

Measuring Harmonics using a Capacitive Current Clamp Sensor

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Introduction

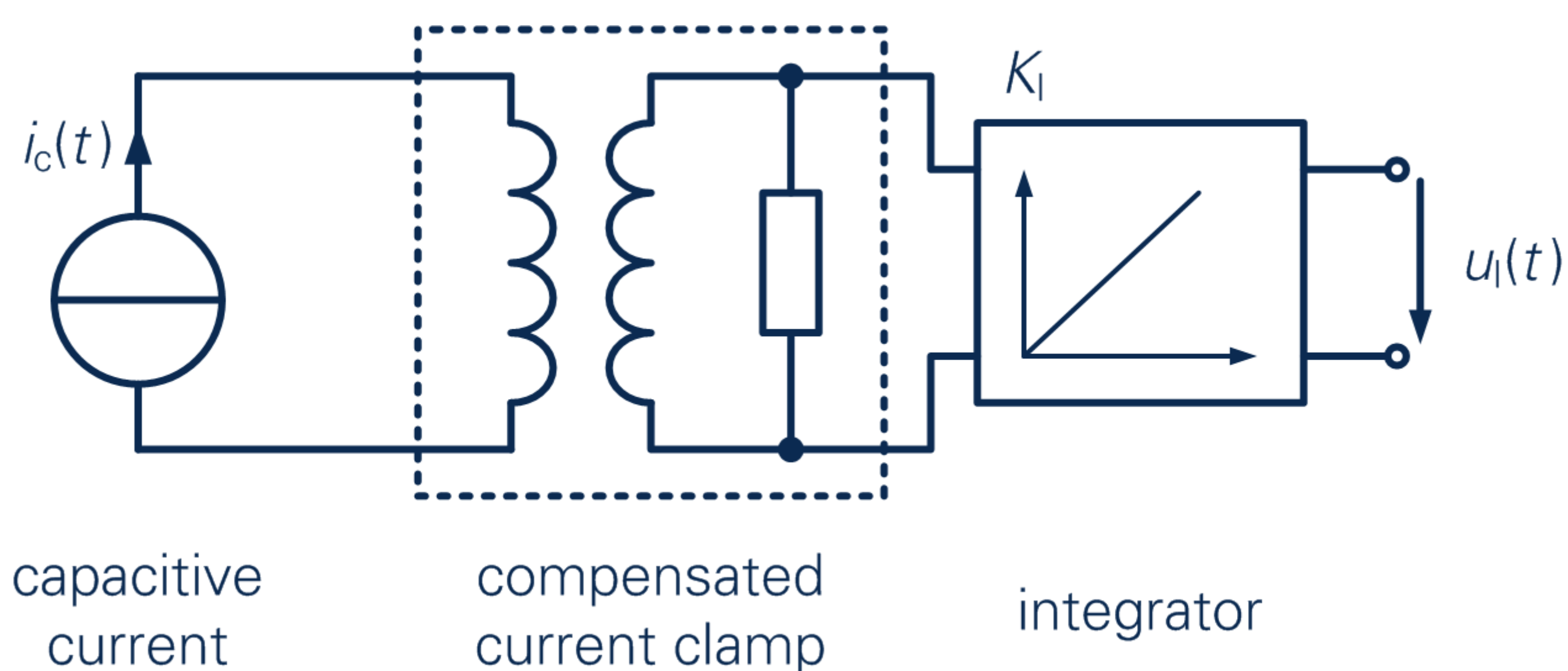
Motivation

- Voltage harmonics are difficult to measure in MV and HV grids
- Current harmonics inside capacitive components correlate with voltage harmonics
- Current flow in line-to-ground capacitances is easy to measure at ground potential

Objective target

- Measure of the current harmonics in line-to-ground capacities and deduce the voltage harmonics
- Set-up a current clamp sensor (CCS) to measure the current harmonics without opening the ground connection of the capacitance

Setup of the current clamp sensor



Setup of the current clamp measuring system.

- Compensated current clamp measures a current and generates a proportional output signal
- Integrating the signal leads to an output signal proportional to the voltage drop across the capacity



Current clamp sensor and integrator.

AMPLITUDE ERROR AND PHASE DISPLACEMENT OF THE CURRENT CLAMP IN DIFFERENT CURRENT RANGES AT 50 HZ. [1]

rated primary current I_{rp} in A	relative amplitude error ϵ_{iu} in %	phase displacement δ_{iu} in crad
9.6	0.006	-0.023
0.96	0.007	-0.023
1.2	-0.005	-0.022
0.12	0.002	-0.023
0.15	-0.001	-0.032

Measuring harmonic levels and THD

- Levels of voltage harmonics \underline{u}_h are determined by regarding the current harmonic \underline{I}_{Ch} , the fundamental current \underline{I}_{Cf} and the harmonic order h

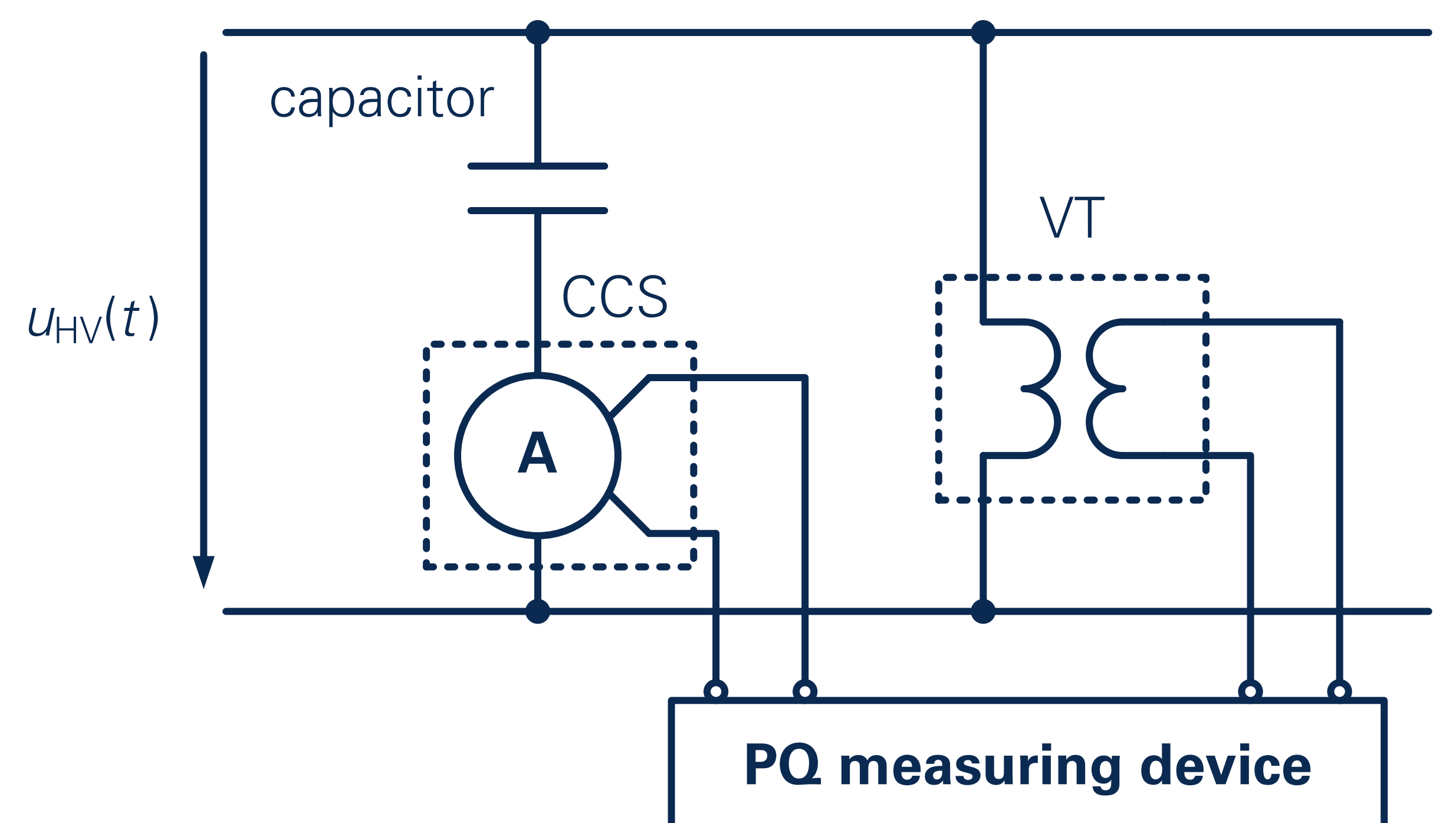
$$\underline{u}_h = \frac{U_h}{U_f} = \frac{I_{Ch}}{h \cdot I_{Cf}}$$

- Regarding the harmonic levels, the total harmonic distortion of the voltage (THD_u) for all harmonics up to the harmonic order n can be computed

$$THD_u = \frac{\sqrt{\sum_{h=2}^n U_h^2}}{U_f} = \sqrt{\sum_{h=2}^n u_h^2} = \sqrt{\sum_{h=2}^n \frac{I_{Ch}^2}{I_{Cf}^2 \cdot h^2}}$$

Measuring voltage harmonics

- Already installed voltage instrument transformers (VTs) measure power frequent voltages with an high accuracy
- Voltage harmonics are determined by combining the measuring results of a VT and the CCS



Current clamp sensor combined with VT.

- Using the fundamental voltage measured by a VT and the harmonic levels determined by the CCS, the voltage harmonics are determined

$$\underline{U}_h = \underline{U}_{fVT} \cdot \underline{u}_h = \underline{U}_{fVT} \cdot \frac{I_{Ch}}{h \cdot I_{Cf}}$$

Acknowledgment

The research project leading to the results described in this poster is part of the European Metrology Research Programme (EMRP), which is jointly funded by the participating countries of EURAMET and the European Union.

References

- [1] E. Mohns, S. Fricke, C. Jäschke and P. Schegner: *A Current Clamp based High Voltage Monitoring System*, 6rd IEEE International Workshop on Applied Measurements for Power Systems, AMPS 2015, September 2015, Aachen, Germany

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