## Appendix A

# Electrical Conductor Spacing

**NOTE: Appendix A is quoted from IPC-2221 Generic Standard on Printed Board Design (February 1998) and is provided for information only. It is current as of publication date of this document. The user has the responsibility to determine the most current revision level of IPC-2221 and specify the specific application to their product. Paragraph and table numbers are from IPC-2221.**

The following statement from IPC-2221 applies to this Appendix ONLY: **1.4 Interpretation – "Shall,"** the imperative form of the verb, is used throughout this standard [IPC-A-610D Appendix A] whenever a requirement is intended to express a provision that is mandatory.

*IPC-2221* – **6.3 Electrical Clearance** Spacing between conductors on individual layers should be maximized whenever possible. The minimum spacing between conductors, between conductive patterns, layer to layer conductive spaces (z-axis), and between conductive materials (such as conductive markings or mounting hardware) and conductors **shall** be in accordance with Table 6-1, and defined on the master drawing. For additional information on process allowances affecting electrical clearance, see Section 10.

When mixed voltages appear on the same board and they require separate electrical testing, the specific areas **shall** be identified on the master drawing or appropriate test specification. When employing high voltages and especially AC and pulsed voltages greater than 200 volts potential, the dielectric constant and capacitive division effect of the material must be considered in conjunction with the recommended spacing.

For voltages greater than 500V, the (per volt) table values must be added to the 500V values. For example, the electrical spacing for a Type B1 board with 600V is calculated as:

600V - 500V = 100V
0.25 mm + (100V x 0.0025 mm)
= 0.50 mm clearance

When, due to the criticality of the design, the use of other conductor spacings is being considered, the conductor spacing on individual layers (same plane) **shall** be made larger than the minimum spacing required by Table 6-1 whenever possible. Board layout should be planned to allow for the maximum spacing between external layer conductive areas associated with high impedance or high voltage circuits. This will minimize electrical leakage problems resulting from condensed moisture or high humidity. Complete reliance on coatings to maintain high surface resistance between conductors **shall** be avoided.

*IPC-2221* – **6.3.1 B1-Internal Conductors** Internal conductor-to-conductor, and conductor-to-plated-through hole electrical clearance requirements at any elevation. See Table 6-1.

*IPC-2221* – **Table 6-1 Electrical Conductor Spacing**

| Voltage Between Conductors (DC or AC Peaks) | Minimum Spacing | | | | | | |
|---|---|---|---|---|---|---|---|
| | Bare Board | | | | Assembly | | |
| | B1 | B2 | B3 | B4 | A5 | A6 | A7 |
| 0-15 | 0.05 mm | 0.1 mm | 0.1 mm | 0.05 mm | 0.13 mm | 0.13 mm | 0.13 mm |
| 16-30 | 0.05 mm | 0.1 mm | 0.1 mm | 0.05 mm | 0.13 mm | 0.25 mm | 0.13 mm |
| 31-50 | 0.1 mm | 0.6 mm | 0.6 mm | 0.13 mm | 0.13 mm | 0.4 mm | 0.13 mm |
| 51-100 | 0.1 mm | 0.6 mm | 1.5 mm | 0.13 mm | 0.13 mm | 0.5 mm | 0.13 mm |
| 101-150 | 0.2 mm | 0.6 mm | 3.2 mm | 0.4 mm | 0.4 mm | 0.8 mm | 0.4 mm |
| 151-170 | 0.2 mm | 1.25 mm | 3.2 mm | 0.4 mm | 0.4 mm | 0.8 mm | 0.4 mm |
| 171-250 | 0.2 mm | 1.25 mm | 6.4 mm | 0.4 mm | 0.4 mm | 0.8 mm | 0.4 mm |
| 251-300 | 0.2 mm | 1.25 mm | 12.5 mm | 0.4 mm | 0.4 mm | 0.8 mm | 0.8 mm |
| 301-500 | 0.25 mm | 2.5 mm | 12.5 mm | 0.8 mm | 0.8 mm | 1.5 mm | 0.8 mm |
| > 500 See para. 6.3 for calc. | 0.0025 mm /volt | 0.005 mm /volt | 0.025 mm /volt | 0.00305 mm /volt | 0.00305 mm /volt | 0.00305 mm /volt | 0.00305 mm /volt |

B1 - Internal Conductors
B2 - External Conductors, uncoated, sea level to 3050 m
B3 - External Conductors, uncoated, over 3050 m
B4 - External Conductors, with permanent polymer coating (any elevation)
A5 - External Conductors, with conformal coating over assembly (any elevation)
A6 - External Component lead/termination, uncoated
A7 - External Component lead termination, with conformal coating (any elevation)

# Electrical Conductor Spacing (cont.)

*IPC-2221* – **6.3.2 B2-External Conductors, Uncoated, Sea Level to 3050 m** Electrical clearance requirements for uncoated external conductors are significantly greater than for conductors that will be protected from external contaminants with conformal coating. If the assembled end product is not intended to be conformally coated, the bare board conductor spacing **shall** require the spacing specified in this category for applications from sea level to an elevation of 3050 m. See Table 6-1.

*IPC-2221* – **6.3.3 B3-External Conductors, Uncoated, Over 3050 m** External conductors on uncoated bare board applications over 3050 m require even greater electrical spacings than those identified in category B2. See Table 6-1.

*IPC-2221* – **6.3.4 B4-External Conductors, with Permanent Polymer Coating (Any Elevation)** When the final assembled board will not be conformally coated, a permanent polymer coating over the conductors on the bare board will allow for conductor spacings less than that of the uncoated boards defined by category B2 and B3. The assembly electrical clearances of lands and leads that are not conformally coated require the electrical clearance requirements stated in category A6 (see Table 6-1). This configuration is not applicable for any application requiring protection from harsh, humid, contaminated environments.

Typical applications are computers, office equipment, and communication equipment, bare boards operating in controlled environments in which the bare boards have a permanent polymer coating on both sides. After they are assembled and soldered the boards are not conformal coated, leaving the solder joint and soldered land uncoated.

Note: All conductors, except for soldering lands, must be completely coated in order to ensure the electrical clearance requirements in this category for coated conductors.

*IPC-2221* – **6.3.5 A5-External Conductors, with Conformal Coating Over Assembly (Any Elevation)** External conductors that are intended to be conformal coated in the final assembled configuration, for applications at any elevation, will require the electrical clearances specified in this category.

Typical applications are military products where the entire final assembly will be conformal coated. Permanent polymer coatings are not normally used, except for possible use as a solder resist. However, the compatibility of polymer coating and conformal coating must be considered, if used in combination.

*IPC-2221* – **6.3.6 A6-External Component Lead/ Termination, Uncoated** External component leads and terminations, that are not conformal coated, require electrical clearances stated in this category.

Typical applications are as previously stated in category B4. The B4/A6 combination is most commonly used in commercial, non-harsh environment applications in order to obtain the benefit of high conductor density protected with permanent polymer coating (also solder resist), or where the accessibility to components for rework and repair is not required.

*IPC-2221* – **6.3.7 A7-External Component Lead/ Termination, with Conformal Coating (Any Elevation)** As in exposed conductors versus coated conductors on bare board, the electrical clearances used on coated component leads and terminations are less than for uncoated leads and terminations.

# Index

# Index (cont.)

# Index (cont.)

# Standard Improvement Form

**IPC-A-610E-2010**

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

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1. I recommend changes to the following:

___ Requirement, paragraph number _____

___ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other _____

2. Recommendations for correction:

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*February 2009*

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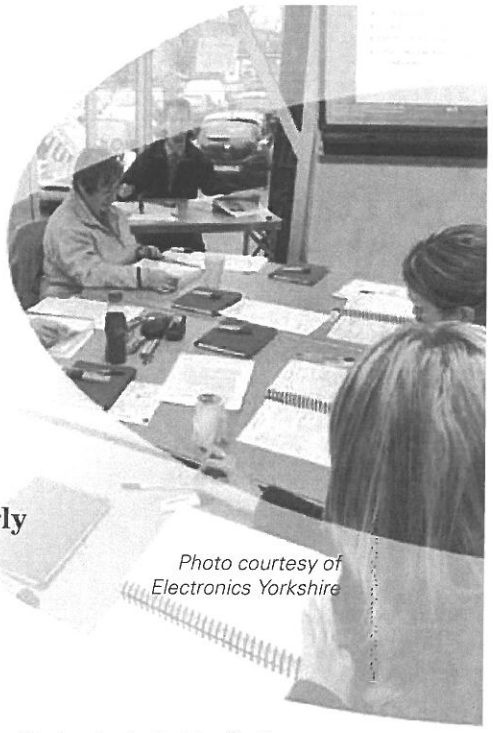

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