

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



MeterEMI

Electromagnetic Interference on Static Electricity Meters EMC Europe Workshop, September 5th 2019, 09h to 12.40h Room 5.

Chair: Paul Wright, NPL Deborah Ritzmann, Peter Davis: NPL Helko van den Brom, VSL Marc Pous, UPC Tom Hartman, Bas ten Have: University of Twente

Agenda:

09.00h Introduction to the problem (Paul Wright, NPL) - 20 mins

09.20h Discussion - 15 mins

09.35h Capturing real-world waveforms for meter testing. (Twente + VSL + UPC)

09.35: Equipment to digitize waveforms, demonstration of measurement equipment and data capture and analysis software - (Marc Pous –UPC) - 25 mins

10.00: Measurements of Appliances in the lab to capture waveforms (Helko van den Brom, VSL) – 15 mins

10.15: Waveform capture on-site (Tom Hartman, University of Twente) - 15 mins

10.30: Discussion – 10 mins

10.40h Coffee Break 25 mins (10.40-11.15)

11.15h Signal analysis techniques to unambiguously specify complex test waveforms.

- 11.15: Triggering and Analysis (Deborah Ritzmann, NPL) 15 mins
- 11.30: Probability distributions (Marc Pous -UPC) 15 mins

11.45: Discussion - 5 mins

11.50h Test Beds for approval of meters

11.55: Testbed for normative approval of static electricity meters based on phantom power. (Peter Davis NPL and Helko Van Den Brom VSL) – 20 mins

12.10: Discussion on outlook for normative standards & testing procedures. - 5 mins

12.15h Latest findings on meter performance. (VSL/Twente Bas Tenhave) (10 mins)

12.25h Final discussions, feedback and stakeholder needs (10 mins)

12.35h Close and lunch

EM interference in 2008...



 Sweden, with 5 million smart (static) meters installed: 1 meter type appeared extremely sensitive to EMI with frequencies in the range of 2 – 150 kHz

(500,000 installed meters)

- Causes: heat pumps, PV panels with inverters, PLC, frequency converters, UPS
 - \Rightarrow can cause significant currents in this frequency range



Henri Schouten, NMi Certin, "Milestones in Metrology", 2012 Example PV inverter spectrum: Approx. 1 A harmonic current at 16 kHz.

Solution: additional tests CLC/IEC Standard





CLC TC13 technical report 50579 (2012)

⇒ IEC std 61000-4-19 (2014): "Test for immunity to conducted, differential mode disturbances in the frequency range 2-150 kHz"

Distortion Effects - Approval Tests for Electricity Meters

- IEC std 61000-4-19 (2014): "Test for immunity to conducted, differential mode disturbances in the frequency range 2-150 kHz".
 - Single swept disturbing tone test mixed with 50Hz line : 2A: to 30kHz; 1A: 30 to 150kHz. Meter errors should be less than $\pm 2\%$ for Class C

ANSI:C12.20 - 2015



UTwente study



Trigger:

- Doubts on the correct reading of static electricity meters in the field
- Increase in apparent energy consumption after replacing a Ferraris meter by a static meter feeds the doubts.

<u>Questions</u>:

- Are there really (still) problems with static electricity meters?
- If so, could EMI be a cause?
- ⇒ Perform tests by applying EM interference to static meters "can we cause error readings of static electrcity meters?"







UTwente study



MSc thesis Anton Melentjevs, June 2015



(a) Lamp array



(d) Radiator 2500(1334)W



(b) CFL from KarWei



(e) Radiator 2000W



(c) LED light by Osram



(f) Dimmer for 230VAC



Loads:

. Resistive	(heater)
2. CFL: 11 W	(30 pieces)
3. LED: 2 W	(20 pieces)

Via a dimmer (4) the load is changed from 0 % to 75 %

5 Meters (4 static, 1 rotating) measure the energy consumption

Result: 3 out of 4 static meters deviate significantly from the rotating meter at certain loads combined with \geq 50 % dimming

Smart Meter Errors



The target is a rollout of at least 80% (200M) Smart Meters in Europe by 2020

"Static energy meter errors caused by conducted electromagnetic interference" Frank Leferink, University of Twente Enschede, published in IEEE Electromagnetic Compatibility Magazine Volume: 5, Issue: 4, Fourth Quarter 2016, 01 March 2017)



Dutch Metroloav

Observations

Test signals are conducted EMI, current is cause of the problem

- This is not a 2 150 kHz problem, but 0.1 20/50 kHz problem?!
- Test signals: broad spectrum reflecting step response
 ⇒ many components vs 'single tone'
- High & fast current peaks \rightarrow maximum *I*, maximum d*I*/d*t*

Current sensor clearly is relevant...

... but there are other issues too (H/W, S/W?)

Combination of specific 'test signals' with specific static meters

- Details can have large influence on size (& sign) of error reading
- Dimmable CFL & LEDs also result in error readings

Are there normative and regulation issues ?



- What interference waveforms occur at real meter supply points?
- Do these waveforms cause errors in MID approved meters?
- What **new test waveforms** might be needed to thoroughly test meter performance?
- What **new test beds** might be needed to approve meters with these new waveforms?
- "Bench Mark" meter immune to this EMI required for billing dispute settlement by utilities.





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What is Euramet?

- Organisation of national metrology laboratories in Europe,
- Runs metrology joint research projects (JRP),
- JRPs funded by H2020 and National Governments (~50:50),
- JRPs also involve universities and/or industrial partners.

What is a pre-normative R&D project?

- Special JRPs dedicated to a standardisation issue.
- Aim to provide R&D to support the work of SDOs e.g.'s:
 - new test methods, instruments, test rigs,
 - new algorithms,
 - test protocols,
 - research the need and justification.

MeterEMI Project Summary Information

- 3 Year joint research project (JRP) May 2018 to April 2021.
- 7 partners.
- 5 National Government Measurement Labs, UK, NL, CZ, CH, NO (NPL, VSL, CMI, METAS, JV).
- 2 Universities: UTwente (NL) and UPC (ES Catalonia).
- ~50:50 EU funded/National Funded.
- EU funds from EMPIR (FP7) Normative Project Fund.
- 4 Technical Work Packages (WP).
- Chief Stakeholder Dutch Network Operators Association (NBNL).
- 25 supporting stakeholders.



Summary of Work Programme – Waveform Capture or Real World Disturbances

- Select and characterise wideband digitisers and transducers.
- Capture waveforms from interesting appliances in the lab.
- Live measurements at multiple meter connection points in several countries.







MeterEmi



- What signals make meters read in error ?
- Separately test processing systems and transducers.
- Test common meter processors, look for error modes with signals at the system inputs.
- Test common current sensors and associated conditioning.
- Finding the weaknesses will help design test waveforms (assuming such waveforms can occur in practice).

Summary of Work Programme – Waveform Analysis

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- Large quantities of data need to trigger event capture.
- Need to decompose waveform
 which features cause errors?
- The waveforms have discontinuities – FFTs don't always help.
- Use time-frequency distribution wavelets, or probability distributions.
- Must be practical and understandable!





Summary of Work Programme – Possible Future Test Beds for Meter Approval

Two possible approaches:



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Summary of Work Programme – Smart Meter Possible Future Approval Tests

- Test a range of installed smart meters on the test beds with the waveforms.
- Devise new meter approval test procedures.
- Specification and Selection of a "Bench Mark" meter.







Future Interactions with Standards Development



Contacts with Committees

- CEN-CENELEC-ETSI Coordination Group
- IEC TC13 WG11/CLC TC13 WG01, will them update when results available.
- SC77A One project partner is a member + national mirrors.
- WELMEC WG11 One project partner is a member.
- Standards of relevance: 61000-4-19; EN50470; 61000-3-8; EN50065-1.

Draft Input for Consideration in New Normative Standards (if/as required)

- New meter test waveforms based on captured real-word conditions.
- Standard specifications for new meter Test Beds for MID testing.
- New Protocols for waveforms, Test Beds and meter testing as inputs to help **any** revisions of IEC 61000-4-19 and EN50470.
- A "Bench Mark" meter design for metering dispute resolution.



Test Beds for the testing and approval of meters

Two approaches:

- Mixed signal Approach
- Phantom Power Approach

Meter test bed: Mixed signal Approach



IEC 61000-4-19 Meter Test Bed

Discussion on outlook for normative standards and testing procedures



Standards and committees:

Meter testing:

2-150kHz Immunity : PLC: EN50470-3

IEC61000-4-19

CLC TC13 WG01 IEC TC13 WG11 IEC SC77A WG6 CLC SC205A