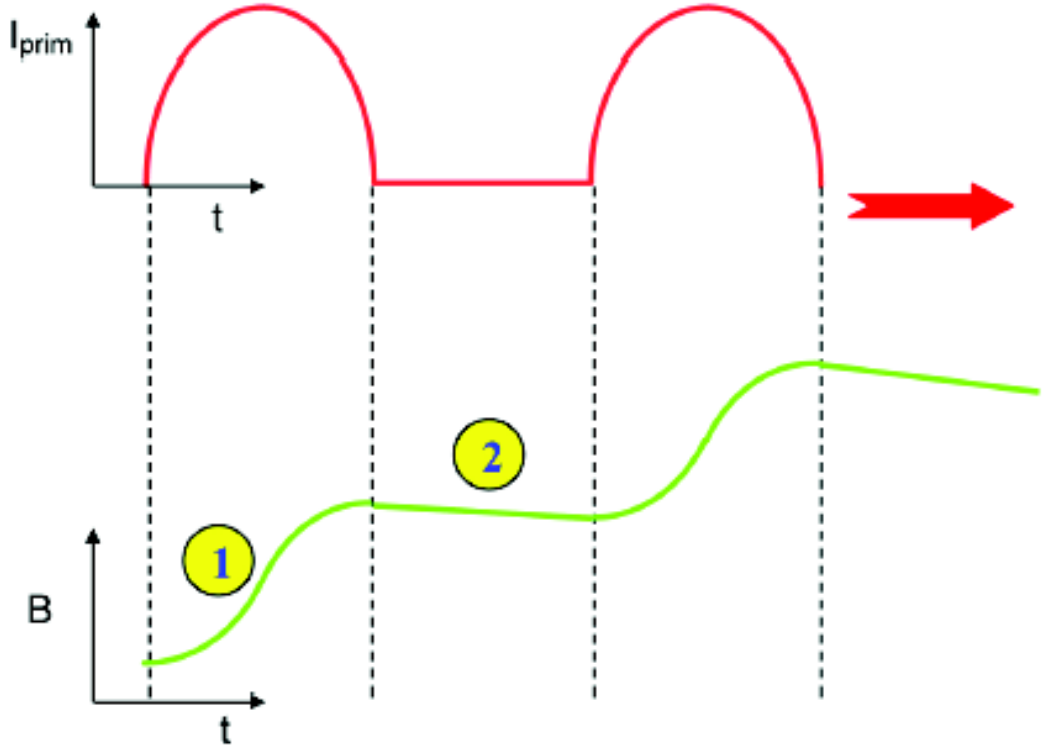
Vacuum cleaner and mixer

(motor controller using phase cutting inverters)



50Hz component in current wave form has strong phase shift (cos φ = 0.7)

Single Core CTs – The DC Problem (1)



DC-tolerance is required for residential energy meters according to IEC 62053-21 and -23:

Operation with completely half rectified current, limited accuracy

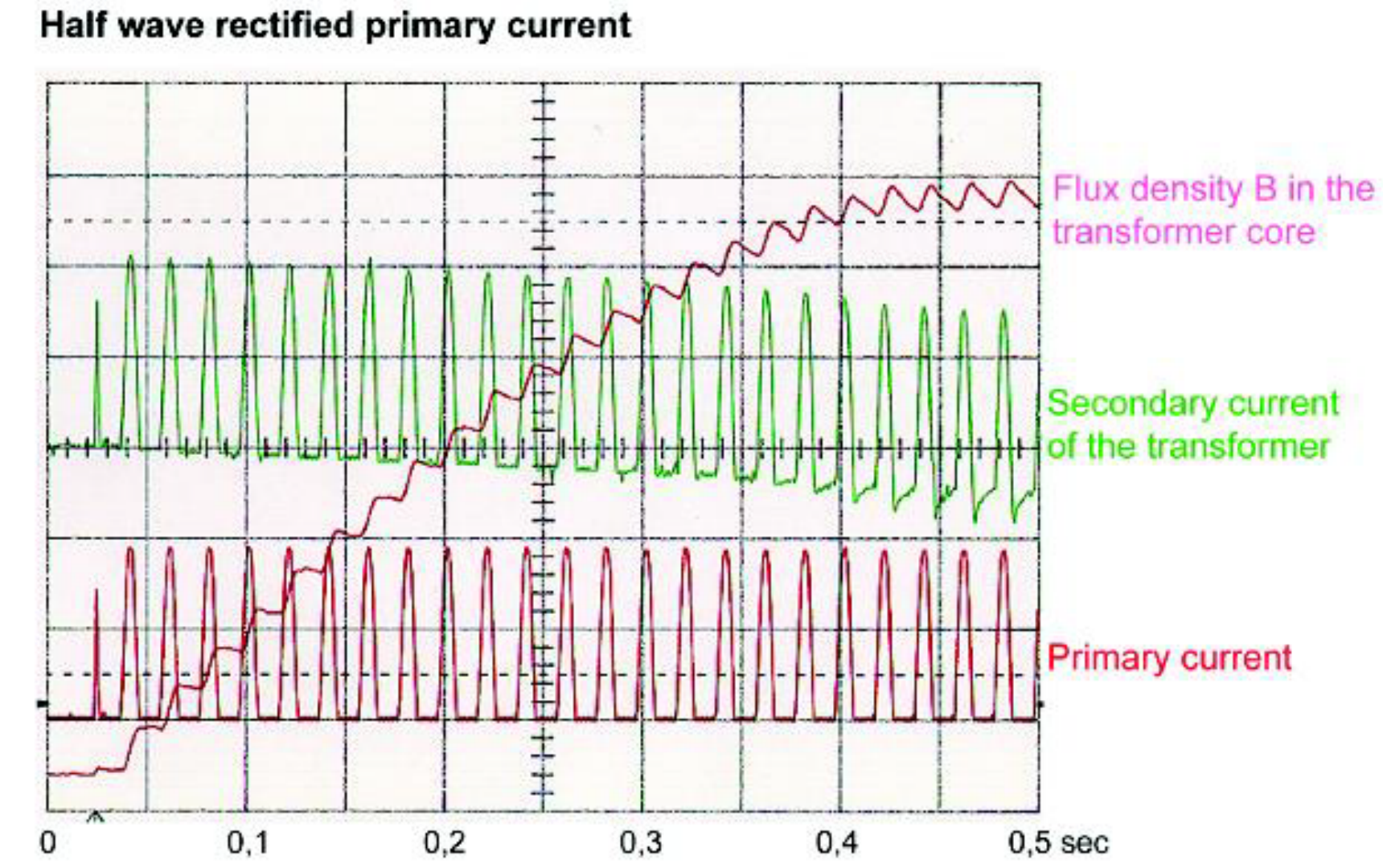
1 $$\Delta B \approx \frac{R}{\omega \cdot A_{Fe} \cdot N_{sec}^2} * \hat{I}_{prim}$$

2 $$\Delta B = B_0 (1 - e^{-\frac{t}{\tau}})$$

$$\tau = \frac{L}{R}$$ some seconds for a good transformer

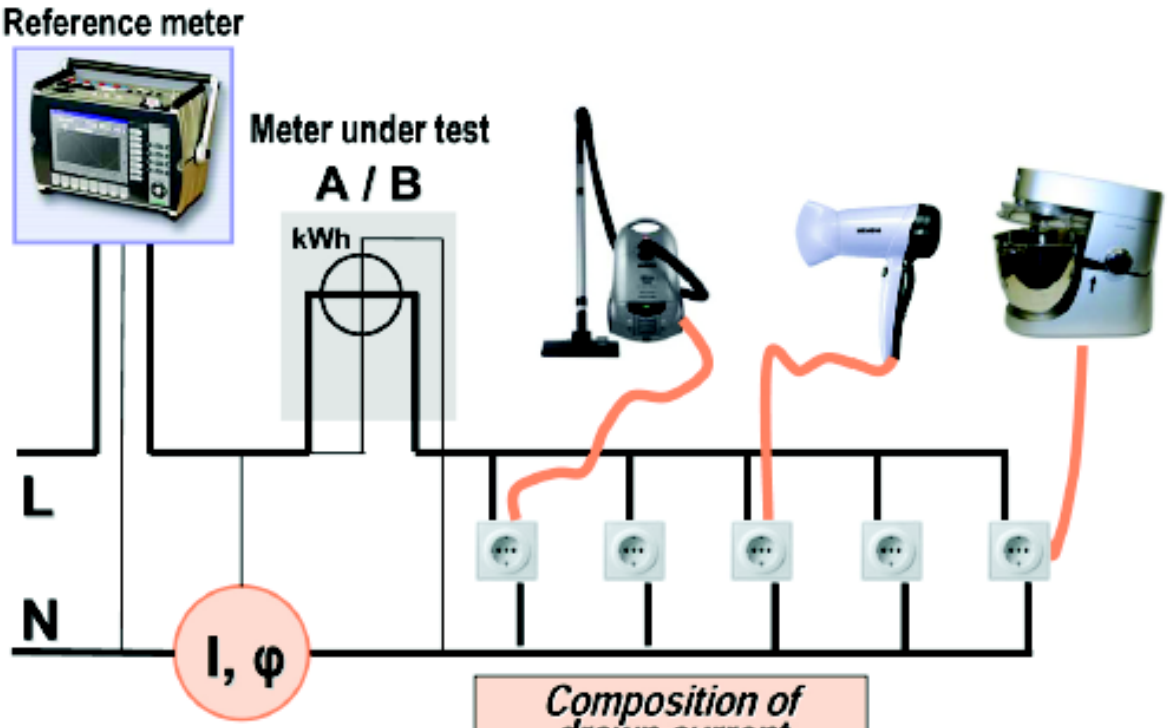
⇒ **The core can´t get rid of it´s flux !**

Single Core CTs – The DC Problem (1)



Meter performance with domestic appliances

Realistic meter test (parallel running loads of domestic appliances)



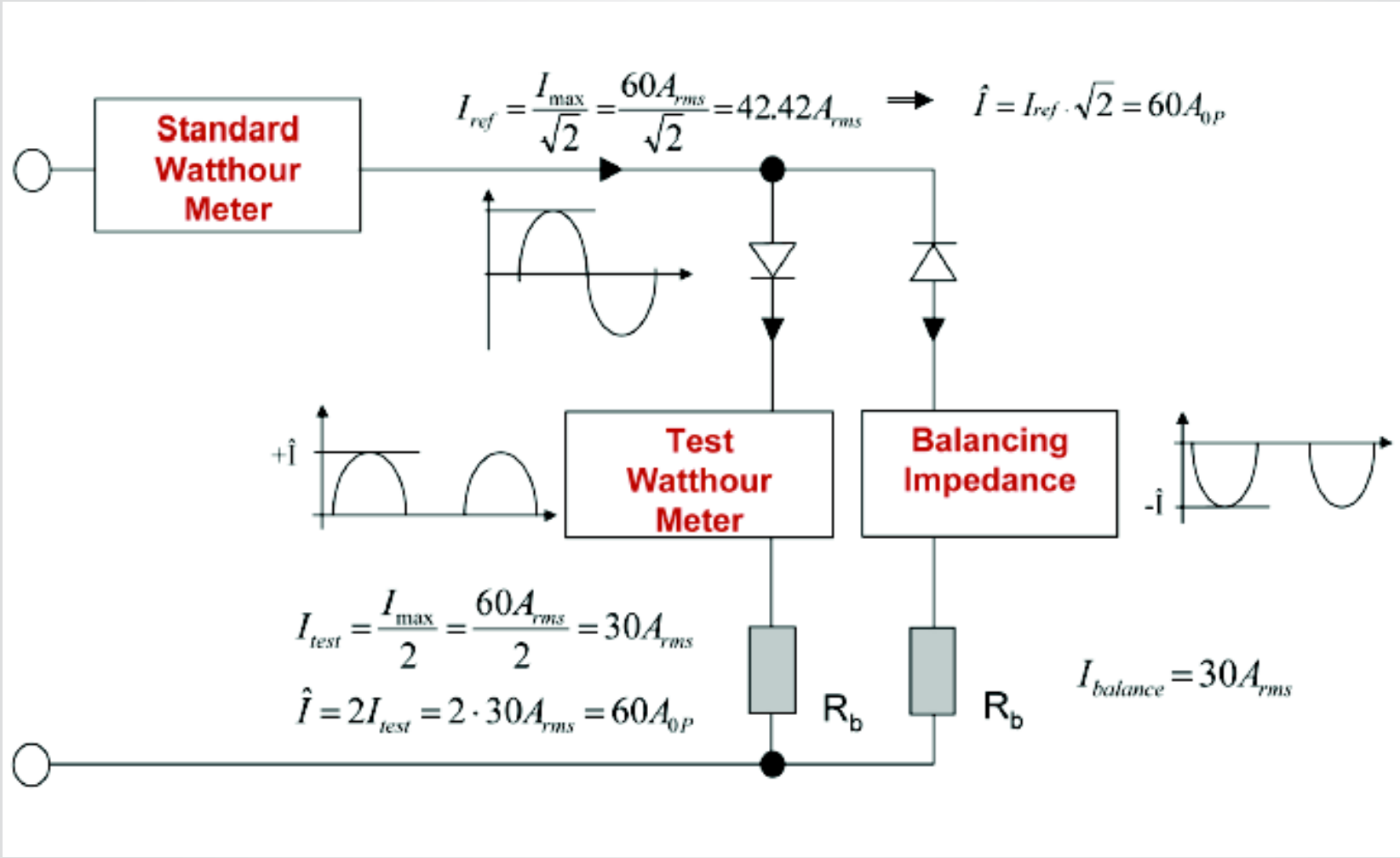
Composition of drawn current	
50 Hz-current	7.4 A
cos φ	0.85 i
DC -current	2 A

Results for meter A and B

Meter A *(linear core)*	- 0,1%
Meter B *(combined core)*	+ 4,5%

Clear deviation from 2% target of IEC standard !!!

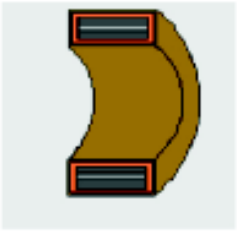
Test procedure according to IEC standards



Combined and single core current transformers

Strip-wound core solutions on the market:

Single core type



One core material needs to fulfill requirements

⇒ Demands for various, h igamorphous and erials
(Linearity, DC capability, temperature dependency, ...)

⇒ Good opportunities for VAC amorphous and nano-crystalline cores with tailored hysteresis loops

Combined core type

Two different cores assembled in a core box:

Competitors attempt to exploit the advantages of high-permeability and low-permeability cores,

⇓ Low error in true AC operation

⇓ DC capability

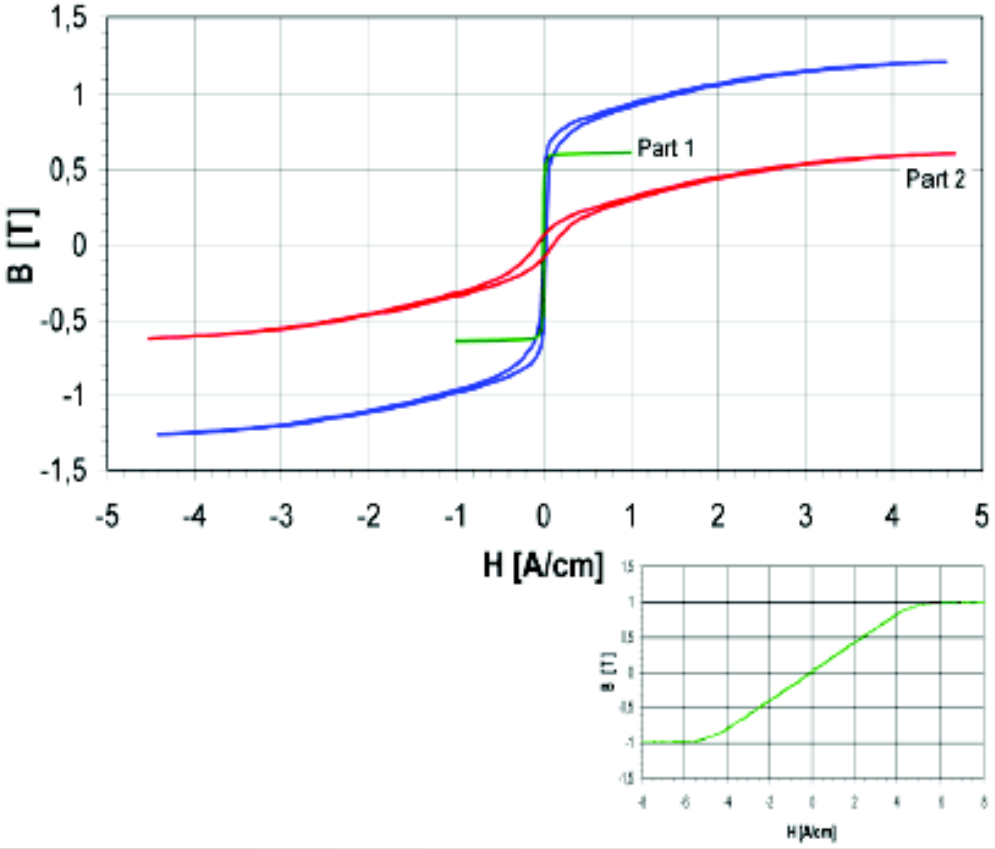
Low cost product from e.g. China

Does it work?

Properties of combined cores

Performance characteristics “Combined Core”:

Hysteresis loop of combined core (part 1, 2 and combined)



Extremely non-linear hysteresis loop, i.e. permeability.

CT performance should be dependent on:

- signal level
- wave form
  (esp. DC contributions)

cores provide

For comparison:

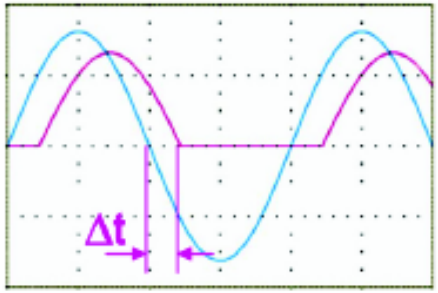
VAC cores provide highly linear loops

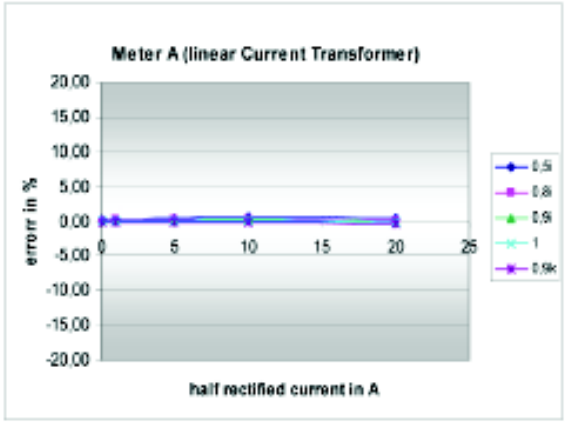
Meter performance with domestic appliances

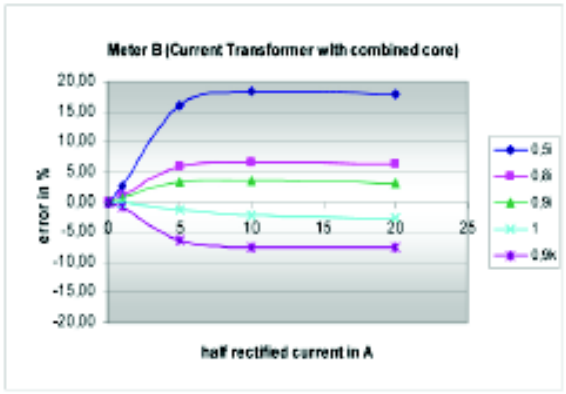
Generalized tests and worst case scenarios:

Test conditions:

Rectified current with variable "phase shift" (Δt)







Meter with linear core CT:

IEC req. fulfilled well
(within ± 0.5%)

⇒ **A true measurement**

Meter with combined core CT:

Up to ≈ +20% (!) error in meter reading

⇒ **A possible rip-off !!!**

Summary and conclusions

Present status:

- **IEC tests do not cover „real life“ current mix**
  - ⇒ **Meter insufficiencies due to combned cores are not revealed**
  - ⇒ **Substantial meter mismeasurements can occur with combined cores.**
- **Publications on this issue**

  Frank Herrmann in Energie Wirtschaft, p. 33, vol. 16, 2007 (german)
  Frank Herrmann in Metering International, p. 121, issue 3, 2007 (engl.)
- **Proposal for norm amendment well received by german IEC council**
- **International IEC council will discuss and probably revise norm accordingly (Oct 2007)**

Thank you