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Design Standard for Printed Electronics on Flexible Substrates

Developed by the Flexible Printed Electronics Design Standard Task Group (D-61a) of the Printed Electronics Committee (D-60) of IPC

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

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1 SCOPE

This standard establishes specific requirements for the design of printed electronic applications and their forms of component mounting and interconnecting structures on flexible substrates. Flexible substrates, as pertain to this standard, are materials, devices or functionalized circuitry which have some amount of flexibility or bendability (not rigid) but are not considered to be stretchable.

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 printed electronic application to produce detailed designs for the printed electronic. This standard is not intended for use as a performance specification nor as an acceptance document.

1.2 Classification IPC standards recognize that electrical and electronic assemblies are subject to classifications by intended end-item use. Three general end-product classes have been established to reflect differences in manufacturability, complexity, functional performance requirements, and verification (inspection/test) frequency. It should be recognized that there may be overlaps of equipment between classes.

CLASS 1 General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

CLASS 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.

CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

1.3 Measurement Units All dimensions and tolerances in this specification are expressed in hard SI (metric) units and bracketed soft imperial [inch] units. Users of this specification are expected to use metric dimensions. All dimensions ≥ 1 mm [0.0394 in] will be expressed in millimeters and inches. All dimensions < 1 mm [0.0394 in] will be expressed in micrometers and microinches.

1.4 Definition of Requirements The words **shall** or **shall not** are used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance.

The word "should" reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this Standard. The text takes precedence over the figures.

1.5 Process Control Requirements The primary goal of process control is to continually reduce variation in the processes, products, or services to provide products or processes meeting or exceeding user requirements. Process control tools such as IPC-9191 or other user-approved system may be used as guidelines for implementing process control.

A documented process control system, if established, **shall** define process control and corrective action limits.

This may or may not be a statistical process control system. The use of statistical process control (SPC) is optional and should be based on factors such as design stability, lot size, production quantities and the needs of the manufacturer (see 11.2).

When a decision or requirement is to use a documented process control system, failure to implement process corrective action and/or the use of continually ineffective corrective actions **shall** be grounds for disapproval of the process and associated documentation.

1.6 Order of Precedence The contract **shall** take precedence over this standard, referenced standards and drawings.

In the event of conflict, the following order of precedence applies:

1) Procurement as agreed and documented between user and supplier.
2) Master drawing, design brief or tech pack reflecting the user's detailed requirements.
3) When invoked by the customer or per contractual agreement, this standard.

When documents other than this standard are cited, the order of precedence **shall** be defined in the procurement documents. The user can specify alternate acceptance criteria.

1.6.1 Conflict In the event of conflict between the requirements of this standard and the applicable drawing(s) and documentation, the applicable user-approved drawing(s) and documentation govern.

Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification. In the event of a conflict between the text of this standard and the applicable documents cited herein, the text of this standard takes precedence. In the event of conflict between the requirements of this standard and drawing(s) and documentation that has not been user approved, this standard governs.

1.6.2 Clause References When a clause in this document is referenced, its subordinate clauses apply, unless the requirement references specific subordinate clauses.

1.6.3 Procurement Documentation The procurement documentation **shall** provide sufficient information to the supplier so the supplier can produce printed boards containing embedded active and passive circuitry and ensure the user receives the desired product. The procurement documentation should specify the requirements that can be selected from within this standard.

1.6.3.1 Selection for Procurement For procurement purposes, performance class **shall** be specified in the procurement documentation. The documentation **shall** provide sufficient information to the supplier so that one can fabricate the printed board and ensure that the user receives the desired product. Information that should be included in the procurement documentation is shown in IPC-D-325.

1.6.4 Appendices Appendices to this standard are not binding requirements unless separately and specifically required by this standard, the applicable contracts, assembly drawing(s), documentation or purchase orders.

1.7 Quality Conformance This standard establishes a quality conformance system for suppliers to demonstrate the continual conformance of materials to the quality requirements of the standard. See Section 11 for quality conformance inspection requirements.

1.8 Abbreviations and Acronyms When used, periodic table elements are abbreviated in the standard. See Appendix C for full spellings of abbreviations (including elements) and acronyms used in this standard.

1.9 Terms and Definitions Terms and definitions **shall** be in accordance with IPC-T-51, IPC-T-50 and the following.

1.9.1 Conductive Adhesive The conductive material interconnects between component terminals and printed pad.

1.9.2 Crease To make a line, ridge or groove on a printed electronic device by adding pressure to fold the substrate or device.

1.9.3 Panelization A method used to reduce manufacturing costs. Panelization consists of a number or array of printed electronics devices which are grouped on a substrate panel. Panel optimizers may be used to determine the most efficient placement of the devices' arrays within the panel. The optimizer calculates all panel placement combinations based on the panel dimensions and the devices to be printed.

1.9.4 Substrate For purposes of this standard, a substrate is any conductive or nonconductive flexible manufactured part or base material. A variety of materials can be used as a base substrate, from traditional flexible printed board materials to paper and other flexible materials.

1.10 Printed Electronics Types Any printed electronics design will be incumbent on requirements from the customer, materials to be used and the printing processes. The following printed electronics types represent the known variations of printed electronics. These types cover all known processes for printing electronics (e.g., screen, aerosol, 3D, etc.). As other types or printing processes are made known, they will be added to this standardized list of types.

The printed electronics type **shall** be specified on the procurement document. If the printed electronics type is not designated below, a unique type designation will be used.

- *Printed electronics – Type 1:* Using printed electronics processes on a planar substrate
- *Printed electronics – Type 2:* Using printed electronics processes on a nonplanar substrate
- *Printed electronics – Type 3:* Using printed electronics processes to fully build and functionalize a device in a 3D space (no starting substrate)

1.11 Standard Printed Electronics Design (SPED) Classifications Standard print electronics design (SPED) types **shall** be in accordance with 1.11.1 through 1.11.3. For purposes of explanation, a basic variation of each SPED is shown in 1.11.1 through 1.11.3.