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A Review on the Characteristics of 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 an essential component in electromagnetic compatibility (EMC) testing and measurement. Its primary purpose is to provide a standardized interface between electronic devices, such as radios, computers, and other electrical equipment, and the power supply grid during conducted emissions testing. A LISN is designed to facilitate accurate and repeatable measurements of electromagnetic interference (EMI) generated by electronic devices when they are connected to the power supply grid. It serves as an essential tool for assessing the compliance of electronic equipment with EMC standards and regulations. A low-pass filter within the LISN helps remove high-frequency noise and disturbances from the power supply, allowing only the emissions of interest to pass through for measurement. a Line Impedance Stabilization Network (LISN) is a critical tool for EMC testing and measurement, providing a standardized and controlled interface between electronic devices and the power supply grid. It enables the assessment of conducted emissions from electronic equipment, helping manufacturers ensure their products comply with EMC regulations and minimizing the risk of interference with other devices and systems.*

Keywords: A Line Impedance Stabilization Network (LISN), electromagnetic interference (EMI)), electromagnetic compatibility (EMC), Equipment under test (EUT), Device under test (DUT)

I. INTRODUCTION

The proliferation of electronic devices in modern society has led to an increasing concern about electromagnetic interference (EMI). EMI can disrupt the operation of electronic systems, leading to malfunctions, data corruption, or even safety hazards. To mitigate EMI and ensure the reliable operation of electronic equipment, stringent electromagnetic compatibility (EMC) standards and regulations have been established worldwide.

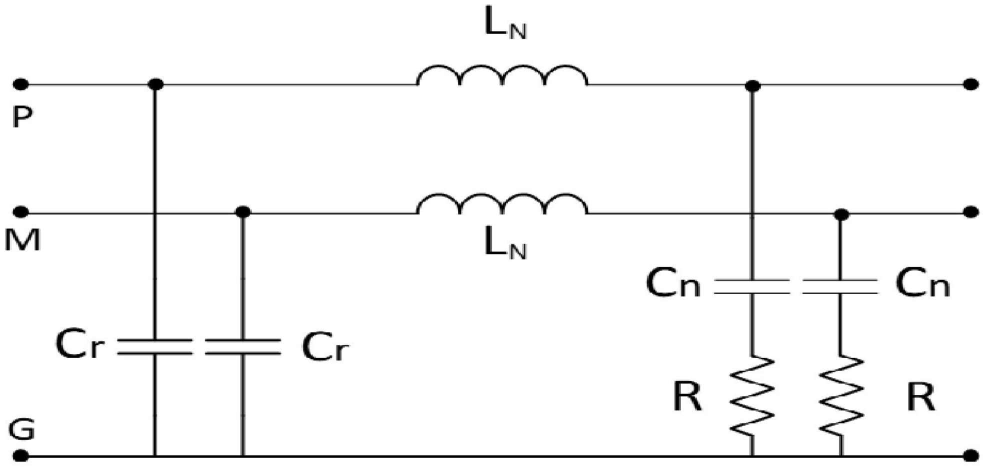

Figure 1 LISN basic diagram

A fundamental component in EMC testing and measurements is the Line Impedance Stabilization Network (LISN). LISNs play a pivotal role in assessing the conducted emissions and susceptibility of electronic devices, helping manufacturers comply with regulatory standards and ensure their products do not interfere with other devices on the

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power grid. This comprehensive guide explores the LISN in detail, including its types and diverse applications. Electromagnetic Compatibility (EMC) refers to the ability of electronic and electrical systems, devices, and equipment to function correctly in their intended electromagnetic environment without causing interference to other systems. In a world where electronic devices are ubiquitous, ensuring EMC is vital for several reason they are EMC ensures that electronic devices do not interfere with each other, minimizing the risk of malfunctions and data corruption. In critical applications, such as medical devices or aviation, EMC is crucial for ensuring the safety of equipment and personnel. Many countries have established EMC standards and regulations that manufacturers must adhere to. Compliance is necessary to market electronic products. Ensuring EMC improves the reliability and longevity of electronic equipment by protecting them from external.[1][2][[3]

II. SOURCES OF ELECTROMAGNETIC INTERFERENCE (EMI)

Electromagnetic interference (EMI) can emanate from various sources, including: This type of interference occurs when electromagnetic energy is emitted from a device and travels through the air. Radiated EMI can originate from antennas, unshielded cables, and poorly designed circuitry. Conducted EMI travels through conductors, such as power lines or signal cables. It can be generated by digital circuits switching rapidly, power surges, or other electrical phenomena. Common-Mode and Differential-Mode EMI.EMI can manifest as common-mode (when unwanted signals appear on both conductors of a cable) or differential-mode (when the interference appears on one conductor with respect to the other) noise.EMI can also be generated internally within electronic devices due to the fast switching of signals within the device's circuitry. To address the challenges posed by EMI and ensure consistent standards, regulatory bodies and organizations worldwide have established EMC standards and regulations. These standards specify the limits for conducted and radiated emissions and immunity levels that electronic devices must meet. Examples of notable EMC standards and regulations include:[4][5][6]

CISPR (International Special Committee on Radio Interference): This organization develops standards related to electromagnetic interference and is recognized worldwide.

FCC Part 15 (Federal Communications Commission): In the United States, Part 15 of the FCC's rules sets limits for radiated and conducted emissions from electronic devices.

EN (European Norm) Standards: Europe has its own set of EMC standards (EN standards) that are harmonized across EU member states.

IEC (International Electro technical Commission): IEC standards cover various aspects of electrical and electronic technologies, including EMC.

Meeting these standards requires rigorous testing, which brings us to the central topic of this guide: Line Impedance Stabilization Networks (LISNs).

III. BASIC PRINCIPAL OF LINE IMPEDANCE STABILIZATION NETWORK (LISN)

A Line Impedance Stabilization Network (LISN), pronounced "listen," is a specialized component used in EMC testing and measurements. It serves as an interface between electronic devices (the Device under Test or DUT) and the power supply grid. The primary purpose of a LISN is to provide a controlled and standardized method for coupling the DUT to the power supply lines during conducted emissions and susceptibility testing. At its core, a LISN acts as a bridge between the DUT and the power source, ensuring that the measurement setup accurately represents real-world conditions while providing the necessary isolation and filtering to facilitate EMC testing. Here are some fundamental principles of a LISN.A LISN includes an artificial impedance network designed to replicate the impedance characteristics of the power grid at specific frequency ranges of interest. This impedance matching ensures that the test setup accurately represents the DUT's typical operating conditions, as specified in EMC standards. Within a LISN, a low-pass filter is often employed to attenuate high-frequency noise and disturbances present on the power supply lines. This filtering ensures that only the emissions of interest, within the specified frequency range, are passed through for measurement LISN provides a designated point where a spectrum analyzer or EMI receiver can be connected to capture and analyze the conducted emissions from the DUT. This measurement point is typically positioned after the artificial impedance network and filtering component. Proper shielding and grounding are essential aspects of LISN design. The

LISN is often enclosed in a shielded box to minimize external interference and ensure accurate measurements. Careful grounding practices are employed to prevent ground loops that can introduce unwanted noise.[7][8]

A typical LISN consists of several essential components that work together to provide a standardized interface for EMC testing. These components include: Power Line Input Connectors: These connectors are used to interface the LISN with the power supply. There are typically two input connectors, one for the Line and one for the Neutral, which are connected to the power source. Power Line Output Connectors: Similar to the input connectors, the output connectors are used to connect the DUT to the LISN. The DUT's power supply is sourced from these connectors. Artificial Impedance Network: This network, often referred to as the "LISN impedance," is a combination of resistors, inductors, and capacitors designed to replicate the impedance characteristics of the power grid. The impedance values are tailored to match the frequency range of interest as specified in EMC standards. The low-pass filter within the LISN is crucial for attenuating high-frequency noise. It typically consists of inductors and capacitors arranged in a specific configuration to create a low-pass filter effect. The cutoff frequency is set to match the upper limit specified in the EMC standard being tested. This point within the LISN allows for the connection of a spectrum analyzer or EMI receiver. It serves as the interface for capturing and analyzing conducted emissions from the DUT. Properly designed shielding and grounding are critical to ensure accurate measurements and prevent unintended interference. The LISN is often enclosed in a shielded enclosure, and the grounding system is carefully established to minimize ground loops.[9][10]

IV. TYPES OF LISNS

LISNs come in different types, each designed to cater to specific testing requirements. The choice of LISN type depends on the nature of the DUT, the EMC standards to be met, and the specific measurements needed. The three primary types of LISNs are:

4.1 Voltage LISN (V-LISN)

V-LISNs is primarily used for measuring conducted emissions on the power supply voltage line. They are connected in series with the Line and Neutral conductors, effectively placing the DUT in between. V-LISNs are commonly employed when assessing the electromagnetic interference (EMI) generated by the DUT when it is powered directly from the mains. This type of LISN is suitable for devices that draw power directly from the AC power source without an intermediate power supply.[11]

4.2 Current LISN (C-LISN)

C-LISNs are designed for measuring conducted emissions on the power supply current line. They are connected in parallel with the Line and Neutral conductors, allowing the measurement of common-mode and differential-mode currents. C-LISNs are often used when assessing EMI on devices powered through a current-carrying conductor, such as a cable. This type of LISN is suitable for devices that receive power through cables, making it applicable to a wide range of electronic equipment.[12]

4.3 Hybrid LISN

Hybrid LISNs combine the characteristics of both V-LISNs and C-LISNs. They offer flexibility in terms of measuring conducted emissions on either the voltage or current line. Hybrid LISNs are versatile and can be used in various testing scenarios. Engineers can select whether to measure emissions on the voltage line or current line, depending on the specific requirements of the EMC test. The choice between V-LISN, C-LISN, or a hybrid LISN depends on factors such as the DUT's power source configuration and the EMC standards applicable to the product being tested. In some cases, both V-LISN and C-LISN measurements may be necessary to obtain a comprehensive assessment of conducted emissions.[13]

V. USES OF LISNS

LISNs have a wide range of applications in the field of electromagnetic compatibility (EMC) testing and measurements. They are indispensable tools for assessing conducted emissions and susceptibility in electronic devices and equipment.

Below are the primary uses of LISNs. EMI Testing EMI testing involves measuring the electromagnetic interference (EMI) generated by an electronic device when it is connected to the power supply grid. The goal is to determine the levels of conducted emissions and assess their compliance with EMC standards. Process: During EMI testing, the DUT is connected to the LISN, which provides a standardized interface to the power source. Conducted emissions are measured at the LISN's EMI measurement point, typically using a spectrum analyzer or EMI receiver. The results are compared to the emission limits specified in relevant EMC standards.EMI testing ensures that electronic devices do not emit excessive interference that could disrupt the operation of other devices or systems sharing the same power grid. Compliance with EMI limits is essential for market access and customer satisfaction.EMI compliance testing is a crucial step in the product development and certification process. It verifies that electronic devices meet the emission limits defined in EMC standards, such as CISPR, FCC Part 15, or EN standards. LISNs play a central role in EMI compliance testing by providing the standardized test setup needed to ensure accurate and repeatable measurements. They create a controlled environment that replicates real-world conditions and helps identify any non-compliance issues. Successful EMI compliance testing is often a prerequisite for obtaining regulatory approvals and certifications required for product distribution and sale Susceptibility testing, also known as immunity testing, assesses how well electronic devices can withstand external electromagnetic interference (EMI) without malfunctioning. It helps determine a device's resilience to interference from sources like radio transmitters, power surges, or other electronic equipment. LISNs are not limited to emissions testing; they are also used in susceptibility testing. In this context, the LISN may inject known levels of interference into the power supply lines to evaluate the DUT's ability to operate reliably in the presence of EMI. Susceptibility testing is especially critical for devices used in safety-critical applications, such as medical equipment and aviation systems. During the development of electronic products, engineers use LISNs to assess the electromagnetic characteristics of prototypes and early-stage designs. LISNs help identify potential EMC issues early in the product development cycle. This proactive approach saves time and resources by allowing engineers to make design improvements to reduce emissions or enhance immunity before reaching the testing and certification phase. Pre-compliance testing involves conducting EMC tests before the formal certification process. While the results of pre-compliance testing are not legally binding, they provide valuable insights into a product's EMC performance.[14][15][16]

VI. DESIGN AND USES OF LISNS

LISNs are often employed in pre-compliance testing to evaluate a product's EMC characteristics and identify any potential issues that may need to be addressed before undergoing formal EMC certification testing. When electronic devices or systems experience interference problems or fail EMC compliance testing, LISNs can be valuable tools for trouble shooting. By isolating and measuring conducted emissions, LISNs can help pinpoint the source of emissions or susceptibility issues. This information is critical for identifying and addressing the root causes of EMC problems. Purpose: In some manufacturing environments, LISNs are used for quality control to ensure that each unit of a product meets EMC requirements before it is shipped to customers. By incorporating LISNs into the manufacturing process, manufacturers can verify that their products consistently meet EMC standards, minimizing the risk of non-compliant units reaching the market. Quality control through LISN testing reduces the likelihood of costly recalls or product returns due to EMC-related issues. The proper design and calibration of LISNs are crucial for accurate and reliable EMC testing. Here are key considerations for designing and calibrating LISNs: Impedance Matching: The artificial impedance network within the LISN should be carefully designed to match the impedance characteristics of the power grid as specified in EMC standards. This ensures that the test setup accurately represents real-world conditions. The low-pass filter should be designed to have a cutoff frequency that aligns with the upper frequency limit specified in the EMC standard being tested. The filter components, including inductors and capacitors, must meet the necessary tolerances and performance criteria. Proper shielding is essential to prevent external interference from affecting test results. The LISN should be enclosed in a shielded enclosure, and grounding practices should be established to minimize ground loops. The EMI measurement point should be positioned after the artificial impedance network and filtering components to capture emissions accurately. LISNs must be calibrated periodically to ensure their accuracy and reliability. Calibration involves verifying that the LISN impedance, filtering, and measurement characteristics meet the specified standards. Calibration should be performed by accredited laboratories, and calibration certificates should provide traceability to national or international standards. Regular verification of the LISN's performance is essential. This involves conducting known-level tests to confirm that the LISN is functioning within its specified parameters. roper maintenance of LISNs is crucial to prevent degradation of performance over time. This includes keeping connectors clean, ensuring the integrity of filter components, and monitoring the shielding.[17][[18][19]

VII. CONCLUSION

Line Impedance Stabilization Networks (LISNs) are indispensable tools in the realm of electromagnetic compatibility (EMC) testing and measurements. They provide a standardized interface between electronic devices and the power supply grid, facilitating accurate assessments of conducted emissions and susceptibility.

LISNs come in various types, including Voltage LISNs (V-LISN), Current LISNs (C-LISN), and Hybrid LISNs, each tailored to specific testing requirements. Their applications encompass EMI testing, EMI compliance testing, susceptibility testing, product development, pre-compliance testing, troubleshooting, and quality control.

The design and calibration of LISNs are critical for achieving reliable and repeatable test results. Careful attention to impedance matching, filter design, shielding, grounding, calibration, and verification processes is essential to ensure the accuracy of LISN measurements. In an increasingly interconnected world where electronic devices are integral to our daily lives, the role of LISNs in ensuring the compatibility and reliability of these devices cannot be overstated. As technology continues to evolve, LISNs will remain essential tools in the pursuit of electromagnetic compatibility and the prevention of disruptive interference in electronic systems

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