Building a Low Cost Line Impedance Stabilization Network for EMI Tests

Abstract – In this paper will be presented a methodology for implementation of the Line Impedance Stabilization Network (LISN), of commutable symmetric kind, as the specified on Standard IEC CISPR 16-1, using low cost easily acquirable components in the electro-electronic business. The Line Impedance Stabilization Network is used for conducted EMI tests in equipment’s witch current is not above 16 A.

Keywords: EMI, LISN, EMC and Standards.

I. INTRODUCTION

To perform Conducted Electromagnetic Interference (EMI) [1] test, a laboratory should own, besides an appropriate test area and climate conditions, equipment’s that follows the IEC CISPR 16-1 [2] standards. The principal equipment’s, indispensable for performing the EMI tests are the Line Impedance Stabilization Network and the EMI receiver.

In Conducted EMI tests, whose are detailed at [3], [4] and [5] references, the objective is to determine the interfering voltage, generated by the equipment under test (EUT) that allows to compare the noise with a specific standard, as, for example, the IEC CISPR 14 [6] Standard. The LISN is necessary to allows that the interfered signal be applied at a known impedance in the input power supply terminals of the EUT, the LISN also provides isolation to the EUT and mains and to couple the interfering voltage to the EMI receiver.

In LISN, the impedance measured between each terminal of the tested equipment and ground must keep invariable, independent from the charge connected in their terminals, even when it is a short circuit, with a measure receiver connected or an equivalent resistance.

The proposed LISN is a commutable symmetric kind, it means, the user can perform measures as well as in the phase or in the neutral terminal, just changing the key position. The presented example has as his most significant characteristic a 50 Ω impedance associated in parallel with a 50 μH inductor associated in series with a 5 Ω resistance.

II. BUILDING A LINE IMPEDANCE STABILIZATION NETWORK

To build a LISN as the description presented in this paper, results in a significant economy in the implementation of an EMI Laboratory, because in the end we will achieve an LISN for Conducted EMI tests with about 80% lower cost from a commercial one.

The Line Impedance Stabilization Network is presented in Figure 1. Table I presents the list of components of the LISN.

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>5 Ω</td>
</tr>
<tr>
<td>R2</td>
<td>10 Ω</td>
</tr>
<tr>
<td>R3</td>
<td>1000 Ω</td>
</tr>
<tr>
<td>R4</td>
<td>50 Ω</td>
</tr>
<tr>
<td>R5</td>
<td>50 Ω (measure instrument impedance)</td>
</tr>
<tr>
<td>C1</td>
<td>8 μF</td>
</tr>
<tr>
<td>C2</td>
<td>4 μF</td>
</tr>
<tr>
<td>C3</td>
<td>0.25 μF</td>
</tr>
<tr>
<td>L1</td>
<td>50 μF</td>
</tr>
<tr>
<td>L2</td>
<td>250 μF</td>
</tr>
</tbody>
</table>

The Line Impedance Stabilization Networks impedance is defined by the following components: L1, C1, R1, R4 and R5. An optional input filter should be necessary if the mains is not well fitted. In this case its components are L2, C2 and R2.

The capacitors C1 and C2 are AC capacitors, mostly adopted in AC motors (polypropylene), achieving the low cost budget.

Subsequently C1 and C3 have high capacitance values. For safety reasons the apparatus should be ground connected.

In the frequency range from 9 kHz to 150 kHz the inductance L2 should have a Q-factor not less than 10. The inductors L2 are coupled inductors, forming a common-core choke in order to block the common mode EMI.
III. BUILDING THE INDUCTOR

The L1 inductor is a coil with 35 turns, shaping one only layer of Ø6mm enameled wire. The step of this turn is 8 mm, rolled in an isolating core of 130 mm or 5 inches as the IEC CISPR 16-1 [2] standard indicates.

The wire diameter is the dimension that considers minimizing the inductors resistive component. However, the coil built was fashioned using a Ø4 mm wire, because the current from the tests equipments is under 5A.

The core was fashioned with a Ø150 mm commercial PVC pipe with 280 mm length. The reduction of this diameter was obtained with a longitudinal slice taking off a 63 mm band. Inside the core, it was placed a Ø75 mm tube and the space between this tube and the Ø150 mm pipe was filled with expanded polyurethane to achieve a good mechanical resistance as showed in Figure 2.

The step rolling control of the inductor was made using a Ø4 mm fishing string (nylon) between each turn.

To suppress internal resonance in this inductor the IEC CISPR 16-1 [2] standard, establishes that 430 Ω ± 10% being connected between the turns 4 and 8, 12 and 16, 20 and 24 and 26 and 32 as showed in Figure 3 and in detail in Figure 4.
To hold the resistors to the coil, the enameled wire was scraped on the turns indicated by the scheme in Figure 3. After welding, it was applied a thermal glue to improve the mechanical stability of the components.

IV. THE CHASSIS

The inductor and the other components must be assembled inside a metallic chassis. The base and the sides may be punched to allow heat dissipation when it is necessary. The suggested dimensions by the Standard are 360 x 300 x 180 mm, Figure 5. In the present design was used a microcomputer case, with dimensions 380 x 320 x 180 mm, as showed in Figure 6.

V. LINE IMPEDANCE STABILIZATION NETWORK VALIDATION

The Line Impedance Stabilization Network should have equivalent impedance presented in Figure 7, with a 20% tolerance as described in the Standards. The validation of the assembled Line Impedance Stabilization Network was made with aide of a signal generator and a measuring signal levels instrument, besides a pattern terminal of 50 Ω.

To execute the validation, the signal generator was adjusted to 9 kHz and the attenuation, caused by the Line Impedance Stabilization Network, was measured. The process was repeated in others frequencies, evaluating the frequency band that the equipment will be used. With the results, a graphic was built as showed in the figure 8.
The maximum tolerance is ± 20 %

**Figure 7** - Impedance of Line Impedance Stabilization Network as agreeing with Standard.

The results obtained with the Line Impedance Stabilization Network show that the impedance is out of the specified values by the standard to frequencies under 20 kHz. To solve this problem better capacitors should be used. Our main objective in this work is to use low cost and easy acquirable components.

The obtained results do not make unpractical the implemented LISN, because the equipment that are going to be tested, usually, works with frequencies above 20 kHz, where the proposed, low cost, Line Impedance Stabilization Network achieve its objectives.

**VI. CONCLUSIONS**

The main point of this work is in the fact of making more accessible the tests realization, diminishing the assembling costs in EMI testing laboratories, reflecting even by academic or industrial environment.

The components utilized to build the Line Impedance Stabilization Network are easily acquired, at local stores, because they are not specific for this usage.

The only problem to use Line Impedance Stabilization Networks is the calibration factor. However it is also necessary, for commercial equipment’s, to guarantee that the measures are correct, it is essential to track the equipment’s to known patterns internationally recognized.

**VII. BIBLIOGRAPHIC REFERENCES**


[6] IEC CISPR 14, Limits and methods of measurement of radio disturbance characteristics of electric motor-operated and thermal appliances for household and similar purposes, electric tools and electric apparatus, 3 ed - amendment 1, Aug.1996.