ERIGRID – Z-NET

Impact of Time variant Grid Impedance on Power Line Communication System

Measuring campaign at TECNALIA, Spain

Virtual ERIGRID Final Conference, 1.4.2020

Dominique Roggo / Dilan Ben M’Rabet

Content

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- Test infrastructure
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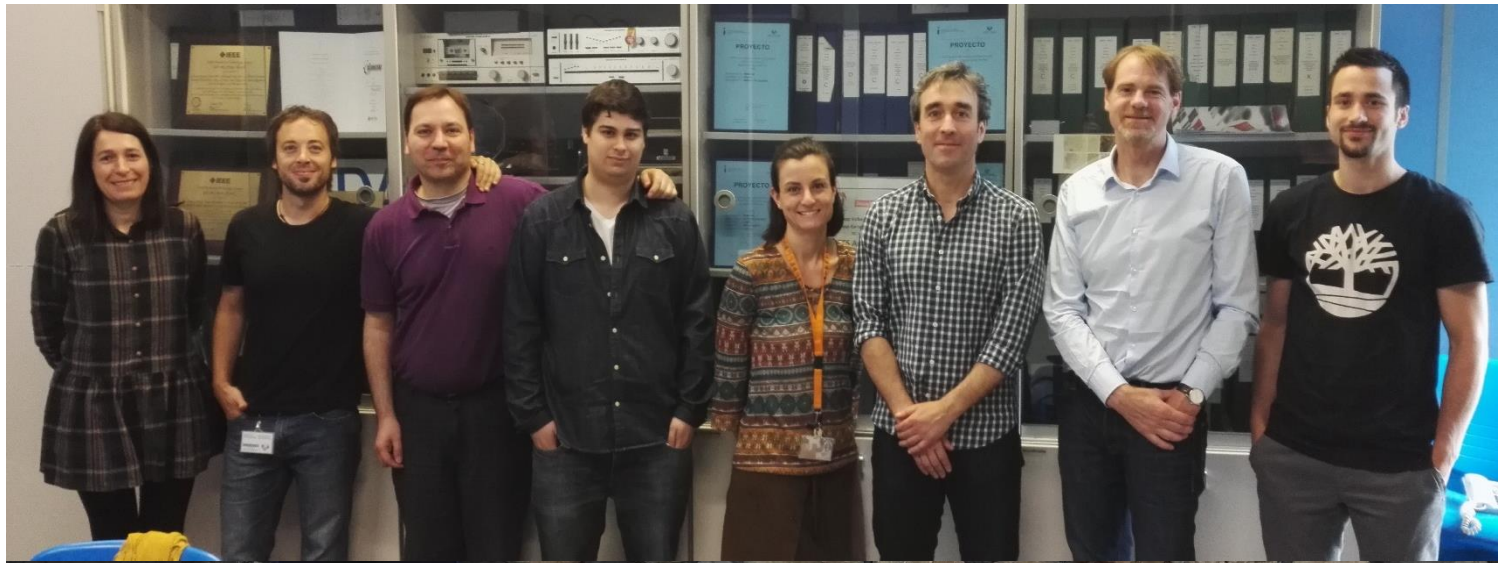
- Benefit



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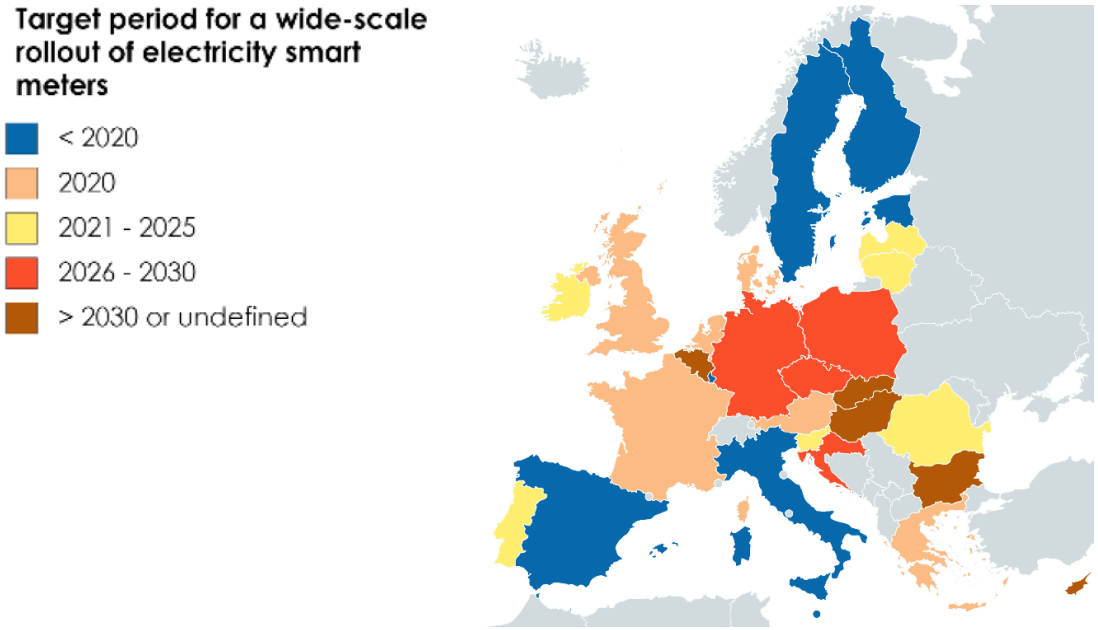
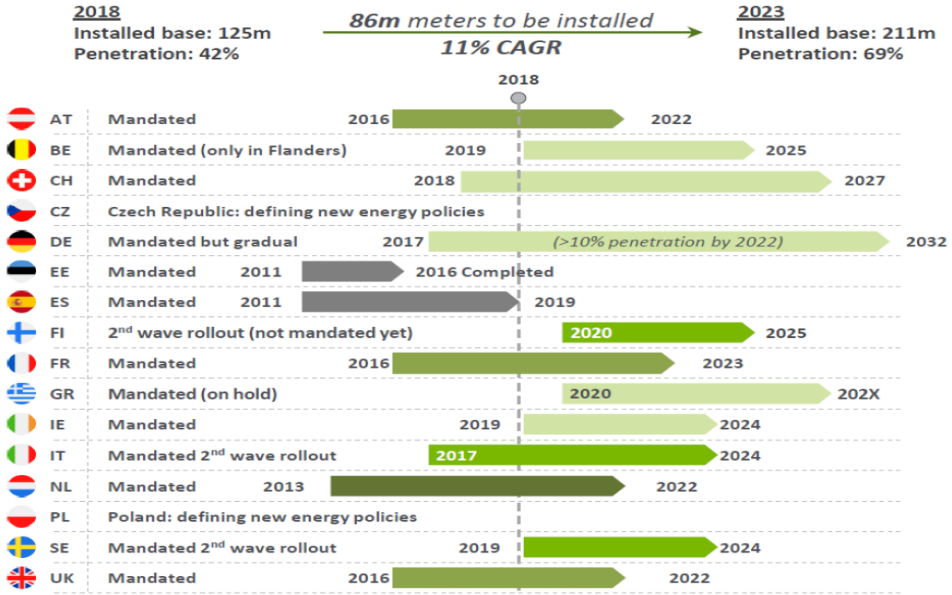
Power Line Communication for Advanced Metering Infrastructure in EU





Countries considering or planning to use PLC:

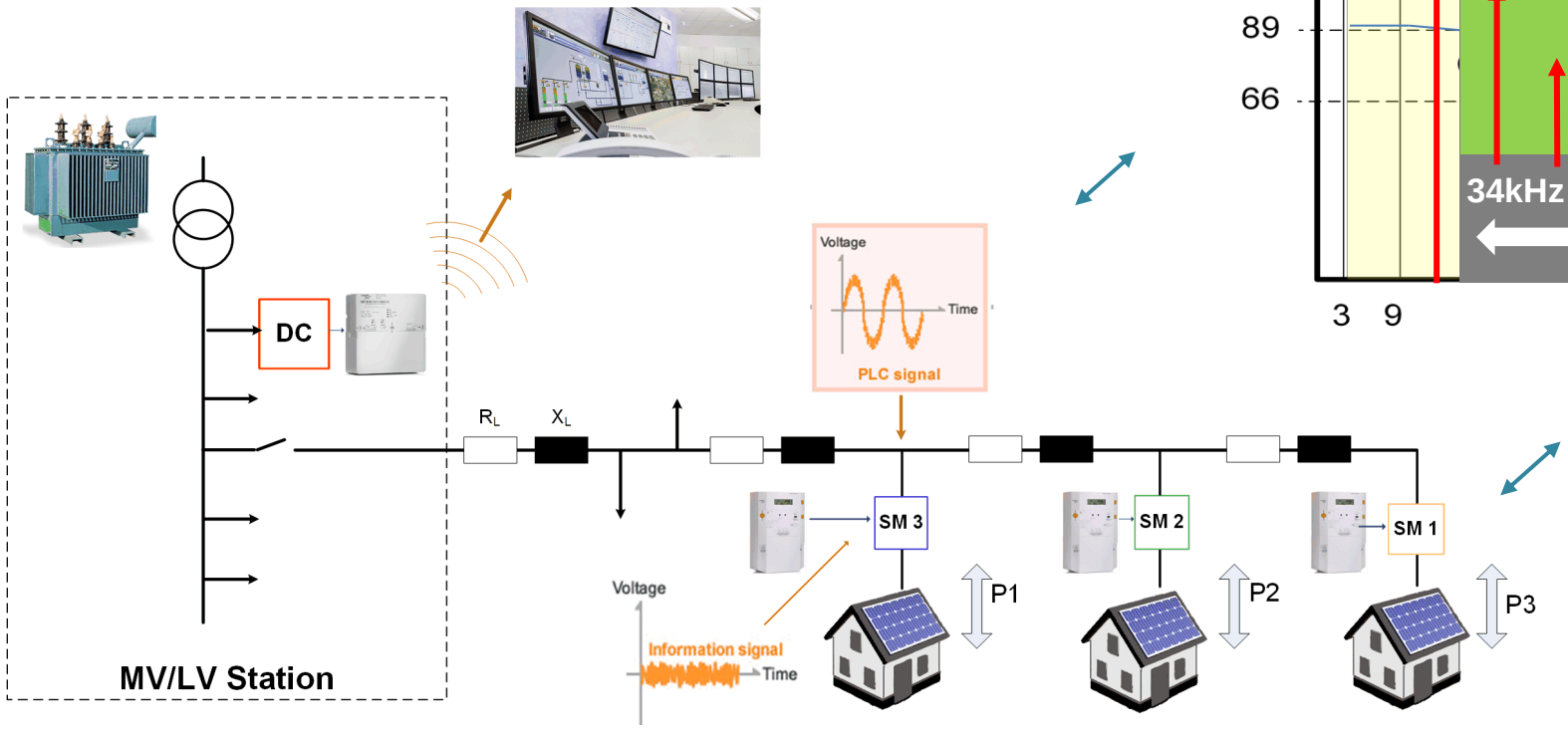
Bulgaria, Estonia, Finland, France, Greece, Hungary, italy, latvia, Lithuania, Netherlands, Poland, Potugal, Romania, Slovenia, Spain, Switzerland…

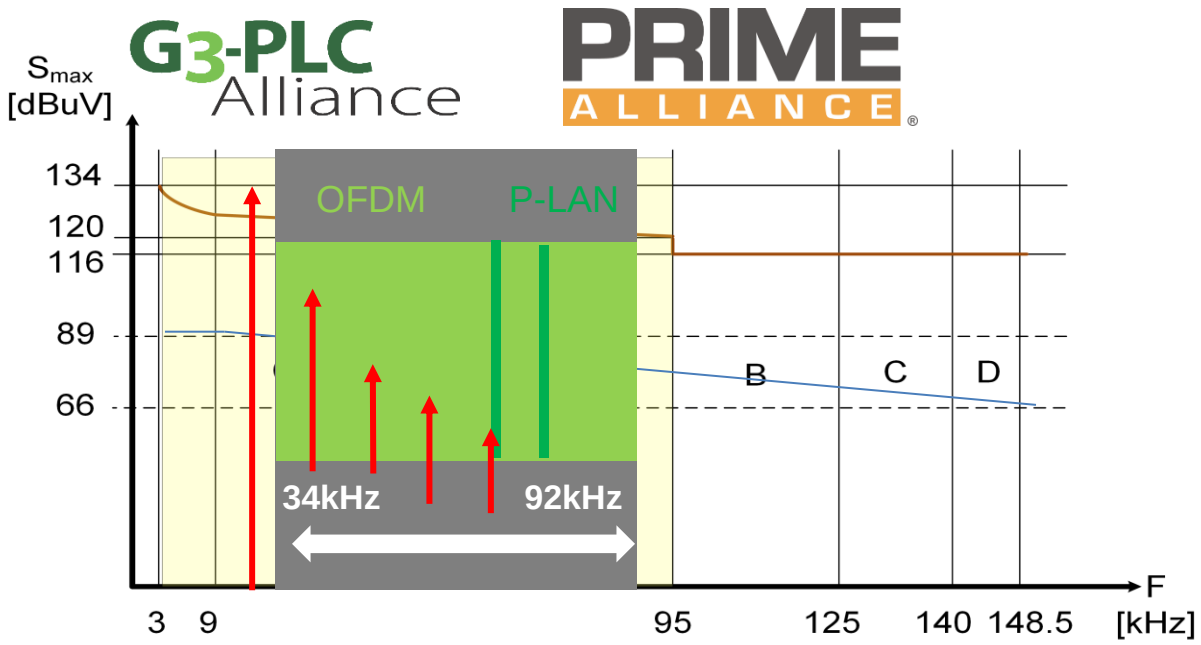
	Provide readings directly to consumer and/or any 3rd party	Upgrade readings frequently enough to use energy saving schemes	Frequency at which consumption data is updated
Austria	YES	YES	15'
Belgium (BR)	N/A		
Belgium (FL)	YES	YES	15'
Belgium (WL)	YES	YES	15'
Bulgaria	YES	YES	Not specified
Croatia	YES	YES	Hourly
France	YES	YES	30'
Germany	YES	YES	15'
Greece	YES	YES	1" (near real-time)

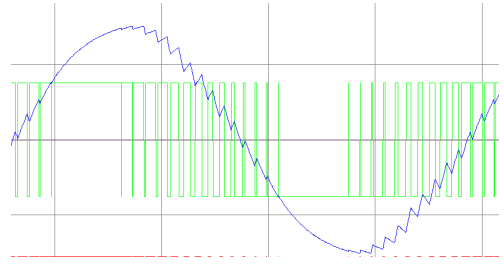
Source: European Smart Metering Benchmark, 2018

Power Line Communication for Advanced Metering Infrastructure

Narrow Band PLC according to:



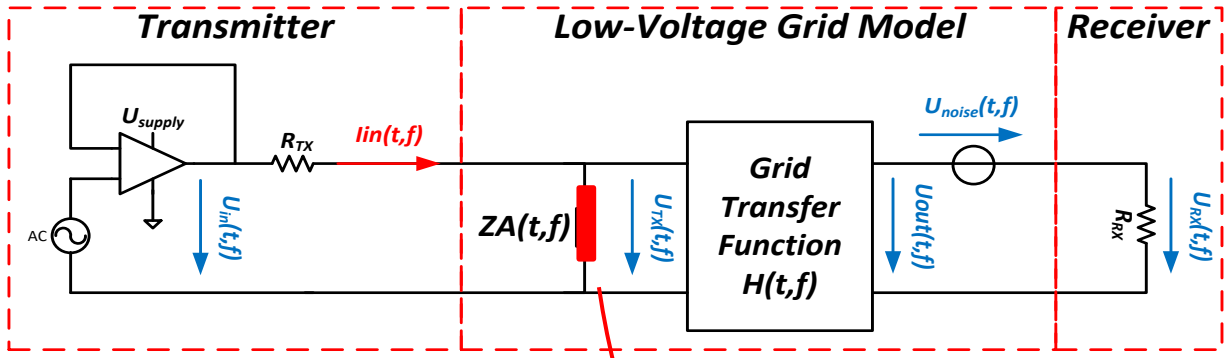




Active In-feed converters (i.e. IEC 61000-3-2)

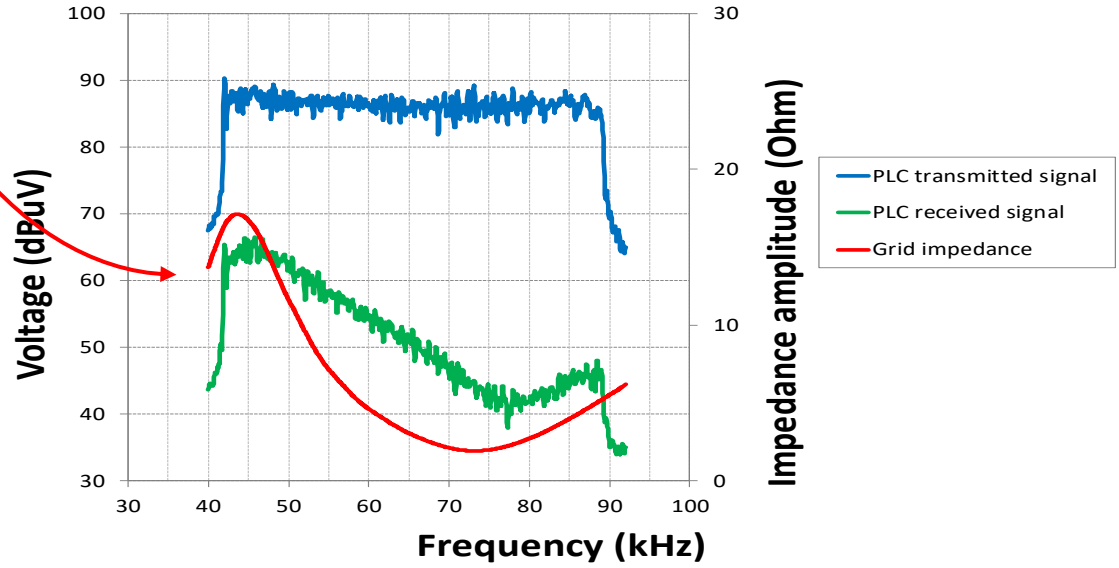
Impact of Frequency Dependent Grid Impedance on NB-PLC

Smart Meter with NB-PLC



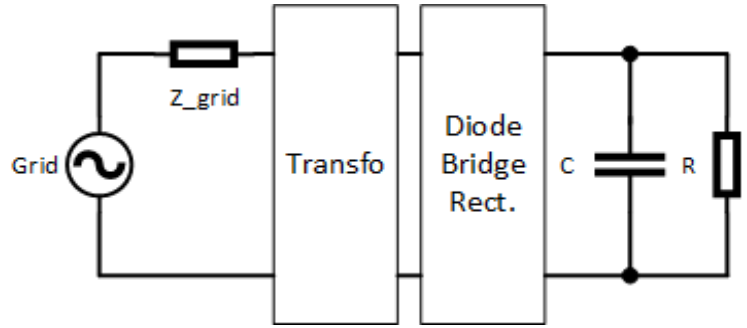
Data Concentrator

- The Frequency Dependent Grid Access Impedance (FDGI) can result in PLC signal attenuation
- Typically due to EMC filters integrated in Power supplies, Inverters and Battery chargers
- Normalization of FDGI Measurement is the objective of Z-NET project funded by Swiss Federal Office of Energy (SFOE/HES-SO/ METAS)

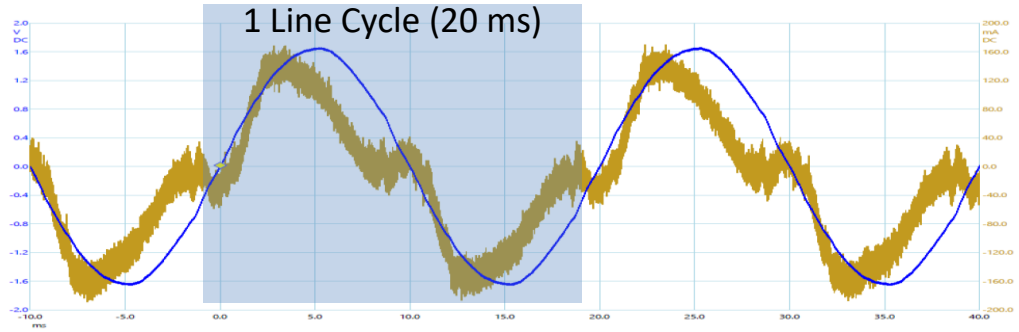


The Z-NET ERIGRID Objectives

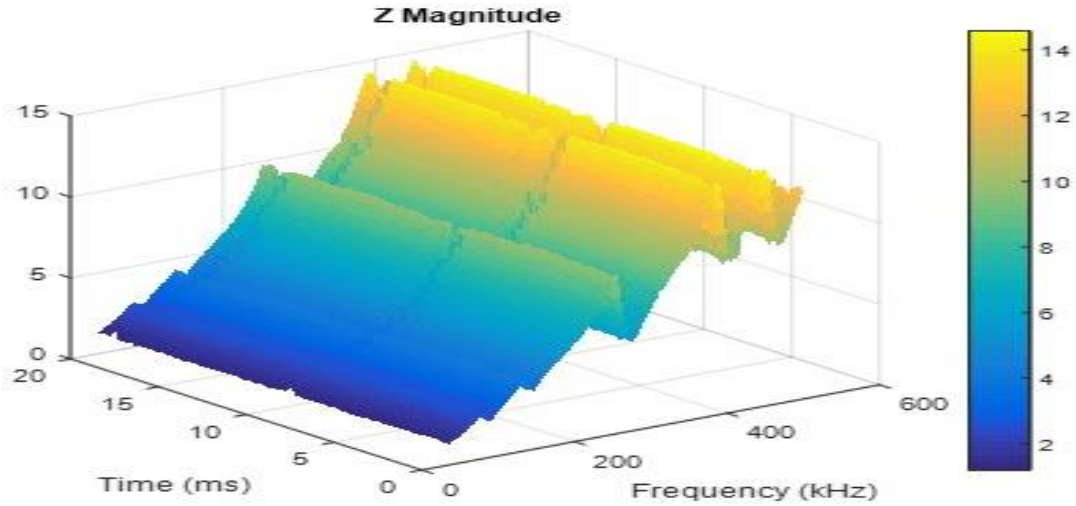
- Measure the impact of different loads on Frequency and Time dependent Grid Impedance in controlled laboratory test bed with many Smart Meters
- Analyse the effect of fast impedance transients on advanced PLC systems
- Evaluate the impedance stabilizer developed by Schaffner
- Information to Normalization



Example of a load generating a time varying impedance with non-linear a current waveform



Line voltage-- and currrent – in Time domain



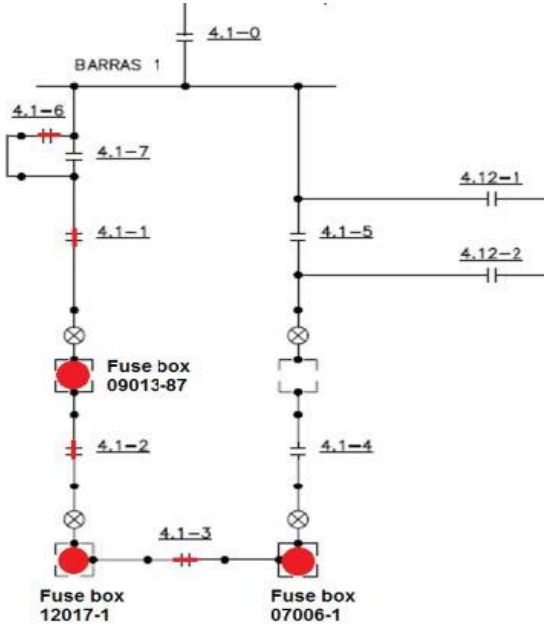
Grid Impedance magnitued in Time and Frequency domain

TECNALIA Research & Innovation Foundation – Smart Grid Technologies Lab – Derio /Bizkaia (Spain)

- Technological Excellence
- Integrated and Multi-disciplinary Projects
- A value contribution for its clients that will be reflected in their business results or in the well-being of society
- Located nearby the **TSR Research Group** at University of Basque Country in **Bilbao**

TECNALIA - Smart Grid Technologies Lab

Fully Programmable Grid Configuration



500 m Cable section I

500 m Cable section II

LV Line Head

Cabinet 1

Cabinet 2

Cabinet 3

Cabinet 4

Data Concentrator (DC)

PRIME SM Type 1

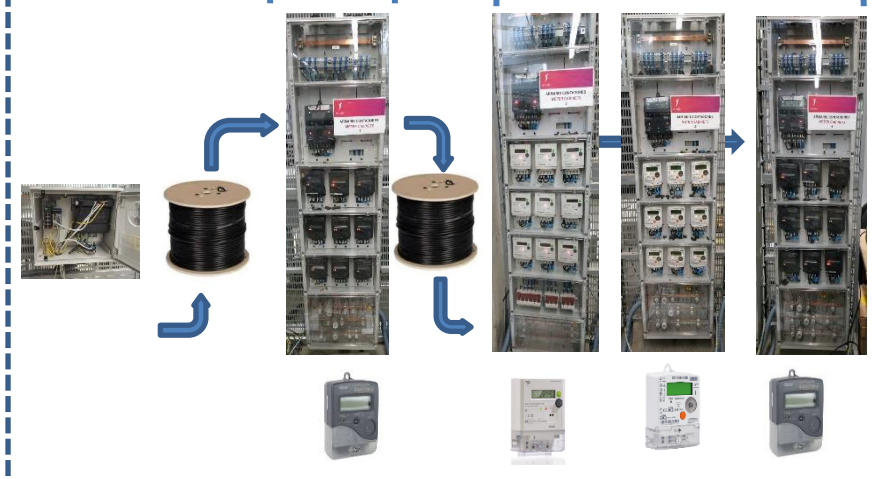
PRIME SM Type 2

PRIME SM Type 3

PRIME SM Type 1

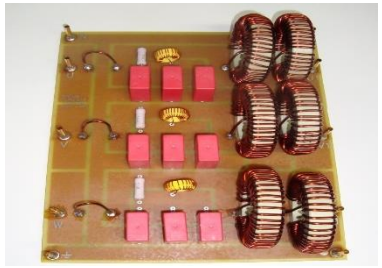
Interfering electronic loads

Points of Coupling for loads and measuring equipment

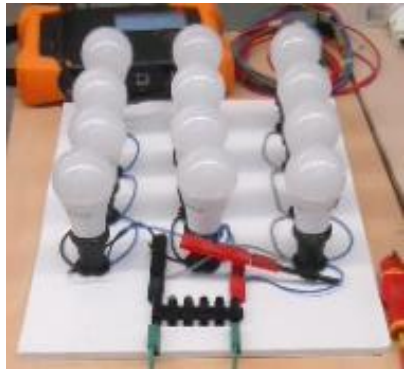


Advanced Metering test bed

Noise generator with grid injection capacity

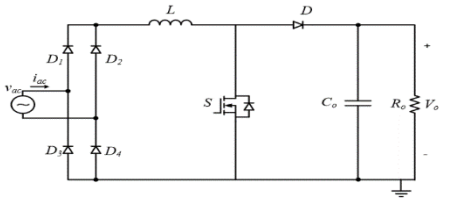


EMC filters



A LED light bulb switch board

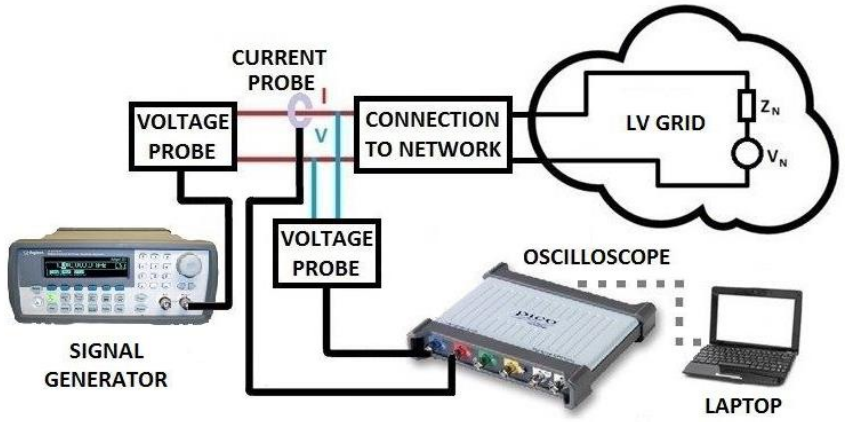
Laptop chargers from different brands

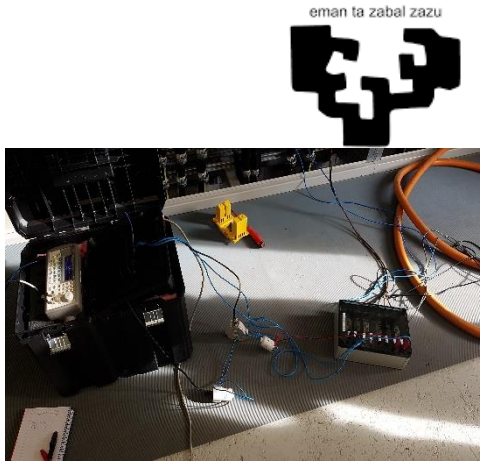


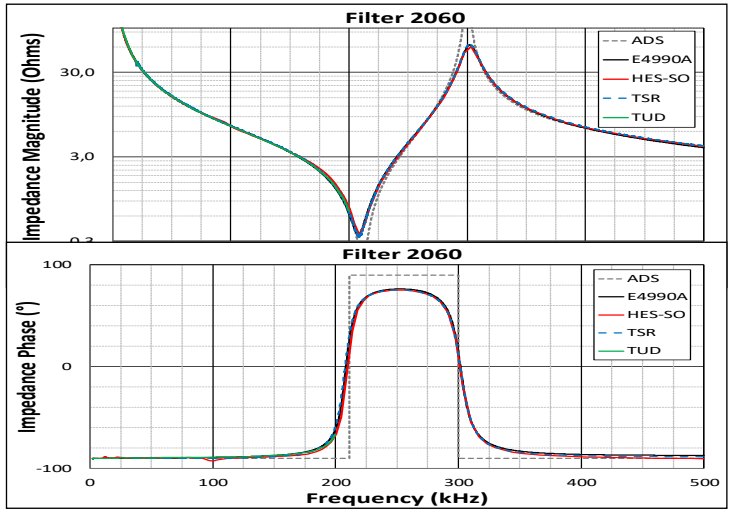
Full wave rectifier

Accessible tools for the measurements

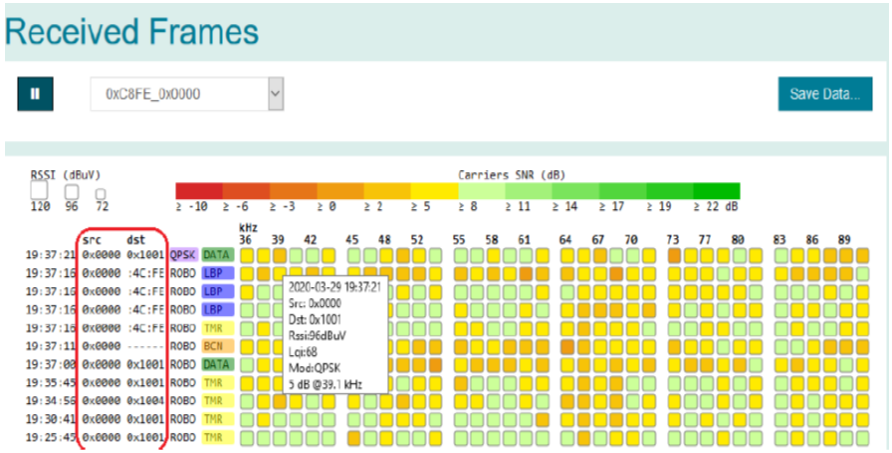
1) 30 .. 500kHz Grid Impedance Meter developed by TSR







2) NEURON N-Box PLC PRIME Sniffer



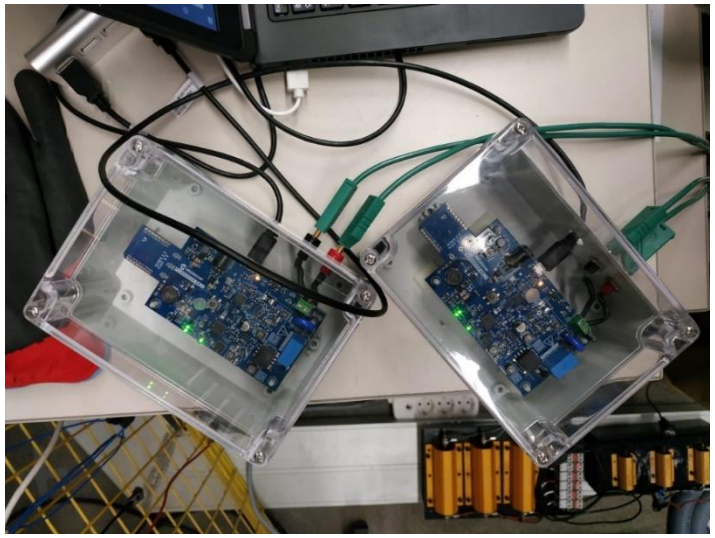
neuron
enabling networks

3) A-Eberle PQ-Box 300

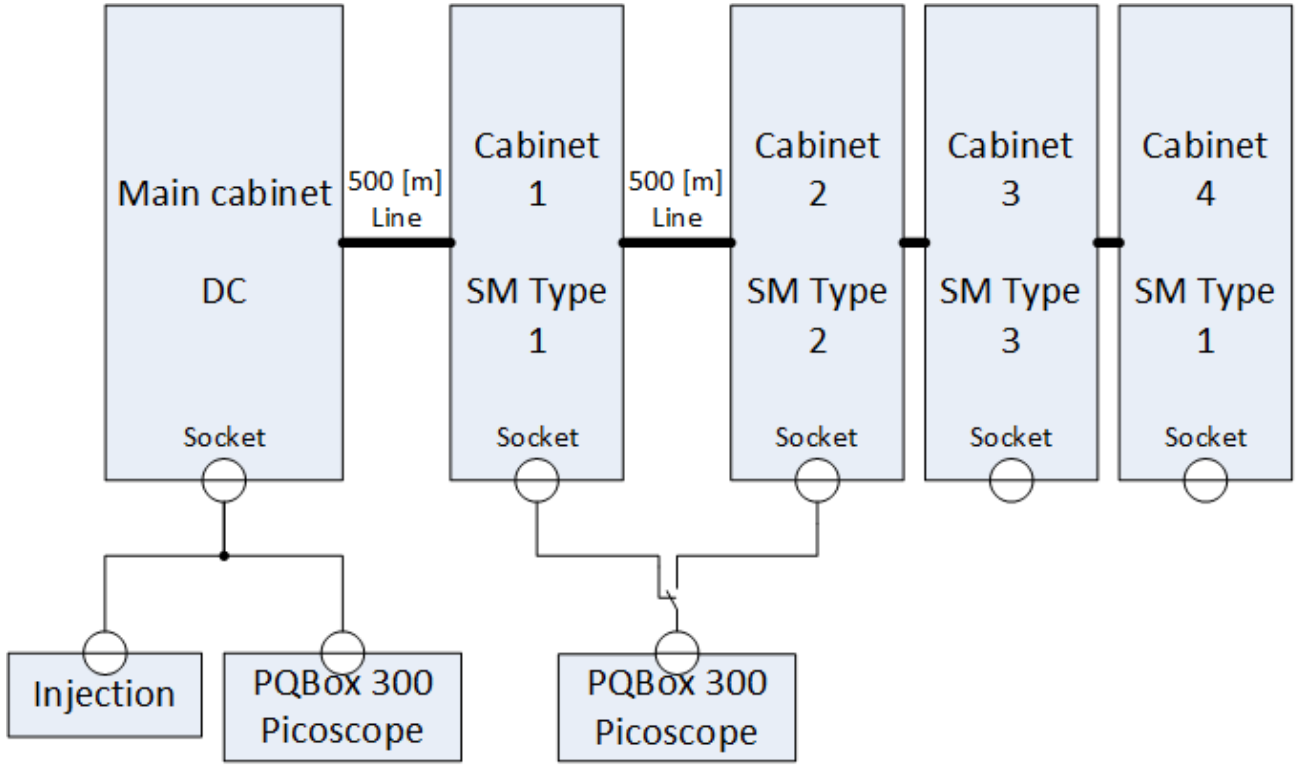
Working plan

Step 0	Mid october 2019
Development of a test plan	
Equipment evaluation	
Step 1	Monday, 18.11.2019
Préparation of the set-up	
Preliminary measurements	
Step 2	Tuesday, 19.11.2019
EMI interference and impact on PLC for loads measurements	
Same with impedance stabilizer	
Measurements results collection and short reporting	
Step 3	Wednesday, 20.11.2019
EMI interference and impact on PLC for loads measurements	
Same with impedance stabilizer	
Measurements results collection and short reporting	
Step 4	Thursday, 21.11.2019
Repeat failed tests or measurements	
Tests in islanded grid generated by converters	
Final results collection and reporting	

Measurement and trials – Case #1

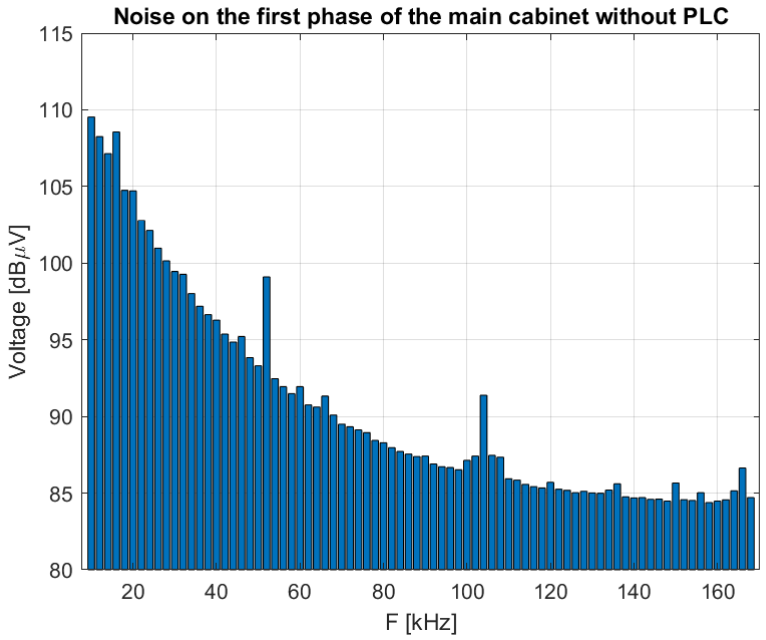


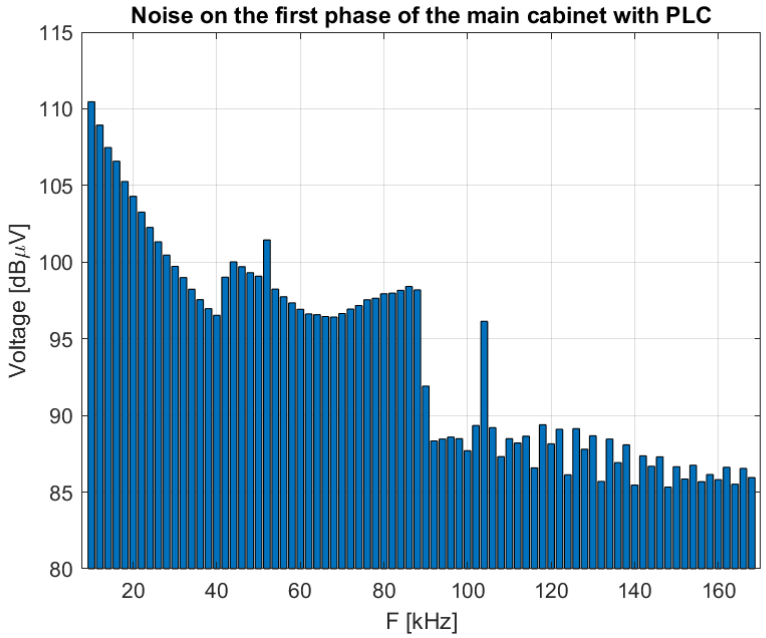
PRIME modems used to inject signals



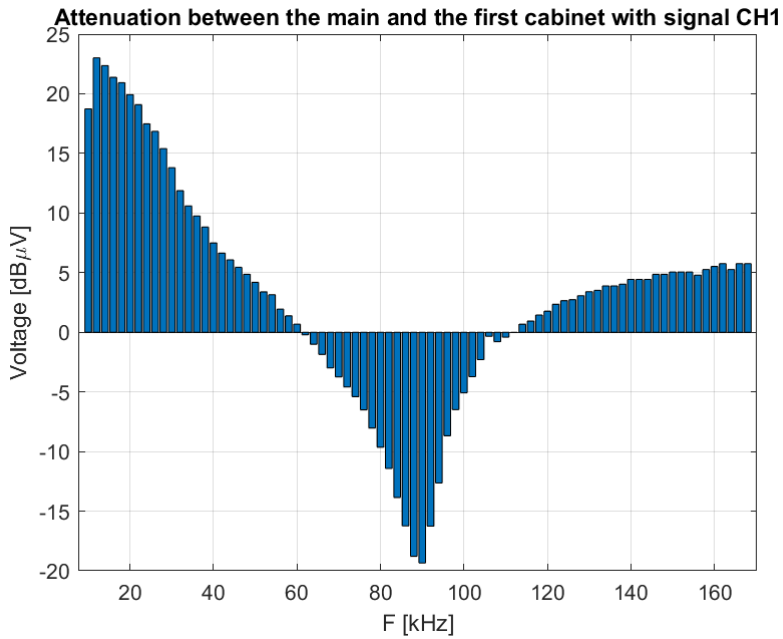
Bloc scheme of the TECNALIA Smart Grid Lab set-up for PLC signals attenuation over lines

Measurements results – Case#1





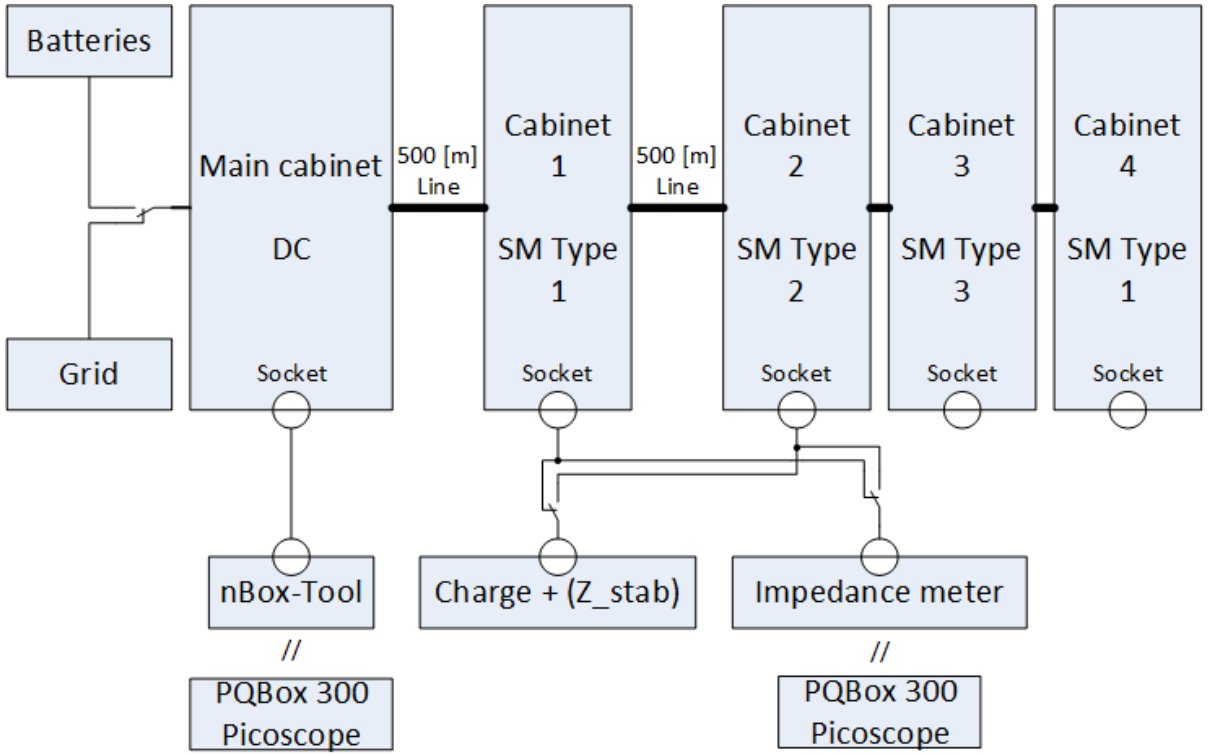
Noise measurement with a PQBox 300 at the main cabinet without & with PLC communication



Attenuation of a signal on CH1 over a 500m line measured with PQBox 300

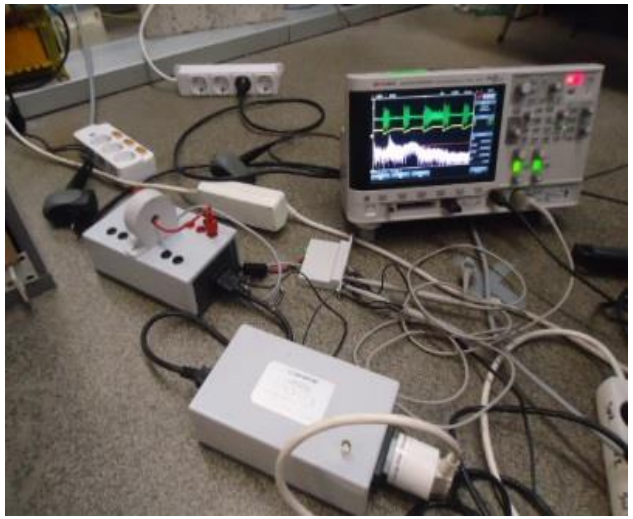
Measurement and trials – Case #2
Line Impedance Stabilizer (Schaffner)

Testing of the Line Impedance Stabilizer (LIS)

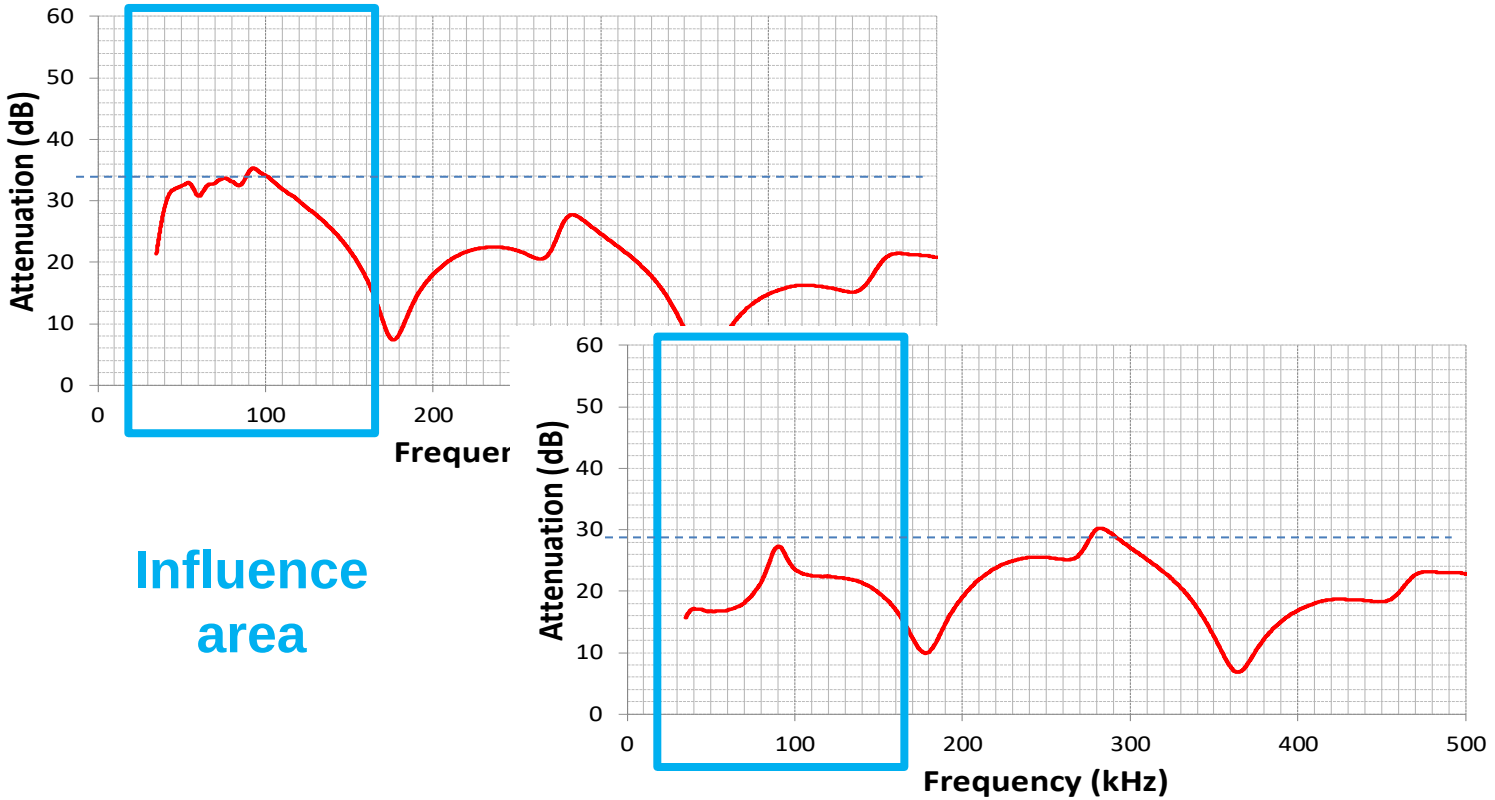


Bloc scheme of the TECNALIA Smart Grid Lab set-up for trials with LIS

Measurements results – Case #2
Line Impedance Stabilizer (Schaffner)

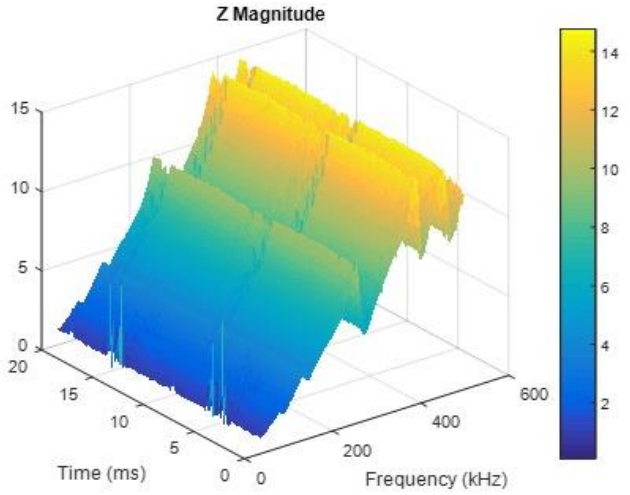


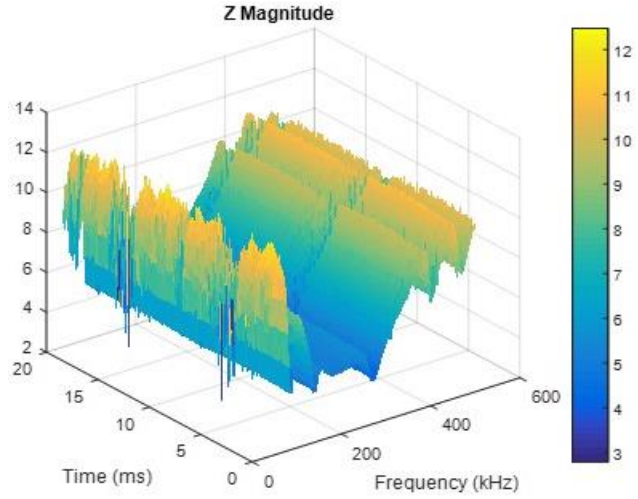
Line Impedance Stabilizer (Schaffner)



Attenuation between the main and the first cabinet with the combined load without and with LIS

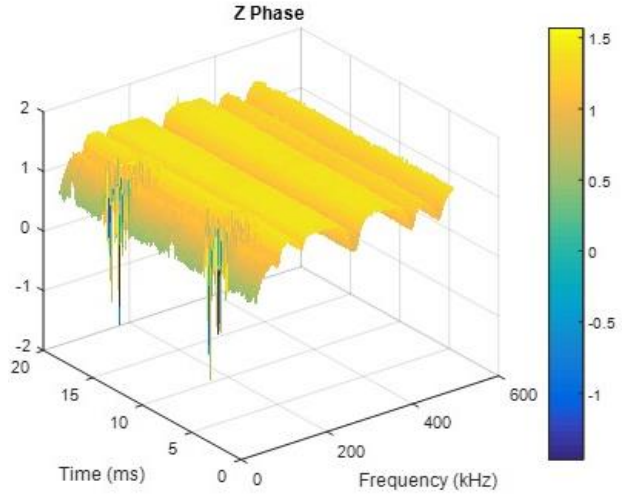
Trials results – Situation #2: Impact of LIS on F&TDFI

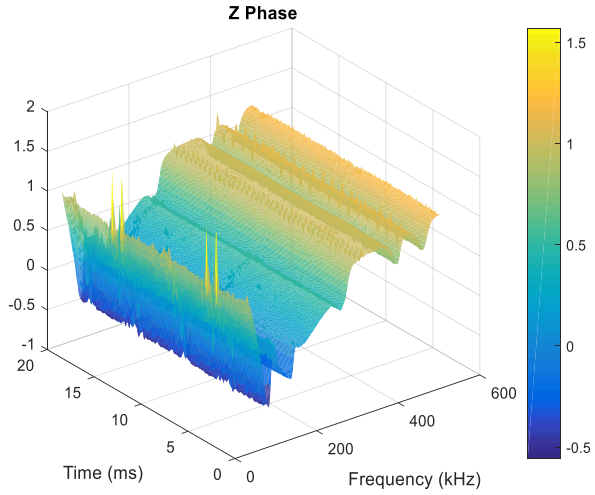




With stabilizer

Without stabilizer

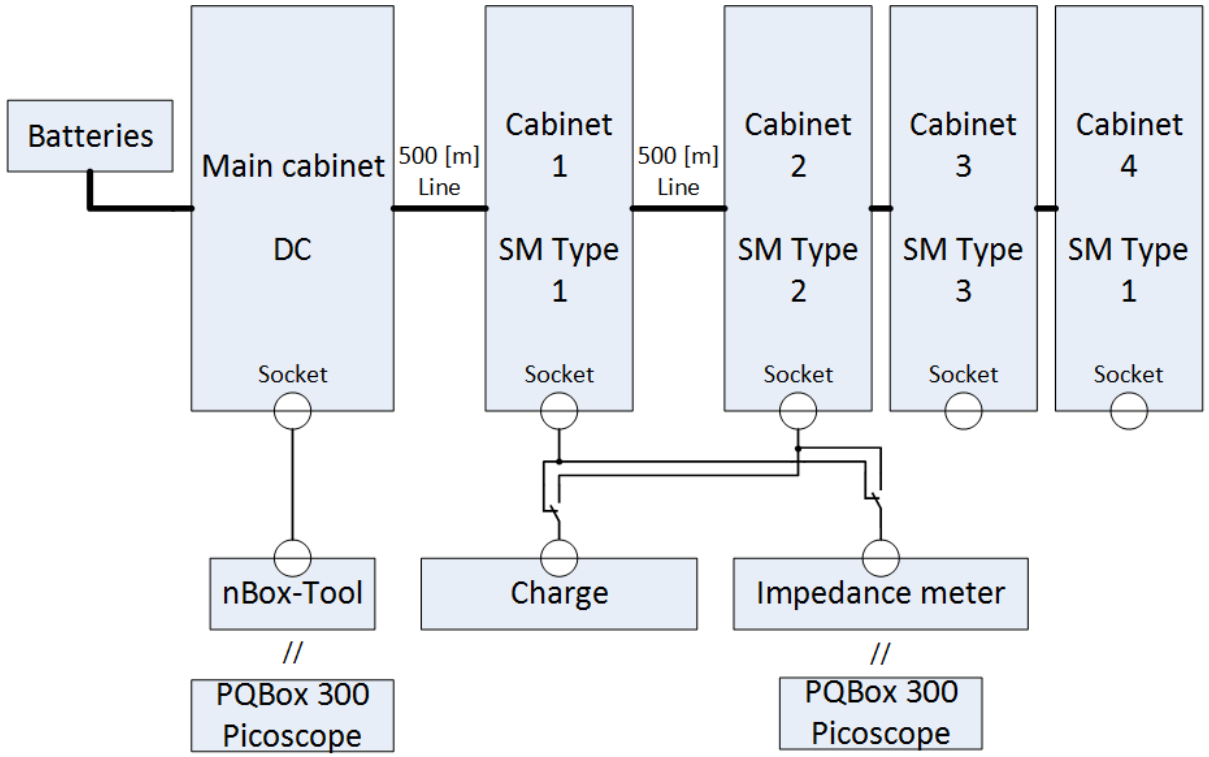




Grid impedance in the cabinet 1, with the combined load connected in the cabinet 1.

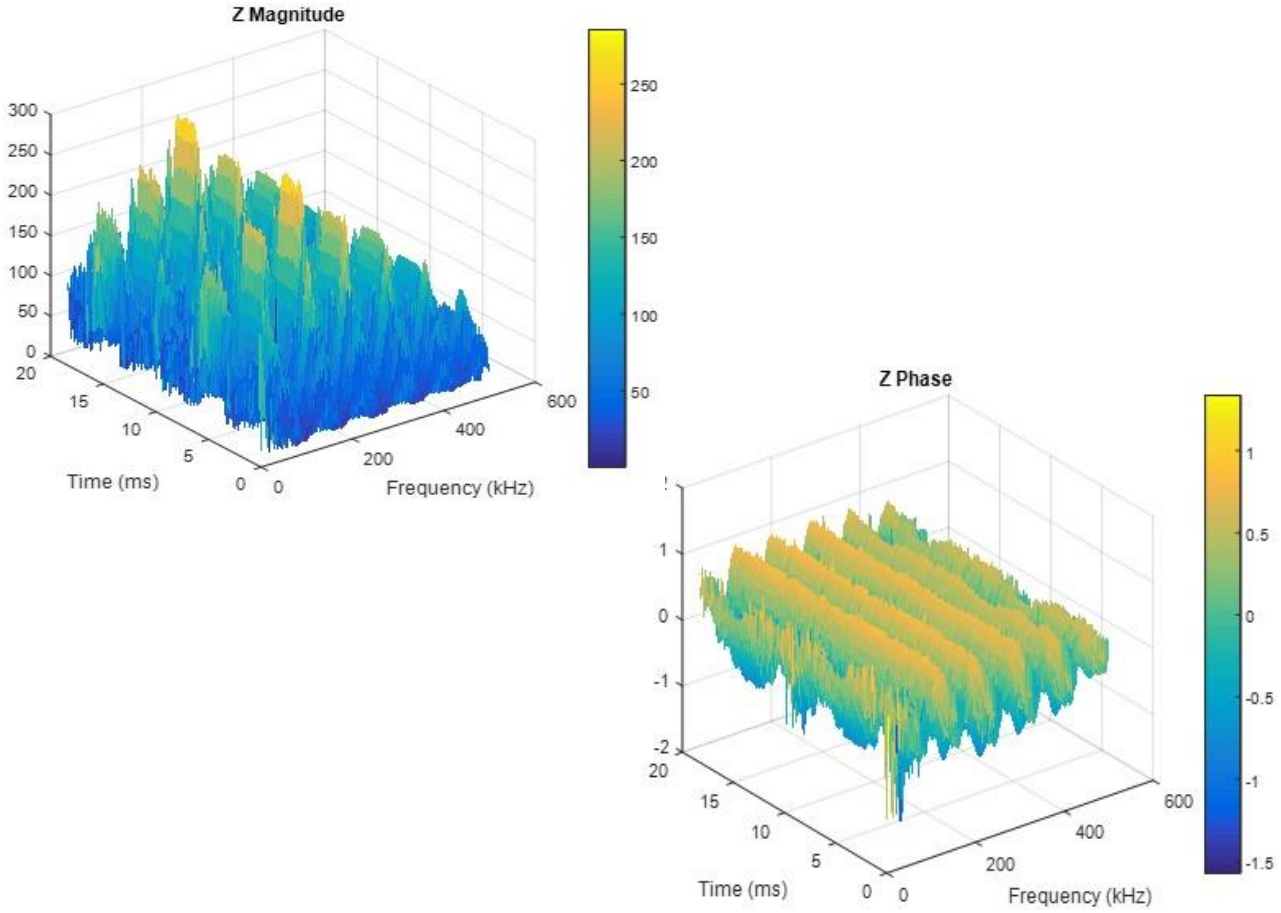
Trials and Measurements – Case #3 Isolated Microgrid

Set of batteries used for the measurements

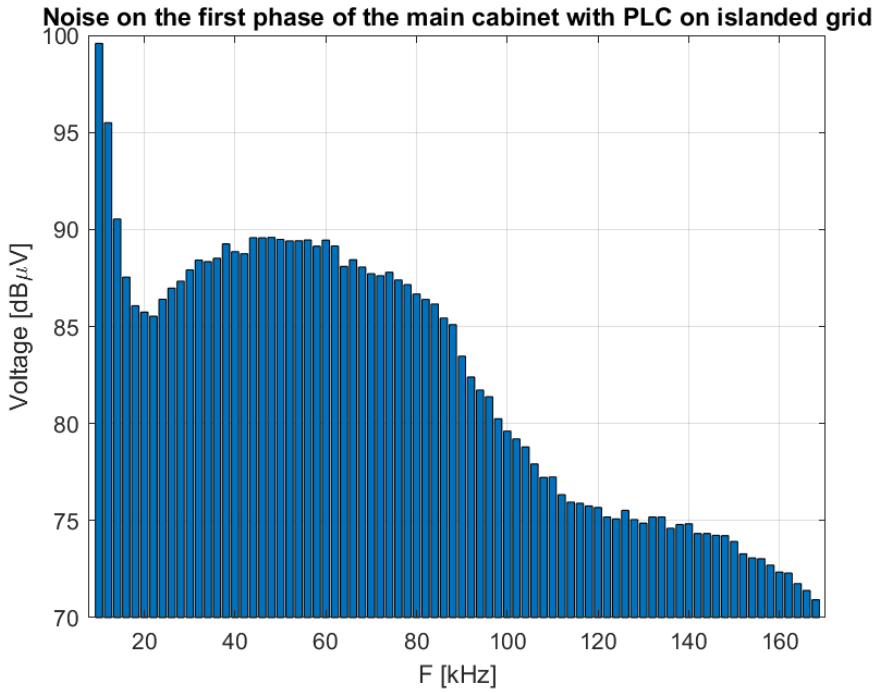


Representation of the TECNALIA laboratory battery setup

Trials results – Case #3 : Isolated Microgrid



Grid impedance in the Cabinet 2, without any load connected in the islanded grid.

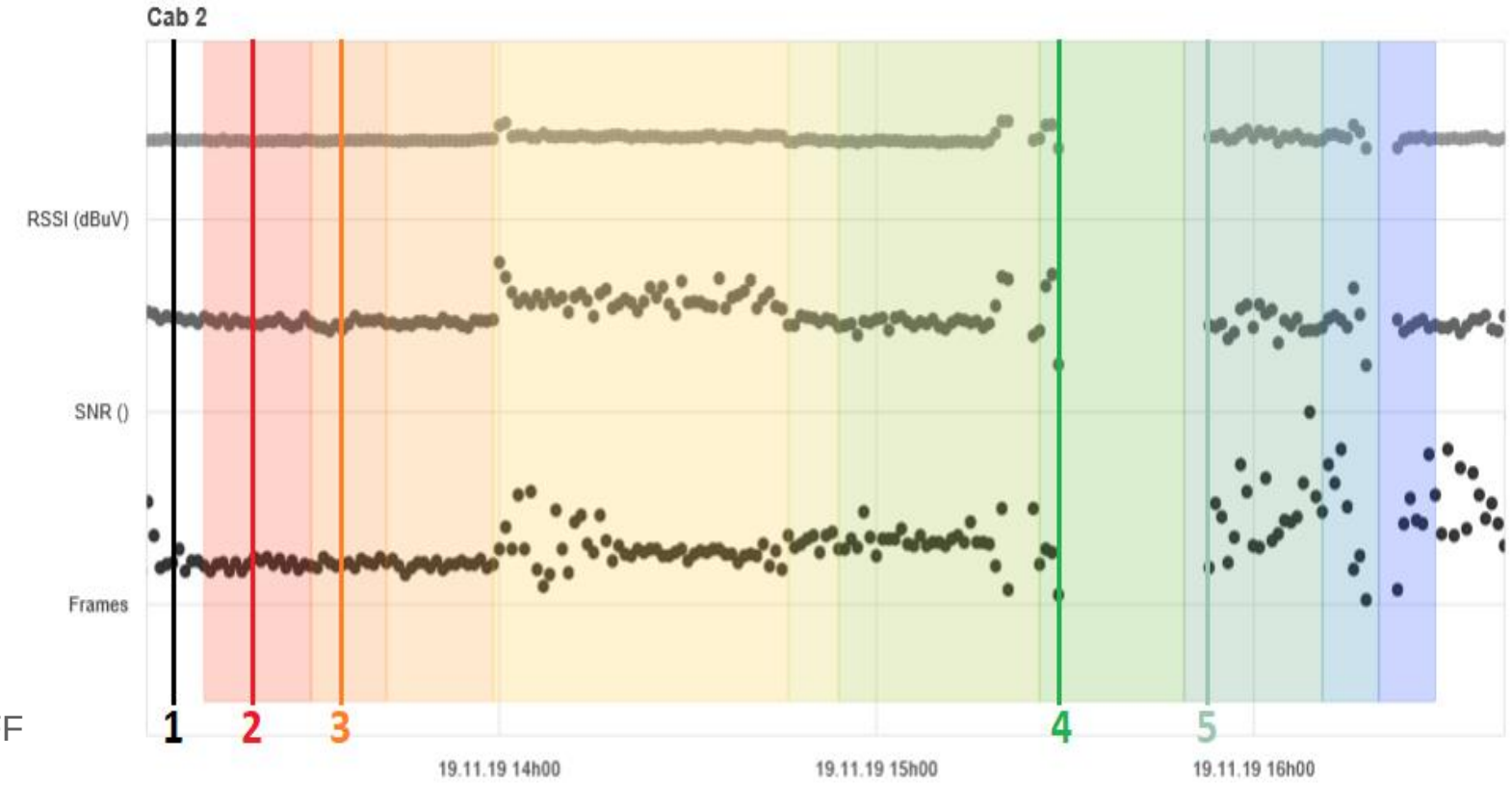


Noise measurement at Main Cabinet with no loads and with PLC on an islanded grid

Trials results – Situation # 2: PLC Communication

Summarize of Communication performance indexes for the SM in the first cabinet

Situation	RSSI [dBµV]	SNR [dB]	Frames [-]
1	104	62.2	24
2	101.1	57.8	24
3	102.6	57.2	25
4	92	30.8	6
5	106.4	56.1	22



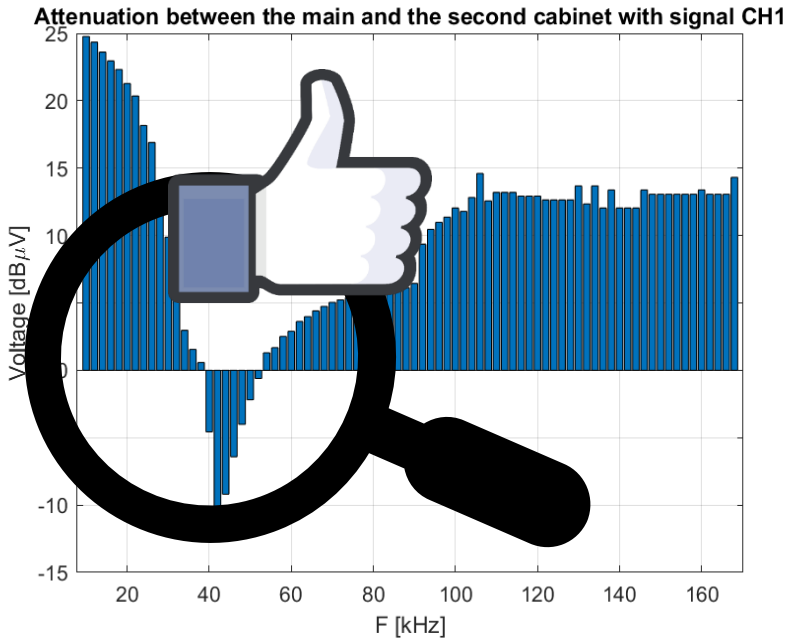
- No loads
- Chargers after SM – Stab ON
- Chargers after SM – Stab OFF
- Leds after SM – Stab OFF
- Chargers on Cab 1, no loads after SM – Stab OFF
- Chargers on Cab 1, Leds after SM – Stab ON
- Chargers on Cab 1, Leds + Noise inject. After SM – Stab ON
- Chargers on Cab 1, Leds + Strong noise inject. After SM – Stab OFF
- Chargers on Cab 1, Leds + Strong noise inject. After SM – Stab ON
- Chargers on Cab 1, Leds + Soft noise inject. After SM – Stab OFF
- Chargers on Cab 1, Leds + soft noise inject. After SM – Stab ON

Outcome

- Impact of a large spectrum of equipment on PLC systems could be tested in an optimal replica of the real application
- Fast Time Varying Frequency Dependent Grid Impedance also have an impact on advanced PLC systems!
- The Grid Impedance meter developed by TSR at UPV/EHU was successfully tested in a Smart Metering environment
- A big step is realized for the Z-NET – SFOE project

- Line Impedance Stabilizer (LIS) from Industrial partner showed very promising results

- Successful collaboration between three research entities, an industrial partner and a Distribution System Operator from different countries



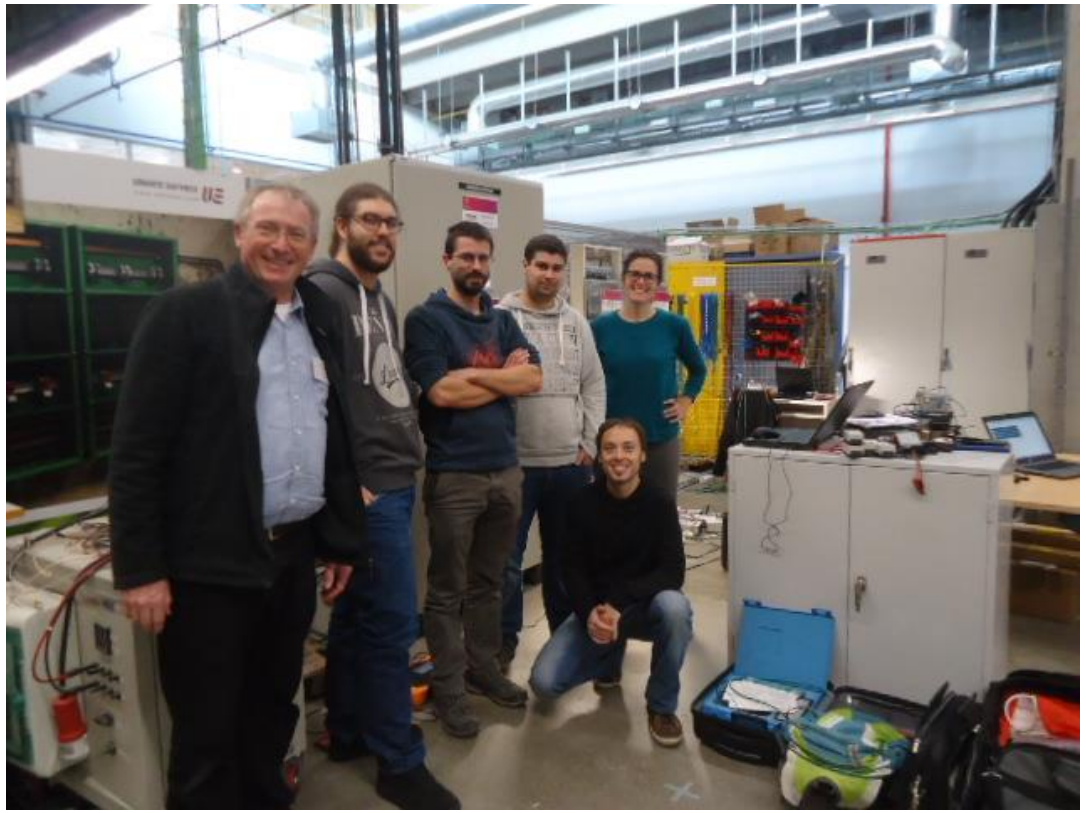
Thanks to the Project Team!

Hes·so VALAIS WALLIS
School of Engineering

tecnalia Inspiring Business

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Office fédéral de l'énergie OFEN



ERIGRID
Connecting European Smart Grid Infrastructures

eman ta zabal zazu

Universidad del País Vasco
Euskal Herriko Unibertsitatea

SIG

SCHAFFNER

Litterature and references

Z-NET – ERIGRID : Pre normalisation of grid impedance measurement in the power line communication frequency band - Grid impedance impact on PLC - Technical Report TA User Project, D. Roggo et Al. February 2020

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https://op.europa.eu/

CENELEC - EN 50065-1

Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 1: General requirements, frequency bands and electromagnetic disturbances

Fernandez, D. de la Vega, D. Roggo, R. Stiegler, L. Capponi, B. Evéquoz, I. Angulo, J. Meyer and A. Arrinda, "Comparison of Measurement Methods of LV Grid Impedance between 9 kHz and 500 kHz," Bilbao, 2019.

Fernández, N. Uribe-Pérez, I. Eizmendi, I. Angulo, D. De la Vega, A. Arrinda and T. Arzuaga, "Characterization of non-intentional emissions from distributed energy resources up to 500 kHz: a case study in Spain," International Journal of Electrical Power & Energy Systems, 2019.

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