TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	Z-NET – ERIGRID
Title	Pre normalisation of grid impedance measurement in the power line communication frequency band - Grid impedance impact on PLC
ERIGrid Reference	**06.011-2019**
TA Call No.	**6**

HOST RESEARCH INFRASTRUCTURE			
Name	**TECNALIA Research & Innovation Foundation - Smart Grid Technologies Lab**		
Country	**Spain**		
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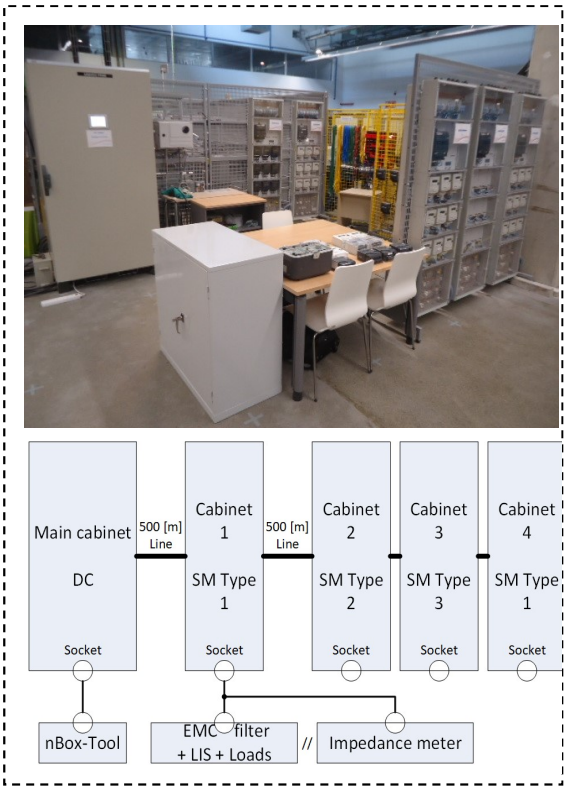
1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

The large-scale deployment of smart meters relies widely on the usage of power line carrier technology for data communication (PLC). On top of various interferences, the Frequency Dependent Grid Impedance (FDGI) measured on the low voltage network greatly influences the propagation of the power line signals and can thus impact the reliability and speed of the communication for smart meters. The precise measure of the frequency dependent line impedance is presently ill defined and only possible with some experimental instruments. This issue motivated the Swiss Federal Office of Energy SFOE to support the Z-NET project: 'Pre normalization of grid impedance measurement in the power line communication frequency band'



The impact of time constant FDGI on PLC has been studied and well documented by the partners of the Z-NET project. But so far, no consensus could be found about the actual influence of Time Variant Grid Impedance on the robustness of advanced PLC systems. How much do strong variations of the grid Impedance due to commutation of semiconductors, occurring repetitively within one fundamental cycle at 50 Hz impact on PLC communication channels?

The objective of the proposed measuring campaign is to gain a better understanding of the communication process and of which parameters or type of electronic loads affect the most the communication channels for advanced PLC systems. This knowledge should help us finalizing the specification of a time variant frequency dependent grid impedance standard to be developed in the frame of the Z-NET project.

The question can only be answered with further tests conducted in laboratory conditions, in the absence of non-controlled perturbation sources.

TECNALIA premises emulate a LVAC distribution grid with two 500m line sections connected in series and several distribution cabinets equipped with 10 Smart Meters each. The main distribution cabinet at the head of the distribution line is equipped with a data concentrator DC while the other cabinets are equipped with 10 Smart Meters (SM) each provided by 3 different suppliers. The Narrowband PLC communication protocol PRIME version 1.3.6 is used between DC and all SM, covering the frequency band between 42 and 89 kHz. Perturbating loads with a specific time variant frequency dependent impedance were connected to the distribution line at the level of the Smart Meter cabinets. The impact of those electronic loads on PLC can be analyzed with the help of a dedicated data network analyzer ('packet sniffer').

Additionally, a Line Impedance Stabilizer device and an EMC filter, both developed by Schaffner, were connected in series between the electronic loads and the Smart Meter. The TSR laboratory at University of the Basque Country (UPV/EHU) recently developed a measurement system to characterize the noise and the impedance variations of electrical grid and isolated loads, even below the mains period, up to 500 kHz.

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

The impact of typical electronic loads on the transmission quality of Wide Band PLC in the CENELEC A frequency range were measured with two different types of Sniffers. Successful measurements of Frequency and Time Dependent Grid Impedance (FTDI) up to 500 kHz, signal attenuation along the line, as well as electric noise at the loads coupling points were realised in complement to transmission quality for each load configuration. One specific tested configuration has been chosen to be presented here. This configuration combines electronic loads connected in parallel to the cabinet #1, in order to disturb the communications between the smart meters hosted in the other cabinets. The combined load was realized with LED bulbs, the laptop power adaptors and a noise generator connected to an amplifier. As expected, the combination of weak Time Dependent Impedances connected in parallel with EMC filters and a high level of non-intentional emissions, degraded significantly the performance of the PRIME PLC system.

The introduction of the Line Impedance Stabilizer (LIS) developed by Schaffner in the circuit clearly improved the PLC transmission performance. In fact, the frequency dependent ‘access impedance’ for the SM located in Cabinet #1 had increased up to a factor 10 in the CENELEC A frequency range. Additionally, the combination of LIS and the EMC filter seems to have as strong impact on Time Variant Impedance during the parts of the 50 Hz cycle when the rectifier bridges diodes are conducting, due to the smoothing of the fast impedance variations. This effect was proven with measurements realized with a simple capacitive load fed through a diode bridge rectifier.

The communication quality was clearly improved under a similar noise level, thanks to a strengthening of the access impedance increase. This is a very strong outcome for the ERIGRID Z-NET trials. These results confirm the outcome of previous research activities on influence of FDGI on PLC at HEVS and SIG-GE in the frame of the REMIGATE project [doi: 10.1049/oap-cired.2017.1285] or those achieved by UPV/EHU [doi: 10.1109/ACCESS.2019.2924253, doi: 10.1016/j.ijepes.2018.08.048]. An industrial partner was able to rebound on those previous research results and to invent a viable technical solution to the PLC issues with parallel connection of ‘noisy’ electronic equipment’s.

Another positive outcome of the ERIGRID Z-NET trials is the fruitful collaboration between 3 research entities and an industrial partner, bringing each expertise in complementary domains. The analysis of the correlations between scenarios, PLC transmission performance and simultaneous measurement of impedance, noise and signal attenuation for each proposed scenario will require some consequent time. A particular attention will be put on the analysis for the impact of the capacitive load fed through a diode rectifier bridge, with strong time dependent impedance variations seen by the load.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

The preliminary results of the work developed in this project are promising and interesting for the scientific community. A dissemination plan has been developed by the working team, in order to organize the dissemination of the main outcomes of the project in relevant peer-reviewed scientific journals and international conferences.

The topics that have been identified for the development of future publications are the following:

- New measurement methodology for the characterization of the access impedance sub-cycle variations in the LV grid for frequencies up to 500 kHz
- Impact of the fast variations of the access impedance of the LV grid on the performance of NB-PLC
- New technique for the impedance stabilization against fast variations of the access impedance of the LV grid up to 150 kHz
- Effects of the impedance stabilization on the performance of NB-PLC

The scientific journals selected for the dissemination of the results are:

- IEEE Transactions on Smart Grid
- IEEE Access
- IET Smart Grid
- Elsevier – Measurement
- Elsevier – International Journal of Electrical Power and Energy Systems
- MDPI – Energies
- MDPI – Applied Sciences

All the publications in scientific journals will be under Open Access conditions.

The international conferences selected for the dissemination of the results are:

- Preliminary results of the characterization of the fast variations of the access impedance of the LV grid
- Characterization of the impedance variation of representative devices connected to LV grid for frequencies up to 500 kHz

The international conferences selected for the dissemination of the results are:

- IEEE SmartGridComm (International Conference on Communications, Control, and Computing Technologies for Smart Grids
- IEEE ISPLC (IEEE International Symposium on Power Line Communications and its Applications)
- EMC Europe
- IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe)
- International Workshop on Applied Measurements for Power Systems (AMPS)

4. PLANNED DISSEMINATION OF RESULTS THROUGH ERIGRID CHANNELS

Contact erigrid-ta@list.ait.ac.at to organise promotion of your results

The working team of this project is open to collaborate in the development of contents for ERIGRID Newsletters, web pages or similar communication ways, with descriptions about our work within ERIGRID network.