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Projet SInERT

SOLUTIONS INNOVANTES POUR L'INTÉGRATION DES ÉNERGIES RENOUVELABLES DISTRIBUÉES SUR LE RÉSEAU ÉLECTRIQUE TUNISIEN

DEVELOPMENT OF A PLC CHANNEL CHARACTERIZATION TOOL IN AN EMBEDDED MEASUREMENT PLATFORM

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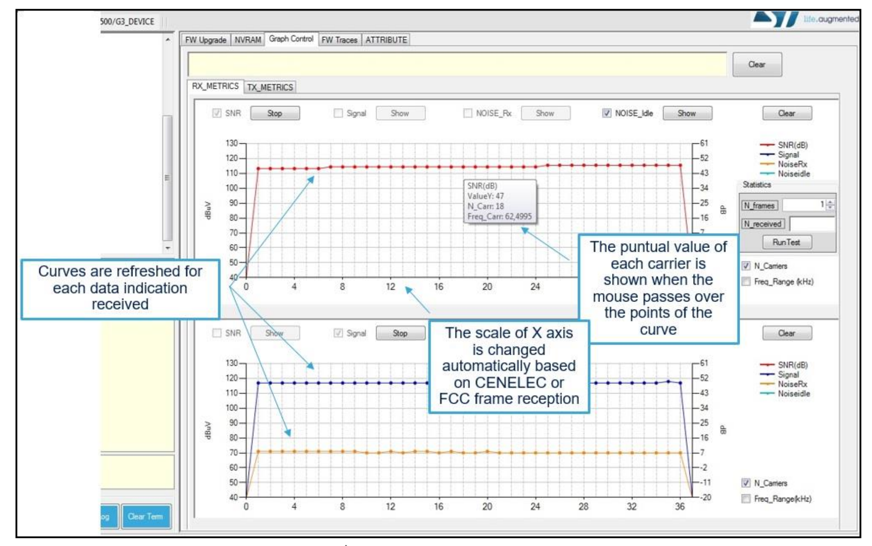
One fundamental aspect for the evolution of Smart Grid framework is the implementation of an always-on communication infrastructure also at distribution network level. In this perspective, the use of power line communication (PLC) technology can be a viable solution, because of its capillarity, simplicity of installation and reduced costs, thanks to the use of existing distribution network as a communication infrastructure. PLC technology is already widely used for automatic meter reading but in recent years it has been also proposed for further applications, such as secondary substation automation, remote control of distributed generators and other smart grid solutions. However, the electrical network topology and the loads connected thereto generate disturbances that can affect significantly the PLC's performance in terms of capacity, coverage, robustness and data transmission rate [1]. For this reason, there is an increasing interest in electrical network characterization. Signal to noise ratio (SNR) or Link Quality Index (LQI) are parameters frequently used for PLC channel characterization. Another important method used for PLC channel characterization is the impedance measurement in the PLC frequency range. Electrical network impedance depends on network topology, cable type and type of connected loads. Several experiments are presented in literature, which report the impedance measurement vs. frequency in different cases of electrical network.
In this framework, the authors propose a different approach for evaluating the PLC channel performances, suggesting the use of already installed devices, i.e. the PLC modem of smart meters, to measure PLC signal and noise levels. To this aim, a new software tool was developed. As case study, it is implemented on a G3 PLC transceiver, the EVALKITST8500-1, widely used for smart metering purposes. Finally, by simply updating the firmware of already installed smart meter, it is possible to perform a PLC channel characterization without connecting external instruments. The software tool allows having a better understanding of signal attenuation influence on communication channel performances. Moreover, it can allow finding possible solutions to avoid disturbed frequency bands or regulating some transmission/reception parameters in order to improve the communication.

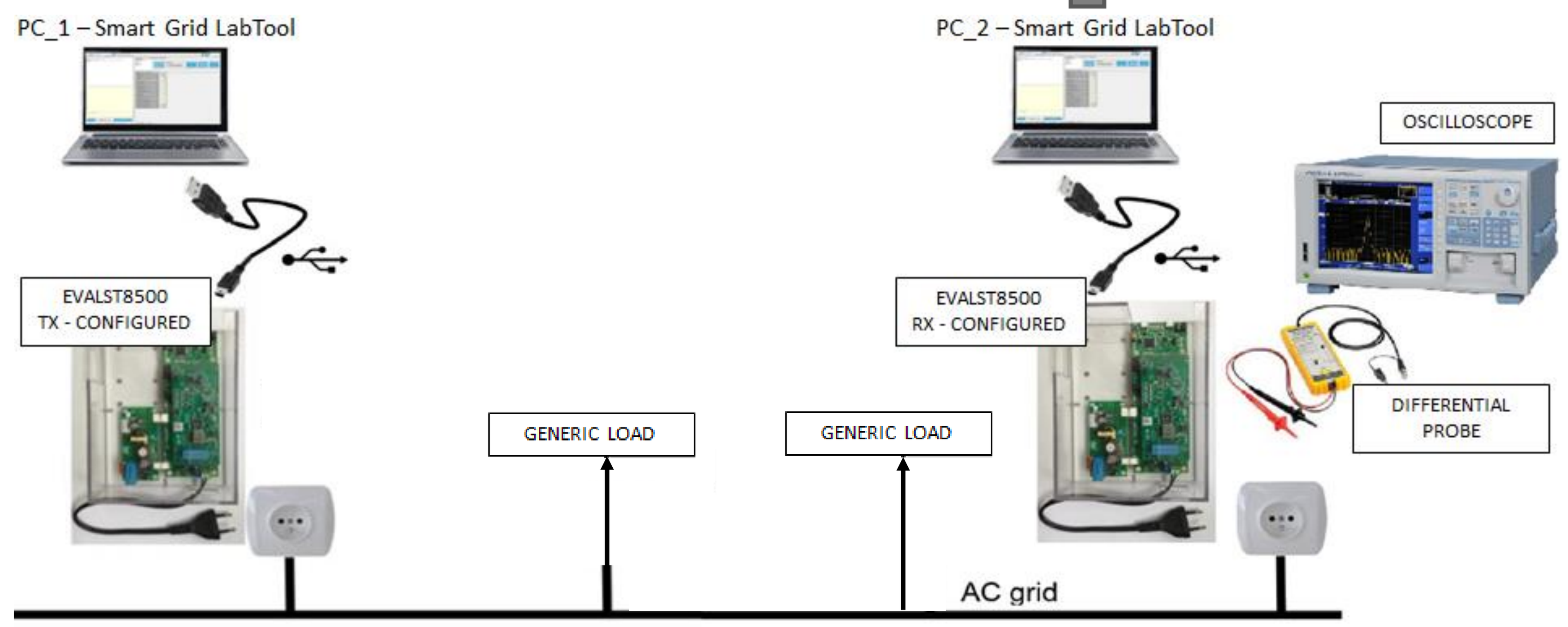
The developed software tool is called PLC Field Analyzer (PLC-FA). It performs an analysis of the PLC channel on LV network for different frequency ranges. The software tool provides a series of parameters useful for estimating the quality of the communication channel (i.e. measuring the received signal and noise levels and calculating the SNR). Moreover, by selecting one of the CENELEC A, B or FCC bands, the software tool can identify and measure the parameters for each carrier of the Orthogonal Frequency Division Multiplexing (OFDM) modulated signal. In this way, the tool allows identifying if some portion of the PLC channel is highly attenuated or it has a higher noise levels. For the acquisition of received signal and noise levels, a new firmware was implemented in the STM32F413 microcontroller of the hardware platform EVALKITST8500-1. A Graphical User Interface (GUI), named Smart Grid LabTool, allows to manage the PLC-FA. The experimental setup is schematized in Fig. 1, where also the PLC-FA front panel is shown for a single signal reception. Different tests were performed to verify the electrical network impedance effect on the signal transmission. In 0 a comparison is shown between two experimental tests performed varying the impedance connected between transmitter and receiver: the first test was performed with a direct connection; the second one was performed by interposing a LC impedance. Moreover, a comparison was performed between the PLC-FA measurements and those obtained with an oscilloscope. The developed measurement system correctly measures the signal spectrum with a maximum deviation of 2.77 dBμV in the case of a direct connection and of 2.45 dBμV in the case of the LC impedance. The results show how the PLC-FA is able to perform a frequency analysis of the communication channel; thus it can be usefully deployed as design and/or diagnostic tool, thus giving suggestions on the band or the carriers to be used to obtain the best transmission performances or locate possible frequency band with a higher level of attenuation or disturbances.

[1] Study report on electromagnetic interference between electrical equipment/systems in the frequency range below 150 kHz, CEI CLC/TR 50627, Ott. 2020

Fig. 1 Measurement setup and detail of curves displayed for a single reception.

In blue the received signal level in dBμV rms (y-axis on the left), in yellow the received noise level in dBμV rms (y-axis on the left), in red the signal to noise ratio in dB (y-axis on the right). In the x-axis, the carrier number is reported.





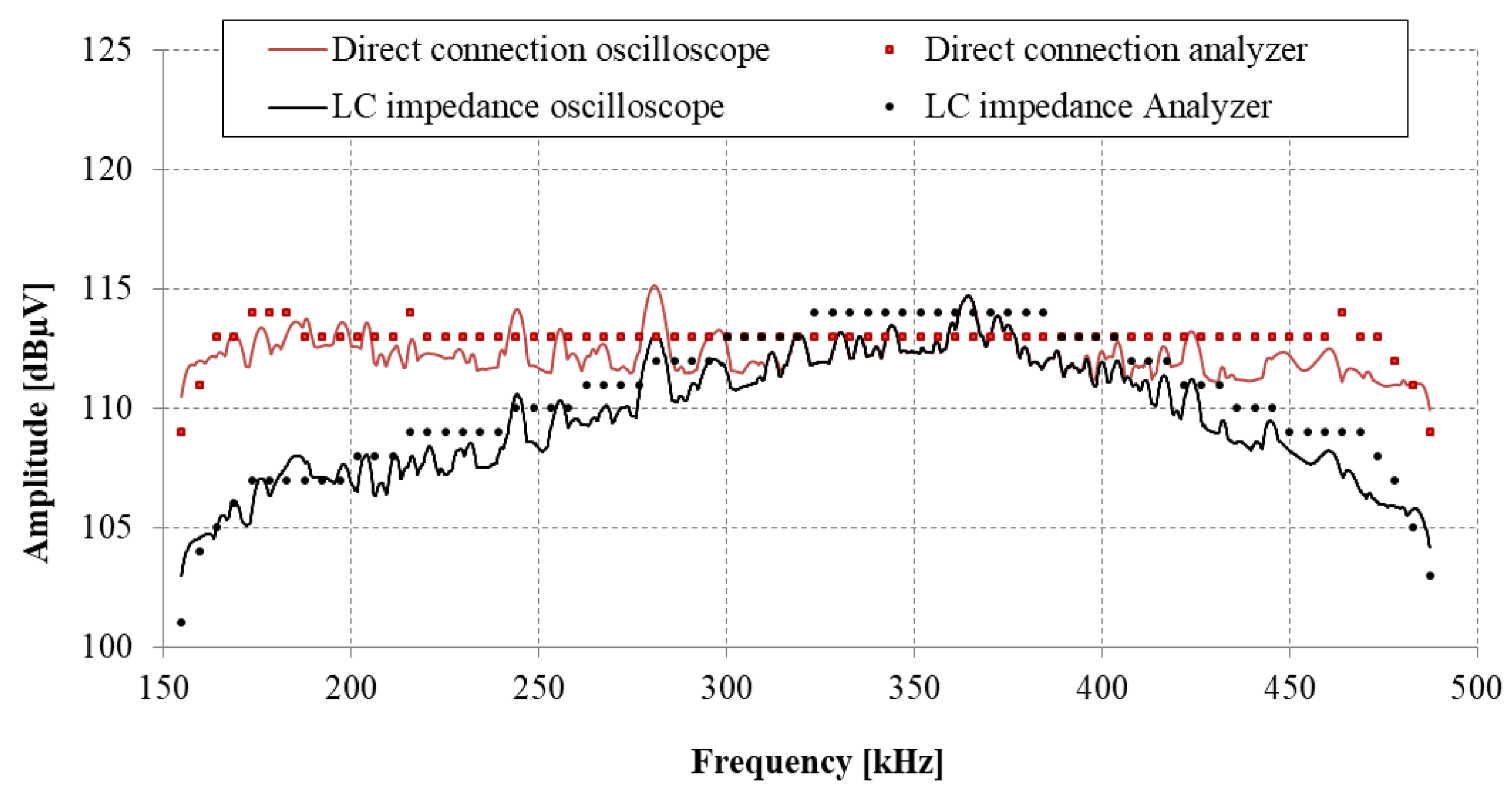


Fig. 2 Comparison between measurement performed with oscilloscope and PLC Field Analyzer in the case of a direct connection or a LC filter impendence connected between receiver and transmitter.

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