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

D. Sakulhirirak[1], V. Tarateeraseth[2], W. Khan-ngern[1]

[1]King Mongkut's Institute of Technology Ladkrabang (KMITL),
Research Center for Communications and Information Technology (ReCCIT),
Faculty of Engineering, Bangkok, Thailand, E-mail: kkveerac@kmitl.ac.th
[2]Srinakharinwirot University, Faculty of Engineering, Ongkharak, Thailand, E-mail: vuttipon@swu.ac.th

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 Ω/50 μH + 5 Ω 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 Ω / 50 μH + 5 Ω V-network and component values are shown in Fig. 1 and Table 1, respectively [1].

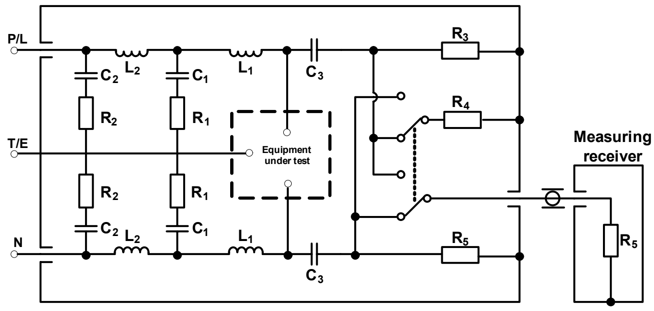

Fig.1: *An artificial mains 50 Ω / 50 μH + 5 Ω V-network*

Table 1: *Components and values of 50 Ω / 50 μH + 5 Ω V-network*

Component	Value
R_1	5 Ω
R_2	10 Ω
R_3	1,000 Ω
R_4	50 Ω
R_5	50 Ω (input impedance the measuring receiver)
C_1	8 μF
C_2	4 μF
C_3	0.25 μF
L_1	50 μH
L_2	250 μH

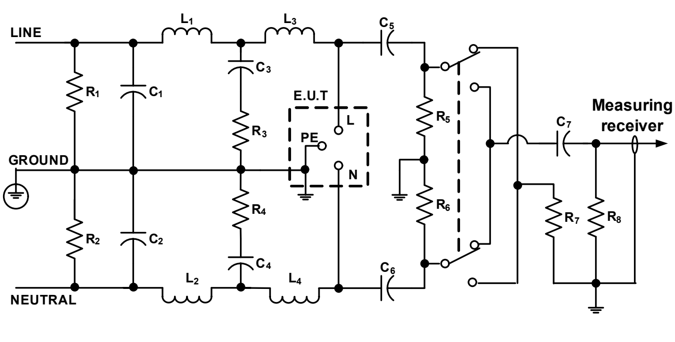

Fig.2: *The schematic of simplified LISN*

Table 2: *Simplified LISN component values*

Component	Value
R_1, R_2	3,900 Ω (1 W)
R_3, R_4	5 Ω (5 W)
R_5, R_6	3,900 Ω (1 W)
R_7	50 Ω (1/2 W)
R_8	1,000 Ω (1/2 W)
C_1, C_2	3 μF
C_3, C_4	8 μF
C_5, C_6, C_7	0.47 μF
L_1, L_2	250 μH
L_3, L_4	50 μH

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.

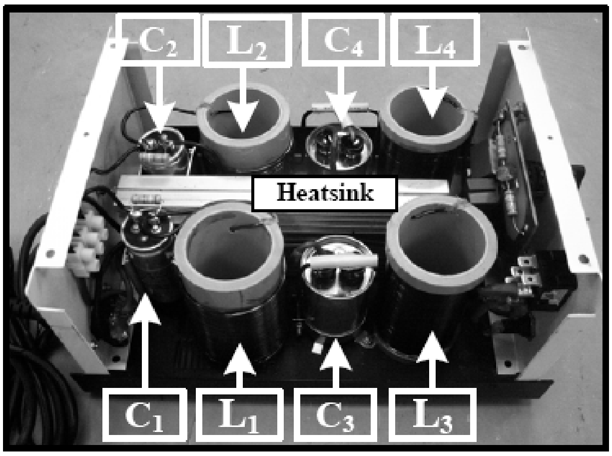

Fig.3: *Top view of the simplified LISN*

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_1 and L_2 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.

Fig.4: *The design inductor*

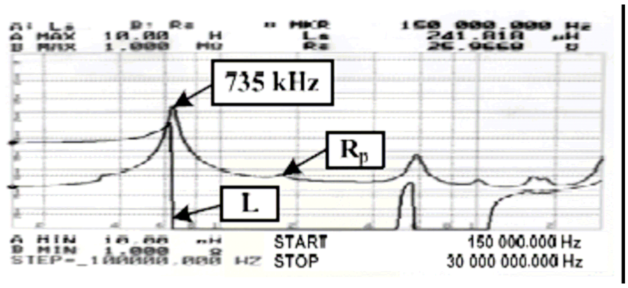

Fig.5: *Measured impedance characteristics of L_1 and L_2*

Inductance of L_1 and L_2 are about 250 μH before 250 kHz approximately. Subsequently, the self resonant frequency (SRF) of L_1 and L_2 is around 735 kHz.

The inductance and parasitic resistance inside inductors L_1 - L_4 are shown in Fig. 5 - 6. Inductance of L_3 and L_4 are about 50 μH at frequency 6 MHz and the SRFs are 17 MHz by approximately as shown in Fig. 6.

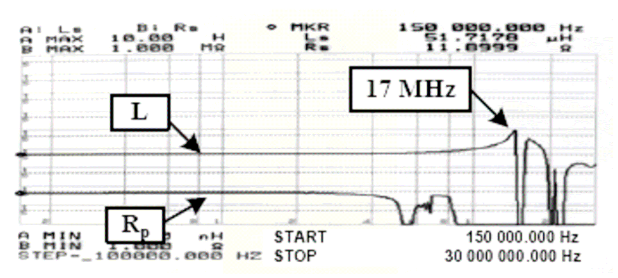

Fig.6: *Measured impedance characteristics of L_3 and L_4*

Capacitors

There are two types of the capacitors that used in simplified LISN; the metallized polypropylene AC (C_1 - C_4) and the metallized polyester (C_5 - C_7). C_1 and C_2 are 3 μF, C_3 and C_4 are 8 μF and C_5, C_6 and C_7 are 0.47 μF. The capacitor as shown in Fig. 7 is composed of capacitance (C), parasitic resistance (R_p) and parasitic inductance (L_p). Figs. 8 - 10 show the characteristics of C_1 to C_7, respectively.

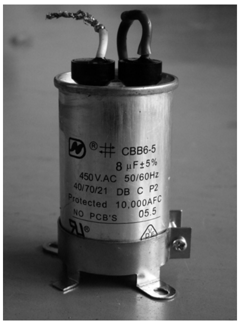

Fig.7: *Equivalent circuit of a capacitor at high frequency*

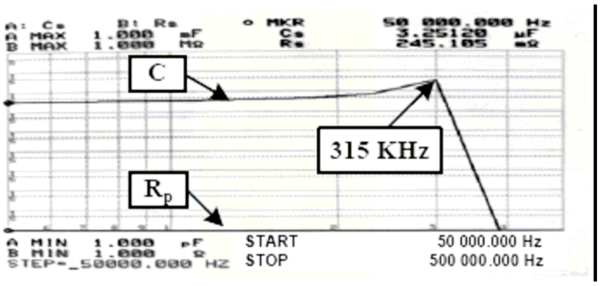

Fig.8: *Measured impedance characteristics of C_1 and C_2*

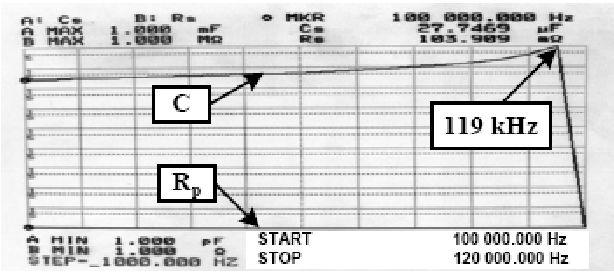

Fig.9: *Measured impedance characteristics of C_3 and C_4*

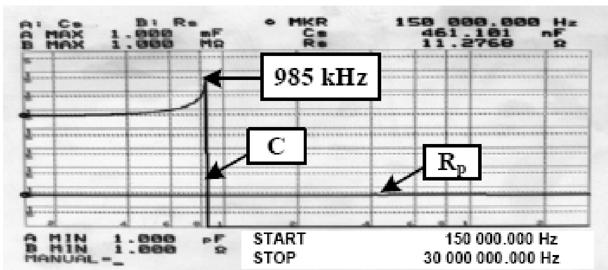

Fig.10: *Measured impedance characteristics of C_5 to C_7*

The capacitances of C_1 and C_2 are 3 µF in frequency range 150 kHz to 315 kHz. C_3 and C_4 are 8 µF in frequency range 50 Hz to 115 kHz and C_5 – C_7 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.

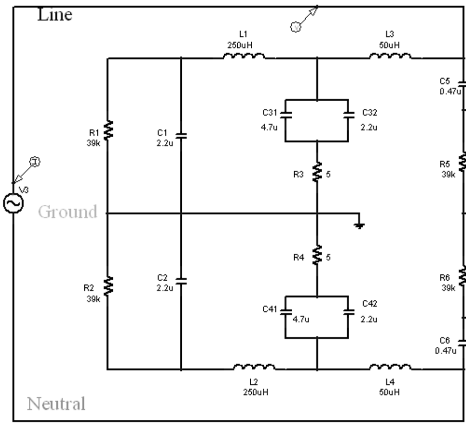

Fig.11: *Simulated circuit by PSpice program*

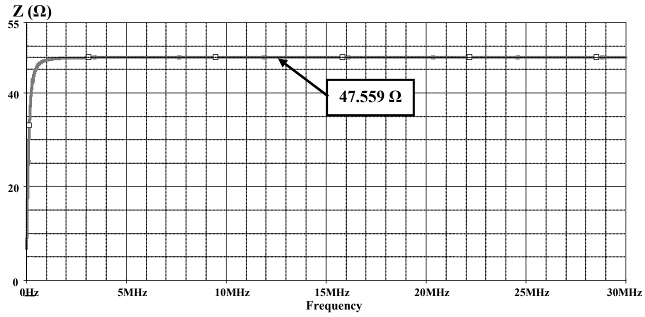

Fig.12: *The impedance at EUT connector*

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

[1] *C.I.S.P.R. Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods*, International Electrotechnical Commission, Geneva, Switzerland, 1999.

[2] David Morgan, *A handbook for EMC testing and measurement.* Peter Peregrinus Ltd., 1994.

[3] Laszlo Tihanyi, *Electromagnetic compatibility in Power Electronics,* IEEE Press, 1995.

[4] *Unplasticized polyvinyl chloride pipes for drinking water services,* TIS 17-2532, 1989.

[5] W. Khan-ngern and V. Tarateeraseth*, Power Electronics (in Thai), V. J. Printing, 3rd edition, 2004*