Conducted Electromagnetic Emissions Analysis and Suppression Methods

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***Abstract*—This paper presents a study regarding the conducted emissions generated by different home appliances present in everyday life. Due to the fact that in the last few years there are a lot of devices which surround us, the electromagnetic compatibility (EMC) is becoming of great interest. This subject is not only about the influence of this apparatus on the human body, but also about the influence of the devices on other devices which are in their close proximity and also on themselves. A device must be in accordance to the EMC norms in order for it to function properly, and thus to be marketed.**

Keywords—conducted emissions range; standard limits; LISN; equipment under test;filter.

I. INTRODUCTION

In the VDE 0870 normative [1] the electromagnetic compatibility is defined as the capacity of an electric device to properly function in its electromagnetic environment, without inadmissible disrupting this environment, also belonging to other devices.

In simple terms, EMC describes the ability of electronic and electrical systems or components to work correctly when they are close together. In practice this means that the electromagnetic disturbances from each item of equipment must be limited and also that each item must have an adequate level of immunity to the disturbances in its environment [2].

In Fig. 1 the scheme for the electromagnetic interference phenomena is represented. An electromagnetic system compatible has to meet three criteria: not to produce interferences with other systems, not to be susceptible to other system's emissions and not to produce emissions with himself [3]. An electric device can be thus considered as electromagnetic compatible if, as a transmitter, it produces tolerable emissions and, as a receiver, has an acceptable susceptibility to the harmful emissions, denoting it has immunity or sufficient resistance to the disturbances. There are three ways of protection against electromagnetic interferences: suppressing the source emissions, making a coupling as inefficient as possible, designing and realization of a receiver as less susceptible as possible.

We will consider the transmitter as the subject of this studies. It is known that the transmitter producing parasitic electromagnetic energy in its environment is considered compatible if the disturbing field intensity produced by it at a certain distance doesn't exceed a limit value set by standards [4].

Due to economic reasons the transmitter compatibility has to be achieved first and only after that the receivers are taken into account. It is known from previous researches that achieving the electromagnetic compatibility of the devices from the design phase implies the increase of costs with approximately 5%, while if the electromagnetic compatibility concept is considered only after the construction of the prototype, the costs increase with 50%. Therefore the concern to enshure compliance with EMC must be continuous at all stages of a product until marketing it [5] [6].

In our country the regulatory standards for electromagnetic compatibility of the equipments, apparatus and fixed instalations is HG 982/2007. This standard imposes conditions for introducing on the market and using these equipments, apparatus. Also, the regulations of EMC Directive 2004/108/EC [7] is used in order to harmonize the Member States legislation on electromagnetic compatibility.

II. TEST SETUP AND CONFIGURATION

Sometimes transmitters introduce conducted emissions over the limit in the network, thus they influence the other device in their proximity. In order for them to function properly, they must be subjected to some tests to determine if they are compliant with the standards in force.

In this study, the authors will determine the electromagnetic perturbations produced by this transmitters through conduction in the supply network [8] [9] [10]. The frequency range for which the emissions will be determined is the one for the conducted emissions, namely between 100 kHz and 30 MHz [18].

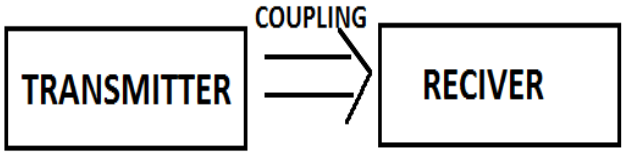

Fig. 1. Electromagnetic interference phenomena.

The test setup needed in order to conduct this sort of tests consists of a LISN (Line Impedance Stabilising Network), a Spectrum Analyzer, a computer and the equipment under test (EUT) [3] [11] [12].

In principle, LISN represents a filtering network with 3 main objectives, namely: line impedance stabilization at 50 Ω in order for the measurements to be reproductive, EUT connection to the network supply port through a low pass filter, attenuating the high frequency parasitic signals from the supply line, and connecting the EUT to the spectrum analyzer through a high pass filter in order to measure the conducted emissions [11] [13].

The test setup as it is stated in the standards together with the testing stand constructed in the Electromagnetic Compatibility Laboratory NUMELEC from the Technical University of Cluj-Napoca are presented in Fig. 2 and Fig. 3 [14] [15] [16] [17].

The Spectrum Analyzer used for this tests is a HAMEG Spectrum Analyzer. This device comes with a software program which is able to display the resultant emissions together with the standard limits imposed. The obtained results are displayed on the PC with the corresponding limits from the EN 50081-1 standard for the quasi-peak and average values [20] [21]

The program also allows us to establish our own limits and to compare the emissions with other standards different from the initial one.

Also, the software program allows the user to export the measured values for a number of points as a file which can be opened in Microsoft Access and can be then interpreted for a better understanding of the results.

The test setup must respect the wire lengths and the placement of the devices as in Fig.2.

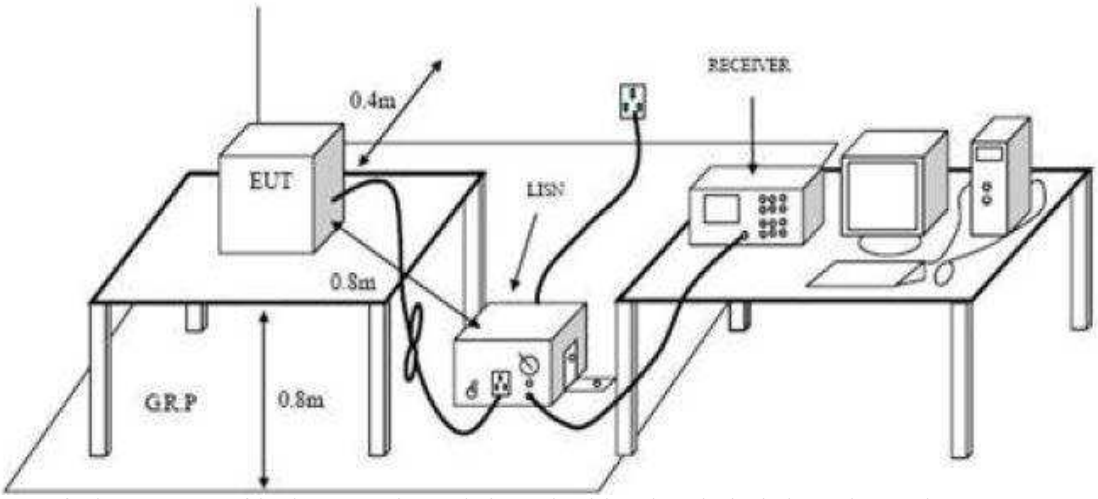

Fig. 2. Test setup for the measurement of the electromagnetic perturbation produced through conduction in the supply network.

Fig. 3. Test setup for the measurement of the electromagnetic perturbation produced through conduction constructed in the Electromagnetic Compatibility Laboratory from the Technical University of Cluj-Napoca.

A. *Devices considered for the study*

In order to determine the conducted emissions, four devices were considered, namely a drill, a blender, a coffee grinder and a hairdryer. For all this devices two different measurements were conducted: with the device on and with the device off. The result for the conducted emissions for the four devices in off mode can be observed in Fig. 4, Fig. 5, Fig. 6 and Fig. 7.

With blue and red the limits from the EN 50081-1 standard for the quasi-peak and average values can be observed for in every result [21].

It can be observed that all the devices under test have conducted emissions under the limits in the frequency range. Only one point exceeds the imposed limit, for the blender, but this can be due to the supply network.

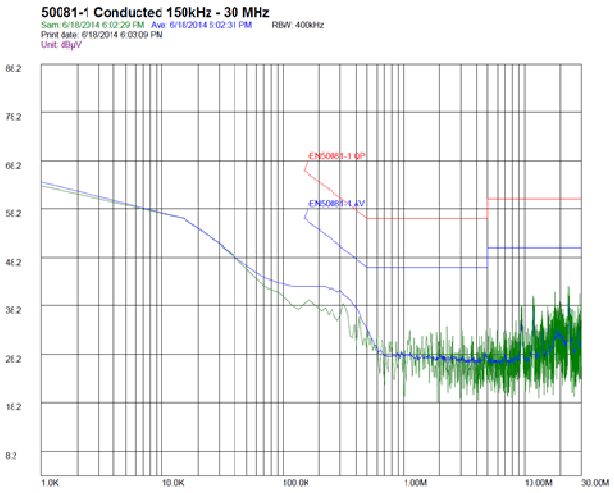

Fig. 4. Conducted emissions for the drill in off mode.

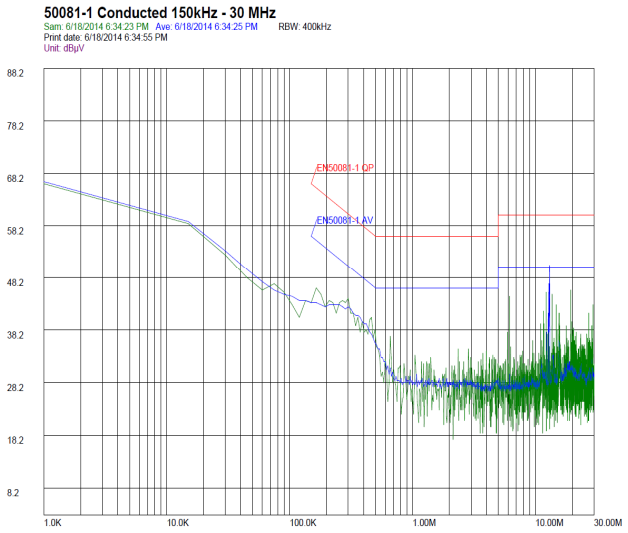

Fig. 5. Conducted emissions for the blender in off mode.

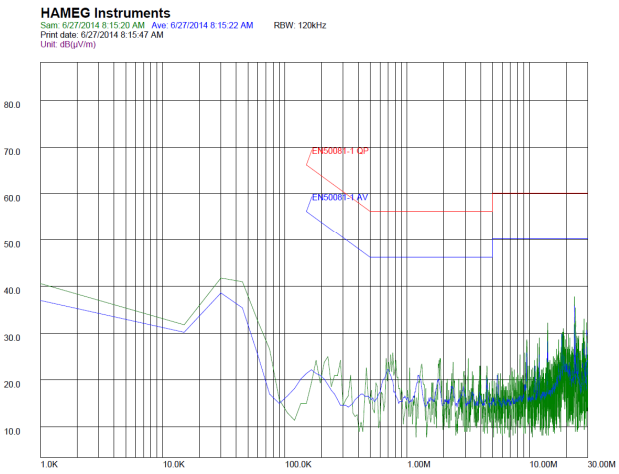

Fig. 6. Conducted emissions for the coffee grinder in off mode.

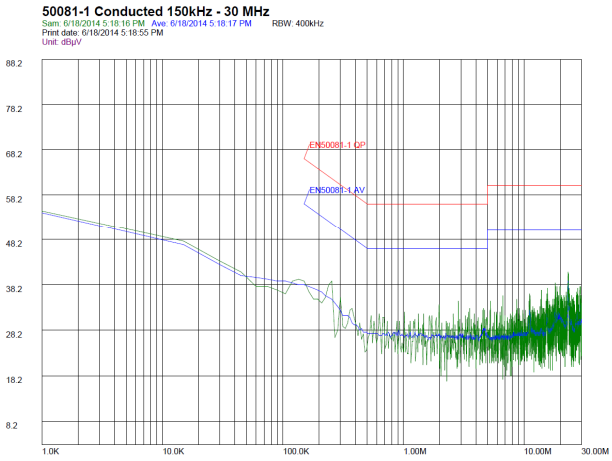

Fig. 7. Conducted emissions for the hair dryer in off mode.

The second step of this study is the determination of the conducted emissions values for the studied devices in on mode. The results are presented in Fig. 8,9,10 and 11.

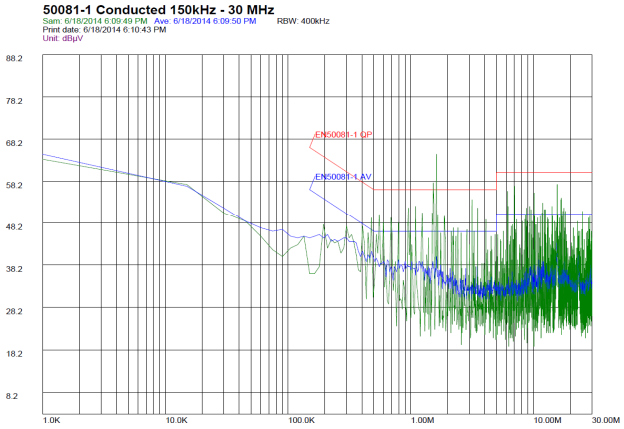

Fig. 8. Conducted emissions for the drill in on mode.

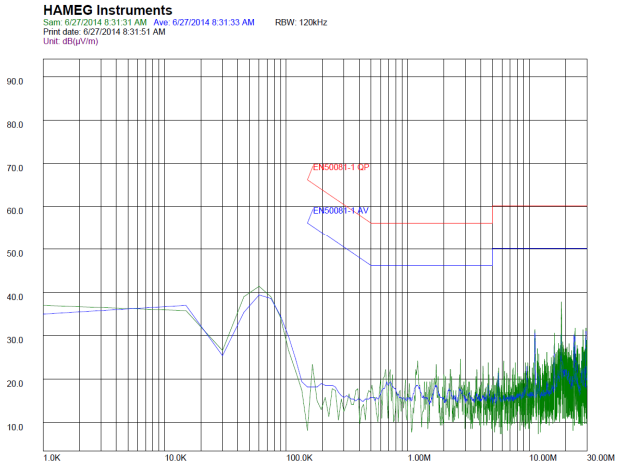

Fig. 9. Conducted emissions for the blender in on mode.

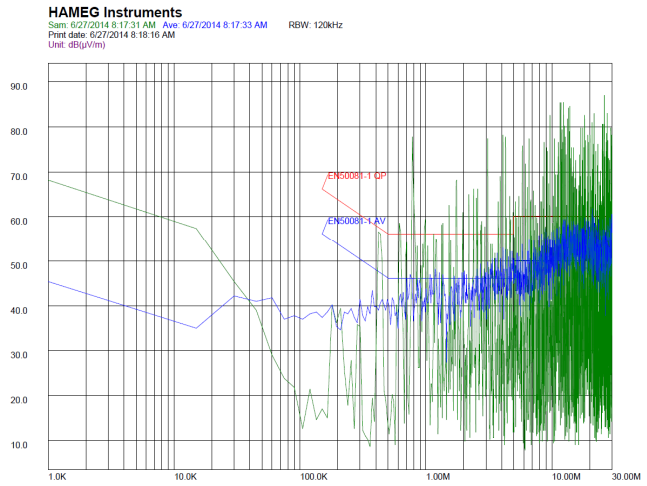

Fig. 10. Conducted emissions for the coffee grinder in on mode.

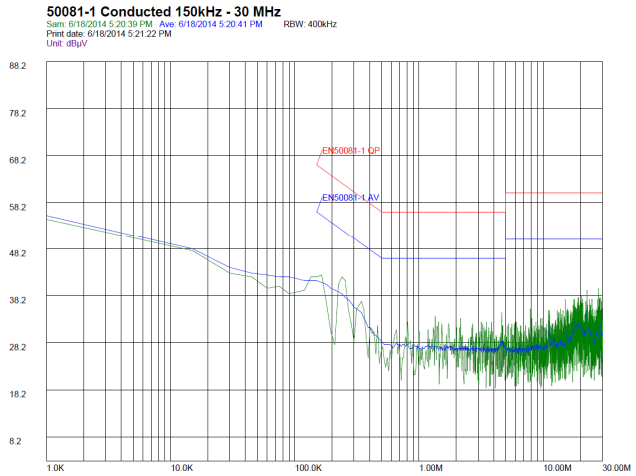

Fig. 11. Conducted emissions for the hair dryer in on mode.

After analyzing the conducted emissions generated by the four devices, it can be observed that the values of the emissions remain under the stated limits in the case of the blender and hairdryer. This can be explained by the fact that this devices are newer and in order to be marketed they had to be subjected to tests to be verified if they are in accordance with the standards in force.

For the other two devices, the emissions exceed the standard limits in a lot of measurement points. The drill is an older device and it can be clearly determined that, when it is on, the emissions are, when in Sample regime, well above the limits.

The same conclusions are drawn for the coffee grinder, where the conducted emission values are even greater.

It can be stated that these devices, being older, could have not be subjected to the EMC compliance testes.

Also maybe their use in time has degraded their components. Another explanations could be the presence of a motor with brushes in their construction which is greater source of conducted emissions; these kind of devices must be checked more throughly when considering the conducted emissions.

III. MINIMISATON TECHNIQUES

One of the main suppression methods for the conducted emissions from the supply network is the use of EMI (Electromagnetic Interference) filters. In order to demonstrate the efficiency of this reduction method, which in some cases can completely eliminate the conducted emissions, the EMC tests were resumed for the devices for which the permissible limits were exceeded. In this case this tests were retaken with a test setup also containing an EMI filter placed between the devices and the LISN. The used filter and its connection created in order to place it in the test setup can be observed in Fig.12. The results obtained for the drill and coffee grinder in the presence of the filter can be seen in Fig. 13 and Fig. 14.

It can be observed that for the test setups where the EMI filter is also present all the measurement values for the drill are under the standard imposed limits, fact which allows these devices to be placed on the market if needed.

In the case of the coffee grinder the EMI filter influences the conducted emissions reducing their value, but that is not enough because there still are a lot of measurement point which exceed the limits imposed by the standards in force.

Fig. 12. EMI filter placed in the test setup and its connection.

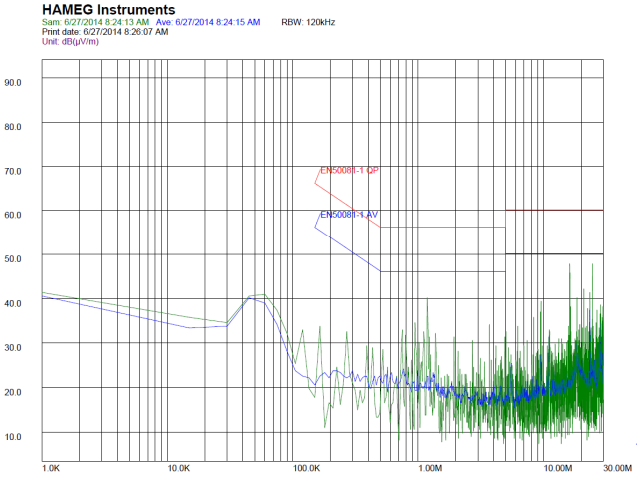

Fig. 13. Conducted emissions for the drill in on mode in the presence of an EMI filer.

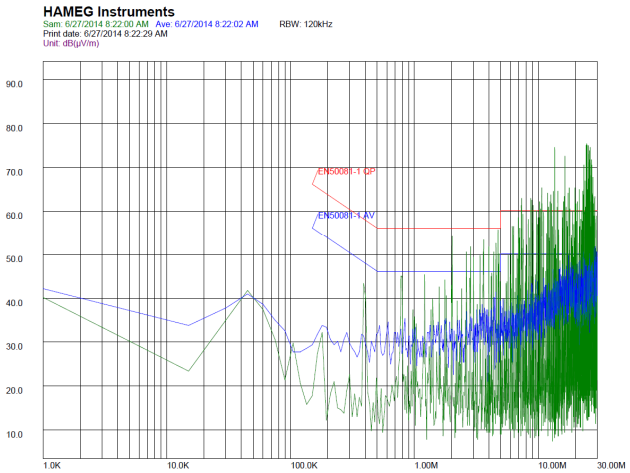

Fig. 14. Conducted emissions for the coffee grinder in on mode in the presence of an EMI filter.

A number of graphs were made in order to better understand the influence of the EMI filter on the conducted emissions. The frequency range for the conducted emissions was divided into three frequency ranges in order to better follow the emissions limits given by the standards, namely 0.15 MHz – 0.5 MHz, 0.5 MHz -5 MHz and 5 MHz -30 MHz.

If we consider the drill in on mode it can be observed that most points that go above the maximum admissible limit are in the frequency range 0.5 MHz – 5 MHz, this representing approximately 2% of the total of measured values, for the frequency range of 5 MHz -30 MHz only 1% from the total values being above the limits. In the frequency range of 0.15 MHz – 0.5 MHz there are 0% of the total number of measurement points that exceed the limits. The graph representing these percentages is represented in Fig. 15.

After inserting the filter in the test setup, a big improvement can be noticed. The number of exceeding points regarding the standard limits for the two cases in the three frequency ranges is represented in Fig.16.

The same thing was observed for the coffee grinder. In Fig. 17 the number of exceeding points from the total measured values for the on mode coffee grinder test setup without a filter is presented. An improvement can be observed for this device also. Even though there still are a lot of exceeding points, their number was reduced. The conclusion is that for each case studied the suitable EMI filter must be calculated.

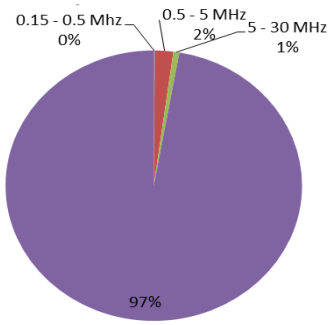

Fig. 15. Number of points exceeding the standard limits for the on mode drill for a test setup without the EMI filter.

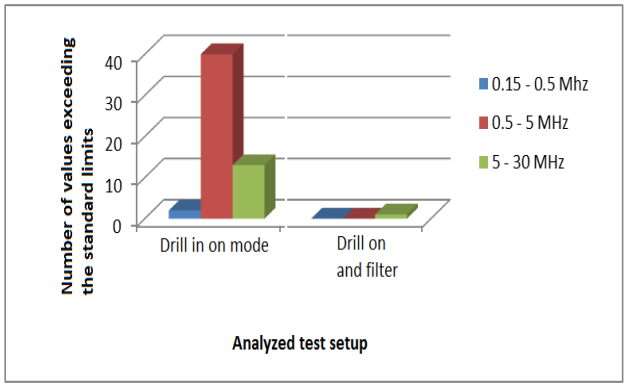

Fig. 16. Comparison of the number of exceeding points for the drill in on mode for the test setup with and without the filter

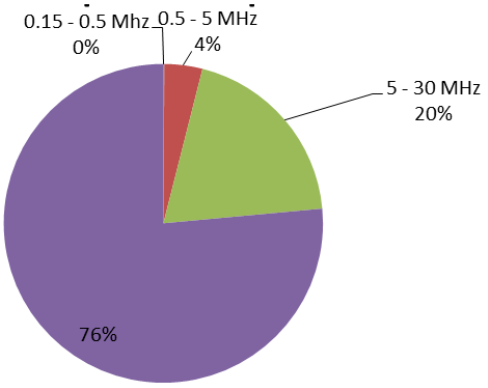

Fig. 17. Number of points exceeding the standard limits for the on mode coffee grinder for a test setup without the EMI filter.

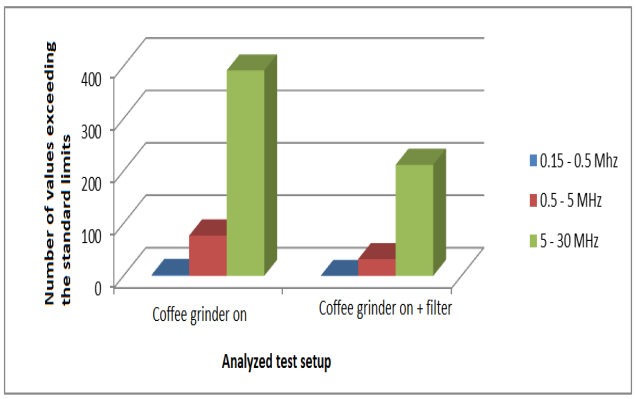

Fig. 18. Comparison of the number of exceeding points for the coffee grinder in on mode for the test setup with and without the filter

IV. CONCLUSIONS

This paper presents a study of the conducted emissions of different house appliances in order to determine if they are compliant with the standards in force. The four studied devices were a hair dryer, a drill, a coffee grinder and a blender.

It was discovered that for all four devices in off mode the conducted emissions values were under the imposed limits by the standard. When the devices were tested in on mode, it was discovered that two of them exceeded the limits, namely the coffee grinder and the drill. It can be stated that these devices, being older, could have not been subjected to the EMC compliance tests. Also their use in time has degraded their components. Another explanations could be the presence of a motor with brushes in their construction, motor which is a greater source of conducted emissions; these kind of devices must be checked more throughly when considering the conducted emissions.

After introducing an EMI filter in the test setup as a solution for these exceeding conducted emissions, the values for the conducted emissions were decreased, and for the drill all the values were under the standard limits. Even though the coffee grinder remained not compliant with the standards in force, its conducted emissions were also reduced.

The conclusion is that the introduction of an EMI filter is a good solution for reducing conducted emissions, but the producer must first determine the best suited EMI filter design for each case.

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REFERENCES

[1] VDE 0870 Normative Elektromagnetische Verträglichkeit bei Cable-Management-Systemen.

[2] IEC Guide 107, Electromagnetic compatibility

[3] Hartal, O., *Electromagnetic Compatibility By Design*, 3rd ed, West Conshohocken, PA: R & B Enterprizes, 1995.

[4] SR EN 55011 Standard de bază privind emisiile conduse, ASRO 1994.

[5] Kumar L.S., Yegneswari R., Subbarao B., Sivaramakrishnan R., "Analysis of repeatability in conducted emission measurements", *Proc. of the DElectrMagnetic Interference and Compatibility,* Page(s):337 – 341, 23-24 Feb. 2006, Bangalore.

[6] Cakir S., Sen O., Cinar, M., Cetintas M., "Alternative conducted emission measurements for industry", *IEEE International Symposium on Electromagnetic Compatibility,* Page(s):1037 – 1042, 1-4 Sept. 2014, Gothenburg, Sweden.

[7] EMC Directive 2004/108/EC.

[8] Hongyu Li, Pommerenke D., Weifeng Pan, Shuai Xu, Huasheng Ren, Fantao Meng, Xinghai Zhang, "Conducted EMI Simulation of Switched Mode Power Supply", *IEEE International Symposium on Electromagnetic Compatibility*, Pp:155 – 160, 17-21 Aug. 2009, Austin, TX.

[9] Păcurar Claudia, Ţopa V., Răcăşan Adina, Munteanu C., Hebedean Claudia, „Spiral Inductors Inductance Computation And Layout Optimization", *Proceedings of the International Conference and Exposition on Electrical and Power Engineering, 7th edition,* Iaşi, România, October 25-27, 2012, pp. 699-704.

[10] Cretu Mihaela, Ciupa Radu, "Magnetic Coil Design for Evaluating the Response of the Spinal Cord during Magnetic Stimulation", *2014 International Conference and Exposition on Electrical and Power Engineering EPE*, 16-18 2014 Oct, pp. 237-244.

[11] Line Impedance Stabilization Network HM6050-2 Manual, Hameg Instruments.

[12] Yung-Chi Tang, Jay-San Chen, Chih-Hung Lee, Cheng-Nan Chiu, "A Case Study on the Consistency Improvement in Radiated-Emission Testing by Using LISN", *IEEE International Symposium on Electromagnetic Compatibility,* pp:259 – 262, 12-16 May 2014, Tokyo.

[13] Nicolae P.-M., Stoica Camelia, Mihai G., "Conducted Emission Measurements for a Laptop", *International Conference on Applied and Theoretical Electricity*, pp. 1 – 4, 23-25 Oct. 2014, Craiova, Romania.

[14] Pocan I., Munteanu, C., Hebedean Claudia, Pleşa, C., Morar, R., Munteanu, I. O. and Suaraşan, I., "Conducted Emissions of "The Assembly Corona Electrostatic Separator –High Voltage Source" and Solutions to Reduce them", *Proceedings of the 3rd Modern Power Systems Conference, MPS 2010* Cluj-Napoca, 18-21 May 2010, pp. 300-305, Cluj-Napoca, Romania.

[15] Bellato A., Bertocco M., Rossetto L., Stellini M., "A low-cost comb generator for the characterization of test sites," in *Proc. of 2011 EMC Europe*, pp. 61-66, 26-30 Sept. 2011, York.

[16] Chih-Hung Lee, Tsung-Yuan Yang, Han-Chang Hsieh, Jay-San Chen, Cheng-Nan Chiu, "A Stable and Low-Cost Site Source for Conducted- and Radiated-Emission Consistency Confirming and Daily Checking of Test Sites", *IEEE International Symposium on Electromagnetic Compatibility,* 12-16 May 2014, pp 497 – 500, Tokyo.

[17] Bucci G., Fiorucci E., Landi C., Bucci N., "A Digital Measurement Station for the Precompliance Testing of Power Electronic Devices", *Proc. of the IEEE International Symposium on Industrial Electronics*, 2002, pp 554 – 559, vol. 2.

[18] Racasan Adina, Munteanu C., Topa V., Pacurar Claudia, Hebedean Claudia, „Electromagnetic Interferences Suppresion in Planar Integrated Devices", *Proc. of the 2014 International Symposium on Electromagnetic Compatibility,* pp: 940-945, 1-4 Sept. 2014 Gothenburg, Sweden.

[19] Spectrum Analyzer HM 5014-2 Manual, Hameg Instruments.

[20] SW 5012E-V153 Software Operating Instructions, Hameg Instruments.

[21] SR EN 50081-1 Standard generic de emisii, mediu rezidenţial, comercial şi uşor industrializat, ASRO 1999.