The Analysis and Design of Line Impedance Stabilization Network for an In-house Laboratory

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ABSTRACT

The analysis and design of Line Impedance Stabilization Network (LISN) is presented. The details will be described how to design and stabilize the impedance of LISN at frequency range 150 kHz to 30 MHz following CISPR 16-1 standard. The impedance response of passive components: resistor, inductor and capacitor will be measured to identify the component parasitic. The comparison of simulated and measured result will be done and analyzed. The low cost and good impedance of the response are achieved, for in-house test, comparing to CISPR standard and also with commercial LISN.

Keywords: LISN, AMN, EMI, EMC

1. INTRODUCTION

It is well known that the Line Impedance Stabilization Network (LISN) or artificial mains network (AMN) is one of the measurement devices for measuring the conducted EMI. According to CISPR 16-1, LISN or AMN has to fulfill three functions: firstly, to maintain the impedance over the working frequency range to the equipment under test (EUT). Secondly, to filter incoming Radio Frequency (RF) noise from the mains supply and finally, to provide a matched 50 ohm RF connection to the EMI receiver [1-2].

This paper focuses on how to design the artificial mains 50 \(\Omega\)/50 \(\mu\)H + 5 \(\Omega\) V-network following CISPR 16-1 step-by-step with the low cost consideration. Furthermore, to guarantee the performance of simplified LISN, the component characteristics at high frequency, impedance analysis by PSpice simulation program is compared with the measured results. The measured results of conducted EMI compared between the standard LISN and simplified LISN and the safety operating current of simplified LISN will be proved.

2. THE SCHEMATIC OF SIMPLIFIED LISN

According to CISPR 16-1, the example of artificial mains 50 \(\Omega\)/50 \(\mu\)H + 5 \(\Omega\) V-network and component values are shown in Fig. 1 and Table 1, respectively [1].
### Table 2: Simplified LISN component values

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>R&lt;sub&gt;1&lt;/sub&gt;, R&lt;sub&gt;2&lt;/sub&gt;</td>
<td>3,900 Ω (1 W)</td>
</tr>
<tr>
<td>R&lt;sub&gt;3&lt;/sub&gt;, R&lt;sub&gt;4&lt;/sub&gt;</td>
<td>5 Ω (5 W)</td>
</tr>
<tr>
<td>R&lt;sub&gt;5&lt;/sub&gt;, R&lt;sub&gt;6&lt;/sub&gt;</td>
<td>3,900 Ω (1 W)</td>
</tr>
<tr>
<td>R&lt;sub&gt;7&lt;/sub&gt;</td>
<td>50 Ω (1/2 W)</td>
</tr>
<tr>
<td>R&lt;sub&gt;8&lt;/sub&gt;</td>
<td>1,000 Ω (1/2 W)</td>
</tr>
<tr>
<td>C&lt;sub&gt;1&lt;/sub&gt;, C&lt;sub&gt;2&lt;/sub&gt;</td>
<td>3 µF</td>
</tr>
<tr>
<td>C&lt;sub&gt;3&lt;/sub&gt;, C&lt;sub&gt;4&lt;/sub&gt;</td>
<td>8 µF</td>
</tr>
<tr>
<td>C&lt;sub&gt;5&lt;/sub&gt;, C&lt;sub&gt;6&lt;/sub&gt;, C&lt;sub&gt;7&lt;/sub&gt;</td>
<td>0.47 µF</td>
</tr>
<tr>
<td>L&lt;sub&gt;1&lt;/sub&gt;, L&lt;sub&gt;2&lt;/sub&gt;</td>
<td>250 µH</td>
</tr>
<tr>
<td>L&lt;sub&gt;3&lt;/sub&gt;, L&lt;sub&gt;4&lt;/sub&gt;</td>
<td>50 µH</td>
</tr>
</tbody>
</table>

In Fig. 2 and Table 2 are presented the simplified LISN schematic and component values similar with the CISPR 16-1. Fig. 3 shows the top view of the Simplified LISN.

3. **THE INDUCTOR AND CAPACITOR CHARACTERISTICS AT HIGH FREQUENCY**

Normally, the LISN is composed of a passive devices; inductors, capacitors and resistors. This section will show the impedance characteristics of devices as a function of frequency range from 150 kHz to 30 MHz. In the final paper, the procedure to evaluate the inductors, complied with CISPR 16, will be provided in the details.

**Inductors**

The inductance of L<sub>1</sub> and L<sub>2</sub> are 250 µH measured by impedance analyzer. The design inductor is shown in Fig. 4 and Fig. 5 is the measured impedance characteristics of the inductors.

**Capacitors**

There are two types of the capacitors that used in simplified LISN; the metallized polypropylene AC (C<sub>1</sub> - C<sub>4</sub>) and the metallized polyester (C<sub>5</sub> - C<sub>7</sub>). C<sub>1</sub> and C<sub>2</sub> are 3 µF, C<sub>3</sub> and C<sub>4</sub> are 8 µF and C<sub>5</sub>, C<sub>6</sub> and C<sub>7</sub> are 0.47 µF. The capacitor as shown in Fig. 7 is composed of capacitance (C), parasitic resistance (R<sub>p</sub>) and parasitic inductance (L<sub>p</sub>). Figs. 8 - 10 show the characteristics of C<sub>1</sub> to C<sub>7</sub>, respectively.
Fig. 7: Equivalent circuit of a capacitor at high frequency

Fig. 8: Measured impedance characteristics of C1 and C2

Fig. 9: Measured impedance characteristics of C3 and C4

Fig. 10: Measured impedance characteristics of C5 to C7

The capacitances of C1 and C2 are 3 µF in frequency range 150 kHz to 315 kHz. C3 and C4 are 8 µF in frequency range 50 Hz to 115 kHz and C5 – C7 are 0.47 µF in frequency range 150 kHz to 985 kHz.

4. SIMULATION

The simulated circuit of simplified LISN, neglected the effect of parasitic elements, is shown in Fig. 11. The AC sweep function of PSpice program is used to simulate the impedance at EUT port.

Fig. 11: Simulated circuit by PSpice program

Fig. 12: The impedance at EUT connector

The simulated result is shown in Fig. 12. The curve increases rapidly in frequency range 30 kHz to 300 kHz and after that the curve provides the stabilized impedance about 48 Ω until 30 MHz. The simulated result of simplified LISN shows stabilized impedance following standard in frequency range of 150 kHz to 30 MHz.

5. FINAL PAPER

- In the final paper, the procedure for designing the inductors in single layer and multi layers complied with CISPR 16-1 standard will be presented.
- The temperature limitation of simplified LISN will be proved by testing with various operating current for guarantee the temperature safety operating of the simplified LISN.

6. REFERENCES