

MEASURING POSITION TO ANALYZE THE INSERTION LOSS OF CHOKES AND EMI FILTERS

Andrzej Wac-Włodarczyk
Paweł A. Mazurek
Institute of Electrical Engineering and Electrotechnologies
Technical University of Lublin
Faculty of Electrical Engineering
ul Nadbystrzycka 38A, 20-618 Lublin, Poland
Tel.+048+81 5381289; Fax. +048+81 5381289;
E-mail. pawelm@eltecol.pol.lublin.pl, andrzejw@eltecol.pol.lublin.pl

Abstract

In real life, an electronic system acts simultaneously as an electromagnetic interferences source and receptor, and both of these properties affect the coexistence between systems. One of the most efficient methods to limit these interferences is the application of the reducing elements to an acceptable level.

The paper presented the information about the new measuring position to tests of insertion loss of EMI choke. These position makes possible the carry out an experiments which relating the opinions of effectiveness of suppression electromagnetic interferences.

The cores of chokes are made from different magnetical materials (ferrite or nanocrystalline materials). Analyzed cores work as smoothing chokes in supply systems of electric devices. Measurements have been realized in range of frequency for 9 kHz to 300 MHz.

1. Introduction to EMC

The electromagnetic compatibility has become an important part of electrical

engineering. Government regulations and safety issues have forced companies to take a greater interest in the electromagnetic properties of their products [1].

Electromagnetic compatibility (EMC) is the ability of an electronic system or subsystem to reliably operate in its intended electromagnetic environment without either responding to electrical noise or generating unwanted electrical noise. Electromagnetic interference (EMI) is the impairment of the performance of an electronic system or subsystem by an unwanted electromagnetic disturbance. And so, the electromagnetic compatibility is achieved by reducing the interference below the level that disrupts the proper operation of the electronic system or subsystem. This compatibility is generally accomplished by means of filters, and special component or equipment shielding.

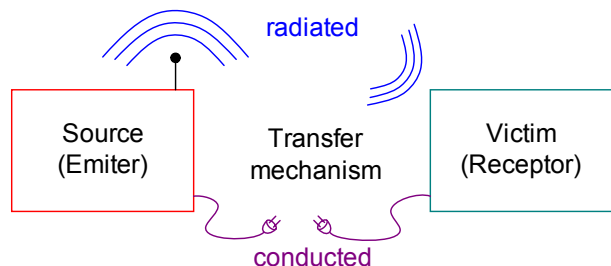


Figure 1. Model of EMI [1,4,6,8]

For EMI (or electrical noise) to interfere with the operations of a circuit, there has to be a source of interference, a receptor for the interference, and a path which couples the source and receptor. Figure 1 shows a graphical representation of the transfer of EMI [1,4,6,8].

EMI is generated by a varying electric or magnetic field and transmitting them by means of conductive, inductive or capacitive coupling, through free space or a combination of these means. Switching power supplies are one of the worst sources for EMI and RFI generation, because of their inherent current voltage waveforms and very fast switching times.

Generally, to suppress power line and signal line emission, some form of filtering is required. Filter attenuation is highly dependent upon source and load impedances.

Filters are designed to suppress RFI voltages that exist line to line (differential mode) and line to ground (common mode), or both. Common mode interference is most frequently encountered. These signals are readily propagated in power systems and equipment. Susceptibility problems are generally the result of common mode interference. Some devices, such as SCRs and switching regulators, can cause differential mode interference to nearby susceptible equipment [4,6].

2. Using soft magnetic materials for interference suppression

EMI filters work by creating a mismatch condition between source and load impedances at high frequencies. This mismatch is created by series inductance and shunt capacitive elements. Soft magnetic core materials for use in EMC noise suppression filters must have special properties [1,3,4,5].

The efficiency of such choking-coil depends considerably on the proper

selection of magnetic material and the dimension and the shape of the core. The core for electromagnetic interference suppression is working as limiter of disturbances and is switching on in series of the circuit between the emission sources and receiver .

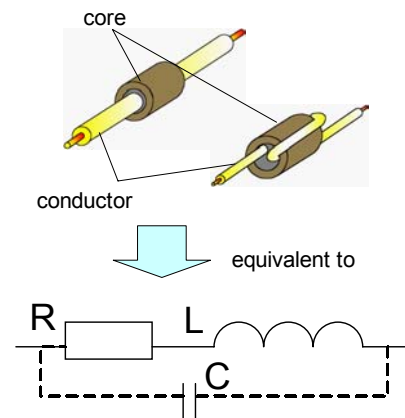


Figure 2. Typical construction of core for EMI suppression and equivalent parameters.

The simplest core – bead, for interference suppression is soft ferrite core installed on conductor (Fig.2) or core of nanocrystalline ribbons [2].

The core is determined by curve of impedance at the interference frequency.

Total impedance of the common mode inductor is composed of two parts, the series inductive reactance (X_S) and series resistance (R_S). At low frequencies, the reactance is the primary contributor to impedance, but as the frequency increases, the real part of the permeability drops and losses within the core rise [2,3,4,5].

The insertion loss is a criterion for the efficiency of EMC components, as measured by using a standardized test setup. The efficiency of choke (defined by characteristic parameter – insertion loss) presented equation 1 [1,4,6]].

$$a = 20 \cdot \lg \frac{U'_z}{U''_z} \text{ dB} \quad (1)$$

where: U'_z – disturbance without choking-coil , U''_z – disturbance with choking-coil

At high frequencies stand up capacities which bring to resonance. Frequency of resonance grows less with growing number of turns. Thus a small number of turns is advantageous. To achieve components with high impedance values and small volumes, the choke material must have the highest initial permeability with good frequency characteristics. Additionally, the core material must retain its high permeability even under the influence of interference signals with high amplitudes or in the presence of a high leakage flux [2,3,6,7].

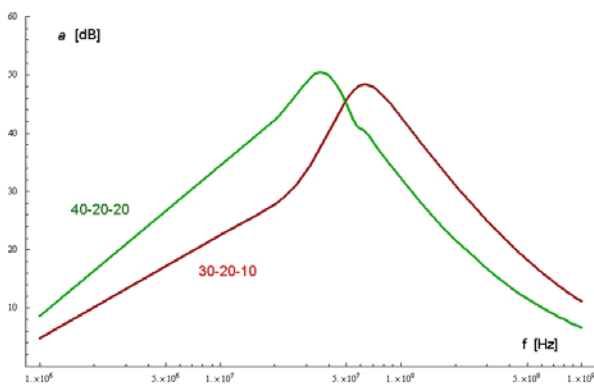


Figure 3. Overall dimensions vs. insertion loss, $\mu_i = 15000$, $N=12$ [5,7,8]

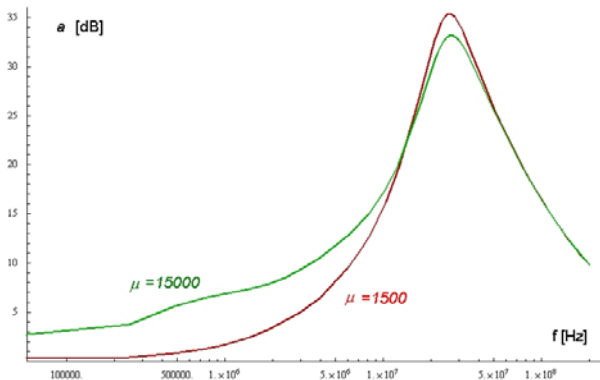


Figure 4. Initial permeability vs. Insertion loss, $N = 7$, overall dimensions 30-20-10 [5,7,8]

Efficient EMI suppression at utilization of choke forces to use correctly well chosen magnetic core. Examining dimensions of space special attention shall be paid to the dimensions of geometrical core, and self-inductance. The analyses of magnetic material are complicated. Enlarged volumes of core not always causes enlargement of

module “suppression” impedance. Additionally, one should remember, that change of configuration of geometrical dimensions without the volume change of core causes changes L (Fig.3).

The magnetic properties (initial permeability) of choking-coil depend on material, and are qualified by its impedance curve and insertion loss (Fig.4), in all frequency spectrum of disturbances.

4. Laboratory position

Laboratory position makes possible the carry out an experiments which relating the opinions of effectiveness of suppression electromagnetic interferences.

The cores of chokes are made from different magnetical materials (mainly the ferrite and nanocrystalline materials). Analyzed cores work as smoothing chokes in supply systems of electric devices. Measurements can be realized in range of frequency for 9 kHz to 300 MHz.

The position consists of signal generator, chokes of soft magnetic materials, line impedance stabilization network and interference meter - digital oscilloscope.

Ferrite KITAGAWA were used to investigations. Soft ferrites are inductors at low frequencies, but become loss (resistive) at higher frequencies. When used as L-only filter soft ferrites usually provide between 3 and 20dB attenuation on typical cables, without significant resonances. When used in more complex filters, soft ferrites provide much more predictable performance. Standard soft ferrite materials for EMC applications are still effective at 1 MHz, with some recent components extending this to 1GHz [3,5].

Line Impedance Stabilising Network (LISN) forms part of the overall equivalent circuit for testing. Its characteristics are defined in CISPR 16-1, which requires an impedance of 50Ω in parallel with $50\mu\text{H} + 5\Omega$ between each phase (live and neutral) and the earth reference point. This reference

is connected to the earth reference plane of the test setup.

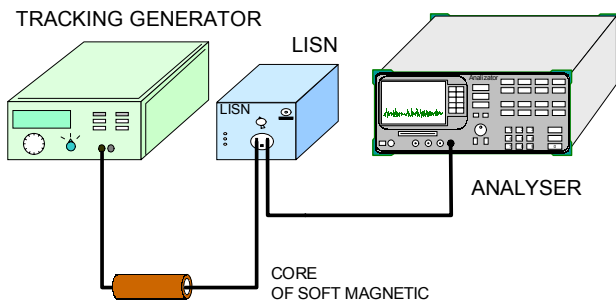


Figure 5. The measuring position to analyses insertion loss and pictures of the most important elements of position (ferrites, LISN, oscilloscope)

The figures 6 and 7 presented selected results of measurements of insertion loss of ferrites on diagrams.

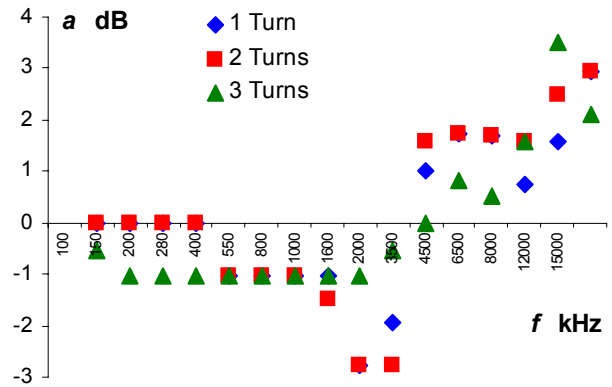


Figure 6. Influence the turn of winding to insertion loss of ferrite TR 28-16-13 (Kitagawa)

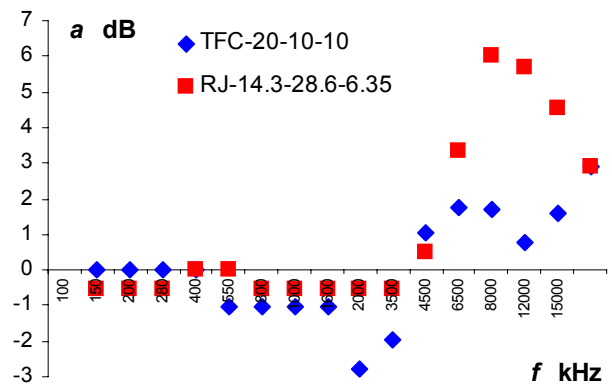


Figure 7. Insertion loss of ferrites TR 28-16-13 and TR (Kitagawa)

Environmental conditions, (temperature, magnetic and electric field intensity in which used choking-coil has to work) have influenced the work of choking coil by change of value of magnetic saturation of core. That effect can introduce high no linearity to circuit and become the following disturbance.

7. Conclusion

The measuring position to tests of insertion loss of EMI choke is use to scientific research and educational process.

The core for electromagnetic interference suppression dampen electric signals on the all range of frequency spectrum. Soft

magnetic core materials for use in EMC noise suppression filters must have highest permeability up to the highest frequencies, highest induction swing values and excellent thermal properties.

8. Appendix and acknowledgments

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