ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

IPC-2141A

Design Guide for High-Speed Controlled Impedance Circuit Boards

Developed by the IPC Controlled Impedance Task Group (D-21c) of the High Speed/High Frequency Committee (D-20) of IPC

Supersedes:
IPC-2141 - April 1996

Users of this publication are encouraged to participate in the development of future revisions.

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1 SCOPE

This guide is intended to be used by circuit designers, packaging engineers, printed board fabricators, and procurement personnel so that all may have a common understanding of each other's area.

The goal in packaging is to transfer a signal from one device to one or more other devices, through a conductor. High-speed designs are defined as designs in which the interconnecting properties affect circuit performance and require unique consideration.

The term ''high-speed'' as applied to logic or digital designs needs clarification in its usage. The three most common interpretations of high-speed are as follows. (1) High-speed as a reference to the rate of change of signal amplitude with time (frequently called the edge rate of a pulse) constitutes the most important usage. The edge rate puts the greatest performance demand on interconnecting structures. (2) High-speed as a reference to the data transmission rate (bits or bytes per second) is often used to describe the ''speed'' of a system. However, high data rates can be achieved with parallel bus architectures that do not necessarily require improved performance of an interconnecting structure. (3) High-speed as a reference to the speed (distance per unit time) of a signal propagating between devices has the smallest usage and, in many cases, is not important to the application.

Controlled impedance is the maintenance of some specified tolerance in the characteristic impedance of an interconnect line (transmission line) that is used to connect different devices on a circuit. Controlled impedance is often a design consideration for high-speed digital or high-frequency analog circuits. However, the reverse is not true, that is, high-speed digital or high-frequency analog circuit designs may not need to consider controlled impedance. The purpose of this document is to help the designer understand when controlled impedance should be considered in his/her circuit design and to describe concepts important to controlled impedance design.

2 APPLICABLE DOCUMENTS

The following standards contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

2.1 IPC[1]

IPC T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-D-356 Bare Substrate Electrical Test Data Format

IPC-TM-650 Test Methods Manual[2]

2.5.5.7 11/92 Characteristic Impedance of Lines on Printed Boards by TDR

IPC-2220 Design Standard Series

IPC-2251 Design Guidelines for the Packaging of High Speed Electronic Circuits

IPC-2252 Design and Manufacture Guide for RF/Microwave Circuit Boards

IPC-4101 Specification for Base Materials for Rigid and Multilayer Printed Boards

IPC-4103 Specification for Base Materials for High Speed/High Frequency Applications

References, if presented at the end of a section, provide a more comprehensive treatment of the subject of that section.

3 ENGINEERING DESIGN OVERVIEW

Packaging of electronic equipment has traditionally been an area for mechanical considerations. However, today's packaging designs are becoming more complex because of the faster switching speeds and higher input/output densities available from today's electronic technologies. To take maximum advantage of device density and speed, designers must pay much more attention to problems of electromagnetic wave propagation phenomena associated with transmission of high-speed pulsed/switched signals within the system. New design disciplines and design strategies are needed. Controlled impedance circuit boards are a part of this strategy.

Interconnection and the packaging of electronic components primarily has been the domain of mechanical designers who were concerned with such factors as weight, volume, power, and form factor, and when interconnections

1. www.ipc.org
2. Current and revised IPC Test Methods are available through IPC-TM-650 subscription and on the IPC Web site (www.ipc.org/html/testmethods.htm).