ISOLATION TRANSFORMER SOLUTIONS TO ELECTROMAGNETIC COMPATIBILITY PROBLEM

Doina Marin**, Vasile Trusca *, Bogdan Nisipeanu **, Constantin Viorel Marin

***S.C. Electroaparataj S.A. *University Politehnica Bucharest*

Abstract *The paper presents some considerations related with shielding for transformers. In the paper is presented the phisic phenomenum that appears in the moment of introducing a shield between the coils, different solutions of isolation transformers and some aplications for this type of transformers.*

Key words: *isolation transformer, common-mode noise, tranverse –mode noise*

INTRODUCTION

The isolation transformers with multiple shields [1] are devices that assure a good performing to the electronic equipment from the point of view of electromagnetical compatibility. The electromagnetical stade established between a transmitter and a receiver presumes the signal transmitted reaches the vised receiver and in the same time the performing of the transmitter does not endange himself safety and does not influence other electromagnetic connexions which are between other transmitters and receivers and the receiver reacts only one chosen transmitter. Distribution network can introduce noises, so for a good performing of the electronical equipment this must be supplied by an isolation transformer multiple shields The transfer of the useful signal from transmitter to receiver may be influenced by a coupling.

ELECTROMAGNETIC COMPATIBILITY ASPECTS

The transfer of the useful signal from transmitter to receiver may be influenced by a coupling.
The couplings may be:

- galvanics: - two electrical circuits with a common part
  - due the grounding
- inductives:due to the influence of the unsteady magnetical fields
- capacitives: due to the influences of the unsteady static electrical fields
- electromagnetic radiation: the noise is produced by electromagnetic radiation field.[1] We must know the nature of the couplings for finding the solutions to eliminate the noises.

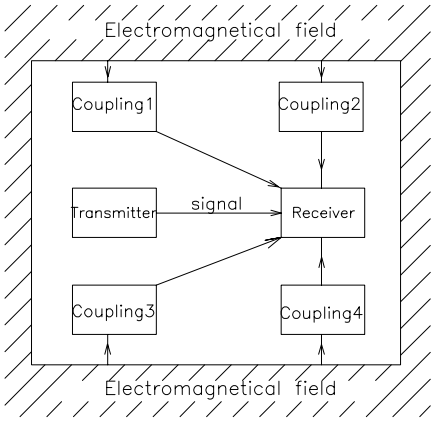

Fig.1.Noises produced by coupling into an electromagnetic field

The coupling that appears is a galvanic one due the grounding[1] in case of the isolation transformer with multiple shields.Fig.1. shows a current source and a proper receiver into an electromagnetic field with many sources and noise generated by couplings [1]. the transformer:

In a transformer there is also an inductive coupling neutralized by design and construction

- short connexions, return wires, coaxial cable connexions for force and measuring circuits
- geometrical disposal for minimal transfer of the magnetical flux into the loop of the adjacent circuit.

Another type of coupling is the electromagnetic radiation coupling and the capacitive coupling due parasitic capacitances [1]. For inductive and capacitive couplings we considere magnetical field independent of electrical field. We can neutralise capacitive coupling by shields connected to ground.

In case of electromagnetic radiation is necessary to consider the dependences of the two vectorial sizes **E** and **H** by Maxwell equations. We can neutralise electromagnetic radiation effect with filter for band, shields, etc.

SOLUTIONS FOR THE SHIELDING OF THE TRANSFORMER

The isolation transformer is a supply for an electronical device. The construction of transformer offers a galvanic separation between primary and secondary coils. The stray capacitance between the two coils facilitates noises transmitted by the network.

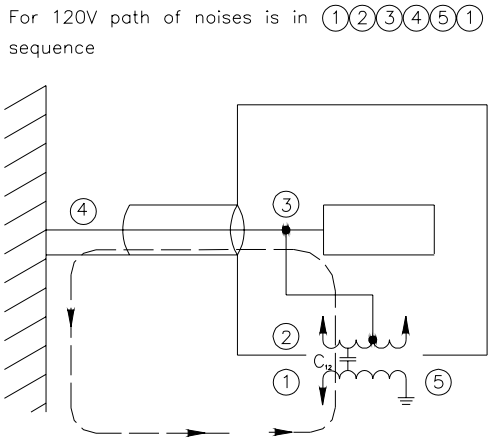

Fig.2. Path of noises into a transformer

Noises due galvanic coupling arrive at primary coil. The transformer allows the noises to circulate to the input of the leading signal. The path is shown in fig.2.[2] The circulation current must be kept outside the signal.

For a transformer the problem is to see how the shield can limit or control this unexpected current. There are some construction where this type of shielding is necessary. The shields are named Faraday shields because they are adequate for controling electrical field. They are simple isolated wrapping of thin conductive foil arround the coils. The materials used for shields are usually the copper but may be also the aluminium[2].

a) One shield solution

If there is one shield[3], this must be connected to the ground, so is shown in fig.3.

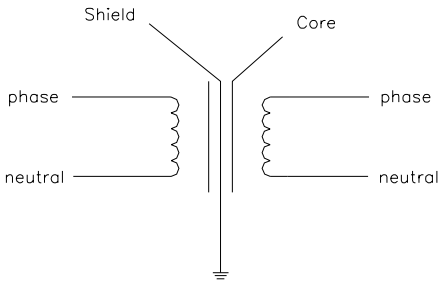

Fig.3.Grounding of shield

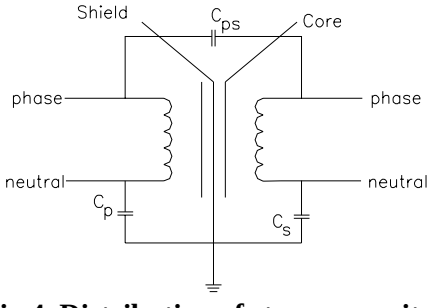

Fig.4. Distribution of stray capacitances

Two new capacitances appear. Both are tied to primary and secondary coil like in fig 4.
For a transformer with no shields, with the primary and secondary winded on the same column there are capacitances between primary-ground, secondary-ground and primary-secondary.
The capacitive effect which appears is given by electrical field existence like is shown in fig.5. There is an electrical field so there is an electrical charge.
Electrical field is a potential field so there is a potential on the conductive surfaces.

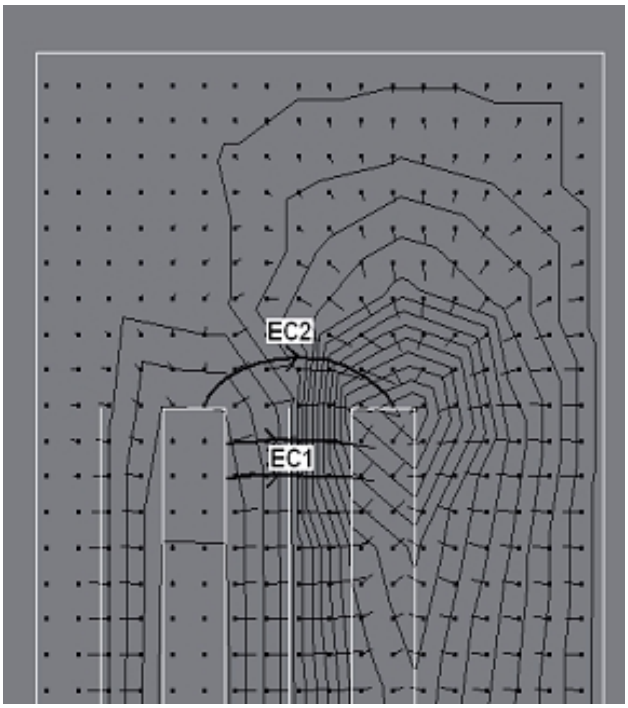

Fig.5. Spectrum of the electrical field lines

So, a capacitive effect appears. This is given by the raport between charge and potential difference. The capacitive effect between primary and secondary is due to the radial lines of electrical field(EC1) and the lines corresponding to the extremity effect of windings(EC2). If we introduce a shield connected to the ground between primary and secondary the primary-shield capacitnce is added to the initial primary-ground capacitance and the secondary-shield capacitance is added to the initial secondary-shield capacitance. In this case the capacitive effect is given only by EC2 so the primary-secondary capacitance decreases between 10-100 times. If the shield is grounded the capacitances Cp and Cs have ground like refference.

The path for noises from primary to secondary is Cps capacitance.

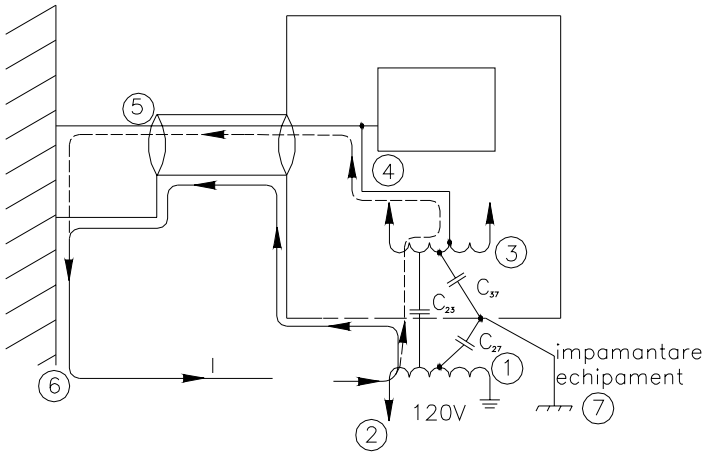

Fig.7. One shield transformer

The shield reduces this capacitance 10-100times and increases total capacitance between phase and neutral of primary and secondary. We observe that is not a complet solution because there are some noises in primary coil and the primary deliveries its in the secondary coil.[2]

b)Two shields solution

Because of competition many factories introduce a second shield like in fig.8.[3]. Noises[2] may be appear in primary supply. With no shield, the capacitance transfers the noises directly from primary to secondary. In case of transformer with one shield the situation supposes that any noise is stopped and no noise reaches to the secondary. Usually isolation

transformer with multiple shields has leakage capacitance without this shield almost 5pF. With shield the biggest part of noise comes back inside protecting tube and does not reach in the secondary coil. There are some noises which circulate in the primary coil. This circulation may appear in the secondary coil. For neutralising this effect a second shield is added.

This shield is connected to one part of primary coil. The path of noises is now between shields and this second shield is shown in fig.9[3].

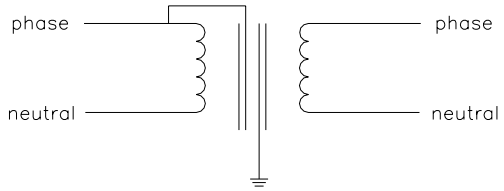

Fig. 8.Two shield solution

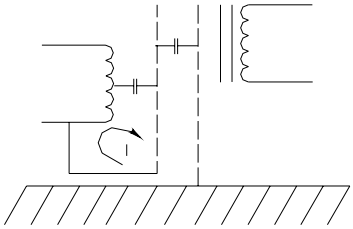

Fig.9.Path of noises

c)Three shields solution

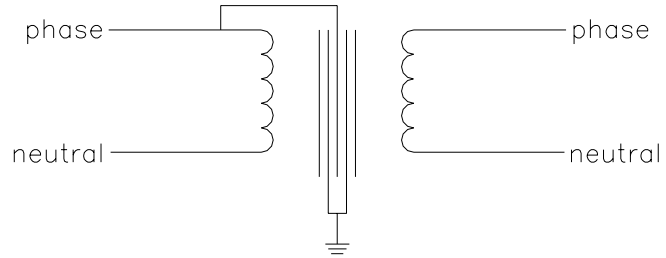

Fig.10.Three shields solution

This type of construction[3] introduces a third shield connected to the ground. In fig.11 is shown this configuration known as the isolation transformer with multiple shields.

This solution is not always necessary. If are asked three shields we must understand how the shields perform.

Noise given by circulation current from the coil to the shield and the noise due leakage capacitance do not reach to the conductive signal. This conexion is shown in fig.11[2].

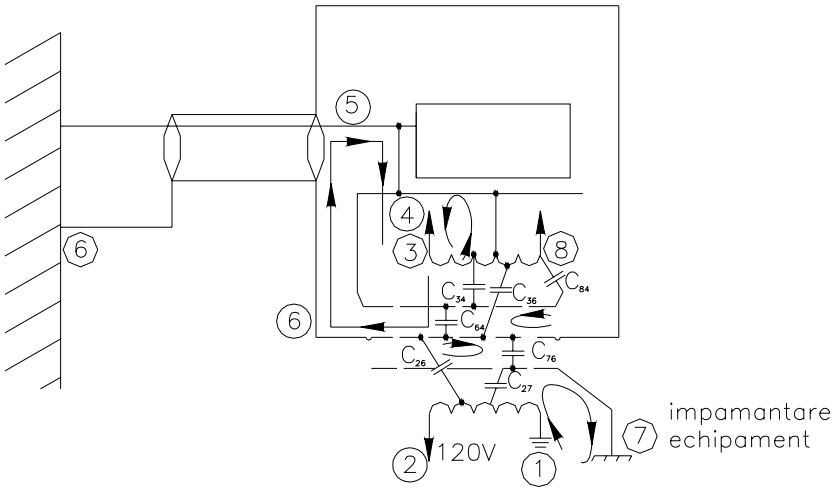

Fig.11. The isolation transformer with multiple shields

C_{34} and C_{27} – direct capacitance coil - shield.

C_{26} and C_{36} - escape capacitance coil– shield.

In the C_{27} capacitance the circulation of current is in 1-2-7-1 sequence.

In the C_{34} capacitance the circulation of current is in 3-4-3 sequence.
In the C_{26} capacitance the circulation of current is in 1-2-6-1 sequence.
In the C_{36} capacitance the circulation of current is in 3-6-5-4-3 sequence.
Also here the current circulates in 6-4, 7-6sequences.[2]

THE TRANSFORMER'S BEHAVIOR TO THE NOISE

In a transformer may appear three forms of noises: common-mode, transverse-mode and electromagnetic radiation.

The common-mode noise appears when the noise current enters by both terminals of the receiver and close by stray capacitances.

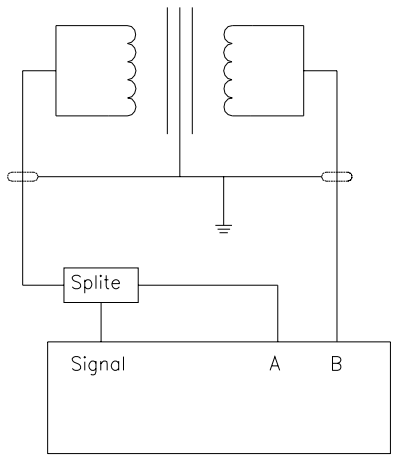

Fig.12. Common-mode measuring scheme

For this type of noise the foreign literature provides a measuring scheme which models circulation current like in the scheme shown in fig.12.[3]

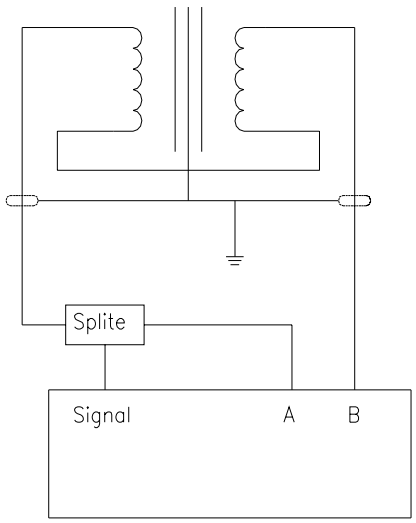

Fig.13. Transverse-mode measuring scheme

The transverse-mode noise appears when the noise current enters by one terminal in the other. For this type of noise the foreign literature provides a measuring scheme which models lines perturbations like the scheme shown in fig.13.[3]

UTILISATION OF THE ISOLATION TRANSFORMER WITH MULTIPLE SHIELDS

Some applications of the isolation transformers multiple shields are:

- **Circuits in the box**
- **Rack circuits**

The conclusion is the following the isolation transformers with multiple shields are absollutly necessary in case we are asked a perfect isolation to the noises.

The paper presents a model of design for this type of transformer when the design theme asks an imposed frequence characteristic and in case this is not asked it may be provided.

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