IPC-2228

Sectional Design Standard for High Frequency (RF/Microwave) Printed Boards

Developed by the High Speed/High Frequency Design Subcommittee (D-21) of the High Speed/High Frequency Committee (D-20) of IPC

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

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Sectional Design Standard for High Frequency (RF/Microwave) Printed Boards

1 SCOPE

This standard establishes the specific requirements for the design of rigid, flexible and rigid-flexible printed boards utilizing radio frequency (RF) and/or Microwave circuity and/or high frequency laminates where RF transmission lines and related passive metal layers are considered as distributed circuits, instead of conventional lumped circuit elements. This standard is used to support product typically requiring materials meeting the requirements of IPC-4103 and fabricated to the requirements of IPC-6018.

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 designs intended to mount and attach components. The components may be through-hole, surface mount, fine pitch, ultra-fine pitch, array mounting or unpackaged bare die.

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

It is incumbent upon the printed board design engineer to work with material suppliers and to initiate a dialogue with a fabricator who has experience with specialty materials and fabrication processes required for manufacturing RF/Microwave designs. The designer should solicit feedback regarding producibility of design attributes to ensure design intent is achievable.

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 herein.

1.5.1 Anisotropy The condition for a substance having differing values for properties, such as permittivity, depending on the direction within the material. Isotropy describes the case where a property is the same in all directions. Isotropy may exist in non-crystalline homogeneous (single phase) substances. In a microwave laminate based on a polymer composite, anisotropy of the dielectric layer exists.

1.5.2 Directional Coupler A device or structure which causes some of the energy propagating along one transmission line to be transferred to a second transmission line so that most of the transferred energy propagates in a specific direction along the second line. The other direction is considered isolated. At lower frequencies this function can be accomplished in a design with lumped capacitive and inductive elements while at microwave frequencies two stripline or microstrip traces that run parallel to each other for a certain distance can serve the purpose. One use for such devices is to sample amplitude or phase of a signal traveling in a specific direction.

1.5.3 Directivity The difference between the isolation and the coupling values of a directional coupler.

1.5.4 Distributed Component An electrical component with dimensions greater than or on the order of the wavelength of the propagating signal. The reactive and resistive electrical characteristics of such a component are said to be distributed.

1.5.5 Ground-to-Ground-Spacing Distance between ground planes in a stripline circuit.

1.5.6 Ground-to-Signal-Spacing Distance between ground and signal planes or conductors in a transmission line.

1.5.7 Impedance A measure of the opposition to the flow of alternating current in a circuit, equal to the ratio of the RMS electromotive force in the circuit to the RMS current produced by it. Impedance is usually represented in complex notation as $Z = R + jX$, where R is the ohmic resistance, X is the reactive, either inductive or capacitive, and j is $\sqrt{-1}$.

1.5.8 Lumped Circuit elements that are not distributed.

1.5.9 Open Circuit A high impedance condition that ideally exhibits 0 dB return loss and a reflection coefficient of 1.0.

1.5.10 Static Relative Permittivity The ratio of the capacitance (C_X) of a given configuration of electrodes with a specified dielectric, filling all the region of electro potential field, to the capacitance (C_V) of the same electrode configuration with a vacuum (or air) as the dielectric.

1.5.11 S-Parameters Parameters used to describe the operations of a microwave circuit: S11 is the input reflection coefficient, S22 is the output reflection coefficient, S21 is the forward transmission, and S12 is the reverse transmission.

1.5.12 Semi-Rigid Cable A coaxial cable that has a solid outer conductor.

1.5.13 Short Circuit A low impedance that ideally exhibits 0 dB return loss and a reflection coefficient of -1.0.

1.5.14 Smith Chart A transmission line calculator used to evaluate and analyze microwave circuitry.

1.5.15 Soft Substrate For the purpose of this document the term soft substrate refers to the materials specified in IPC-4103.

1.5.16 TEM Mode (Transverse Electromagnetic Mode) A mode of electromagnetic wave propagation in which, at any point along the line, the electrical and the magnetic fields both lie in a plane perpendicular to the direction of propagation. This efficient mode is characteristic of free space and is favored by coaxial and stripline transmission lines up to a frequency where other modes, with propagation characteristics different from that of the TEM mode, can exist. The frequency at which these other modes can exist is dependent on frequency and the dimensions of the line perpendicular to the direction of wave propagation.

1.5.17 VSWR (Voltage Standing Wave Ratio) A measure of the degree of mismatch between a load and a transmission line.

1.5.18 Wavelength The distance an electromagnetic wave propagates during one full cycle. It is the ratio of the propagation velocity in length units per unit time to the frequency in cycles per unit time.

1.5.19 As Agreed Between User and Supplier (AABUS) 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 using homogeneous Dielectric Materials without blind or buried vias

Type 4 – Multilayer Printed Board using mixed Dielectric Materials without blind and/or buried vias

Type 5 – Multilayer Printed Board using homogeneous Dielectric Materials with blind and/or buried vias

Type 6 – Multilayer Printed Board using mixed Dielectric Materials with blind and/or buried vias

Type 7 – Single-sided or Double-sided Metal and or Composite Backed Printed Board

Type 8 – Multilayer Metal and or Composite Backed Printed Board with or without 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.

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 IPC[1]

IPC-A-600 Acceptability of Printed Boards

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

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

IPC-2221 Generic Standard on Printed Board Design

IPC-2222 Sectional Design Standard for Rigid Organic Printed Boards

IPC-2223 Sectional Design Standard for Flexible and Rigid/Flexible Printed Boards

1 www.ipc.org