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EIA STANDARD

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Loop Inductance Measurement Test Procedure for Electrical Connectors (1 nH-10 nH)

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Electronic Components Industry Association

EIA-364-109

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(From Standards Proposal No. 4831 and reaffirmed by Standards Proposal No. 5361.06, formulated under the cognizance of the EIA CE-2.0 Committee on National Connector and Socket Standards).

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TEST PROCEDURE No. 109

LOOP INDUCTANCE MEASUREMENT TEST PROCEDURE
FOR
ELECTRICAL CONNECTORS (1 nH – 10 nH)

(From EIA Standards Proposal No. 4831, formulated under the cognizance EIA CE-2.0 Committee on National Connector Standards.)

1 Introduction

1.1 Scope

This procedure applies to interconnect assemblies, such as electrical connectors and sockets.

1.2 Object

This standard describes a test method to measure the loop inductance (1 nH – 10 nH range) in the frequency domain using probes and vector network analyzer.

NOTE — This test method is written for test professionals who are knowledgeable in the electronics field and are trained to use the referenced equipment. Because the measurement values are heavily influenced by the fixture and equipment this method cannot describe all of the possible combinations. The major equipment manufacturers provide Application Notes for more in-depth technical description of how to optimize the use of their equipment. It is imperative that the referencing document include the necessary description and sketches for the test professional to understand how to setup and perform the requested measurements.

1.3 Definitions

1.3.1 Specimen environment impedance

The impedance presented to the signal conductors by the fixture. This impedance is a result of transmission lines, termination resistors, attached receivers or signal sources, and fixture parasitics.

1.3.2 Inductance

The property of a circuit or circuit element that opposes a change in current flow. Inductance causes current changes to lag behind voltage changes. It is measured in Henrys.

1.3.3 Self inductance (L)

The inductance of a single conductor.

1.3.4 Mutual inductance (L_m)

The common property of two electric conductors whereby a voltage (electromotive force) is induced across one conductor by a change of current in the other conductor.

1.3.5 Loop inductance (L_{Loop})

The inductance of two or more conductors in which the current flows into one conductor and returns through the other(s). The loop is defined as the current path inscribed by the 'drive' and 'return' path in the conductors.

$$L_{Loop} = L_1 + L_2 - (2 * L_m)$$

where: L_1 = self inductance of the driven conductor

L_2 = self inductance of the return path conductor(s)

L_m = mutual inductance between the drive and return path conductors.

1.3.6 Mutual inductance coupling coefficient (K_m)

The measure of degree of magnetic coupling between two conductors. It is a unitless parameter and is defined as follows:

$$K_m = \frac{L_m}{\sqrt{L_1 * L_2}}$$

1.3.7 Inductive reactance

The resistance presented to an alternating current (ac) due to the inductance of a connector and is measured in ohms. It is also the imaginary term of the impedance and is directly proportional to the inductance and to the frequency of the applied voltage.

1.3.8 Termination (electronics usage)

An impedance connected to the end of a transmission line, typically to minimize reflected energy on the line.

2 Test resources

2.1 Equipment

A vector network analyzer shall be used. Microprobes, semi-rigid coax, or similar high frequency test hardware shall be used to minimize fixture influence on the measurement results. It is recommended that a precision x-y positioning station be used to prevent probe damage and provide precision, consistent probe placement. See annex A for sketches of the probes and test equipment set up.

NOTES

- 1 The test professional should be aware of the frequency limitations of the fixture.
- 2 The test professional should be aware of any limitations of any mathematical functions performed (e.g. normalization, inverse FFT, or software filtering.)

2.2 Fixture

The generic term “probe(s)” is used throughout the procedure to refer to semi-rigid coax, commercially available microprobes, or similar test hardware.

The “fixture” shall consist of either the probes alone or the probes in conjunction with a test board.

2.2.1 General

2.2.1.1 The fixture shall provide a low inductance path to the specimen. It is recommended that the fixture inductance be less than the specimen inductance. This can be aided by keeping the trace lengths as short as possible, and the traces as wide as possible.

2.2.1.2 The specimen may be probed directly or through a test board. It is recommended that the specimen be probed directly (without a test board) to minimize measurement error. Test boards, when used, shall provide pads such that the probes may contact the board. Measurement variations can be minimized by keeping the pads as small as possible as this will allow repeatable microprobe placement and more uniform pad thickness.

2.2.1.3 The fixture shall allow one signal line to be driven at a time. The fixture shall allow one or more return path conductors to be connected to the measuring equipment. The fixture(s) shall allow for enough measurements throughout the specimen such that variations in geometries, materials, transmission paths, etc. may be demonstrated and provide a representative sampling of specimen performance.

NOTE — The fixture geometry and materials will impact the measurements due to the fixture parasitics. Usually the product's intended use dictates the most meaningful way to fixture it.

2.2.1.4 The far end of the driven line should be terminated in a low inductance electrical short circuit to the return conductor(s). The short circuit may be achieved by using a copper block or by shorting together all contacts on the test board.

2.2.2 Specimen environment impedance

Unless otherwise specified in the referencing document, the specimen environment impedance shall match the impedance of the test equipment. Typically this will be 50 ohms.

2.2.3 Calibration features

NOTE — The term “calibration” used in this document is not to be confused with the periodic factory equipment calibration. Calibration is used in the sense of characterizing the fixture so that when the “fixture plus specimen” measurement is taken, the characteristics of the specimen alone can be accurately determined.

2.2.4.1 Equipment calibration standard

For calibration of the vector network analyzer, calibration standards shall be used to conduct the open, short, and load calibration. When probes are used the calibration shall be conducted such that the calibration plane is at the tip of the probes. For example a ceramic substrate with open, short, and load standards may be used.

NOTE — Other calibration techniques such as through-reflect-line may be used. The calibration standard and fixture shall incorporate features appropriate to the calibration method(s) being used.

2.2.4.2 Test board characterization structure

The test board, if used, shall provide a reference structure such that a loop inductance measurement can be conducted. This structure shall be identical to that used for the measurement of the specimen, except that a short circuit is included between the driven and return paths where the specimen would otherwise be located. It is recommended that a ground plane be used as the return path to provide the lowest possible inductance, to minimize the effect of the fixture on the measurement result. See annex C for a discussion of calibration and reference traces.

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3 Test specimen

3.1 Description

For this test procedure the test specimen shall be as follows:

3.1.1 Connectors

A connector or mated connector pair.

3.1.2 Sockets

A socket and test device.

4 Test procedure

4.1 Set the vector network analyzer to measure S_{11} for loop inductance.

4.2 Calibrate the equipment and fixture according to the manufacturer's specifications using the calibration standard. The calibration plane is to be directly at the probe interface to the fixture; see 2.2.4.1 for more detailed information. Unless otherwise specified in the referencing document it is recommended that the following equipment settings be used:

- Smith chart format,
- set network analyzer to display inductance values,
- minimum of 401 measurement points,
- frequency span – conduct both wideband and narrowband sweeps,
- no smoothing,
- averaging set to 16 or higher.

NOTE — “Wideband” sweep is typically the full range of the network analyzer and “narrowband” sweep is over a limited range (for example 100 MHz wide).

4.3 Fixture measurement

Position the probes to touch the interface pads of the test board characterization structure. Measure and record the loop inductance of the fixture from the Smith chart at the frequency(s) of interest.

NOTE — A loop inductance vs. frequency graph may be generated through the use of data acquisition software and spreadsheet software, if specified in the referencing document.