EMI on Static Electricity Meters: Latest findings on meter performance

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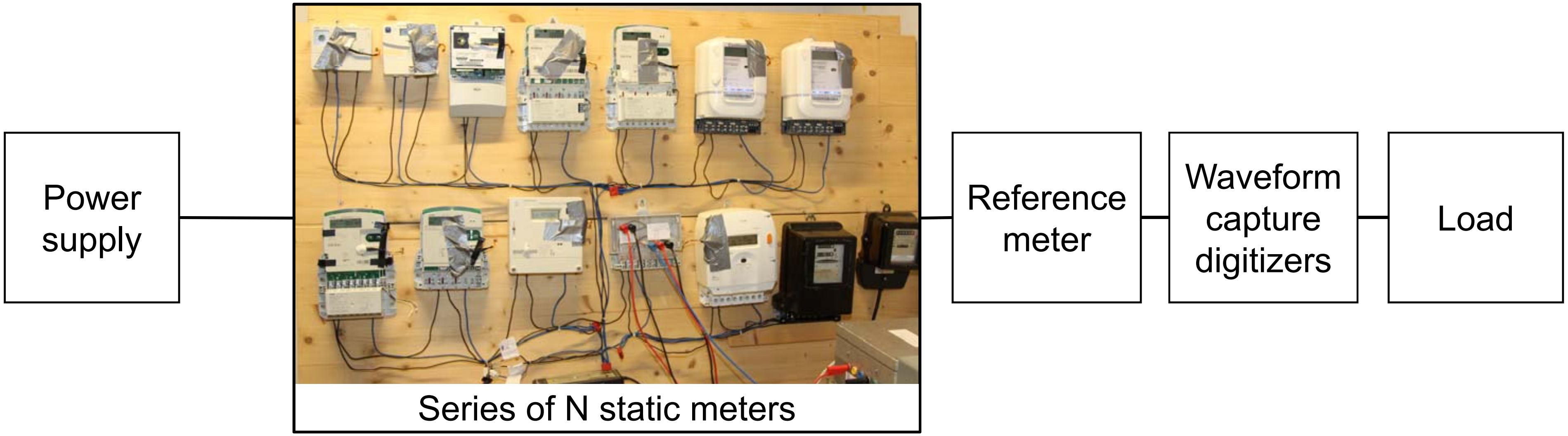
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Introduction

- New meter deviations found when using commercially available water pump
- Which was based on consumers complaints
- Tested static meters are representable for installed meters in The Netherlands
- Studies focus on meter deviations related to:
    1. Current slope
    2. Peak amplitude
    3. Phase shifting
    4. Grid impedance
- Resulted in 3 conference papers:
    1. "Faulty Readings of Energy Meters Caused by Conducted Electromagnetic Interference from a Water Pump", University of Twente, ICREPQ'19
    2. "Misreadings of Static Energy Meters due to Conducted EMI caused by Fast Changing Current", University of Twente, APEMC 2019
    3. "Inclination of Fast Changing Currents Effect the Readings of Static Energy Meters", University of Twente, EMC Europe 2019

- Results are confirmed by studies of VSL

Measurement method



Reference: B. Have, C. Keyer, and F. Leferink, “Monitoring of Power Measured by Static Energy Meters for Observing EMI Issues,” *2018 International Symposium on Electromagnetic Compatibility (EMC Europe),* pp. 903-907, 2018.

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Paper 1

- Reports on static meter errors:

International Conference on Renewable Energies and Pov
Tenerife (Spain), 10th to 12th April, 2
Renewable Energy and Power Quality Jour
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Faulty Readings of Static Energy Meter
Electromagnetic Interference fro

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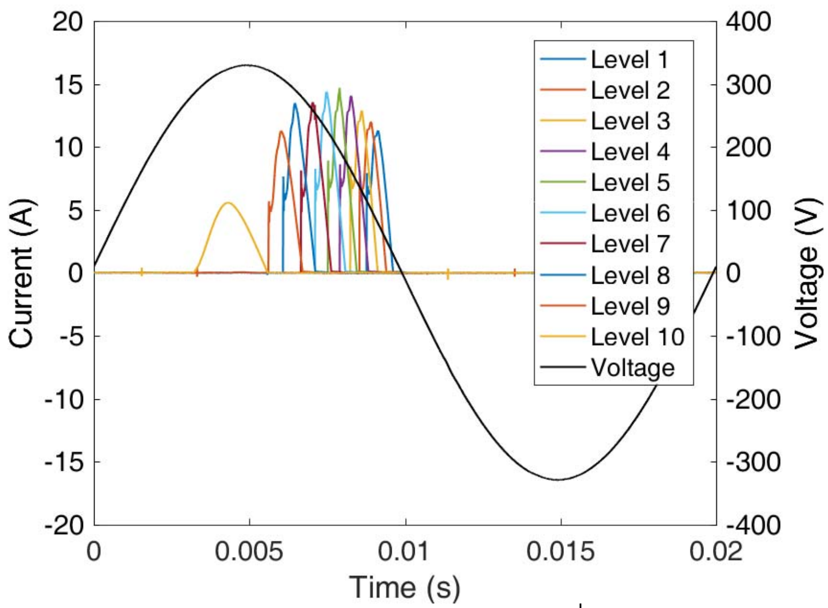
Thales Nederland B.V., Hengelo, The



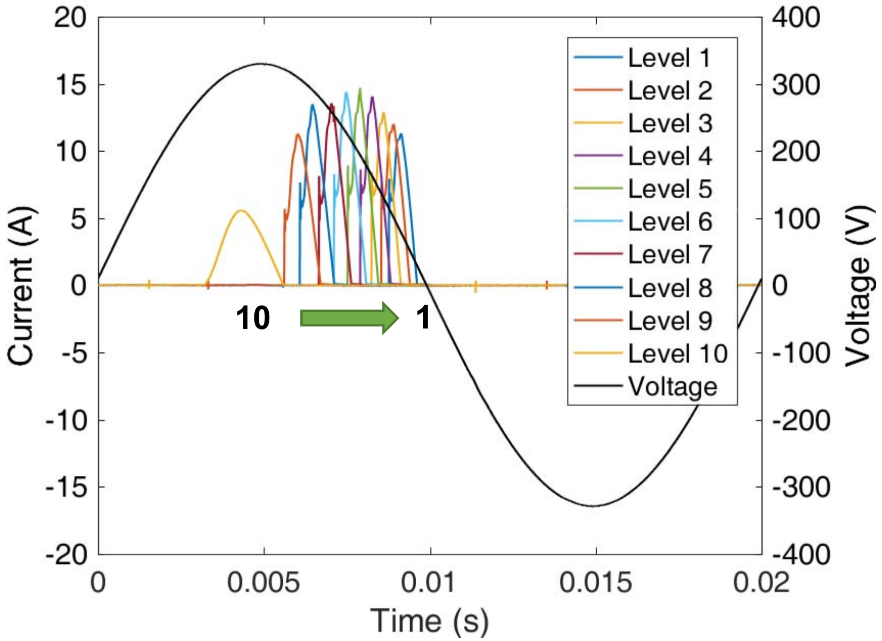
Meter deviations between -61% and +2675%

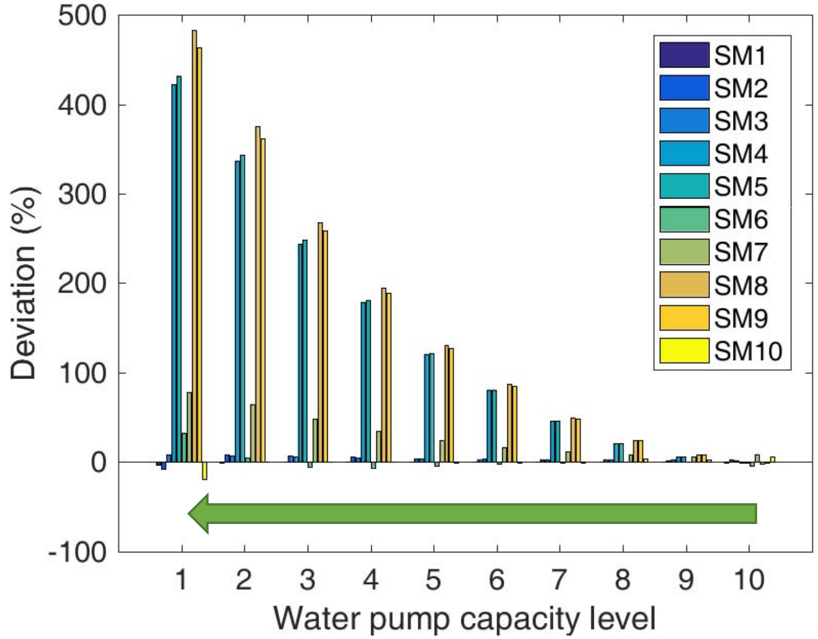
Based on consumer complaint about water pump for fish pond

red to a conventional electromechanical
When a mains power supply of the building
ations between 582% and -32% were found
publications, and higher readings were found when lighting [6], [7]. Static electricity meters are currently widely

Paper 1

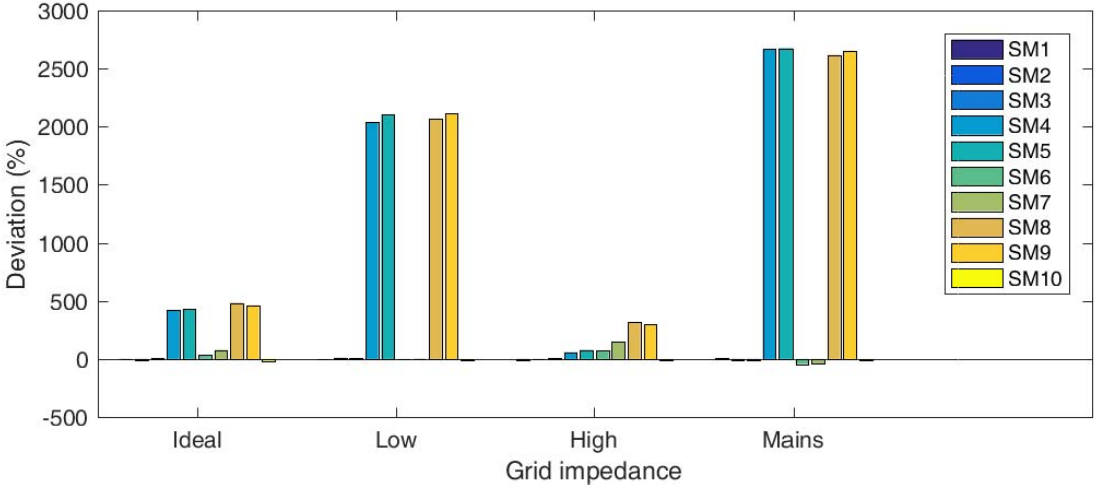
- Load: Water pump with phase controlling dimmer

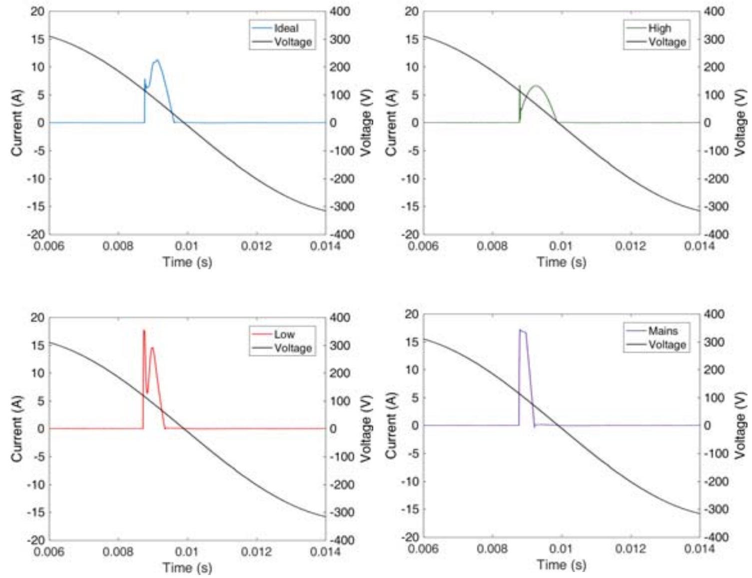




Paper 1

- Load: Water pump with phase controlling dimmer
- Changing mains impedance changes drawn current
- Four different mains impedances:
    1. Ideal source voltage with standard impedance
    2. Ideal source voltage with lower impedance, adding capacitance
    3. Ideal source voltage with higher impedance, adding line inductance
    4. Building's mains supply





Grid impedance	Rise time [μs]	Rising edge [A]	Slope [A/μs]
Ideal	5.8	6.3	1.1
Low	13.8	14.1	1.0
High	5.4	6.3	1.2
Mains	18.8	13.7	0.7

MeterEmi

EMPIR EURAMET

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UNIVERSITY OF TWENTE.

Paper 2

- Reports on static meter errors:

EMC Sapporo & APEMC 2019

Misreadings of Static Energ
Conducted EMI caused by Fast

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Meter deviations between -91% and +175%

Abstract—Readings of static energy meters can be affected by conducted electromagnetic interference (EMI). Previous research reported many cases where lower and higher readings of static energy meters were observed. In this paper experiments with a water pump, controlled by speed regulators, resulted in huge errors in energy readings of static meters with respect to a reference meter. The speed regulators are intended to be used in conjunction with such water pumps. The tests were performed using a non-distorted mains power supply created by a four-quadrant amplifier with an internal impedance in accordance with the standards. The deviations observed are between -91% and +175% compared to the reference meter. The current waveforms

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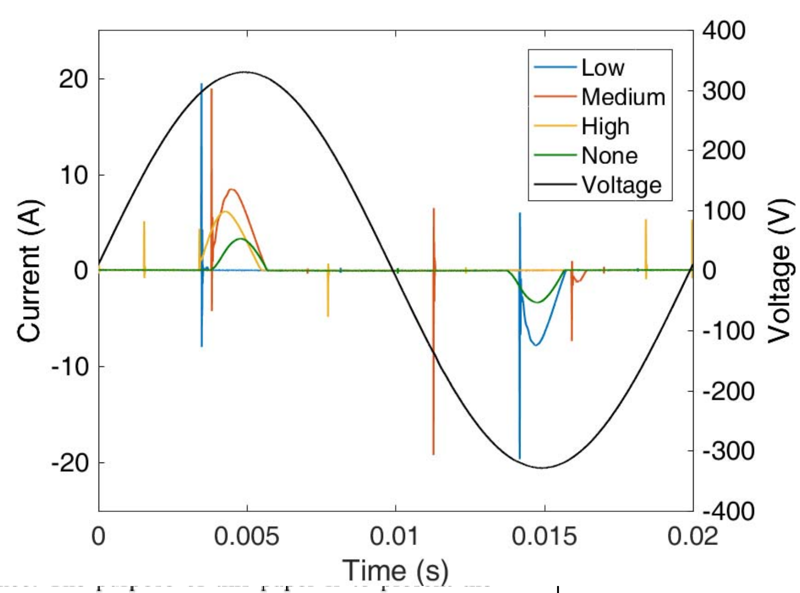
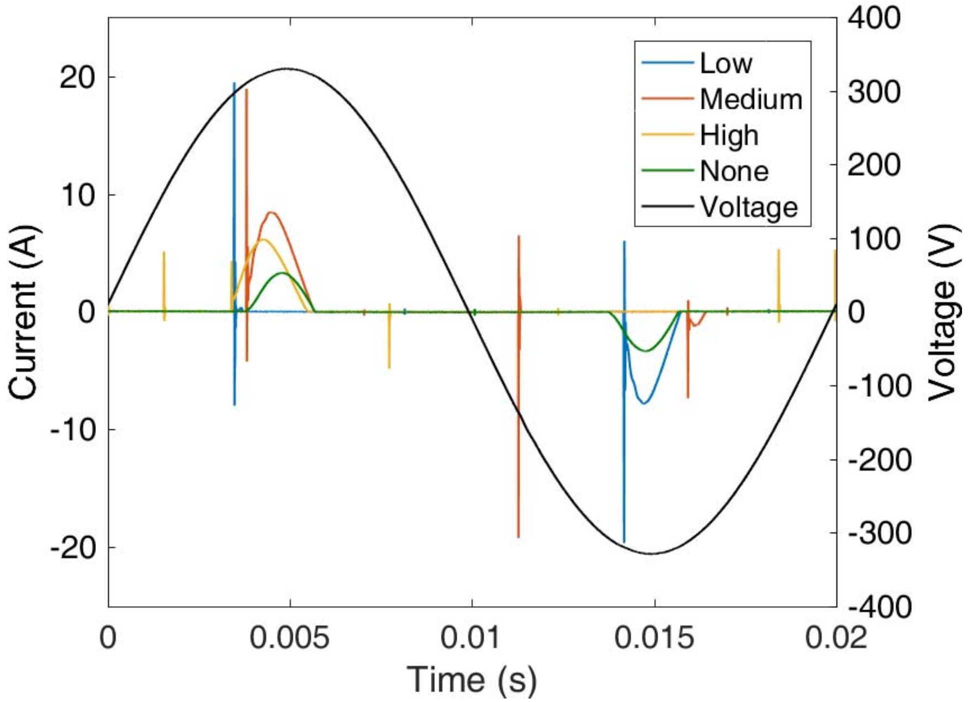
mains impeda
results of the investigation of static meter deviations due to fast rising current spikes. The slope of these spikes is expressed and the steepness of the slope is correlated with the misreadings of



Paper 2

- Load: Water pump with power (speed) regulator



Blue pulse:
Slope of 10,7 $\mathrm{A}/\mu\mathrm{s}$
Rising edge of 16,0 A
Deviations between -91% and +3%

Orange pulse:
Slope of 8,2 $\mathrm{A}/\mu\mathrm{s}$
Rising edge of 15,2 A
Deviations between -72% and +10%

Yellow pulse:
Slope of 2,0 $\mathrm{A}/\mu\mathrm{s}$
Rising edge of 4,2 A
Deviations of +/-10%

Paper 3

Inclination of Fast Changing Currer
Readings of Static Energy M

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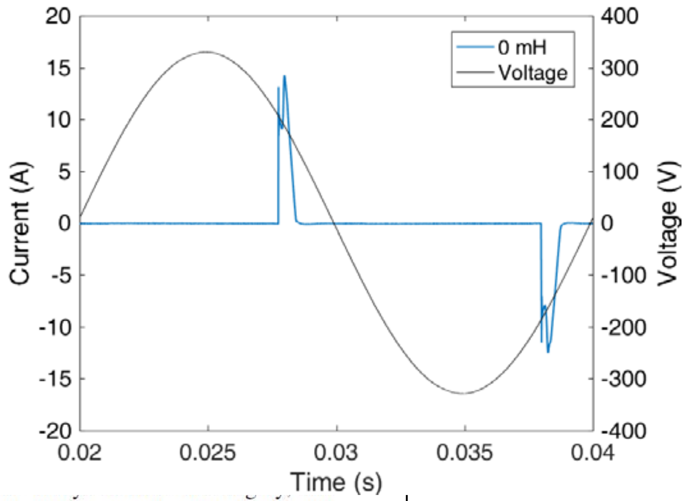
Meter deviations between -6% and +342%

Abstract—**Static energy meters ca ... ings due to conducted electromagn ... previous research cases lower and higher readings of static energy meters were observed. In this paper an overview of previously reported lab experiments is given and further analyzed. The various situations are showing errors in the energy readings with respect t ... supply created by a four-quadrant amplifier combined with a line impedance stabilization network (LISN) to create a stable line impedance. The setup creates a pulsed current waveform with a short rise time. By using various line inductances the slope of the pulse is lowered and a correlation between the inclination of**

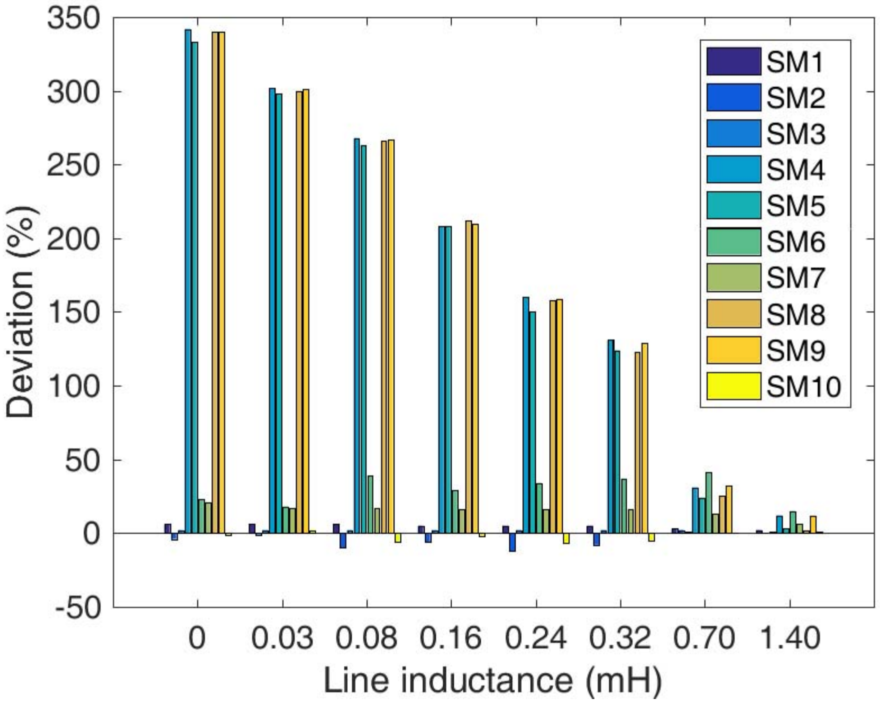
In this paper these re ... deviations of static meters ... additional measurements were done that show a correlation ... inductances in series. The experiments are performed using an ideal power supply with a standardized mains impedance. The corresponding current slopes are expressed and the inclination is correlated with the misreadings of the meters. The purpose

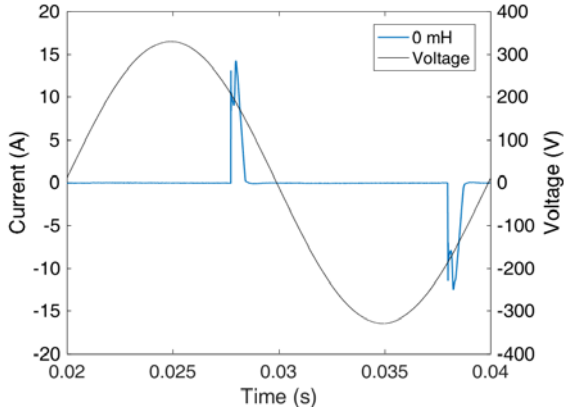


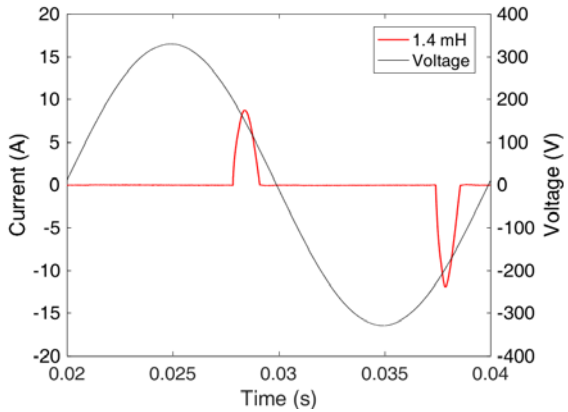
Shows correlation between inclination current slope and meter errors

Paper 3

- Load: Dimmer combined with series of CFL and LED lamps
- Current slope reduced by inserting 8 different line inductance values

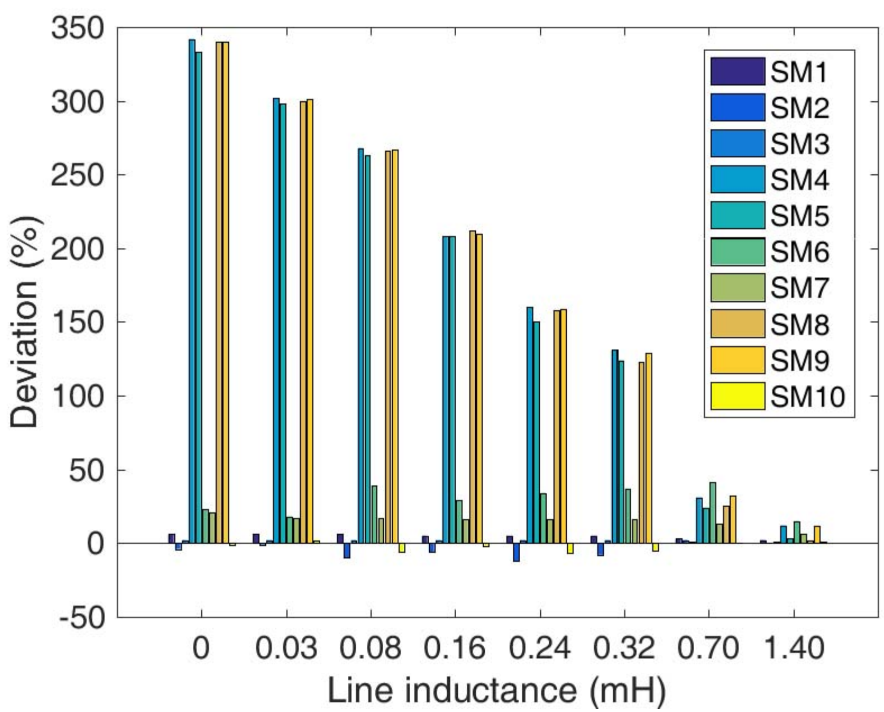


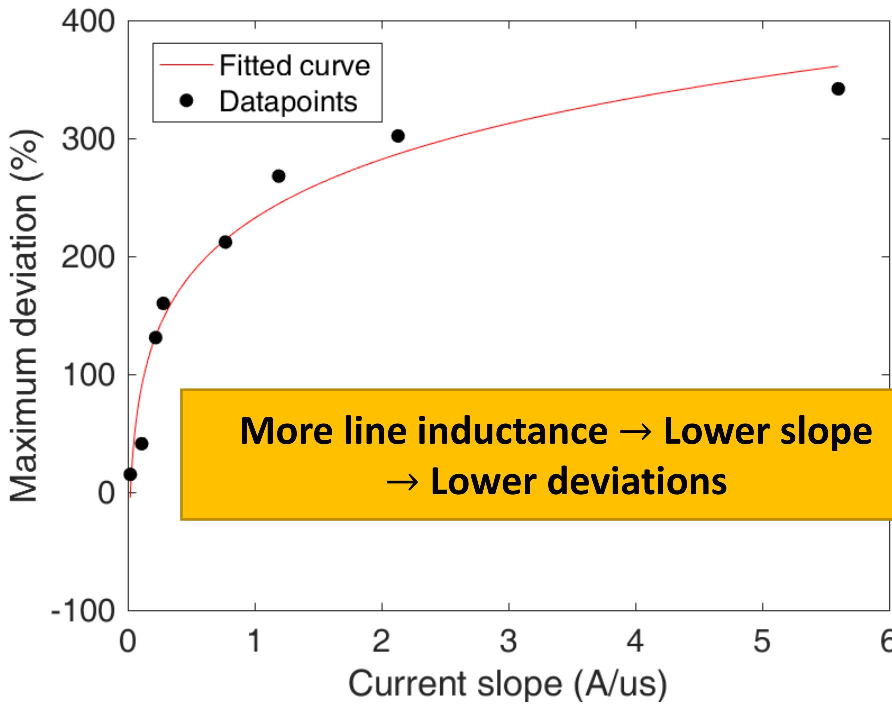




Paper 3

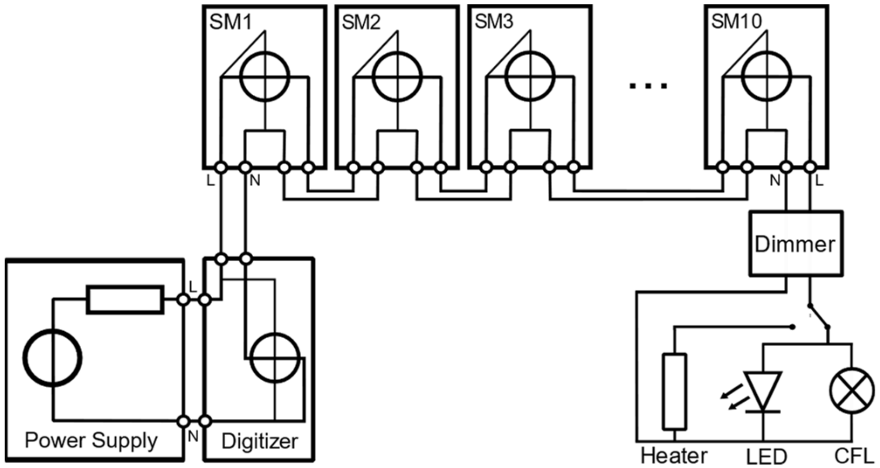
- Load: dimmer with series of CFL and LED lamps
- Current slope reduced by inserting 8 different line inductance values in series with the load

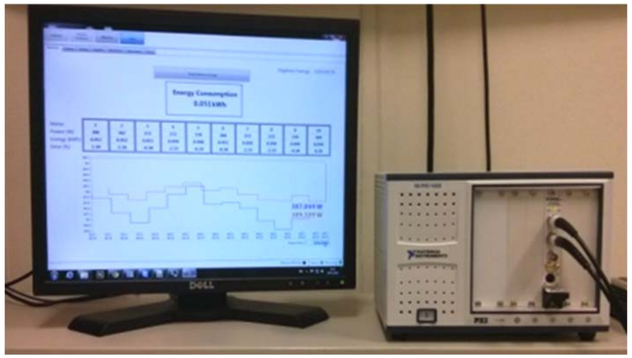




More line inductance → Lower slope → Lower deviations

VSL static meter studies, follow-up of UTwente





Measurements:

- Current and voltage waveform, FFT
- Energy of all meters (pulse output)

Traceable to international standards

Observations VSL 2015-2019

More that 50 different static meters were tested at VSL

- Different manufacturers, different types of sensors (Rogowski, Hall, CT, shunt)
- Different loads (CFL, LED, pond pump, heater, …) with phase-firing dimmer
- Current signals: broad spectrum reflecting step response

  → not a pure 2 – 150 kHz problem: many components vs. ‘single tone’
- High & fast current peaks → maximum I, maximum dI/dt
- Details can have large influence on size (& sign) of the meter error

Clearly the type of current sensor is relevant:

- Most of the Rogowski and ~25 % of the Hall type meters show (large) errors
- Some shunt and CT meters show errors

  … so there must be other issues too (hardware, software, …?)

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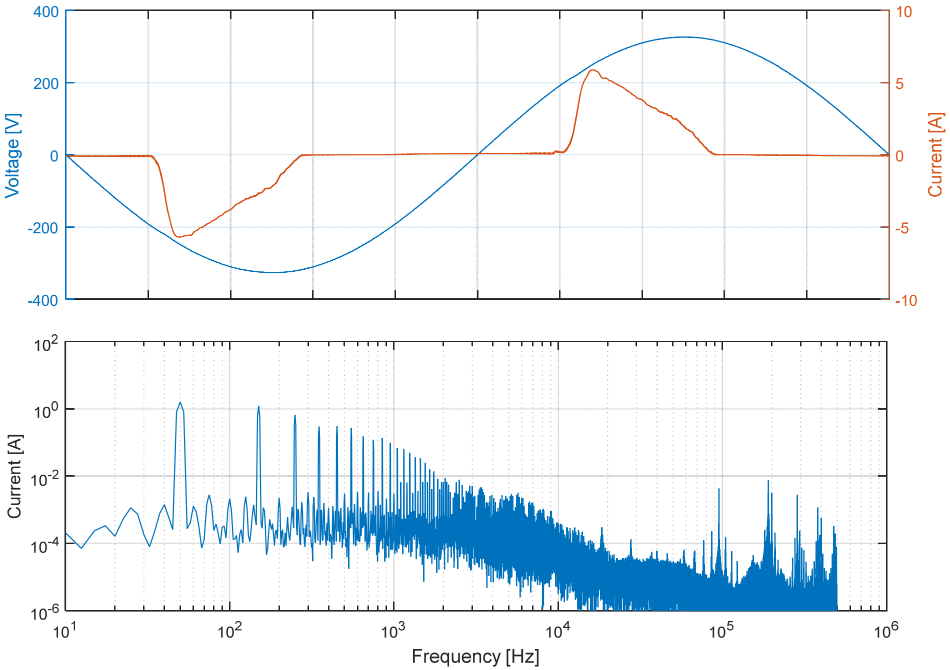
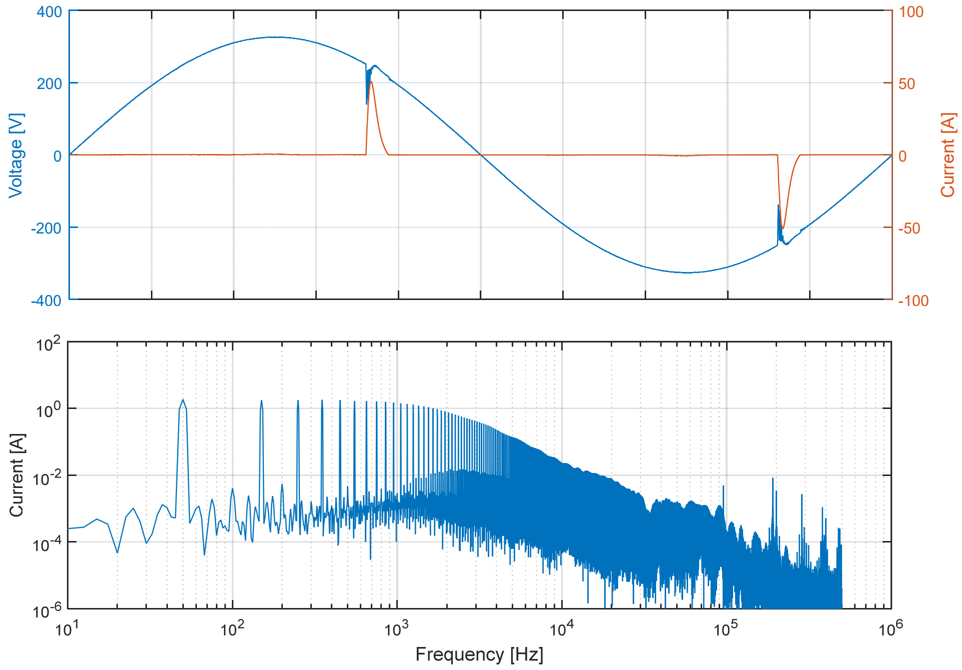
Test signal example: CFL lamps + dimmer





NB: the CFLs are non-dimmable; on dimming, the power remains the same (~ 340 W), but the current shape changes strongly (more wideband)

The step is fast: ~ 50 μs (> 200 μs in present EN50470-3 std)

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Thanks for your attention!