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Propagation Delay Test Procedure for Electrical Connectors, Sockets, Cable Assemblies or Interconnection Systems

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(From Standards Proposal Number 4155, formulated under the cognizance of the CE-2.0 National Connector Standards Committee.)

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CONTENTS

Clause Page

1 Introduction 1

1.1 Scope 1
1.2 Object 1
1.3 Definitions 1

2 Test resources 2

2.1 Equipment 2
2.2 Material 2
2.3 Fixture 2

3 Test specimen 3

3.1 Description 3

4 Test procedure 4

4.1 Probe technique 4
4.2 Insertion technique 4
4.3 Reference fixture technique 5

5 Details to be specified 5

6 Test documentation 5

Table

1 Recommended measurement system (including fixture and filtering) rise time requirements 4

Figure

1 Rise time measurement points 6
2 Propagation delay measurement points 6
A.1 Technique diagrams A-1
A.2 Single-ended terminations A-2
A.3 Differential (balanced) terminations A-3

Annex

A Normative A-1

B Informative B-1

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TEST PROCEDURE No. 103

PROPAGATION DELAY TEST PROCEDURE FOR ELECTRICAL CONNECTORS, SOCKETS, CABLE ASSEMBLIES OR INTERCONNECTION SYSTEMS

(From EIA Standards Proposal No. 4155, formulated under the cognizance EIA CE-2.0 Committee on National Connector Standards)

1 Introduction

1.1 Scope

This standard is applicable to electrical connectors, sockets, cable assemblies or interconnection systems.

1.2 Object

This standard describes a method for measuring the time it takes for a digital signal to propagate from one specified point to a second specified point.

1.2 Definitions

1.2.1 Measurement system rise time

Rise time measured with the fixture in place, without the specimen, and with filtering (or normalization). Rise time is typically measured from 10% to 90 % levels; see figure 1.

1.2.2 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.

1.2.3 Propagation delay

The time required for a signal to travel between two specified points of an interconnect system; see figure 2.

1.2.4 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

2.1.1 Pulse generator and oscilloscope, TDR or other suitable equipment with a measurement system rise time less than or equal to the measured propagation delay.

2.1.2 Probes

Probes, where applicable, shall have suitable rise time performance and circuit loading characteristics (resistance and capacitance).

2.2 Material

When the fixture is a printed circuit board, the reference trace and the test trace should be made on the same printed circuit board to reduce any difference in PCB fabrication processes, dielectric material variations, etc.

2.3 Fixture

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 for single-ended measurements and 100 ohms for differential.

2.3.1 Method A, single-ended

The fixture shall allow one signal line to be driven at a time. The driven line shall be terminated according to one of the methods of figure A.2 with the specimen environment impedance. Unless otherwise specified a 1:1 signal to ground ratio shall be used with each end having all grounds commoned. Each line adjacent to the driven line(s) shall also be terminated in the specimen environment impedance at both near and far ends.

2.3.1.1 Probe technique

The fixture shall be designed to allow the signal to be probed at the two points between which the delay is to be measured; see figure A.1.a.

2.3.1.2 Insertion technique

The fixture shall be designed to allow measurement of propagation delay with and without the specimen; see figure A.1.b.

2.3.1.3 Reference fixture technique

Two fixtures shall be designed that include the same fixture electrical length and characteristics of environment transmission line. The “specimen fixture” includes the specimen. The “reference fixture” does not include the specimen. The fixture electrical length does not include the specimen length; see figure A.1.c.

2.3.2 Method B, differentially driven

The fixture shall allow one signal pair to be driven at a time. The driven line shall be terminated according to one of the methods of figure A.3 with the specimen environment impedance. Unless otherwise specified a 2:1 signal to ground ratio shall be used. Each line adjacent to the driven line(s) shall also be terminated in the specimen environment impedance at both near and far ends.

2.3.2.1 Probe technique

The fixture shall be designed to allow the signal pair to be probed at the points between which the delay is to be measured; see figure A.1.a.

2.3.2.2 Insertion technique

The fixture shall be designed to allow measurement of propagation delay with and without the specimen; see figure A.1.b.

2.3.2.3 Reference fixture technique

Two fixtures shall be designed that include the same fixture electrical length and characteristics of the environment transmission line. The “specimen fixture” includes the specimen. The “reference fixture” does not include the specimen. The fixture electrical length does not include the specimen length; see figure A.1.c.

3 Test Specimen

3.1 Description

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

3.1.1 Separable connectors

A mated connector pair.

3.1.2 Cable assembly

Assembled connectors and cables, and mated connectors.
3.1.3 Sockets

A socket and test device or a socket and pluggable header adapter.

4 Test procedure

Unless otherwise specified the measurement system rise time shall be less than or equal to the measured delay. The measurement system rise times specified in table 1 are recommended. The three techniques below apply to single-ended and differential measurements. For differential measurements, it is necessary to determine whether any phase and/or amplitude errors exist between the probe/channels and to provide necessary compensation for these errors so that each step arrives at the specimen simultaneously. Two measurements shall be performed as described in 4.2 or 4.3 and the time difference recorded; see figure 2 and A.1. Unless otherwise specified, for all three techniques the delay shall be measured at both the 10% and 50% amplitudes. Place the specimen a minimum of 5 cm from any object that would affect measured results.

NOTES

1 The test professional should be aware of limitations of any math operation(s) performed by an instrument, (e.g. normalization or software filtering).

2 Specimen induced skew shall not be compensated. When skew is observed a waveform plot shall be provided.

3 The input and output step amplitudes may not be equal due to attenuation in the device under test. When this occurs, the output step 10% and 90% levels are to be referenced from the maximum output voltage, regardless of what voltage was put in.

Table 1 - Recommended measurement system rise time (including fixture and filtering)

Measured (expected) propagation delay of the specimen, picoseconds	Measurement system rise time, picoseconds
100 – 500	100
>500 - 1,000	500
> 1,000	1000

4.1 Probe technique

Measure the time difference between the input and output voltages. This is the propagation delay.

4.2 Insertion technique

Measure the time difference of the output voltage with and without the specimen. This is the propagation delay.

4.3 Reference fixture technique

Measure the time difference between the “reference fixture” and the “specimen fixture”. This is the propagation delay.

5 Details to be specified

The following details shall be specified in the referencing document:

5.1 Measurement system rise time, if other than specified in table 1

5.2 Termination value (and tolerances)

5.3 Signal/ground pattern, including the number and location of signal and grounds to be wired for this test. It is recommended that the specimen locations represent the maximum and minimum delays.

5.4 Points between which the delay shall be measured.

5.5 Specimen environment impedance if other than 50 ohms for single-ended and 100 ohms for differential.

6 Test documentation

Documentation shall contain the details specified in clause 5, with any exceptions, and the following:

6.1 Title of test

6.2 Test equipment used, and date of last and next calibration

6.3 Test procedure and method

6.4 Fixture description

6.5 Measurement system rise time (including fixture and filtering, 10% to 90%)

6.6 Measured propagation delay(s)

6.7 Waveform plots (when required); see clause 4, note 2

6.8 Observations

6.9 Name of operator and date of test

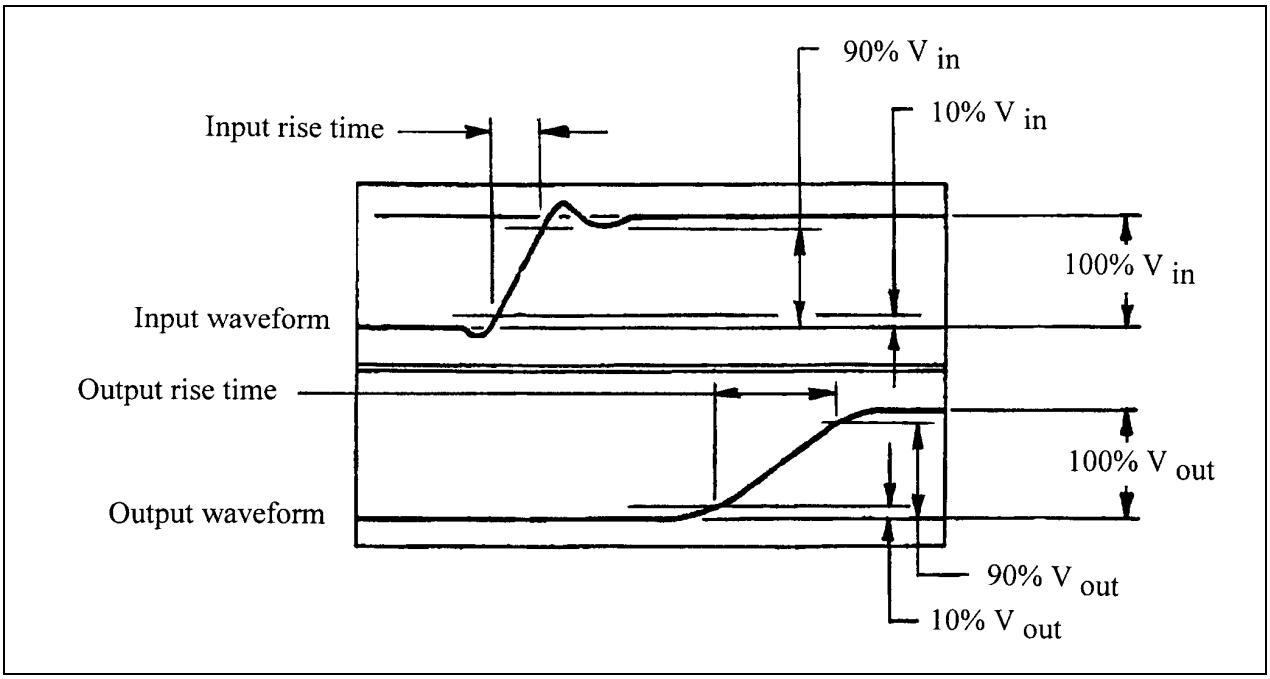
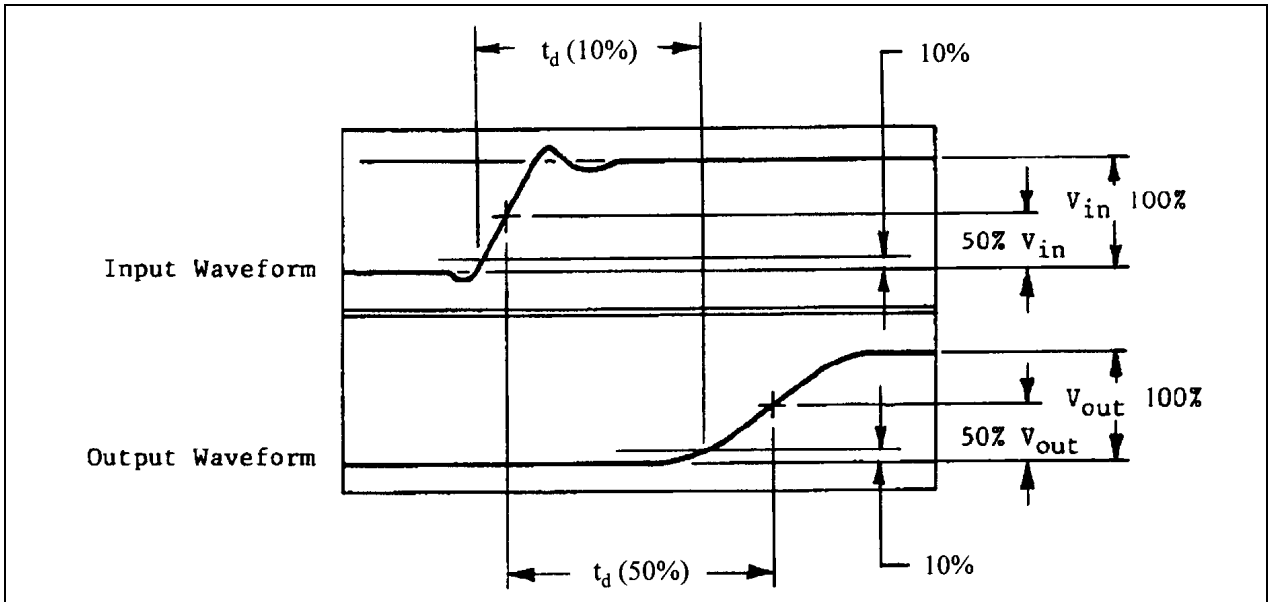


Figure 1 - Rise time measurement points



NOTE — Ignore overshoot and undershoot when calculating 0% and 100% levels.

Figure 2 - Propagation delay measurement points

Annex

A Normative

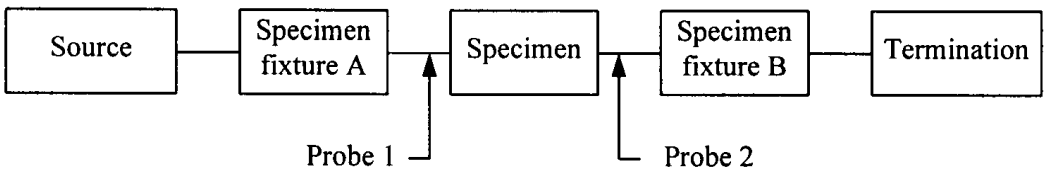


Figure A.1.a - Probe technique

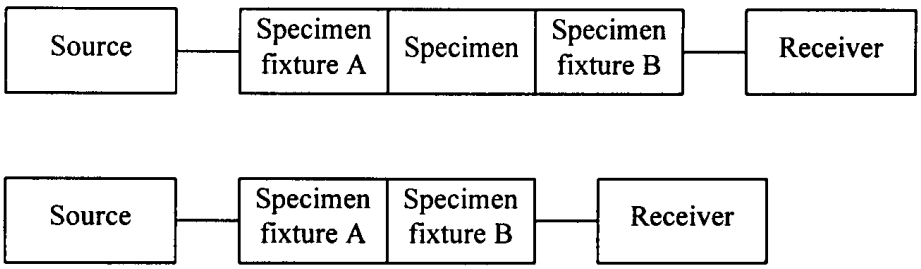


Figure A.1.b - Insertion technique

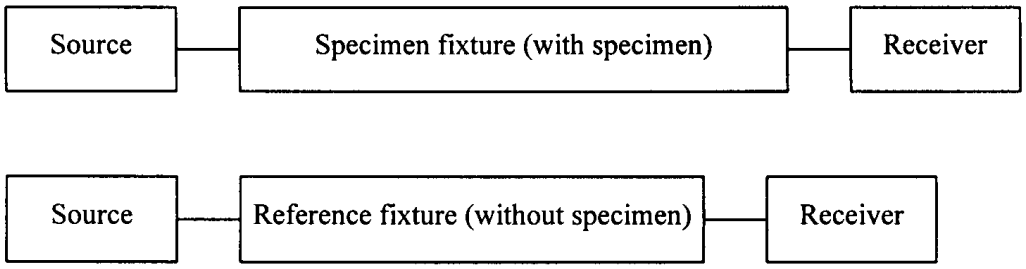
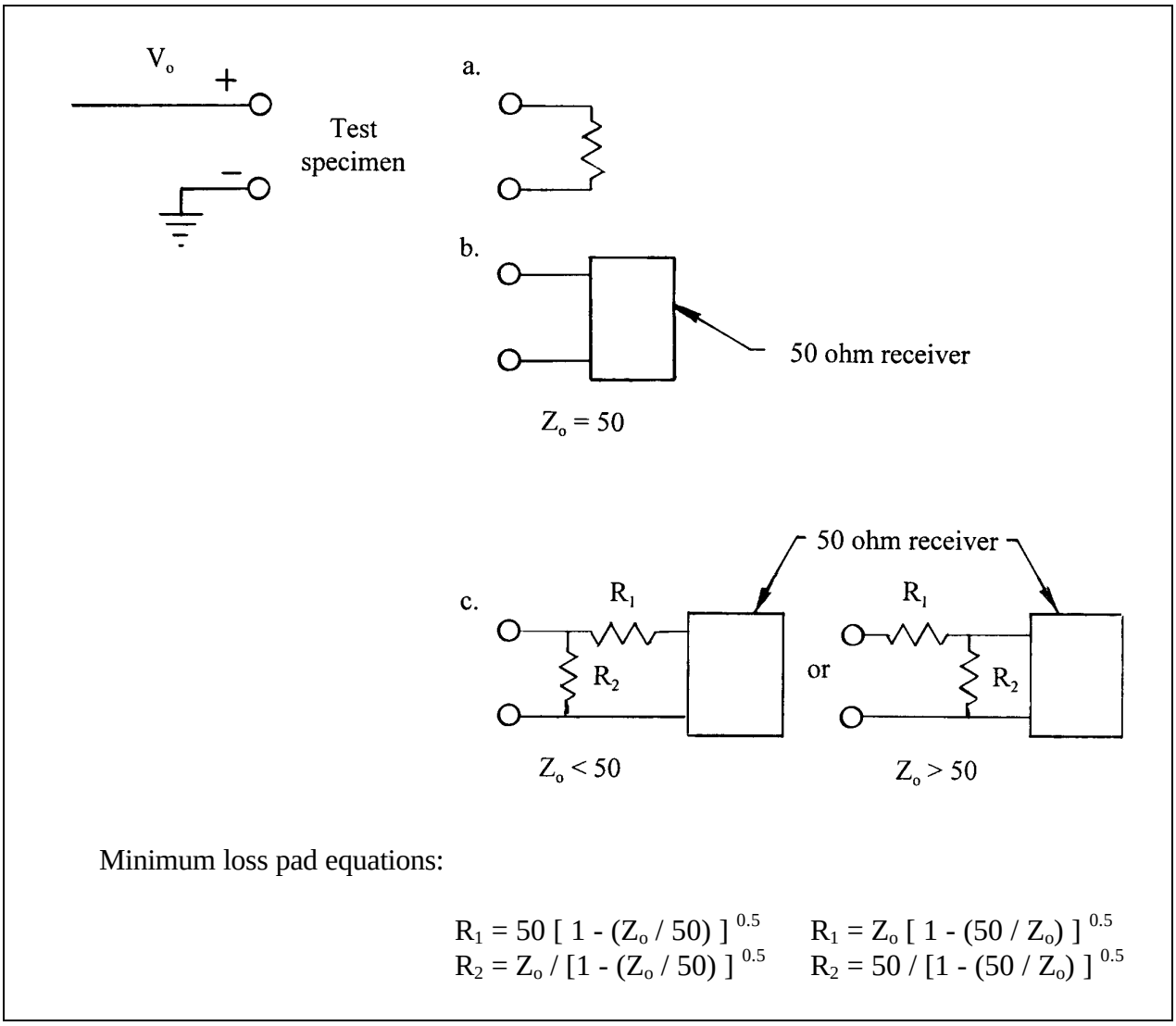


Figure A.1.c - Reference fixture technique

Figure A.1 - Technique diagrams

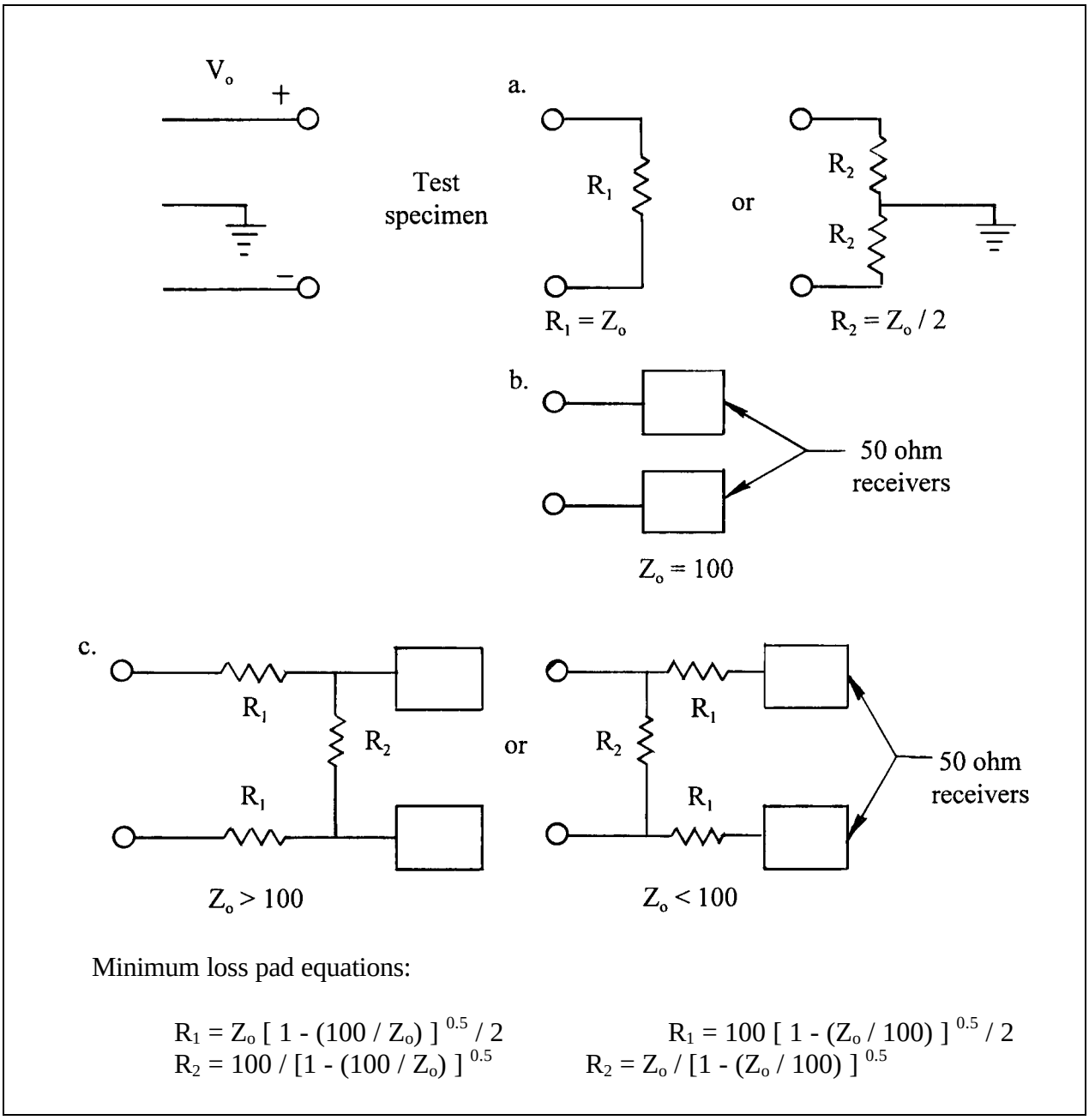


Minimum loss pad equations:

$R_1 = 50 [1 - (Z_o / 50)]^{0.5}$ $\quad R_1 = Z_o [1 - (50 / Z_o)]^{0.5}$

$R_2 = Z_o / [1 - (Z_o / 50)]^{0.5}$ $\quad R_2 = 50 / [1 - (50 / Z_o)]^{0.5}$

Figure A.2 - Single-ended terminations



Minimum loss pad equations:

$R_1 = Z_o [1 - (100 / Z_o)]^{0.5} / 2$
$R_2 = 100 / [1 - (100 / Z_o)]^{0.5}$

$R_1 = 100 [1 - (Z_o / 100)]^{0.5} / 2$
$R_2 = Z_o / [1 - (Z_o / 100)]^{0.5}$

Figure A.3 - Differential (balanced) terminations

B Informative

B.1 Practical guidance

Near perfect resistive terminations of the signal lines may not be possible at high frequencies due to parasitic reactances in both signal and ground conductors. These reactances will have an impact on measured results. In this case it is desirable that the test fixture duplicate the exact geometry (parasitics) of the actual application. This may involve the use of transmission lines in addition to the components of figures A.1 and A.2. Most instruments used for these measurements are internally terminated in 50 ohms at both source and detector ports.