JRP 18NRM05 SUPRAEMI

# EXPERIENCES OF (2 TO 150) kHz MEASUREMENTS IN LABORATORY AND UNDER CONTROLLED GRID CONDITIONS

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LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS

# SUMMARY

Mesurands

Mass-market appliances

Laboratory Method of Measurement

Some Laboratory Results

On site Measurements

Comparison results: laboratory and on site

Conclusions

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Measurands

Voltage harmonics : quasi-peak (QPk), peak (Pk) and average (Av)

Current harmonics: quasi-peak, peak and average

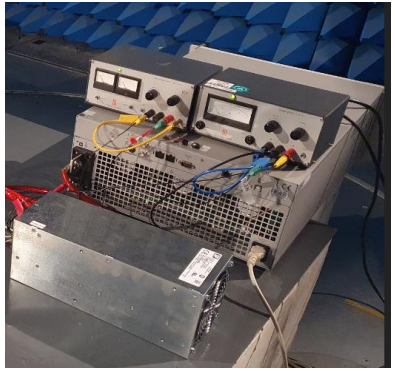
Raw voltage

Raw current

of selected mass-market appliances.

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Mass-market appliances



a. Induction single plate cooker
b. LED lamp
c. Desktop computer Core i5
d. Combined appliances: a+b+c
e. AC/DC converter for electric vehicle (EV) applications

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Laboratory Method of Measurement

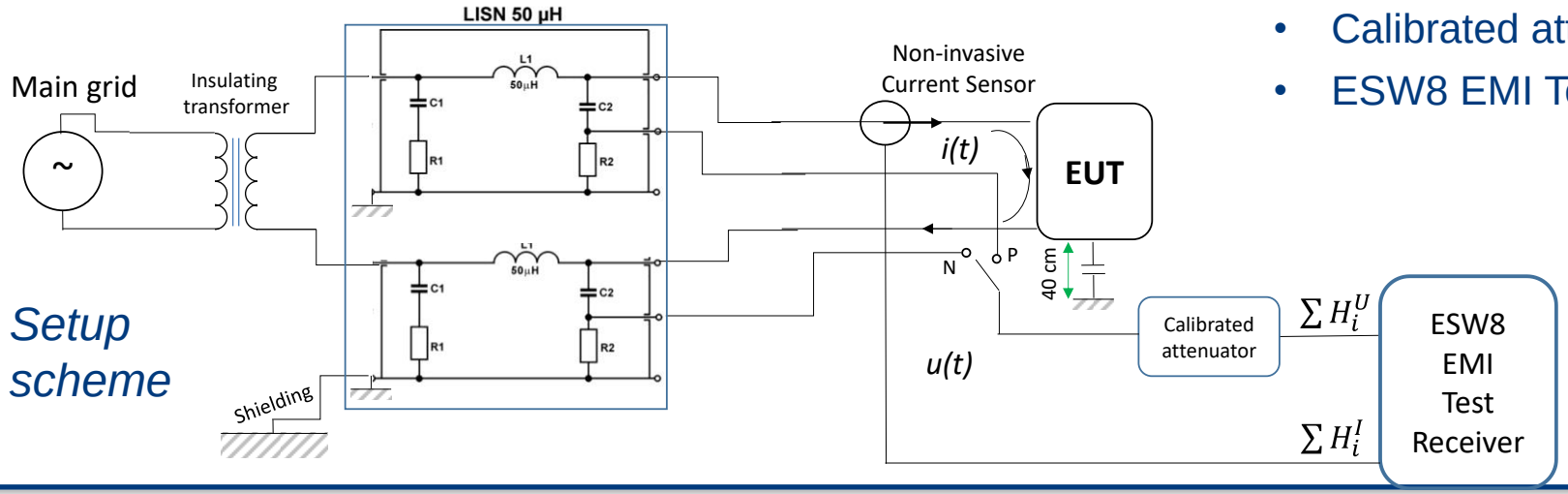
### *Principle*

- CISPR 16 detector
- Conducted emissions
- Measure between phase/neutral and the ground

### *Devices*

- LISN 50 µH
- FCC current probe
- Calibrated attenuators
- ESW8 EMI Test Reciever

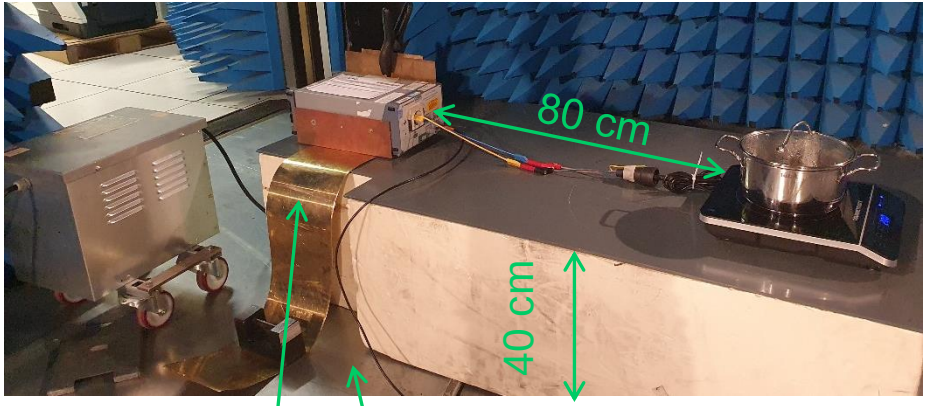
### *Setup scheme*



# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Laboratory setup

- *Voltage measurements*




Shielded LISN (no radiated emission)

Ground plan

CISPR 16-2-1 (EN 55016-2-1 : 2014)

Conducted disturbances measurements

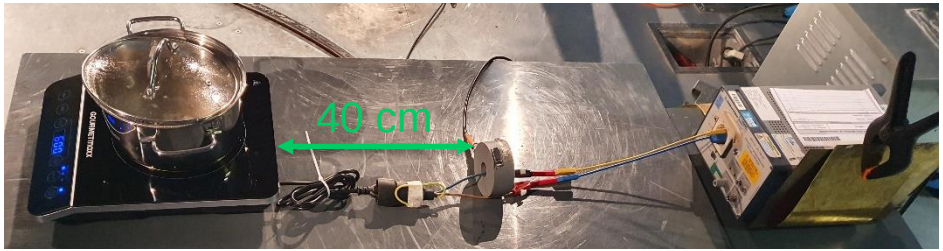
Controled environment

Electromagnetic anechoic chamber

(minimizes the amplitude of unwanted ambient signals)

23,0 °C ± 1,0 °C

- *Current measurements*



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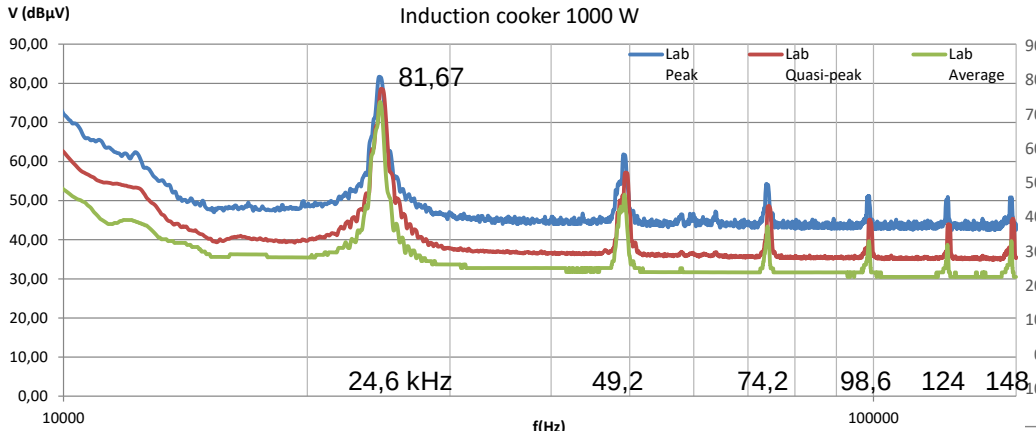
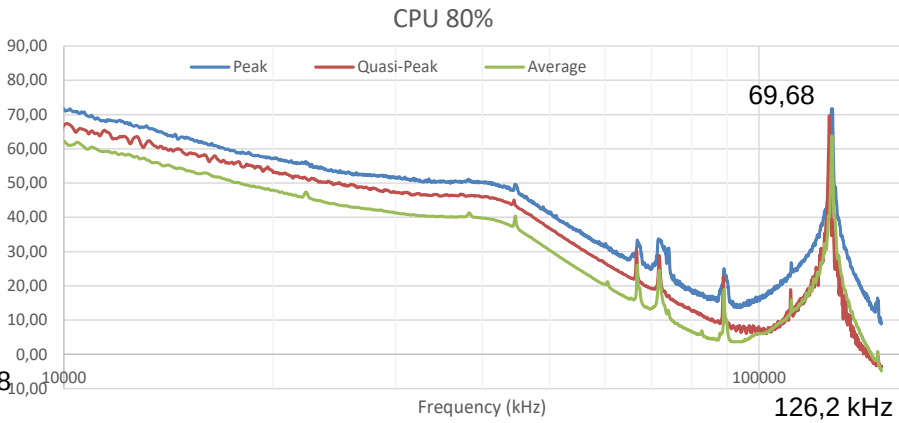
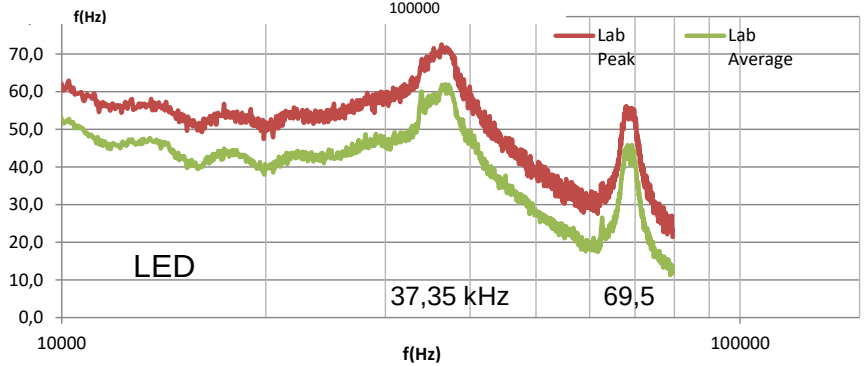
# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Laboratory results: voltage harmonics, individual measurements

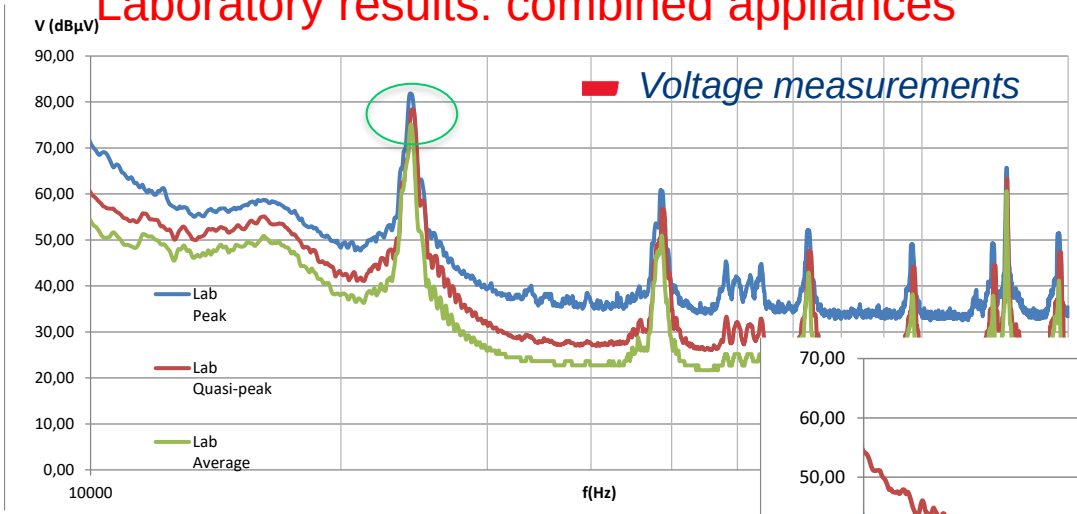


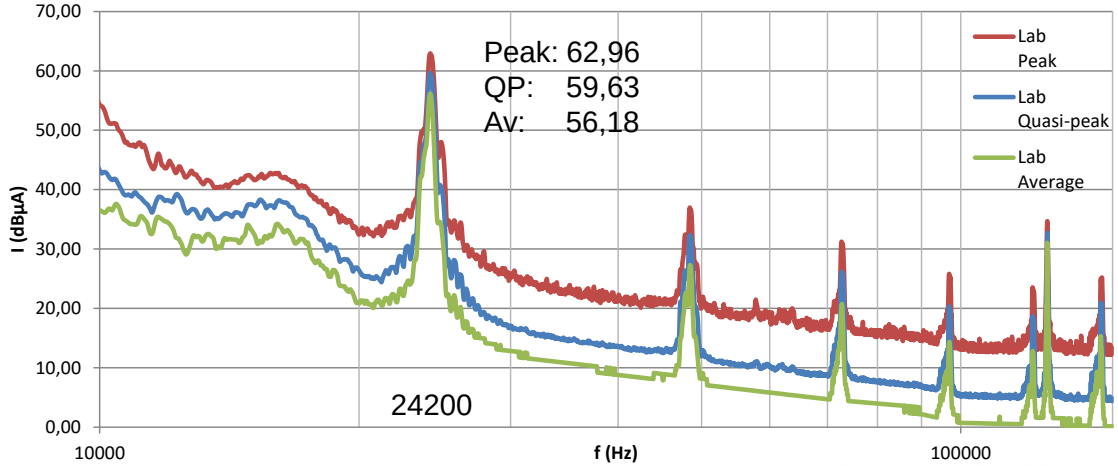



# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Laboratory results: combined appliances




| Frequency (kHz) | Peak (dBµV) | Quasi-Peak (dBµV) | Average (dBµV) |
|---|---|---|---|
| 10 | 71,05 | 60,30 | 54,17 |
| 24,25 | **81,84** | **78,38** | 50,97 |
| 48,5 | 60,89 | 56,77 | 50,97 |
| 58,3 – 64,3 | 44,29-44,58 | 32,66-31,64 | 24,45-25,18 |
| 72,8 | 52,16 | 47,65 | 42,93 |
| 97,3 | 49,15 | 44,18 | 38,22 |
| 126,3 | 65,66 | 63,36 | 60,61 |
| 146,1 | 51,47 | 47,14 | 41,20 |




Current measurements



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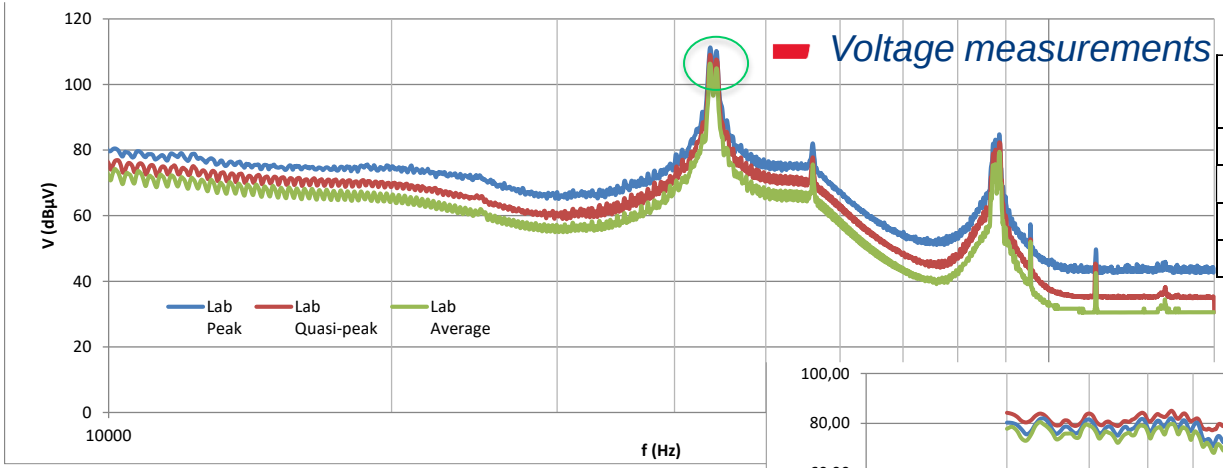
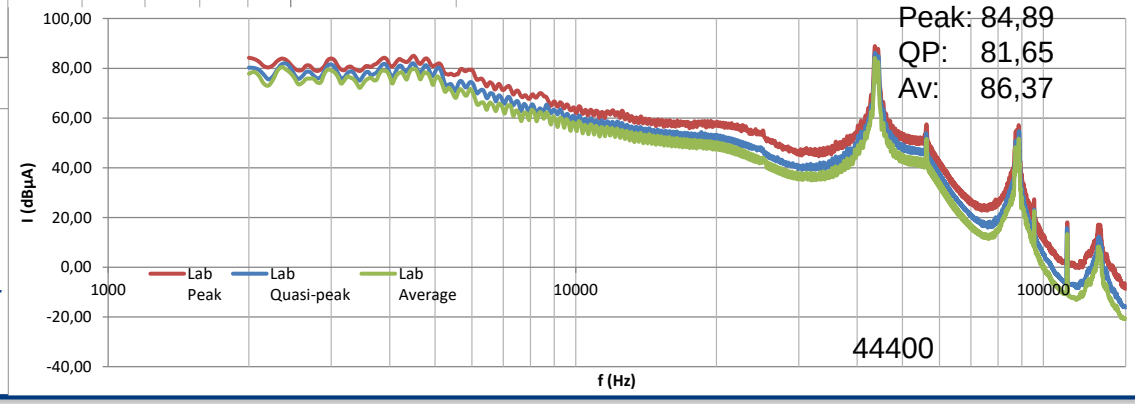
# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Laboratory results: AC/DC converter




| Frequency (kHz) | Peak (dBµV) | Quasi-Peak (dBµV) | Average (dBµV) |
|---|---|---|---|
| 10 | 79,7 | 75,94 | 72,05 |
| 43,6 | **111,29** | **109,07** | **106,35** |
| 56,1 | 82,03 | 77,81 | 75,65 |
| 88,6 | 84,80 | 82,38 | 79,48 |




Current measurements



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# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

On site measurements

Concept Grid (EDF):
A real distributive network with tailor-made use-cases

## Main goal

Comparison tests among laboratory measurements and real grid measurements.

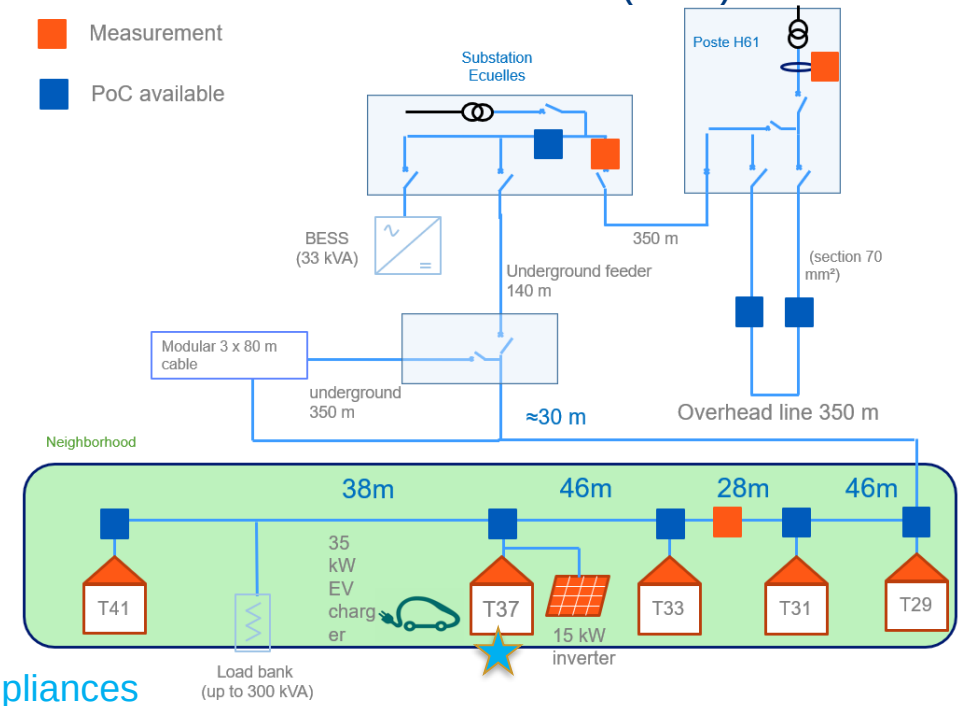
# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## On site measurements

- House T37 supplied from Ecuelles
- No loads connected in other houses
- No EV charger connected

- Concept grid plateform is linked to the rest of EDF laboratories
- No « islanding » mode of supply

## Concept Grid schematics and the available Points of Connections (PoC)




PoC for mass-market appliances

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

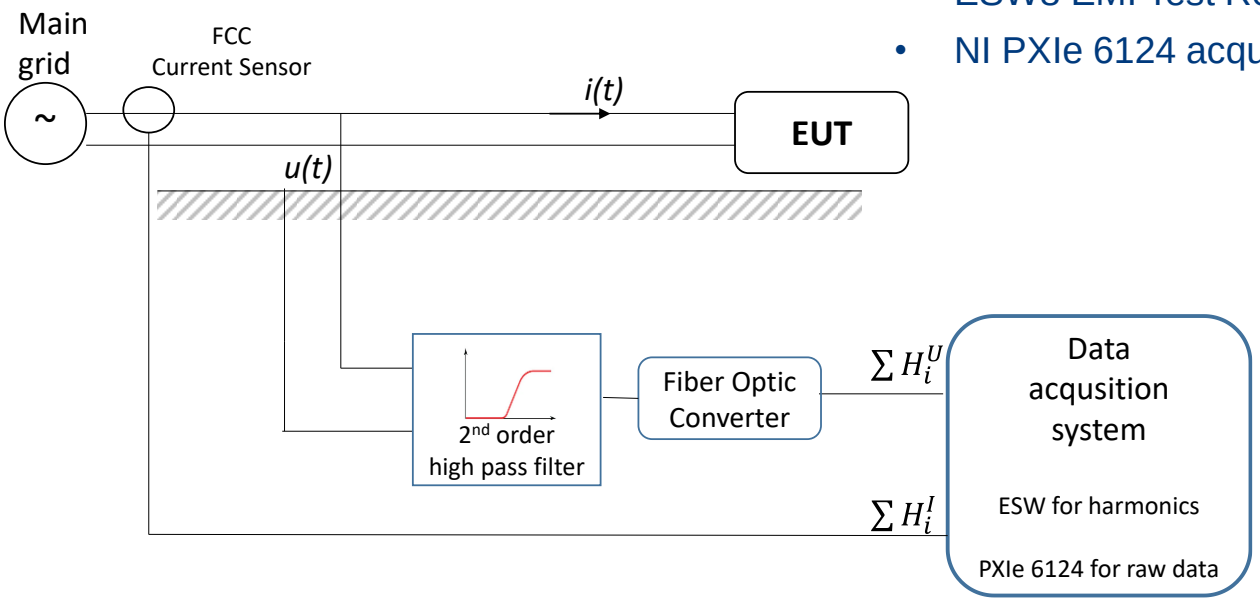
## On site measurements

« - » No LISN 50 µH

« + » Filter + optic converter to insure safety measurements

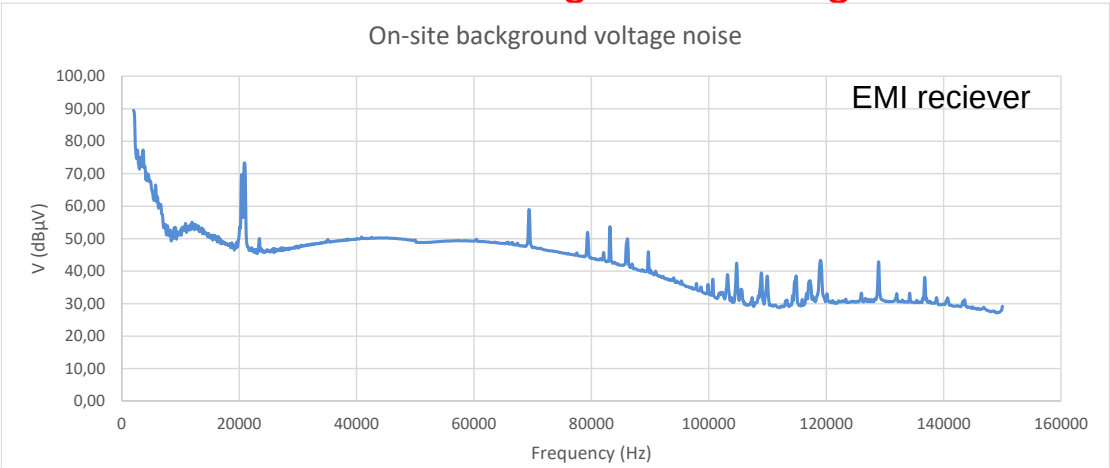
- FCC current probe: inductive, non-invasive
- ESW8 EMI Test Reciever: for harmonics
- NI PXIe 6124 acquisition card, 16 bits: for raw data

*Setup scheme*

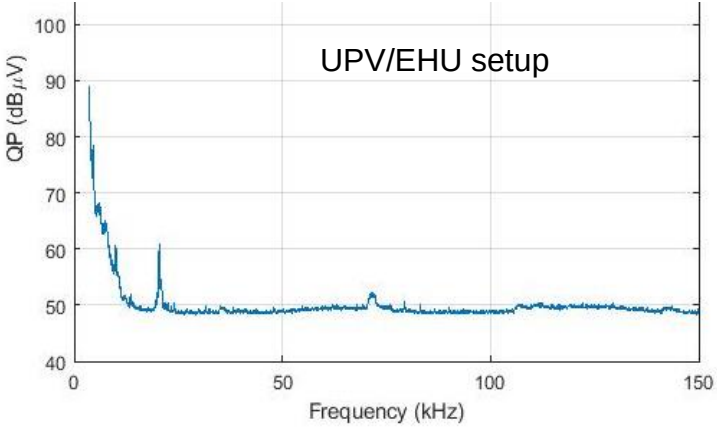


# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## On site results: Background voltage noise




| Frequency (kHz) | Quasi-Peak (dBµV) |
|---|---|
| 20,8 | 73,04 |
| [25;65] | ~50 |
| 69,4 | 58,87 |
| 83,1 | 53,69 |
| 104,7 | 42,47 |
| [100; 150] | 30,34 |
| 119 | 43,29 |
| 128,9 | 42,88 |

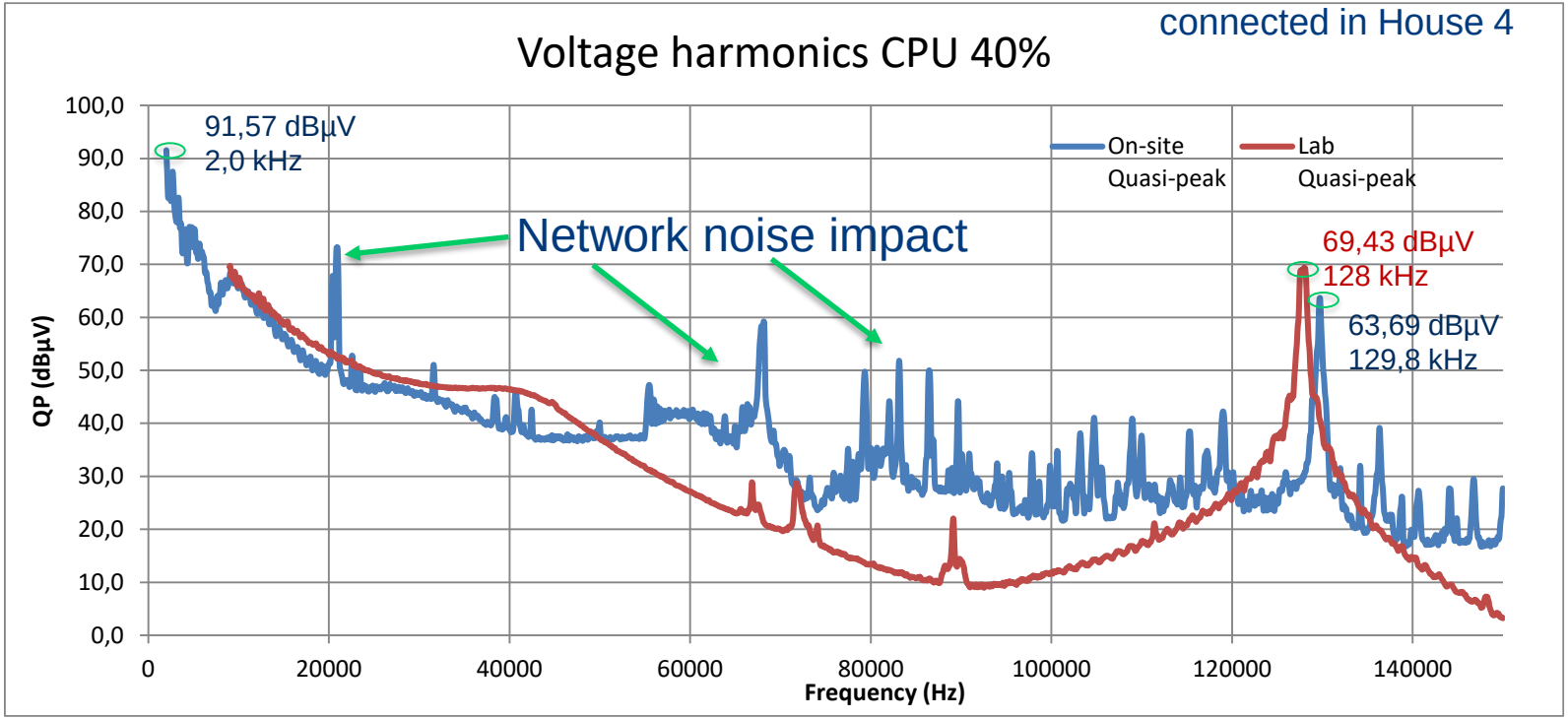



- Mix of background noise and/or noise floor of the measurement system
- Peak at 20,8 kHz always present
- Some peaks at certain frequencies like at 69,4 kHz
- Important background noise at higher frequencies (from 60 kHz)

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Results: Desktop computer Core i5

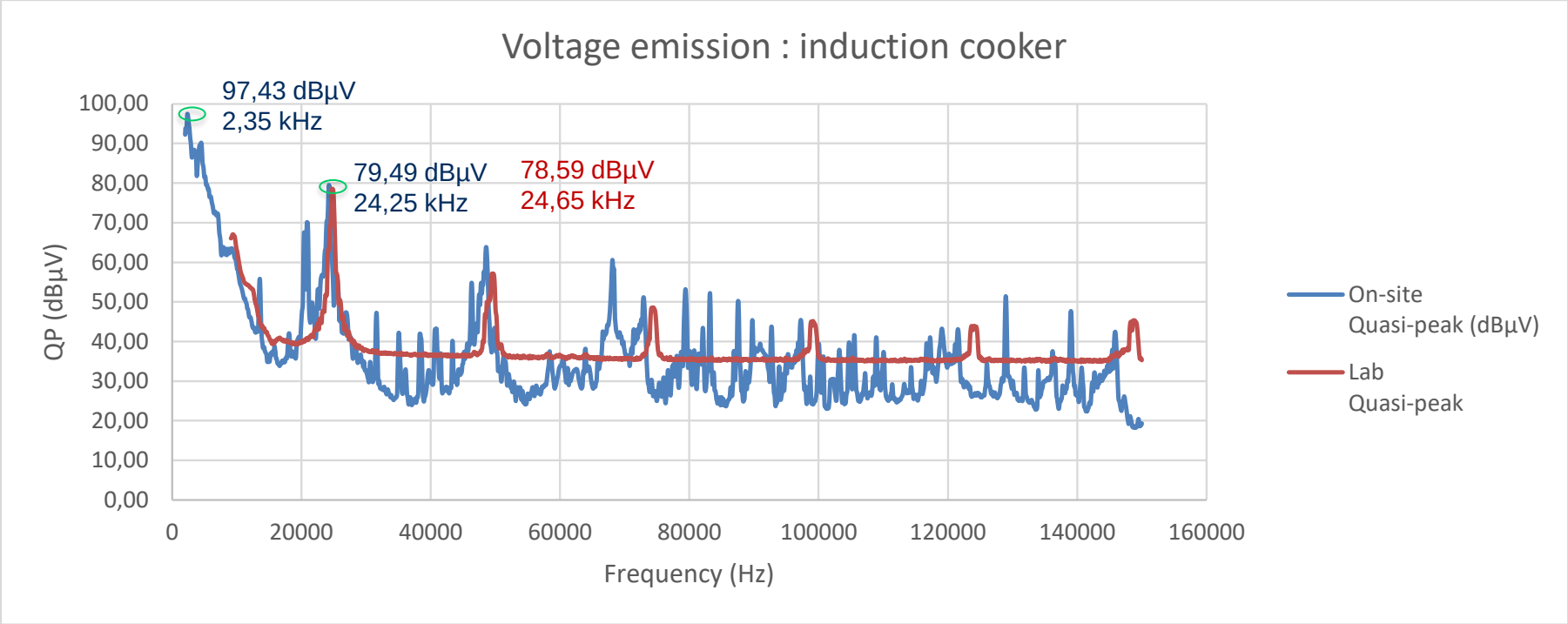
- Smart meter with PLC were connected in House 4



# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

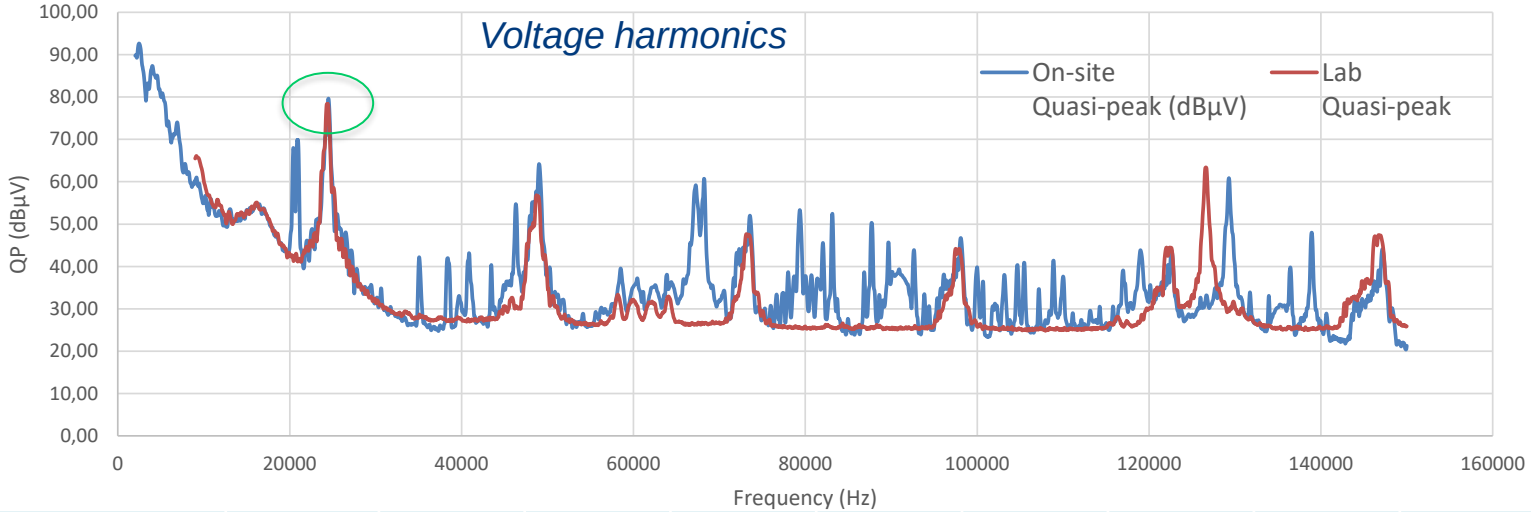
## Results: Induction single plate cooker

- Network by default



# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

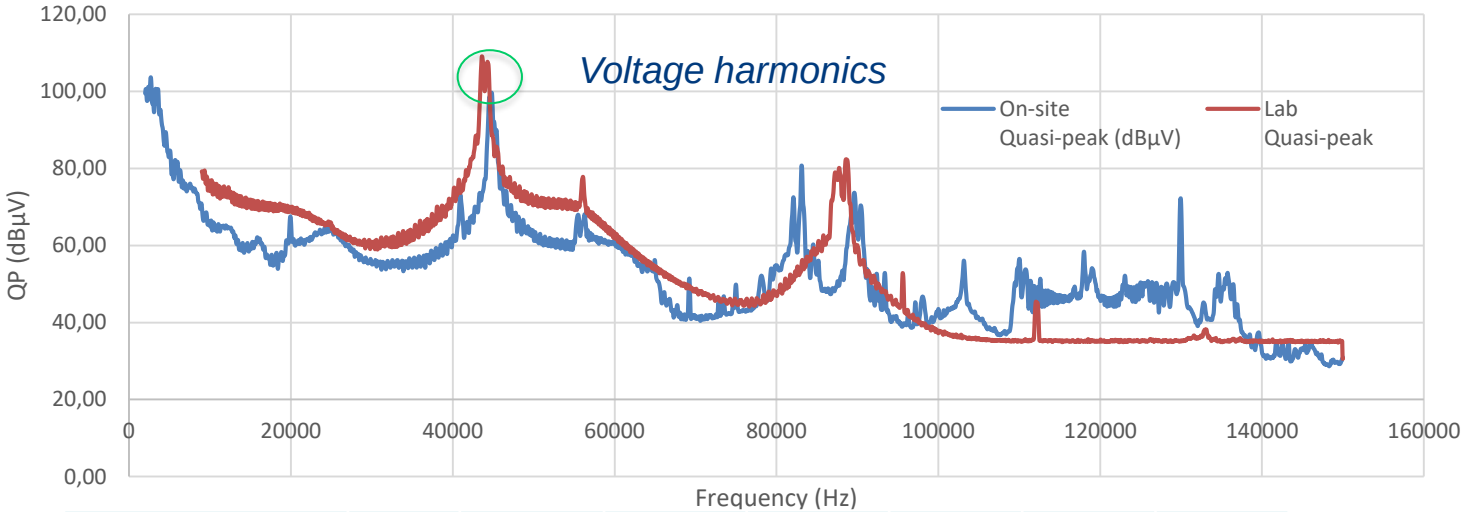
## Results: Combined appliances (induction cooker + LED + computer)




| Frequency (kHz) | 2,4 | 24,45 | 48,5 | 68,2 | 73,0 | 79,4 | 126,3 | 129,25 | 146,1 |
|---|---|---|---|---|---|---|---|---|---|
| Laboratory meas. (dBµV) | - | **78,38** | 56,77 | 26,44 | 47,65 | 25,67 | 63,36 | | 47,14 |
| On-site meas. (dBµV) | **92,66** | **79,46** | 64,21 | 60,74 Network noise impact | 52,04 | 52,92 Network noise impact | | 60,89 | 39,13 |

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

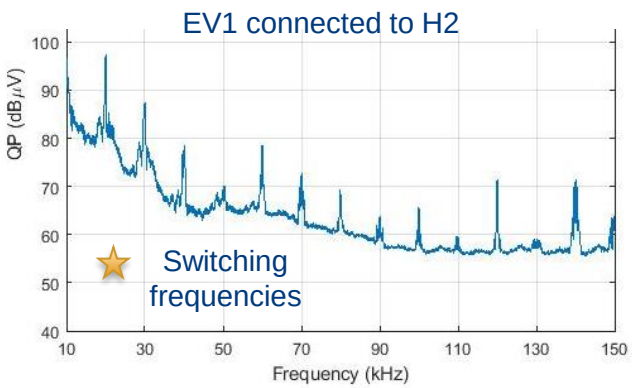
## Results: AC/DC converter for electric vehicle applications

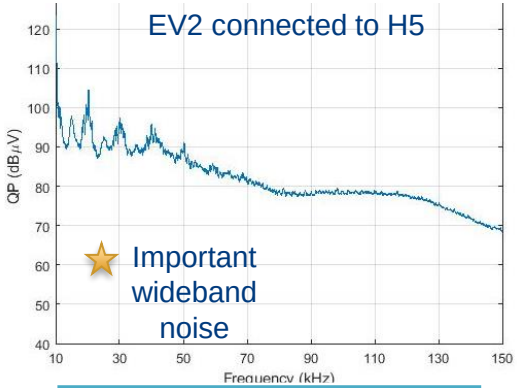


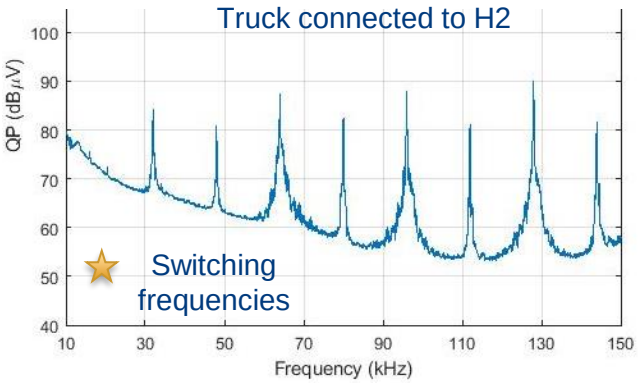

| Frequency (kHz) | 10 | 43,6 | 44,55 | 56,1 | 83,1 | 88,6 | 89,6 |
|---|---|---|---|---|---|---|---|
| Laboratory meas. (dBµV) | 75,94 | **109,07** | | 77,81 | | **82,38** | |
| On-site meas. (dBµV) | 66,01 | | 98,57 | 68,06 | **80,70** | | 73,61 |

# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Results: voltage emission of different EV chargers




| EV 1 | |
|---|---|
| Frequency (kHz) | QP (dBμV) |
| 20 | 97 |
| 30 | 87 |
| 60 | 78 |
| 120 | 71 |
| 140 | 71 |

| EV 2 | |
|---|---|
| Frequency (kHz) | QP (dBμV) |
| 10 | 123 |
| 20 | 104 |
| 30 | 97 |
| 40 | 95 |
| 50 | 91 |

| Truck | |
|---|---|
| Frequency (kHz) | QP (dBμV) |
| 32 | 84 |
| 64 | 97 |
| 96 | 87 |
| 128 | 90 |
| 144 | 82 |



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# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

**Maximum values observed for Quasi-Peak**

| Combined appliances | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 2,4 | 92,66 |
| 24, 25 | 79,46 |

| AC/DC converter | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 43,6 | 109,07 |
| 83,1 | 80,7 |

| EN IEC 61000-2-2:2002/A2:2019 | |
|---|---|
| Frequency (kHz) | **Compatibility** level (dBµV) |
| 9 - 50 | - |
| 30 - 50 | 122 - 119 |
| 50 - 150 | 113 - 89 |

| EV 1 | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 20 | 97 |
| 30 | 87 |
| 60 | 78 |
| 120 | 71 |
| 140 | 71 |

| EV 2 | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 10 | 123 |
| 20 | 104 |
| 30 | 97 |
| 40 | 95 |
| 50 | 91 |

| Truck | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 32 | 84 |
| 64 | 97 |
| 96 | 87 |
| 128 | 90 |
| 144 | 82 |

| Discussed **emission** limits | |
|---|---|
| Frequency (kHz) | QP (dBµV) |
| 9 - 50 | 110 |
| 50 - 150 | 82,5 |



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# MEASUREMENTS OF 2 TO 150 kHz EMISSIONS

## Conclusions

- CISPR 16 method provides individual emissions measured in a controlled environment
- Laboratory measured emissions of combined appliances are not higher than individual emissions because the switching frequencies are not the same for the studied devices
- On-site measured emissions are impacted by the quality of the network especially on high frequencies (f > 60 kHz)
- The wideband noise has amplitudes that vary with frequency
- The narrowband emissions are high-level narrowband peaks at harmonic frequencies of the switching frequencies, quite relevant in EV chargers
- On-site measurements on equipment that does not generate much noise, the measurements highlight the background (wideband) noise (combined appliances). On the other hand, for equipment with high emissions, the noise is merged by the measurement, which is more accurate (AC/DC converter).
- The wideband noise is lower than the discussed limits in the interval (2 to 150) kHz.
- However, the EV chargers might emit high-level narrowband peaks which border on the limits.

*Thank you for your attention.*