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Enhanced the Efficiency of Electronics Circuit by using Line Impedance Stabilization Network

Md. Farooque Azam[1] and Brijendra Mishra[2]

Department of ECE[1,2]

Nagaji Institute of Technology & Management Gwalior, MP, India

Abstract: *A Line Impedance Stabilization Network (LISN) is a crucial tool in the field of electromagnetic compatibility (EMC) testing and measurement. Its primary purpose is to ensure that conducted emissions from electrical and electronic devices are accurately measured in a controlled and standardized manner. After both circuit simulation in LTSpice firstly input noise simulation without LISN in first circuit and after that second circuit simulation in which we simulate input noise simulation with LISN we reached on the final conclusion is that by stabilizing the impedance of the power supply line, LISNs help filter out external interference and noise, allowing for precise measurements of the emissions generated by the DUT. They provide a standardized impedance interface between the device under test (DUT) and the measuring equipment, ensuring consistent and repeatable EMC testing results. We get desired result after simulation when we analysis both circuit simulation in details we get 33% improvement in frequency, noise decreases in terms of frequency and we get 3% improvement in power at output in LISN applying circuit.*

Keywords: Advanced Design System (ADS), Artificial Mains Network (AMN), Radio Frequcency (RF), Line Impedance Stabilization network (LISN), Electromagnetic Compatibility (EMC), Electromagnetic Interference (EMI)

I. INTRODUCTION

Line Impedance Stabilization Networks (LISNs) are essential tools in the field of electromagnetic compatibility (EMC) testing for electronic devices. These networks play a crucial role in ensuring that electronic circuits and devices comply with regulatory standards by providing a standardized way to measure conducted emissions and susceptibility to electromagnetic interference (EMI). In this article, we will delve into the fundamentals of LISNs, their significance in electronics testing, and how they are applied in circuits.Electromagnetic Compatibility (EMC) refers to the ability of electronic devices to function properly without generating or being affected by electromagnetic interference (EMI). EMI is the unwanted electromagnetic radiation or disturbance that can disrupt the operation of electronic equipment, leading to malfunctions, data corruption, or safety hazards.EMC testing is crucial to ensure that electronic devices meet regulatory requirements and can coexist in the same electromagnetic environment without causing or suffering from interference. EMC testing involves two primary aspects: conducted emissions and susceptibility testing. Conducted emissions testing assesses the electromagnetic noise generated by a device and emitted through its power and signal cables. Susceptibility testing evaluates a device's immunity to external EMI.LISNs are specialized components used in conducted emissions testing to ensure accurate and repeatable measurements. They serve two primary purposes. LISNs provide a standardized and well-defined interface between the electronic device under test (DUT) and the measurement equipment, such as spectrum analyzers and EMC receivers. This standardization ensures that measurements are consistent and can be compared across different test setups and laboratories.Separate the DUT from the power source: A key function of LISNs is to isolate the DUT from the power source and create a controlled impedance path for the measurement equipment to monitor the conducted emissions. This isolation prevents reflections and ensures that emissions measured are solely from the DUT, not from the power grid.[1][2][3][4][5]

The input filter is designed to attenuate common-mode and differential-mode noise from the power line, allowing only the conducted emissions of interest to reach the DUT. It often includes capacitors, inductors, and resistors to achieve this.The AMN is a network that simulates the impedance of the power grid, typically 50 ohms in Europe and 50/60 ohms in North America. It ensures that the DUT is exposed to the same impedance as it would encounter in real-world

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operation.The DUT is connected to the output of the LISN. This connection is made through coaxial cables and connectors, ensuring that the DUT's emissions are captured accurately.Measurement Equipment: Spectrum analyzers or EMC receivers are connected to the LISN's output to capture and analyze the conducted emissions from the DUT. LISNs are widely used in various stages of electronic circuit development, testing, and certification. Pre-compliance Testing: Engineers use LISNs during the development phase to assess a device's EMC performance before formal compliance testing. This allows for early detection of potential EMI issues, reducing design iteration cycles and development costs.When seeking regulatory approval, electronic devices are subjected to formal EMC compliance testing. LISNs are indispensable in this process to ensure that the conducted emissions are measured accurately and meet the specified limits set by regulatory bodies like the Federal Communications Commission (FCC) in the United States or the European Union's CE directives. In cases where a device fails EMC testing, LISNs are invaluable tools for pinpointing the source of EMI and diagnosing potential remedies. By isolating conducted emissions, engineers can identify problematic areas within the circuit and apply mitigation techniques effectively.Manufacturers incorporate LISNs into their production lines to perform ongoing quality control checks, ensuring that every unit meets EMC requirements. This helps maintain product consistency and prevents non-compliant devices from reaching the market.[6][7][8]

II. RELATED WORKS

While Line Impedance Stabilization Networks (LISNs) may not be directly integrated into electronics circuit methodology, their role in EMC testing profoundly influences the design and development of electronic circuits. By ensuring accurate and standardized measurements of conducted emissions, LISNs guide design decisions, influence component selection, and enable iterative testing and validation. The application of LISNs enhances the overall quality, reliability, and regulatory compliance of electronic products, ultimately benefiting both electronics engineers and manufacturers. As the electronics industry continues to evolve, the importance of EMC testing with LISNs remains steadfast in ensuring the electromagnetic compatibility of electronic devices in an increasingly interconnected world. We design two circuits in LTSpice software for analysis the result. In first circuit we simulate input noise without LISN and in second circuit we simulate input noise with LISN.[9]10][11]

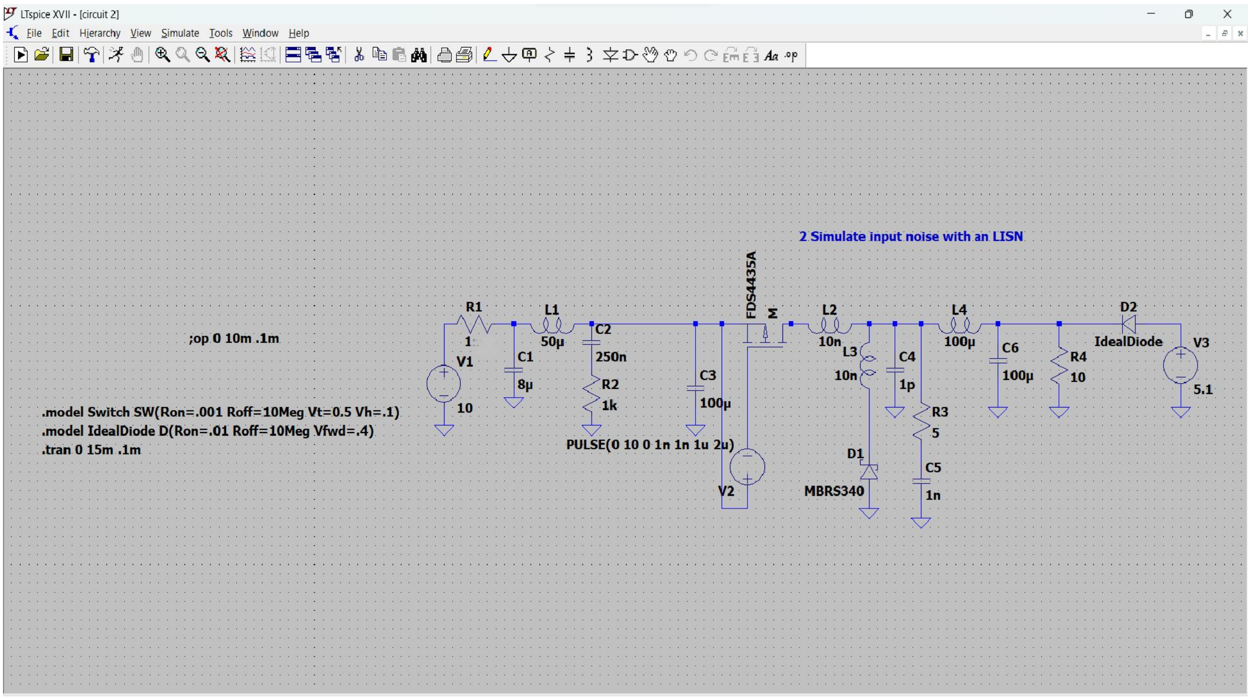

Figure 1 Simulate input noise circuit with LISN circuit

Circuit given in figure 1 we simulate input noise with LISN in LTSpice software. A Line Impedance Stabilization Network (LISN) is an essential tool used in electromagnetic compatibility (EMC) testing to measure and control the

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electromagnetic interference (EMI) generated by electronic devices. It provides a standardized way to couple the device under test (DUT) to the power line and measure the conducted emissions. LISN designs can vary depending on specific standards and requirements, so it's essential to refer to relevant standards and consult with experts for your specific needs.[12][13][14]

LISN implementation can be complex, especially when designed for compliance with specific EMC standards. It's essential to consult the relevant standards (such as CISPR 16) for detailed guidelines and specifications. Additionally, for accurate results, calibration and periodic verification of the LISN are necessary. It is recommended to work with professionals experienced in EMC testing for precise and reliable results.[15][16][17]

TABLE 1 Line Impedance Stabilization Networks (LISN) Parameters

Parameter	Unit	Value
L	[μH]	50
C	[μF]	8
C	[nF]	250
R	[Ω]	1

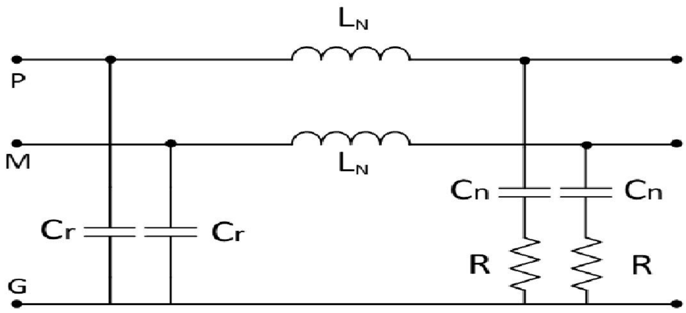

Figure 2 LISN BASIC DIAGRAM

Line Impedance Stabilization Network is a device commonly used in EMI measurements. Its role is to provide a precise impedance value deigned by the standard in a required frequency range (typically from 150kHz up to 30MHz). Moreover, LISN acts as a low-pass filter separating the source grid from the EUT which allows to measure only disturbances generated by the device. LISN used in the study is the one designed and its role is to simulate the real grid impedance in the circuit. In the analyzed grid, LISN is connected between EMI filters of the converters and DC voltage source. Parameters of LISN are presented below.[18][19]

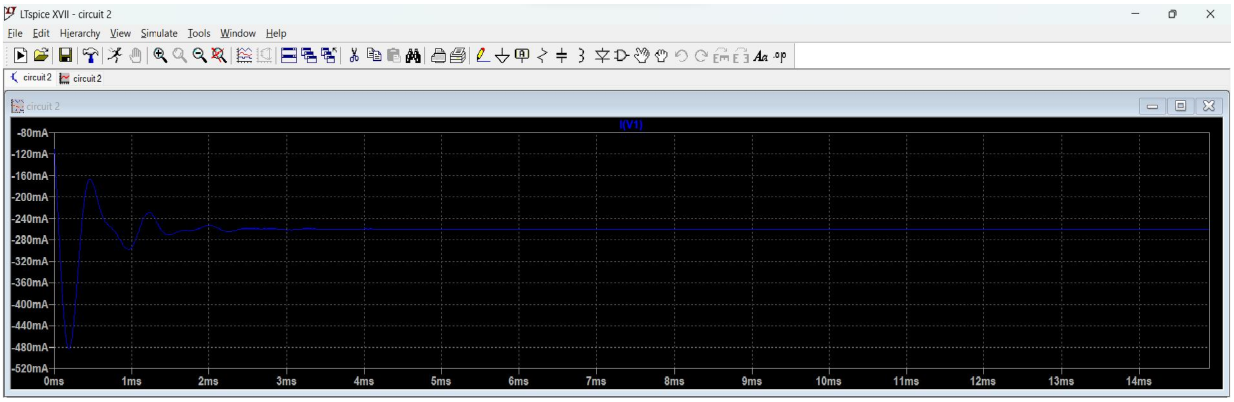

Figure 3 Current of input voltage V_1

Current of input voltage V_1 given in figure 3 which shows the stability improvement.

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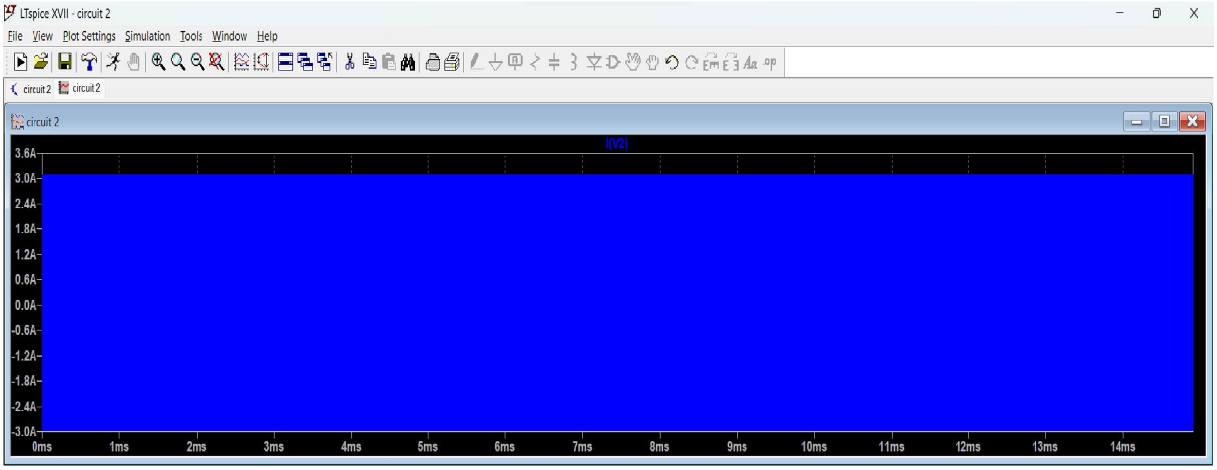

Figure 4 Current of voltage V_2

Current of voltage V_2 given in figure 4 shows the decreased stability. noise generated at current of voltage V_2

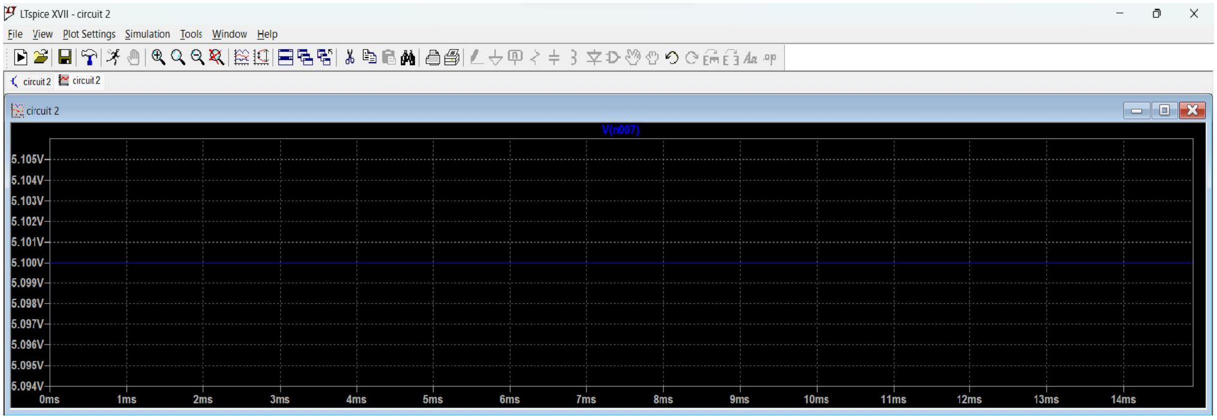

Figure 5 Stable Voltage of V_{n007}

We analysis the voltage of V_{n007} which given in figure 5 we found that stability of the voltage increased. Figure 5 shows the true more accurate stability graph of the voltage V_{n007} is given in figure 5 we get 5.11 Volt which is accurate stable voltage.

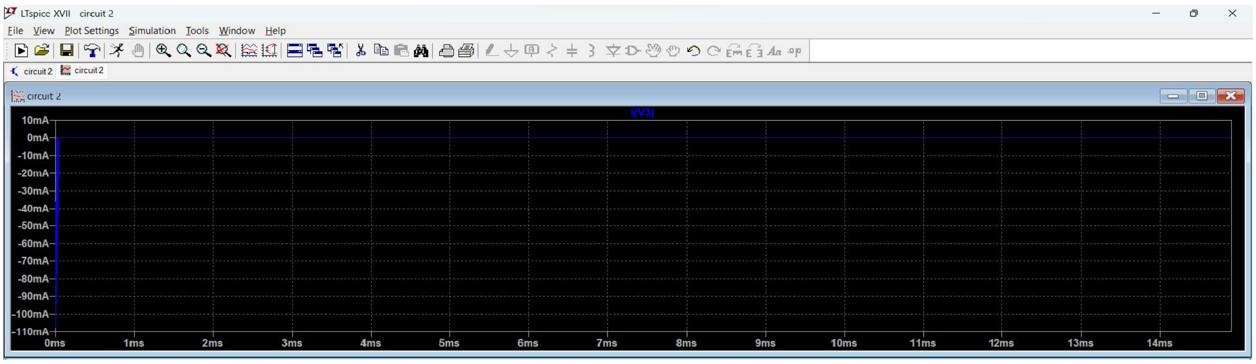

Figure 6 Current of output voltage V_3

Current of output voltage V_3 given in figure 6 which shows the stable position of the current in figure 6. Noise decreases at the output voltage V_3

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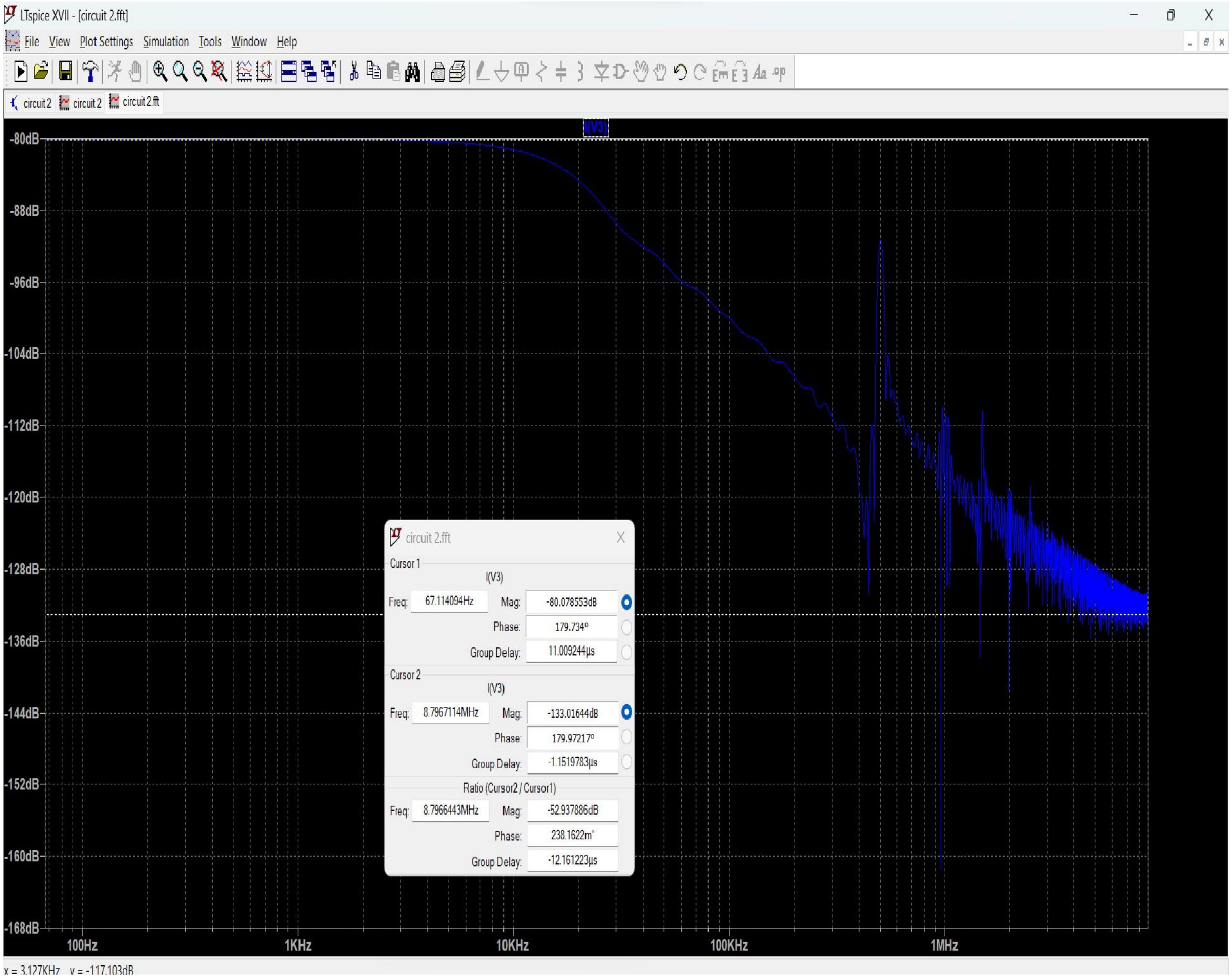

Figure 7 Frequency range without LISN at V_3

In figure 7 we analysis the frequency range by LTSpice toolkit which given at cursor 1 is 67 Hz to 8.79 MHz at cursor 2. So the frequency range of circuit with LISN lies in the range of 67 Hz to 8.79 MHz. which shows the 33% improvement in the frequency compared to without applying LISN in the circuit. its shows significant improvement in noise compared to without applying LISN in the circuit.

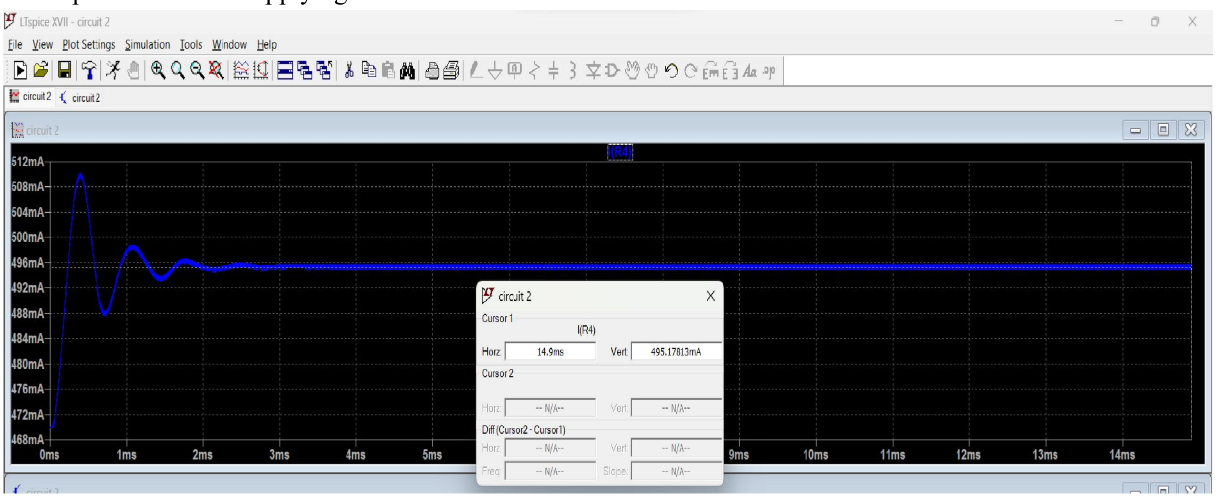

Figure 8 Stable Current of Resistance R_4

Stability of resistance R_4 current increases in figure 8 resistance R_4 current become stable in figure 8 and we get more stability with the use of LTSpice toolkit we get 496 mA stable current accurate value. We reached on the conclusion that we get enhanced power nearly 3% at the output when we applied LISN and simulate noise with LISN compared to without LISN result.

TABLE 2 SIMULATION TABLE

RESULT	SIMULATION WITH OUT LISN	SIMULATION WITH LISN	IMPROVMENT
Output Voltage	5.09 volt	5.11 volt	1%
Output Current	480 mA	496 mA	3%
Power	2.45 W	2.55 W	3%
Output Frequency	102 Hz to13.23 MHz	67 Hz to 8.76 MHz	33%
Output Noise	-77 dB to -131 dB	-80 dB to -133 dB	-3 dB reduction

In this simulation we take two circuit in first circuit we simulate input noise without LISN we get output voltage 5.09 volt after that we simulate input noise with LISN we get output voltage 5.11 volt when compare both result we get 1% improvement in from power at the output in LISN based circuit. When we analysis the output current of both result we get 480 mA current from without LISN and 496 mA from with LISN so we get 3% more current at output by with LISN compared to without LISN when we calculate the power of both result we get 2.45 Watt power from without LISN and 2.55 from with LISN we get 3% efficiency from with LISN compared to without LISN we get output frequency range from 102 Hz to 13.23 MHz from without LISN and 67 Hz to 8.76 from with LISN so when we analysis the both result. frequency range we get 33% less frequency range from with LISN compared to without LISN so LISN decreases the frequency efficiently so noise decreases efficiently LISN gives good result when we analysis both circuit we get -3 dB reduction in noise in in which we applied LISN compared to without LISN. so when we analysis both result noise value at output we found that 33% difference in frequency range in with LISN compared to without LISN. we get desired result. Line Impedance Stabilization Networks (LISNs) are indispensable tools in the field of electromagnetic compatibility (EMC) testing for electronic circuits and devices. By providing a standardized interface, isolating the device under test (DUT) from the power source, and enabling accurate conducted emissions measurements, LISNs ensure that electronic products meet regulatory requirements and perform reliably in the presence of electromagnetic interference (EMI).Engineers and manufacturers must understand the role of LISNs in EMC testing and consider their application throughout the product development lifecycle. While challenges such as cost and complexity exist, the benefits of using LISNs in electronics circuits are clear: improved product quality, faster time to market, and compliance with regulatory standards, ultimately leading to greater customer satisfaction and trust in electronic products.

III. CONCLUSION

Line Impedance Stabilization Networks (LISNs) are indispensable tools in the field of electromagnetic compatibility (EMC) testing for electronic circuits and devices. By providing a standardized interface, isolating the device under test (DUT) from the power source, and enabling accurate conducted emissions measurements, LISNs ensure that electronic products meet regulatory requirements and perform reliably in the presence of electromagnetic interference (EMI).Engineers and manufacturers must understand the role of LISNs in EMC testing and consider their application throughout the product development lifecycle. While challenges such as cost and complexity exist, the benefits of using LISNs in electronics circuits are clear: improved product quality, faster time to market, and compliance with regulatory standards, ultimately leading to greater customer satisfaction and trust in electronic products..

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