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A PARALLEL STUDY BETWEEN TODAY AND YESTERDAY ABOUT ELECTROMAGNETIC CONDUCTED DISTURBANCES

BY

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Abstract. This article analyses the disturbances produced by various appliances frequently used in every household through conduction within the supply network. The importance of EMI filters which reduce emissions in the supply network and the necessity to conform to electromagnetic compatibility standards imposed by the legislation in force are also illustrated.

Key words: conducted disturbances; EMI filter; electromagnetic compatibility standards; appliances; LISN.

1. Introduction

EMC compliance is now a fundamental element of the electrical/electronics equipment design process, with legislation in Europe to make compliance obligatory (Ciupa, 2010).

Considering the technical progress in most activity fields and the appearance of new and diverse electronic equipment and appliances, the old but still actual issue of electromagnetic compatibility (EMC) must be posed. Therefore according to the German VDE 0875 Standard, electromagnetic compatibility is defined as the capability of an electric device to function correctly in its own electromagnetic medium without disturbing other equipment

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or electric devices present in the same environment as it through its own functioning. In other words, EMC represents equipments', devices' and/or electric and electronic systems' ability to coexist "on good terms" meaning to function correctly without disturbing one another while in close proximity.

To be able to discuss an electric compatibility issue we must take in to consideration the elements presented in Fig. 1, and to talk about an electromagnetic compatible system then it must meet these requirements: to not produce any interference with other systems, to not be susceptible to other systems' emissions and to not produce any disturbance with itself.

Fig. 1 – Electromagnetic disturbance phenomenon.

Paying attention to the simplified scheme of the electromagnetic interference phenomenon these emissions may be avoided using three methods: suppressing the source (broadcaster) emission, most agreed choice, if technically possible, taking the economics into account Fig. 2 (Schwab & Wolfgang, 2011); making a coupling as ineffective as possible (acting upon the coupling mechanism) and designing and constructing a receiver as least susceptible as possible to the sources' emissions.

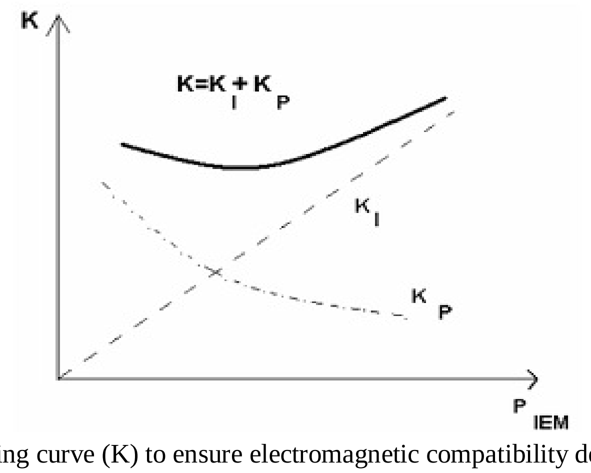

Fig. 2 – Spending curve (K) to ensure electromagnetic compatibility depending on the probability electromagnetic disturbance (P_{IEM}) appearance.

In the specialty literature it is a well-known fact that achieving EMC in the design phase implies 5% larger costs, and if EMC is not achieved, doing so after the prototype is finished raises costs by 50%. Having this in mind, EMC must be considered in all phases of making the product (Kumar *et al.*, 2006; Cakir *et al.*, 2014). In Romania, the legislation on which electromagnetic compatibility is based is H.G. nr. 57/2015 concerning electromagnetic compatibility. 30 days after being published in the official gazette, this Government decision repeals H.G. nr. 982/2007. Through this, European Union Directive no. 2004/108/CE is transposed into Romanian law. This directive appoints minimum requirements which devices and electric and electromagnetic equipment must meet before being put on the market (EMC Directive 2004/108/EC).

2. Arranging the Testing Stand and Performing Tests

Within this study the authors aim to create a parallel between the old and the new electrical devices, to highlight the technical progress or the need to continually adjust to the market needs, to the everyday dynamics of the 21st century. Thus, tests have been made to appliances from different generations used in any home. Some are older than 20 years, others are from newer generations designed according to different norms and current standards. The testing aims to measure electromagnetic disturbances produced through conduction in the supply network, whether if during their use their emissions fit within the limits the current standards impose and while using EMI filters to reduce these disturbances. The frequency range in which the measures are made is the typical range for conducted electromagnetic disturbances, namely 150 kHz to 30 MHz (Răcăşan *et* al., 2014). Arranging the testing stand found at the Electromagnetic Compatibility Laboratory in the Electrotechnics and Measurements Department from the Cluj-Napoca, Technical University is according to standards and seen in Figs. 3,…,5. The testing procedure for the best precision and the least error of measurements must accurately follow the location parameters, distances and cable lengths as mentioned in the EMC standard and presented in Fig. 3.

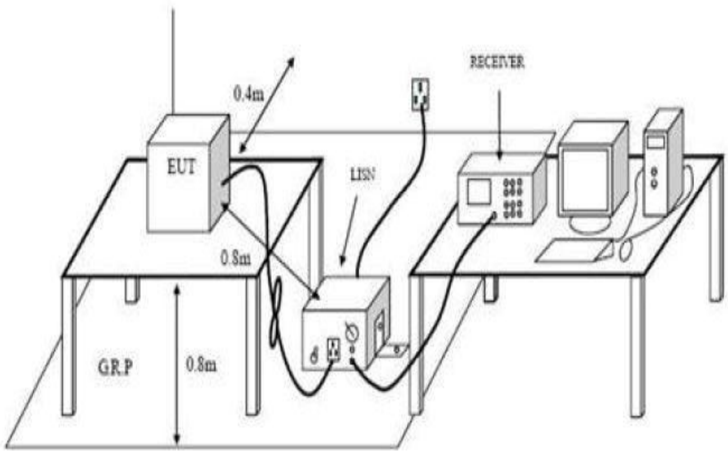

Fig. 3 – Testing stand for electromagnetic disturbances produced through conduction in the supply line.

Fig. 4 – Testing stand for electromagnetic disturbances produced through conduction in the supply line from the Electromagnetic Compatibility Laboratory of Cluj Napoca Technical University.

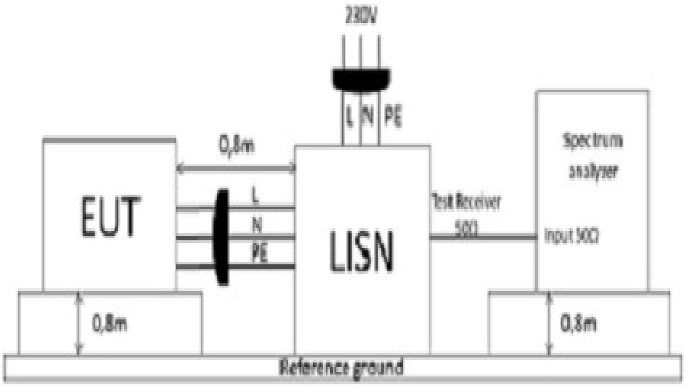

Fig. 5 – LISN connection electrical scheme.

As shown in Figs. 3 and 4, in order to make the tests, a spectrum analyzer, a line impedance stabilization network (LISN), a laptop and the equipment under testing (EUT) are required. Therefore the device we want to test must be directly linked to the LISN (Fig. 5), and the measurements obtained may be visualized using the spectrum analyzer. The LISN used during testing is of HAMEG HM6050-2 type and meets the German VDE 0876 standard. It mainly acts as a filter which serves three main purposes: it stabilizes the line impedance to 50 Ω, it allows the tested device to connect through a filter that permits lower frequencies and connects the EUT to the spectrum analyzer to measure the emissions after they have passed through a pass-up filter (Hartal, 1995; 2009; Hongyu Li *et al*., Yung-Chi Tang *et al*., 2014; Nicolae *et al*., 2014). The spectrum analyzer used is also type HAMEG and comes with software which allows viewing average, peak and quasi-peak values. All measurements can be evaluated using a PC considering the limits of EN 50081-1 standard (Fig. 6) for average and quasi-peak values (Spectrum Analyzer HM 5014-2 Manual; SR EN 50081-1; 1999).

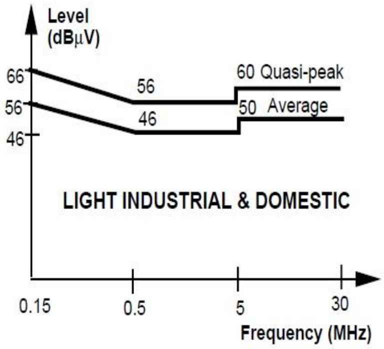

Fig. 6 – Permissible interference limits for EN 50081-1.

To determine electromagnetic disturbances produced through conduction in the supply network the following equipment was tested: two vacuum cleaners, one of an older generation and one of a newer one, as well as two mixers, one from an older generation and one from a newer one. Thus, in Figs. 7 and 8 are the stands for the two vacuum cleaners, in Figs. 9 and 10 are shown the results when the devices are turned off, and in Figs. 11 and 12 the results when they are turned on.

The red and blue lines are the EN 50081-1 standard limits for average (AV) and quasi-peak (QP) values (SW 5012E-V153).

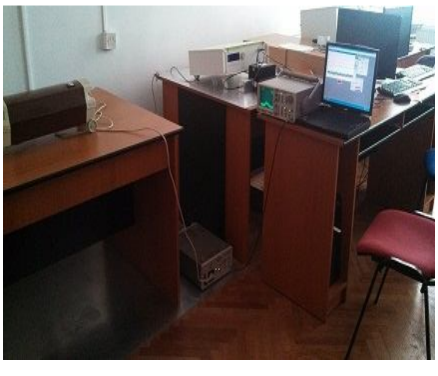

Fig. 7 – Old vacuum cleaner stand .

Fig. 8 – New vacuum cleaner stand.

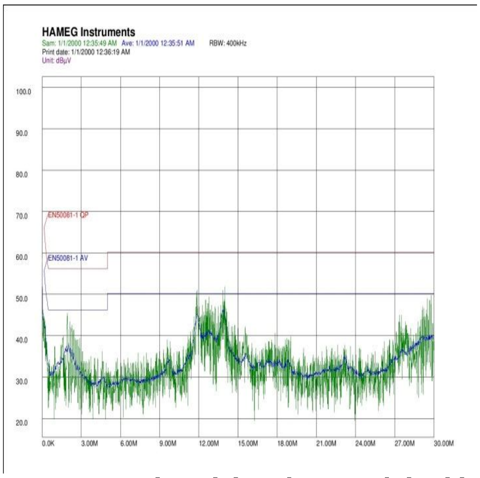

Fig. 9 – Conducted disturbances while old vacuum is turned off.

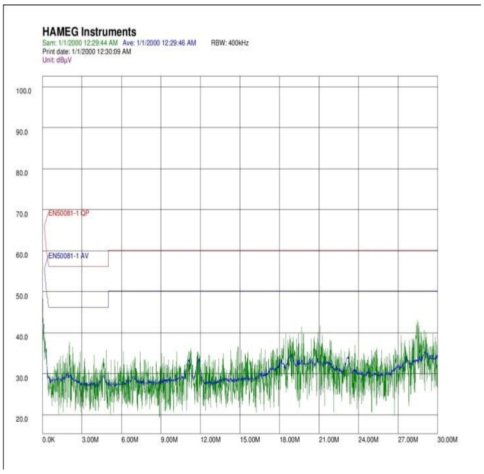

Fig. 10 – Disturbances while new vacuum is turned off.

It is easily noticeable that although it fits the standard limits, the old generation vacuum cleaner, even when turned off, induces disturbances close to limits.

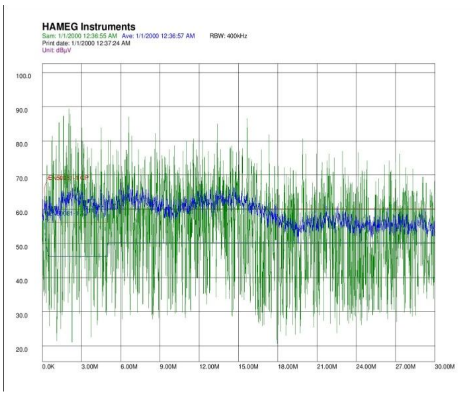

Fig. 11 – Conducted disturbances while old vacuum is turned on.

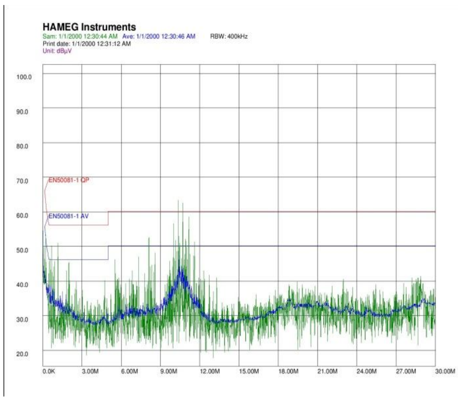

Fig. 12– Conducted disturbances while new vacuum is turned on.

Regarding the second device tested, Figs. 13 and 14 show the stands for the two mixers, while Figs. 15 and 16 show the results when they are turned off and Figs. 17 and 18 the results when they are working.

Fig. 13 – Old mixer stand.

Fig. 14 – New mixer stand.

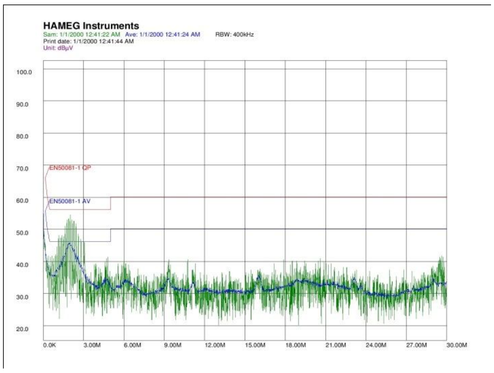

Fig. 15 – Conducted disturbances while old mixer is turned off.

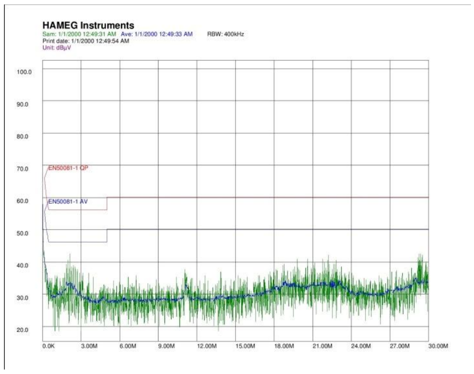

Fig. 16 – Conducted disturbances while new mixer is turned off.

It is easily noticeable that, as with the vacuum cleaners case, the older generation mixer, even turned off, induces higher disturbances in the network than the new generation one.

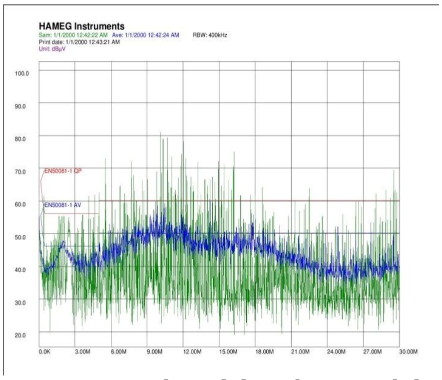

Fig. 17 – Conducted disturbances while old mixer is turned on.

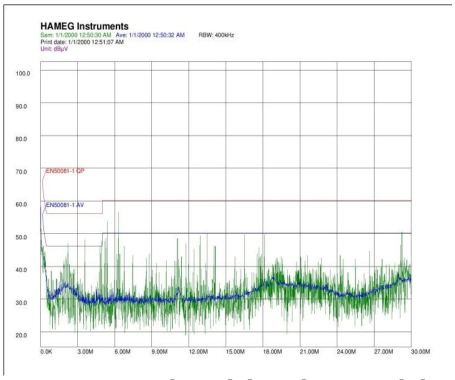

Fig. 18 – Conducted disturbances while new mixer is turned on.

After analysis of data, it can be seen that older generation devices are high disturbers and that they induce conducted disturbances in the supply network which can affect other devices' linked to the same network function; even in the case of the newer generation vacuum cleaner which was supposedly build according to the current standards the limit was exceeded at some points. In fact the old devices are used longer than the new devices and this may be an explanation of this disturbances, but not the only one.

3. Using Emi Filters to Reduce Conducted Disturbances

To suppress electromagnetic disturbances produced through conduction in the supply network EMI (Electromagnetic Interference) filters are recommended (Fig. 19).

Fig. 19 – EMI filter.

Fig. 20 presents the wiring diagram and Fig. 21 presents typical attenuation/resonance frequency characteristics. These chokes employ current-compensated windings to present a large inductance to common-mode noise signals and handle peak currents without saturating, utilizing toroidal ferrite cores to pack high inductance values into compact form-factors.

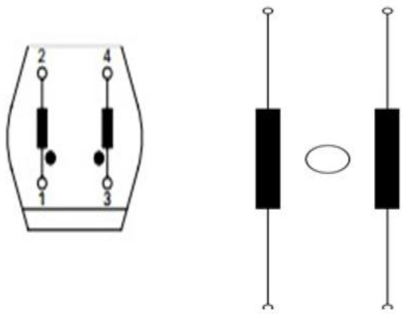

Fig. 20 – Wiring diagram.

To show the efficiency of the method, the tests with the vacuum cleaners and mixers have been redone while using the EMI filter. In the electric mounting, this filter is put between the equipment under testing (EUT) and the line impedance stabilization network (LISN), as seen in Fig. 22.

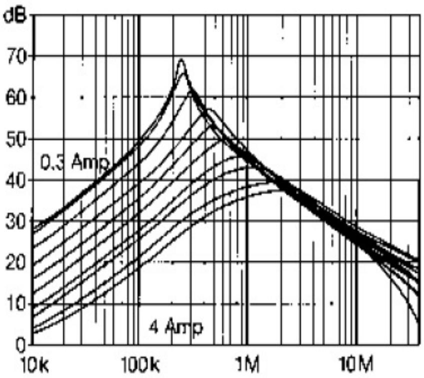

Fig. 21 – Typical attenuation/resonance frequency characteristics.

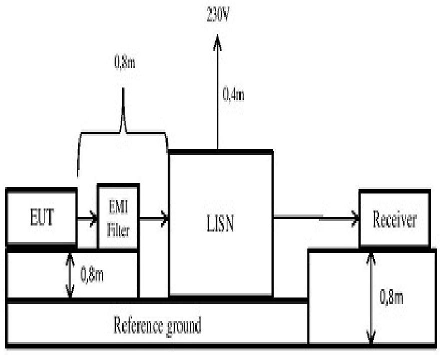

Fig. 22 – Block diagram of the EMI filter stand.

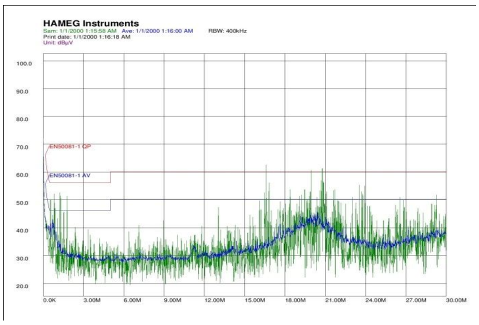

Fig. 23 – Conducted disturbances while old vacuum cleaner is turned on and has EMI filter.

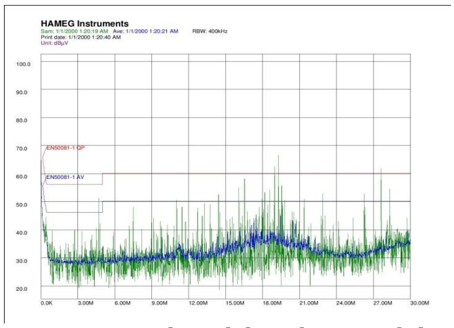

Fig. 24 – Conducted disturbances while old mixer is turned on and has EMI filter.

Looking closely over the measurements made with the EMI filter Figs. 23 and 24, one cannot reach but the conclusion that the efficiency of these filters, when it comes to reducing electromagnetic disturbances produced through conduction in the supply network of various electrical devices. After inserting the filter in the test setup, a big improvement can be noticed

4. Conclusions

The present article has aimed to create a parallel between old and new electrical devices through testing the electrical compatibility of ordinary appliances found in the home of any person in the 21st century regarding electromagnetic disturbances produced through conduction in the supply network.

If we compare Figs. 9, 11, 15 and 17 with what is seen in Figs. 10, 12, 16 and 18 a real progress is obvious regarding the appearance on the market of products which induce as little disturbance as possible. In other words, because of the overload this power grid is put under by the actual civilization, the need to use equipment which better corresponds to current needs and requirements of electromagnetic compatibility imposed by standards and, ultimately, society arises.

Comparing on one hand Figs. 11 and 17 to Figs. 23 and 24 on the other gives hope that there may very well be a “reliable friend” found in conduction, more precisely the EMI filters and their efficiency. Of course it is known that EMI filters have many applications like suppressing high interference levels, or suppressing equipment with no earth connection and many others.

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STUDIU COMPARATIV PRIVIND PERTURBAȚIILE ELECTROMAGNETICE PRODUSE PRIN CONDUCȚIE DE DIFERITE DISPOZITIVE ELECTRICE

(Rezumat)

Sunt analizate perturbațiile electromagnetice conduse produse în rețeaua de alimentare de diferite echipamente electrocasnice utilizate frecvent în fiecare locuință. De asemenea este ilustrată importanța utilizării filtrelor EMI care reduc emisiile în rețeaua de alimentare şi necesitatea respectării cerințelor standardelor de compatibilitate electromagnetică impuse de legislația specifică aflată în vigoare.