Impedance Measurement of Electrical Equipment on the Power Network

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Abstract

The access impedance value depends mainly on the connected load equipment on the power line. Measurements of the access impedance at the power plug are presented in [1]. This paper presents a method to measure the individual impedance of electrical equipment on the power network.

I. Introduction

THE precise knowledge of the access impedance of the power line and its connected loads is an important factor to design efficient PLC communication systems. The optimal signal transmission circumstances over the power line are rarely to be implemented because of the time and frequency variant impedance of power line. In [1], an accurate access impedance measurements in the frequency range 30-500 kHz on the power plug using current-voltage (I-V) measurements principle are presented. The system calibration procedures and measurements processes are well investigated. The influence of the connected loads on the access impedance is showed in [1]. However, the actual impedance of the connected device at the power plug is not considered and measured. In this paper, we present a method to measure the individual impedance of the connected equipment and devices to the power grid.

II. Measurement Method Description

Fig. 1 describes the PLC Access Impedance Measurement System (AIMS) [1]. The PLC AIMS injects a signal in defined frequency steps into the power line and measures the resulting voltage u_m and the current u_{sh} as the voltage drop over 2 Ω resistor shunt. These two delivered voltages from the oscilloscope are corrected and the Fourier series for each frequency step is then calculated to describe the measurement system by the transfer function $H = U_{sh}(f)/U_m(f)$. The Device Under Test (DUT) represents the connected load equipment to the power line.

A simplified schematic of AIMS with the equipment impedance measurement setup is shown in Fig. 2. We replace the microcontroller, the DDS, the amplifier and the coupling transformer equivalently by a voltage source with an internal impedance Z_i. The coupling circuit model with the measurement cables are simplified by the serial parasitic impedance $Z_{ps}(f)$. The effects between the measurement cables are represented by the parallel parasitic impedance $Z_{pp}(f)$. The influence of the two frequency dependent impedances Z_{ps} and Z_{pp} is extracted and measured by the calibration measurements.

The measurement method of equipment impedance on the power network is described as follow: We connect an isolation transformer (IT) to the output of the AIMS as an DUT and measure its access impedance $Z_{IT}(t, f)$ on the network. The purpose of connecting the isolation transformer to the AIMS is the high impedance representation of the transformer on

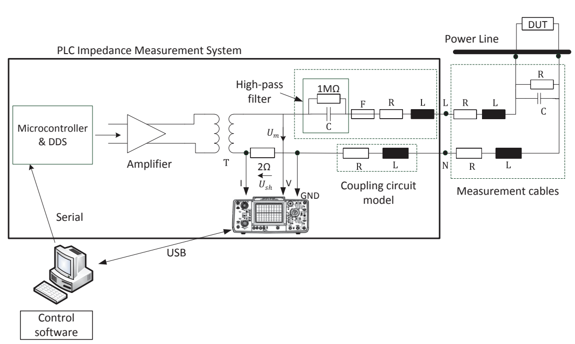

Fig. 1: Access Impedance Measurement System (AIMS)

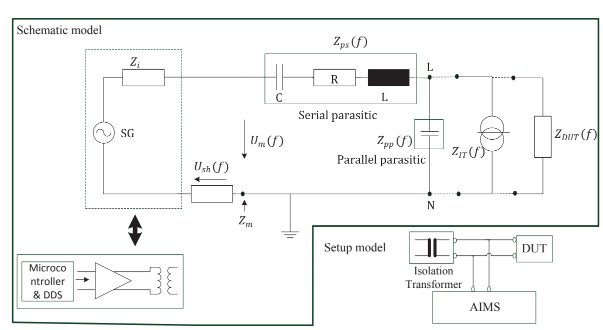

Fig. 2: AIMS schematic & setup model for equipment impedance measurement method

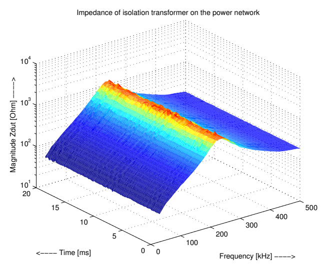

Fig. 3: Impedance of isolation transformer on the power network

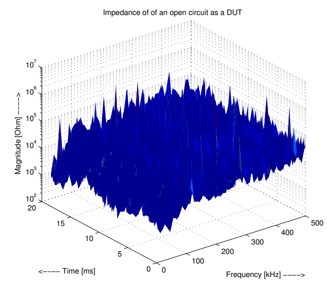

Fig. 4: Impedance of an open circuit as a DUT

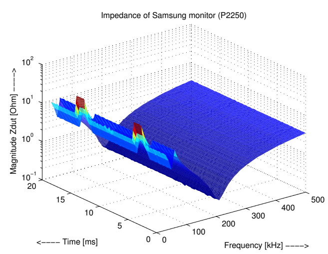

Fig. 5: Impedance of Samsung monitor P2250 on the power network

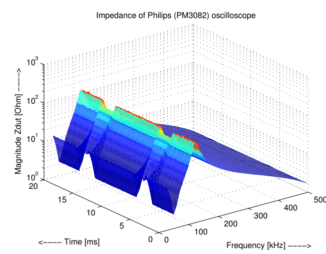

Fig. 6: Impedance of Philips PM3082 oscilloscope on the power network

the power network as shown in Fig. 3. It has been also showed that the impedance of the IT is time invariant and can be considered as only frequency dependent $Z_{IT}(f)$.

The impedance of the load equipment has to be low, especially in frequencies up to 500 kHz, in respect to the impedance of the IT. Therefore, we connect the load equipment as DUT in parallel to the isolation transformer to find the impedance of the connected equipment from the already measured IT impedance. The measured access impedance $Z_m(t, f)$ bei the AIMS and the impedance of the connected load equipment $Z_{DUT}(t, f)$ on the power line is given as:

$$Z_m(f,t) = \frac{1}{\frac{1}{Z_{IT}(f)} + \frac{1}{Z_{DUT}(t,f)}} \quad \text{and} \quad Z_{DUT}(f,t) = \frac{-Z_m(f,t) \cdot Z_{IT}(f)}{Z_m(f,t) - Z_{IT}(f)}. \tag{1}$$

III. Measurement Results

To verify our measurement method, we measure the impedance of an open circuit as a DUT in parallel to the IT as in (1). The measurement results are shown in Fig. 4 and confirm the measurement method. The measured impedance is very high as expected, between 4kΩ and 200kΩ. Fig. 5 and Fig. 6 present measurements of the magnitude of the impedance of Samsung monitor P2250 and Philips oscilloscope PM3082 on the power network. The measurement results show that the impedance of the Samsung monitor is time variant in CENELEC band and below 0.3Ω in the frequency of 210kHz, but the impedance of the Philips oscilloscope is time invariant and has the lowest value, below 4Ω in the frequency of 50kHz.

IV. Conclusion

This paper presents a method to measure the impedance of equipment on the power network using access impedance measurement system. The measurement results showed that the impedance behavior of equipment are different for each device on the power network. Some devices have time variant impedance and others have time invariant impedance. This measurement will be later used to identify the connected load from the measured access impedance on the power network.

References

[1] G. Hallak and G. Bumiller, *Time Variant PLC Access Impedance Measurements and Optimization of Calibration Methods*, SmartGridComm2016 (In Process), Sydney, 2016.