The EMC Impact due Household Appliances in Smart Grid Networks

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Abstract— The Smart Grid technology has become a reality day by day due its clean proposal which can provide, for example, the link between wind and solar power with electric cars. However, the "smart" factor of the technology is obtained through electronic components, which are in general, the major responsible of unintentional emissions and coupling. Therefore, in this work, the EMC — Electromagnetic Compatibility of household appliances is deal with the use of a conducted emission technique. The obtained results are compared to the existing standards.

1. INTRODUCTION

Having as main goal improve the grid reliability, power quality and energy efficiency, the Smart Grid technology has become a subject of study nowadays [1]. However, the smartness of the grids is provided by electronics, which are in general the major responsible of unintentional emissions.

Due to the increase of the microelectronic and embedded electronic systems, every electronic device must be submitted to stricter EMC measurement, and their entries in the market are directly related to it responses on these test. However, only in the late 70s that the problems related to EMC — Electromagnetic Compatibility became of public knowledge, in general, due to the problems presented by TVs, communication devices, audio and video displays, among many other applications [2].

Basically, as far as the smart grid control is developed with microelectronic components, the conducted emission levels from the household appliance should be carefully observed, in order to guarantee the correct operation of the network. Moreover, the grid behavior must also be certified in order to ensure the correct operation of the devices connected to it in terms of electromagnetic compatibility. In this work, only the household devices will be investigated. This is extremely important because with no disturbances the voltage quality is perfect, otherwise not.

In order to analyze the conduct emission phenomena in some household appliance that are normally connected to the residential grid, the EMC Pre-Compliance Board — EPCB built in [3], and a LISN — Line Impedance Stabilization Network were employed.

The test setup, was performed in accordance to CISPR and FCC — Federal Communications Commission, agency in charge of standardization of radio communications and cable in the U.S. The preliminary results were compared to CISPR 14-1 [4] and CISPR 22 [5], depending on the class of the household appliance DUT.

In this work, the conducted emission levels from the household appliance are observed in order to ensure the correct operation of the devices connected to grid in terms of EMC. The obtained results were compared to the regulatory standard and it can be observed that most of the devices are out of it, thus compromising the performance of the grid as a whole.

2. SMART GRIDS NETWORK

The electrical power grids were developed using relatively few AC plants (50 or 60 Hz with very high-power), AC or DC interconnected, with many substations to attend residential or low-power industrial demands, as can be seen in Fig. 1. The Smart Grids (SG) are an evolution of the electrical power grids and are based on a more efficient employment of the generation, transmission, and distribution infrastructure. Its use is mandatory in order to manage the relationship between demand and power supply to avoid contingencies in the electrical system [6]. In this way, it is necessary to develop a whole telecommunications framework for a successful smart grid implementation. Inherently, its characteristic needs a strong interaction, composed by communication networks, real-time monitoring, and data management [7]. So, nowadays its integration is transforming the whole electrical energy scenario.

Therefore, the conducted emission levels from the household appliance are observed in order to ensure the correct operation of the devices connected to grid in terms of EMC.

Figure 1: The smart grid network.

3. ELECTROMAGNETIC COMPATIBILITY

With the increase of the microelectronic and embedded electronic systems, every electronic device must be submitted to stricter EMC measurement, and their entries in the market are directly related to it responses on these test. Although the challenges related to interference during the Second War, only in the late 70s that the problems related to EMC — Electromagnetic Compatibility became of public knowledge, in general, due to the problems presented by TVs, communication devices, audio and video displays, among many other applications [4].

The Electromagnetic Interference — EMI is the process in which electromagnetic energy is transmitted from one electronic device to another via radiated or conducted emission, or both. On the other hand, the electromagnetic susceptibility — EMS deals with devices that are sensitive to interference from other devices. Thus, the EMC tests usually comprise both EMI and EMS measurement of the same electronic device.

The EMC setup tests, at the level of electronic systems are defined by the standards CISPR 25 /2002 for spurious emissions, and ISO-11452 for interference and susceptibility measurements. Thus, two major standards have been defined, with a first one for radiated and conducted emission and the second one for immunity RF test.

In general terms, the conducted interference is that in which occurs undesirable transfer of electromagnetic energy along a conductor through disturbances between the phase line and the ground power supply, and is governed by the standard IEC 61967-4. There are several tools and methodologies to perform conducted tests, and the frequency range normally used is 150 kHz–30 MHz, except in military applications that eventually require the extension band.

The most common method used for this type of analysis is the LISN, also known by AMN — Artificial Mains Network, which works through the AC power supply of the device to be analyzed. Another method widely used in performing conducted interferences measurements is the $1/150\,\Omega$, where is possible to measure the noise current in each driven pin of the DUT — device under test.

4. MEASUREMENTS

In order to analyze the conduct emission phenomena in some household appliance that are normally connected to the residential grid, the EMC Pre-Compliance Board — EPCB built in [3], and a LISN — Line Impedance Stabilization Network were employed.

The test setup, as shown in Fig. 2, was performed in accordance to CISPR and FCC — Federal Communications Commission, agency in charge of standardization of radio communications and cable in the US. The preliminary results were compared to CISPR 14-1 [4] and CISPR 22 [5], depending on the class of the household appliance DUT.

The obtained results for the electric heater, vacuum cleaner, blu-ray, sattelite TV decoder, blender and hairdryer were compared to the CISPR 14-1 standard, Figs. 3 and 4(a), which refers

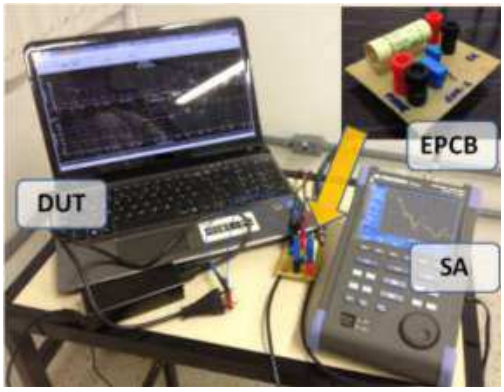

Figure 2: Conducted emission test setup using an EPCB.

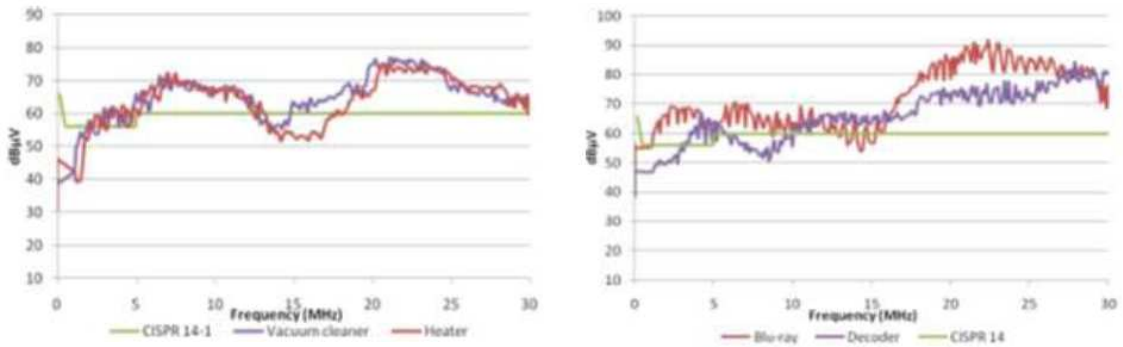

Figure 3: Measurement results of some household appliance. (a) Vacuum cleaner, heater. (b) Blu-ray and satellite TV decoder.

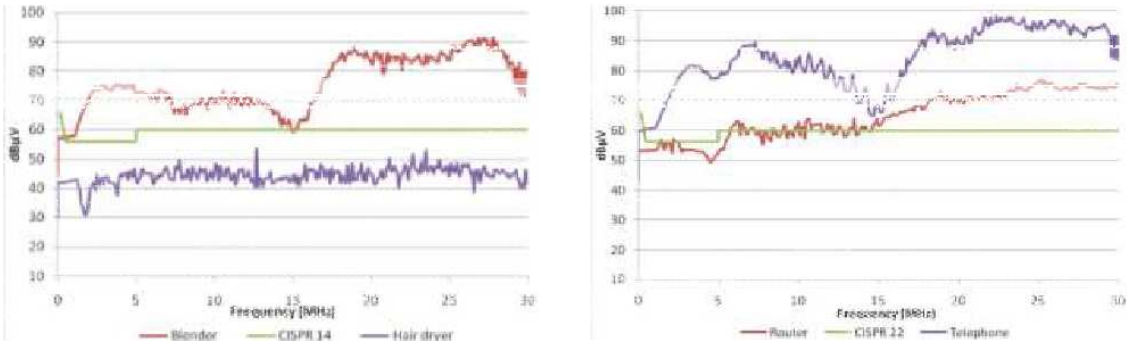

Figure 4: Measurement results of some household appliance. (a) Blender and hair dryer. (b) Router and wireless telephone.

to the conducted emissions allowed level, for household appliance devices. In the other hand, the router, wireless telephone, LED and tube TV, personal laptop and the printer were compared to the CISPR 22 standard, Figs. 4(b) and 5.

Basically, as far as the smart grid control is developed with microelectronic components, the conducted emission levels from the household appliance should be carefully observed, in order to guarantee the correct operation of the network.

It can be easily observed from the obtained results, most of the analyzed appliances are out of the standards. Therefore, without any solution to prevent the undesirable emissions, the grid performance will certainly be compromised.

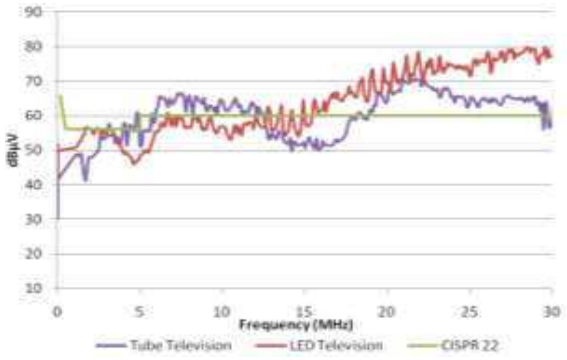

Figure 5: Measurement results of some household appliance: tube TV and LED TV.

5. CONCLUSIONS

In this work, the conducted emission levels from the household appliance are observed in order to ensure the correct operation of the devices connected to grid in terms of electromagnetic compatibility. In general terms, the conducted interference is that in which occurs undesirable transfer of electromagnetic energy along a conductor through disturbances between the phase line and the ground power supply. The obtained results were compared to the regulatory standard and it can be observed that most of the devices are out of it, thus compromising the performance of the grid as a whole.

ACKNOWLEDGMENT

The authors would like to thank CAPES for the partial financial support.

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