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Sectional Design Standard for Rigid Organic Printed Boards

Supersedes IPC-2222A
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An international standard developed by IPC



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Sectional Design Standard for Rigid Organic Printed Boards

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

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Sectional Design Standard for Rigid Organic Printed Boards

1 SCOPE

This standard establishes the specific requirements for the design of rigid organic printed boards.

The following overview describes what are the core knowledge and competencies to best serve in the role of *Printed Board Design Layout* as a stand-alone professional, or as the engineer performing this responsibility. Today's printed board designer needs to address numerous perspectives for success within a given schedule, with the goal of making the first design iteration work as intended, summarized as:

- Layout Solvability – Complex Packaging Skillset
- Electrical Integrity – Signal & Power Performance on all Layers
- Manufacturability – Design for Excellence (DfX) Considerations for High Yield and Lower Cost
- Application considerations – Environmental, Performance, Shelf life, etc.

The result provides for optimal component placement, routing density and electrical performance to achieve an efficient design with high yield and defect-free manufacturability.

1.1 Purpose The requirements contained herein are intended to establish specific design details that **shall** be used in conjunction with IPC-2221 to produce printed boards that perform as an integral part of functional electronic hardware.

The organic materials may be homogeneous, reinforced, or used in combination with inorganic materials; the interconnections may be single, double, or multilayered. They may be any combination able to perform the physical, thermal, environmental, and electronic function.

1.2 Document Hierarchy Document hierarchy **shall** be in accordance with the generic standard IPC-2221.

1.3 Presentation Presentation **shall** be in accordance with the generic standard IPC-2221.

1.4 Interpretation Interpretation **shall** be in accordance with the generic standard IPC-2221.

1.5 Definition of Terms The definition of all terms used herein **shall** be in accordance with IPC-T-50 and as defined in 1.5.1.

1.5.1 As Agreed Between User and Supplier (AABUS) A bilateral agreement which indicates additional or alternate requirements to be decided between the user and the supplier in the procurement documentation. Examples include contractual requirements, modifications to purchase documentation and information on the drawing. Agreements can be used to define test methods, conditions, frequencies, categories or acceptance criteria within a test, if not already established.

1.6 Classification of Products Classification of products **shall** be in accordance with the generic standard IPC-2221 and as defined in 1.6.1.

1.6.1 Printed Board Type This standard provides design information for different printed board types. Printed board types are classified as:

Type 1 – Single-Sided Printed Board

Type 2 – Double-Sided Printed Board

Type 3 – Multilayer Printed Board without blind or buried vias

Type 4 – Multilayer Printed Board with blind and/or buried vias

Type 5 – Multilayer Metal Core Printed Board without blind or buried vias

Type 6 – Multilayer Metal Core Printed Board with blind and/or buried vias

1.7 Applicability The contents of this standard may not apply to certain leading-edge technologies. Refer to IPC-2221 for additional information.

1.8 Revision Level Changes Changes that were incorporated in the current revision of this specification are indicated throughout by gray shading of the relevant subsection(s). Changes to a figure or table are indicated by gray shading of the Figure or Table header.

2 APPLICABLE DOCUMENTS

The following specifications of the revision in effect at the time of order form a part of this document to the extent specified herein. If a conflict of requirements exists between this specification and those listed below, this specification **shall** take precedence.

2.1 IPC¹

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

IPC-TM-650 Test Methods Manual²

2.2.18 Determination of Thickness of Laminates by Mechanical Measurement

2.2.18.1 Determination of Thickness of Metal-Clad Laminates, Cross-sectional

IPC-2152 Standard for Determining Current Carrying Capacity in Printed Board Design

IPC-2221 Generic Standard on Printed Board Design

IPC-4101 Laminate/Prepreg Materials Standard for Printed Boards

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

IPC-4562 Metal Foil for Printed Wiring Applications

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-7092 Design and Assembly Process Implementation for Embedded Components

2.2 Underwriters Laboratories³

UL 746E Standard Polymeric Materials, Materials Used in Printed Wiring Boards

3 GENERAL REQUIREMENTS

General requirements **shall** be in accordance with the generic standards IPC-2221.

3.1 Performance Requirements Finished rigid printed boards **shall** meet the performance requirements of the applicable performance specification (e.g., IPC-6012, IPC-6018, etc.).

4 MATERIALS

4.1 Material Selection Material selection **shall** be in accordance with the generic standard IPC-2221.

4.2 Dielectric Base Materials (Including Prepregs and Adhesives) Dielectric base materials **shall** be in accordance with the generic standard IPC-2221 and the following subsections.

4.2.1 Epoxy Laminates Epoxies are the most common resin materials, which are combined with glass cloth to produce laminates. When compared to other laminate materials, epoxies offer advantages in availability and relative ease in processing. The many different types and blends of epoxies exhibit a wide range of selection for usage or soldering processes; epoxies with a T_g (glass transition temperature) from 110 to 180 °C are available from most laminate suppliers. Another material property to be considered is the T_d (Decomposition Temperature) for any thermal excursion encountered, including fabrication, assembly and rework. Pb-free assembly has become an important material selection criterion. The keyword 'Lead-Free' is used throughout IPC-4101 to provide a direct link to suitable materials when Pb-free assembly is planned.

1. www.ipc.org

2. Current and revised test methods are available on the IPC website (www.ipc.org/test-methods.aspx)

3. www.ul.com

4.2.2 High T_g Laminates High T_g laminates include those made from resins such as Epoxy, Cyanate Ester, Triazine blends and Polyimide with a T_g rating in excess of 180 °C. High T_g resin laminates offer the advantages of increased material performance range for use, rework and environmental temperature resistance. Disadvantages include the need for specialized processing and higher material cost. High T_g materials also tend to reduce warpage; however, balanced construction remains the most important factor regarding printed board flatness.

4.2.3 Special Clad Materials The use of surface mount technology may require the use of special clad materials when coefficient of thermal expansion (CTE) matching is critical. Examples of these special materials include copper-clad Invar, epoxy or polyimide with aramid fiber and polyimide/quartz. The most common usage is for Class 3 printed boards, although there may also be some application for Class 2 product. These materials offer the advantages of improved reliability since they can better match component expansion characteristics. Better matched expansion is expected in order to subject solder connections to less stress and provide improved reliability. These materials may require unique processing during printed board fabrication, which is a disadvantage.

4.2.4 Other Laminates Laminates such as paper-based phenolics, etc., have acceptance in some consumer products where the complexity is quite low due to lesser material and manufacturing costs. These materials are associated with very high-volume products with lower performance requirements than those usually associated with epoxy type laminates.

4.3 Laminate Materials Laminate materials **shall** be in accordance with the generic standard IPC-2221 and the following paragraphs.

When metal clad, foil type **shall** be as specified in IPC-4562. Unclad laminates without an adhesive, per IPC-4101 or IPC-4103, may be used in multilayer printed boards for additional dielectric spacing between layers.

The printed board design **shall** be such that temperature rise due to current flow in conductors, when added to all other sources of heat at the conductor/laminate interface, will not result in an operating temperature in excess of that specified for the laminate material and/or printed board. These sources of heat can include heat dissipated by parts mounted on the printed boards, the equipment's general temperature rise and the specified operating ambient temperature for the equipment. See IPC-2152 for further discussions on temperature rise in printed boards as a result of current flow in conductors.

There are many factors that contribute to successful management of thermal issues as they relate to the materials ability to perform and sustain temperature rise. Proper thermal analysis should consider all environmental variables and component thermal properties. Such factors should be offset by the designs capacity to dissipate heat through conduction and other means. These will contribute to the materials abilities to perform for the established Maximum Operating Temperature (MOT) based on their base Relative Thermal Index (RTI). Reference printed board thermal management in IPC-2221 for further guidance.

When products do not have UL requirements, hot spot temperatures should be considered. Example RTI values are provided in Table 4-1. To determine precise RTI values, a UL database such as that described in 4.3.1 should be reviewed for the laminate material selected.

4.3.1 UL Parameters When UL requirements are imposed, the material used **shall** be approved by UL for use in multilayer printed boards for additional dielectric spacing between layers. Printed boards **shall** be fabricated from materials evaluated in accordance with UL 746E. Hot spot temperatures **shall** be considered. Example RTI values are provided in Table 4-1. To determine precise RTI values, a UL database **shall** be reviewed for the laminate material selected.

The UL IQ database can be found at <https://www.ul.com>. Access to the database is free with registration.

It is recommended that the designer select material using an appropriate derating factor from the RTI values given in Table 4-1. The values in Table 4-1 are based on long term thermal aging tests by UL and may be mandatory for designs to be used in UL approved products. The temperature values in Table 4-1 represent the RTI of the laminate. RTI is the maximum temperature for a material, where a class of critical properties will not be unacceptably compromised through thermal degradation over the reasonable life of an electrical product. UL-746E provides additional information regarding the properties evaluated during the establishment of RTI values. The printed board materials **shall** have acceptable mechanical and electrical RTI values and acceptable performance properties including flammability classification at the thickness range and at the intended MOT of the completed printed board. The MOT is the maximum continuous use temperature that the printed board may be exposed to under normal operating conditions. When combining dissimilar materials in one printed board, the MOT **shall not** exceed the lowest rated material. UL-796 provides additional information regarding the properties evaluated