ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

IPC-2221

Generic Standard on Printed Board Design

ANSI/IPC-2221
February 1998

A standard developed by IPC

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September 1991

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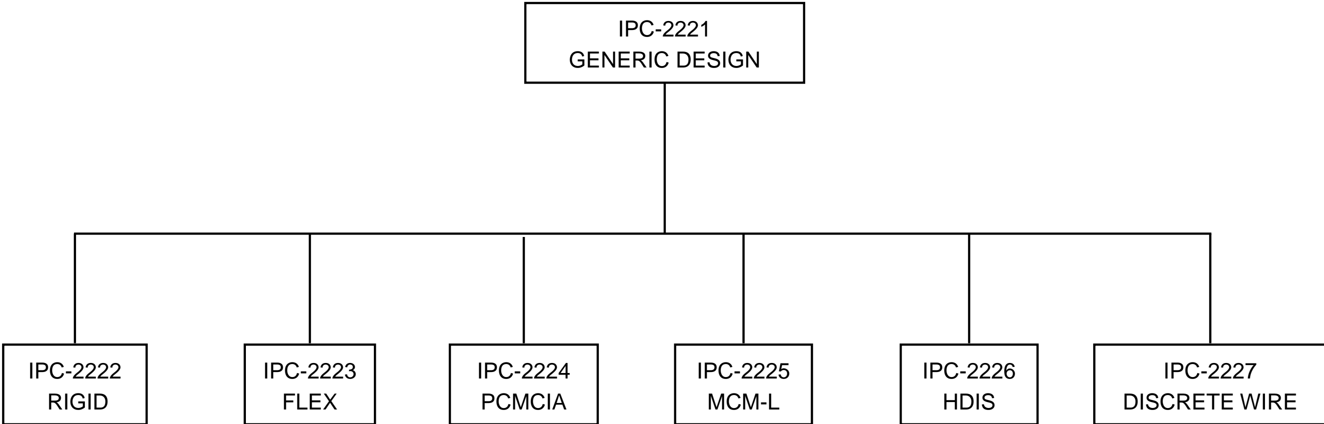
HIERARCHY OF IPC DESIGN SPECIFICATIONS
(2220 SERIES)



FOREWORD

This standard is intended to provide information on the generic requirements for organic printed board design. All aspects and details of the design requirements are addressed to the extent that they can be applied to the broad spectrum of those designs that use organic materials or organic materials in combination with inorganic materials (metal, glass, ceramic, etc.) to provide the structure for mounting and interconnecting electronic, electromechanical, and mechanical components. It is crucial that a decision pertaining to the choice of product types be made as early as possible. Once a component mounting and interconnecting technology has been selected the user should obtain the sectional document that provides the specific focus on the chosen technology.

It may be more effective to consider alternative printed board construction types for the product being designed. As an example the application of a rigid-flex printed wiring board may be more cost or performance effective than using multiple printed wiring boards, connectors and cables.

IPC's documentation strategy is to provide distinct documents that focus on specific aspect of electronic packaging issues. In this regard document sets are used to provide the total information related to a particular electronic packaging topic. A document set is identified by a four digit number that ends in zero (0).

Included in the set is the generic information which is contained in the first document of the set and identified by the four digit set number. The generic standard is supplemented by one or many sectional documents each of which provide specific focus on one aspect of the topic or the technology selected. The user needs, as a minimum, the generic design document, the sectional of the chosen technology, and the engineering description of the final product.

As technology changes specific focus standards will be updated, or new focus standards added to the document set. The IPC invites input on the effectiveness of the documentation and encourages user response through completion of "Suggestions for Improvement" forms located at the end of each document.

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Generic Standard on Printed Board Design

1.0 SCOPE

This standard establishes the generic requirements for the design of organic printed boards and other forms of component mounting or interconnecting structures. The organic materials may be homogeneous, reinforced, or used in combination with inorganic materials; the interconnections may be single, double, or multilayered.

1.1 Purpose The requirements contained herein are intended to establish design principles and recommendations that **shall** be used in conjunction with the detailed requirements of a specific interconnecting structure sectional standard (see 1.2) to produce detailed designs intended to mount and attach passive and active components.

The components may be through-hole, surface mount, fine pitch, ultra-fine pitch, array mounting or unpackaged bare die. The materials may be any combination able to perform the physical, thermal, environmental, and electronic function.

1.2 Documentation Hierarchy This standard identifies the generic physical design principles, and is supplemented by various sectional documents that provide details and sharper focus on specific aspects of printed board technology. Examples are:

IPC-2222 Rigid organic printed board structure design
IPC-2223 Flexible printed board structure design
IPC-2224 Organic, PC card format, printed board structure design
IPC-2225 Organic, MCM-L, printed board structure design
IPC-2226 High Density Interconnect (HDI) structure design
IPC-2227 Organic board design using discrete wiring

The list is a partial summary and is not inherently a part of this generic standard. The documents are a part of the PWB Design Document Set which is identified as IPC-2220. The number IPC-2220 is for ordering purposes only and will include all documents which are a part of the set, whether released or in-process proposal format at the time the order is placed.

1.3 Presentation All dimensions and tolerances in this standard are expressed in SI (metric) units. Users of this and the corresponding performance and qualification specifications are expected to use metric dimensions.

1.4 Interpretation "**Shall**," the imperative form of the verb, is used throughout this standard whenever a requirement is intended to express a provision that is mandatory. Deviation from a "**shall**" requirement may be considered if sufficient data is supplied to justify the exception.

The words "should" and "may" are used whenever it is necessary to express non-mandatory provisions. "Will" is used to express a declaration of purpose.

To assist the reader, the word "**shall**" is presented in bold characters.

1.5 Definition of Terms The definition of all terms used herein **shall** be as specified in IPC-T-50.

1.6 Classification of Products This standard recognizes that rigid printed boards and printed board assemblies are subject to classifications by intended end item use. Classification of producibility is related to complexity of the design and the precision required to produce the particular printed board or printed board assembly.

Any producibility level or producibility design characteristic may be applied to any end-product equipment category. Therefore, a high-reliability product designated as Class "3" (see 1.6.2), could require level "A" design complexity (preferred producibility) for many of the attributes of the printed board or printed board assembly (see 1.6.3).

1.6.1 Board Type This standard provides design information for different board types. Board types vary per technology and are thus classified in the design sectionals.

1.6.2 Performance Classes Three general end-product classes have been established to reflect progressive increases in sophistication, functional performance requirements and testing/inspection frequency. It should be recognized that there may be an overlap of equipment between classes. The printed board user has the responsibility to determine the class to which his product belongs. The contract **shall** specify the performance class required and indicate any exceptions to specific parameters, where appropriate.

Class 1 General Electronic Products Includes consumer products, some computer and computer peripherals, as well as general military hardware suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board or printed board assembly.

Class 2 Dedicated Service Electronic Products Includes communications equipment, sophisticated business machines, instruments and military equipment where high

performance and extended life is required, and for which uninterrupted service is desired but is not critical. Certain cosmetic imperfections are allowed.

Class 3 High Reliability Electronic Products Includes the equipment for commercial and military products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated, and must function when required such as for life support items, or critical weapons systems. Printed boards and printed board assemblies in this class are suitable for applications where high levels of assurance are required and service is essential.

1.6.3 Producibility Level When appropriate this standard will provide three design complexity levels of features, tolerances, measurements, assembly, testing of completion or verification of the manufacturing process that reflect progressive increases in sophistication of tooling, materials or processing and, therefore progressive increases in fabrication cost. These levels are:

Level A General Design Complexity—Preferred
Level B Moderate Design Complexity—Standard
Level C High Design Complexity—Reduced

The producibility levels are not to be interpreted as a design requirement, but a method of communicating the degree of difficulty of a feature between design and fabrication/assembly facilities. The use of one level for a specific feature does not mean that other features must be of the same level. Selection should always be based on the minimum need, while recognizing that the precision, performance, conductive pattern density, equipment, assembly and testing requirements determine the design producibility level. The numbers listed within the numerous tables are to be used as a guide in determining what the level of producibility will be for any feature. The specific requirement for any feature that must be controlled on the end item **shall** be specified on the master drawing of the printed board or the printed board assembly drawing.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. If a conflict of requirements exist between IPC-2221 and those listed below, IPC-2221 takes precedence.

2.1 Institute for Interconnecting and Packaging Electronic Circuits (IPC)[1]

IPC-A-22 UL Recognition Test Pattern

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

IPC-L-109 Specification for Resin Preimpregnated Fabric (Prepreg) for Multilayer Printed Boards

IPC-MF-150 Metal Foil for Printed Wiring Applications

IPC-CF-152 Composite Metallic Material Specification for Printed Wiring Boards

IPC-FC-232 Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring

IPC-D-279 Design Guidelines for Reliable Surface Mount Technology Printed Board Assemblies

IPC-D-310 Guidelines for Phototool Generation and Measurement Techniques

IPC-D-317 Design Guidelines for Electronic Packaging Utilizing High-speed Techniques

IPC-D-322 Guidelines for Selecting Printed Wiring Board Sizes Using Standard Panel Sizes

IPC-D-325 Documentation Requirements for Printed Boards

IPC-D-330 Design Guide Manual

IPC-D-350 Printed Board Description in Digital Form

IPC-D-356 Bare Substrate Electrical Test Data Format

IPC-D-422 Design Guide for Press Fit Rigid Printed Board Backplanes

IPC-TM-650 Test Methods Manual

Method 2.4.22 Bow and Twist

IPC-ET-652 Guidelines and Requirements for Electrical Testing of Unpopulated Printed Boards

IPC-CM-770 Printed Board Component Mounting

IPC-SM-780 Component Packaging and Interconnecting with Emphasis on Surface Mounting

IPC-SM-782 Surface Mount Design and Land Pattern Standard

IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments

IPC-MC-790 Guidelines for Multichip Module Technology Utilization

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Board

1. The Institute for Interconnecting and Packaging Electronic Circuits, 2215 Sanders Road, Northbrook, IL 60062-6135

IPC-SM-840 Qualification and Performance of Permanent Polymer Coating (Solder Mask) for Printed Boards

IPC-2510 Series

IPC-2511 Generic Requirements for Implementation of Product Manufacturing Description Data and Transfer Methodology

IPC-2513 Drawing Methods for Manufacturing Data Description (formerly IPC-D-351)

IPC-2514 Printed Board Manufacturing Data Description (formerly IPC-D-350)

IPC-2515 Bare Board Product Electrical Testing Data Description (formerly IPC-D-356)

IPC-2516 Assembled Board Product Manufacturing (formerly IPC-D-355)

IPC-2518 Parts List Product Data Description (formerly IPC-D-354)

IPC-2615 Printed Board Dimensions and Tolerances

IPC-4101 Laminate/Prepreg Materials Standard for Printed Boards

IPC-6011 Generic Performance Specification for Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-100002 Universal Drilling & Profile Master Drawing

IPC-100047 Composite Test Pattern Basic Dimension Drawing - Ten Layer

IPC-100103 Master Drawing for Capability Test Board (Ten Layer Multilayer Board without Blind or Buried Vias)

SMC-TR-001 An Introduction to Tape Automated Bonding Fine Pitch Technology

2.2 Joint Industry Standards[1]

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

J-STD-003 Solderability Tests for Printed Boards

J-STD-005 Requirements for Soldering Pastes

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

J-STD-012 Implementation of Flip Chip and Chip Scale Technology

J-STD-013 Implementation of Ball Grid Array and Other High Density Technology

2.3 Military[2]

MIL-G-45204 Gold Plating (Electrodeposited)

2.4 Federal[2]

QQ-N-290 Nickel Plating (Electrodeposited)

QQ-A-250 Aluminum Alloy, Plate and Sheet

QQ-S-635 Steel

2.5 American Society for Testing and Materials[3]

ASTM-B-152 Copper Sheet, Strip and Rolled Bar

ASTM-B-579 Standard Specification for Electrodeposited Coating of Tin-Lead Alloy (Solder Plate)

2.6 Underwriters Labs[4]

UL-746E Standard Polymeric Materials, Material used in Printed Wiring Boards

2.7 IEEE[5]

IEEE 1149.1 Standard Test Access Port and Boundary-Scan Architecture

2.8 ANSI[6]

ANSI/EIA 471 Symbol and Label for Electrostatic Sensitive Devices

3.0 GENERAL REQUIREMENTS

The information contained in this section describes the general parameters to be considered by all disciplines prior to and during the design cycle.

Designing the physical features and selecting the materials for a printed wiring board involves balancing the electrical, mechanical and thermal performance as well as the reliability, manufacturing and cost of the board. The tradeoff checklist (see Table 3-1) identifies the probable effect of

2. Application for copies should be addressed to Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094
3. American Society for Testing and Materials, 100 Barr Habor Drive, West Conshohocken, PA 19428-2959
4. Underwriters Labs, 333 Pfngsten Road, Northbrook, IL 60062-2002
5. IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331
6. ANSI, 655 15th Street N.W., Suite 300, Washington, DC 20005-5794