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Users of this publication are encouraged to participate in the
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Guidelines for Printed Board Component Mounting

1 SCOPE

This document provides information for preparation of components for assembly to printed boards, contains a review of some pertinent design criteria, impacts and issues, techniques of general interest for assembly (both manual and machines) and discusses considerations of, and impacts upon, subsequent soldering, cleaning, and coating processes. The information herein consists of compiled data representing commercial and industrial applications.

This section discusses general recommended assembly guidelines. Later sections discuss information concerning specific packaging types.

Sections 2 through 5 provide guidelines for the specific component within each sectional document. The parts are described in detail and each section outlines specifics affecting the part class. The descriptions and classifications provided are those generally used in the industry with reference to military and commercial applications.

Due to the rapid progress and evolution in packaging and assembly technology today, this document may not cover all currently available components or assembly techniques such as lead free.

1.1 Purpose The purpose of this document is to illustrate and guide the user seeking answers to questions related to accepted, effective methods of mounting components to printed wiring boards.

1.2 Classification of Board Types and Assemblies

1.2.1 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 could be an overlap of equipment between classes. These performance classes are the same for both bare boards and assemblies. 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 computers and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is the function of the completed electronic assembly.

Class 2 – Dedicated Service Electronic Products

Includes communications equipment, sophisticated business machines, and instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 – High Performance Electronic Products

Includes the equipment and products where continued performance or performance-on-demand is critical, such as in life support items or flight control systems. Equipment downtime cannot be tolerated and must function when required. Assemblies in this class are suitable for applications where high levels of assurance are required, service is essential, or the end-use environment may be uncommonly harsh.

1.2.2 Producibility Levels IPC standards usually 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 Producibility

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, 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 is for any feature. The specific requirement for any feature that must be controlled on the end item should be specified on the master drawing of the printed board or the printed board assembly drawing.

These levels for assemblies are:

- Level A – Through-hole component mounting only.
- Level B – Surface mounted components only.
- Level C – Simplistic through-hole and surface mounting intermixed assembly.

- Level X – Complex intermixed assembly, through-hole, surface mount, fine pitch and BGA.
- Level Y – Complex intermixed assembly, through-hole, surface mount, ultra fine pitch and chip scale.
- Level Z – Complex intermixed assembly, through-hole, ultra fine pitch, COB, flip chip, and TAB.

1.2.3 Product Types It is important to understand the complex relationship between board types and assembly classifications. The term “board” no longer refers just to rigid boards. It now includes single-sided, double-sided and multilayer boards made from rigid, flexible, rigid-flex combinations or boards with high-density microvia dielectric material combinations.

This guideline recognizes that printed boards and printed board assemblies are subject to classifications by intended end item use and other designations based on assembly characteristics. 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 1.2.2) could require Level A design complexity (preferred producibility) for many of the attributes of the printed board or printed board assembly.

1.2.3.1 Rigid Board Types The following rigid board types are classified in IPC-2222 and IPC-6012, *Design and Qualification and Performance Specification for Rigid Printed Boards*:

- Type 1: Single-Sided Printed Board.
- Type 2: Double-Sided Printed Board.
- Type 3: Multilayer Board without Blind or Buried Vias.
- Type 4: Multilayer Board with Blind and/or Buried Vias.
- Type 5: Multilayer Metal-Core Board without Blind or Buried Vias.
- Type 6: Multilayer Metal-Core Board with Blind and/or Buried Vias.

1.2.3.2 Flexible Printed Boards The following flexible printed board types are classified in IPC-2223 and IPC-6013, *Qualification and Performance Specifications for Flexible Printed Boards*:

- Type 1: Single-sided flexible printed wiring containing one conductive layer, with or without stiffeners.
- Type 2: Double-sided flexible printed wiring containing two conductive layers with plated-through holes, with or without stiffeners.
- Type 3: Multilayer flexible printed wiring containing three or more conductive layers with plated-through holes, with or without stiffeners.

- Type 4: Multilayer rigid and flexible material combinations containing three or more conductive layers with plated-through holes.
- Type 5: Flexible or rigid-flex printed wiring containing two or more conductive layers without plated-through holes.

1.2.3.3 PC Card Printed Boards PC Card printed boards are classified by IPC-2224, *Sectional Standard for Design of PWBs for PC Cards*.

1.2.3.4 Single-Chip and Multichip Printed Boards Single chip and multichip printed boards are classified in IPC-2225 and IPC-6015, *Design and Qualification and Performance Specification from Organic Multichip Module Mounting and Interconnecting Structures*.

1.2.3.5 High Density Interconnect Printed Boards The following HDI printed board types are classified in accordance with IPC-2226 and IPC-6016, *Design Qualification and Performance Specification for High Density Interconnect (HDI)*:

- Type I – 1 [C] 0 or 1 [C] 1 with through-vias from surface to surface.
- Type II – 1 [C] 0 or 1 [C] 1 with through-vias buried in the core and from surface to surface.
- Type III – Greater/equal 2 [C] greater/equal to 0.
- Type IV – P greater/equal to 0 where P is a passive substrate with no electrical connecting functions.
- Type V – Coreless constructions using layer pairs.
- Type VI – Alternate constructions in which electrical interconnections and mechanical structure are formed simultaneously.

1.2.4 Printed Circuit Board Assembly Types A type designation signifies further sophistication describing whether components are mounted on one or both sides of the packaging and interconnecting structure. Type 1 (Figure 1-1) defines an assembly that has components mounted on only one side; Type 2 (Figure 1-2) is an assembly with components on both sides.

The need to apply certain design concepts should depend on the complexity and precision required to produce a particular land pattern or printed board structure. Any design class may be applied to any of the end-product equipment categories. Therefore, a moderate complexity (Type 1B) would define components mounted on one side (all surface mounted) and, when used in a Class 2 product (dedicated service electronics), is referred to as type 1B, Class 2. The product described as Type 1B, Class 2 might be used in any of the end-use applications with the selection of class being dependent on the requirements of the customers using the application. See Table 1-1 for description of various board and assembly types.

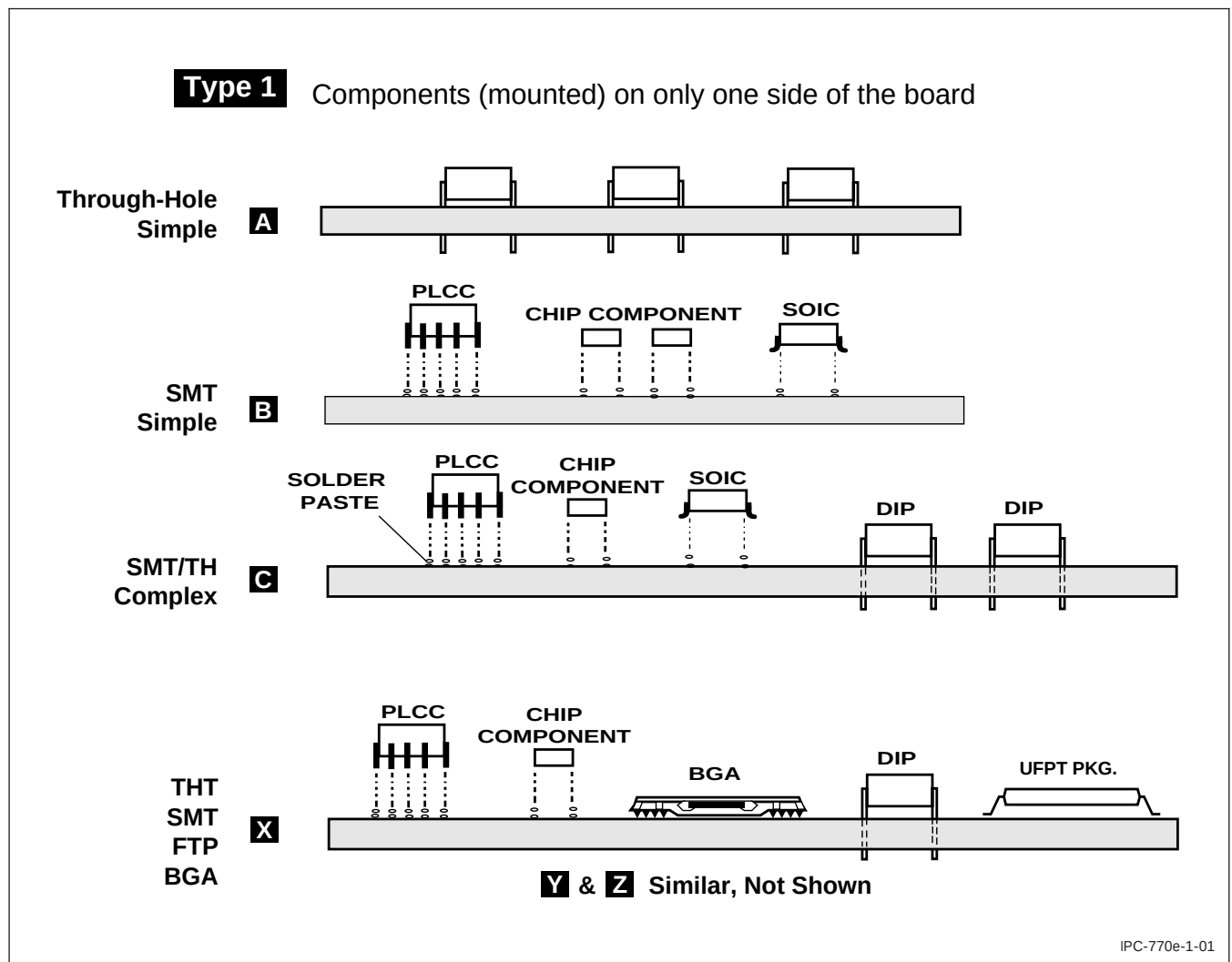


Figure 1-1 Type 1 Printed Board Assembly

1.3 Order of Precedence In the event of any conflict in the development of new designs, the following order of precedence shall prevail:

1. The procurement contract.
2. The approved master drawing or assembly drawing (supplemented by an approved deviation list, if applicable).
3. This standard.
4. Other applicable documents.

1.4 Presentation All dimensions, tolerances and other forms of measurement (temperature, weight, etc.) in this standard are expressed in SI (System International) units with Imperial English equivalent dimensions provided in brackets. Dimensions and tolerances use millimeters as the main form of dimensional expression; micrometers are used when the precision required makes millimeters too cumbersome. Celsius is used to express temperature. Weight is expressed in grams. Users are cautioned to

employ a single dimensioning system, and not intermix millimeters and inches. Reference information is shown in parentheses.

1.5 Terms and Definitions The definition of all terms used herein shall be as specified in IPC-T-50 (those terms denoted with an asterisk are cited directly from IPC-T-50), or as listed below:

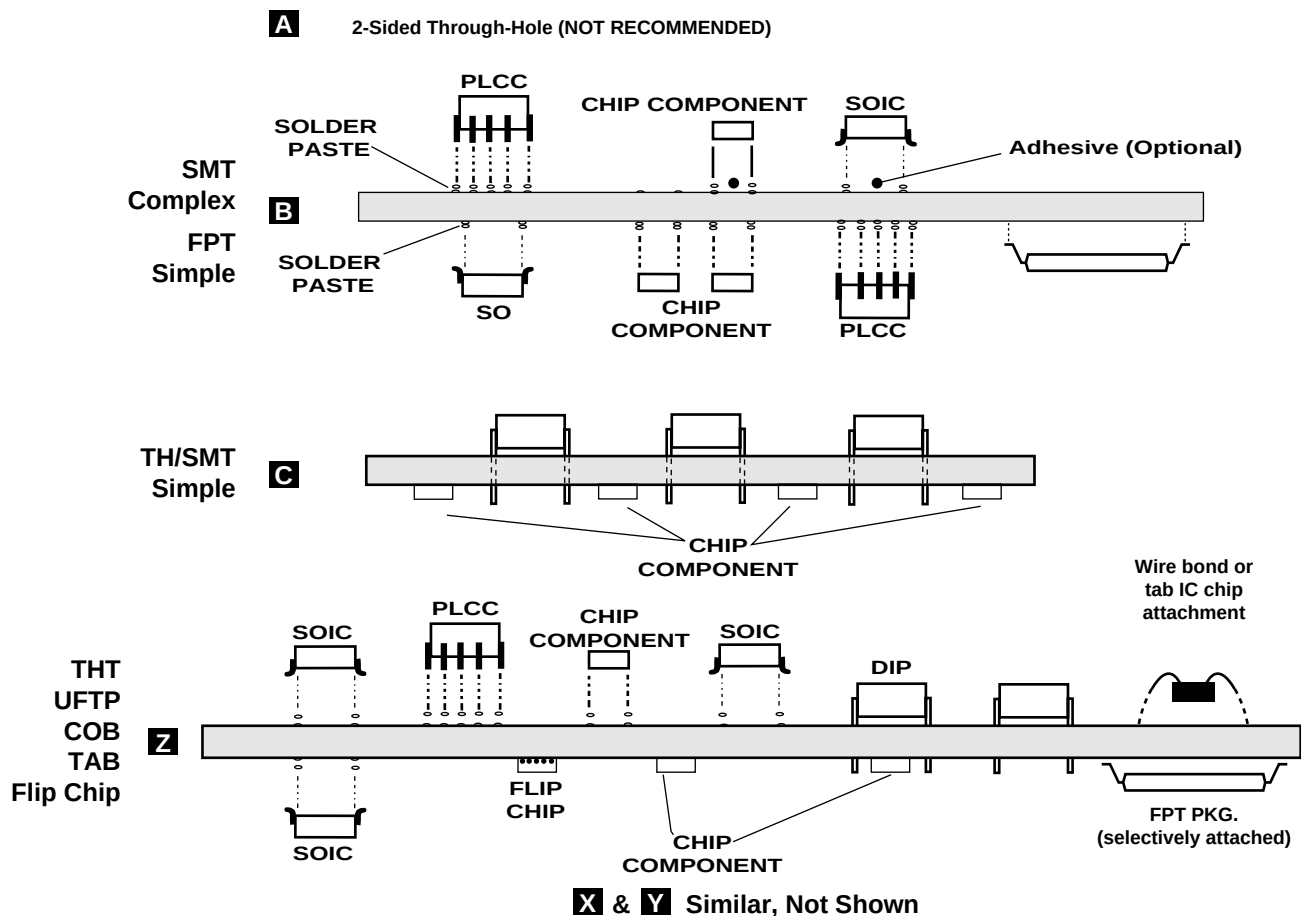
Anisotropic Conductive Contact – An electrical connection using an anisotropic conductive film or paste wherein conductive particles of gold, silver, nickel, solder, etc., are dispersed. When it is compressed, an electrical connection is attained only in the direction of compression.

Application Specific Integrated Circuit (ASIC) – A semiconductor device intended to satisfy a unique circuit function.

Axial Lead – Lead wire extending from a component or module body along its longitudinal axis.

Ball Lift – A category of ball bond failure in which the ball lifts from the surface of the integrated circuit or component package.

Type 2 Components (mounted) on both sides of the board



IPC-770-1-02

Figure 1-2 Type 2 Printed Board Assemblies

metallization or lifts the metallization from the surface of the underlying oxide or silicon.

Ball Grid Array (BGA) – A surface mount package wherein the bumps for terminations are formed in a grid on the bottom of a package.

Ball Bond* – The welded connection of a bond wire to the bond pad of an integrated circuit die. The bond wire is melted to form a ball and the ball is bonded by use of thermo-compression or thermosonic techniques.

Bonding Time (Reflow) – The time duration from the commencement of thermode heatup until the reflow thermo profile is completed.

Castellation – A recessed metallized feature on the edge of a leadless chip carrier that is used to interconnect conducting surfaces or planes within or on the chip carrier.

Ceramic Quad Flat Pack (CQFP) – A Quad Flat Package (QFP) made of a ceramic material hermetically sealed with leads extending from all four sides.

Table 1-1 Interconnection Acronyms and Definitions

PB Printed Board (Bare Board) (All Board Types) The general term for completely processed printed circuit and printed wiring configurations. This includes single-sided, double-sided and multilayer boards made from rigid, flexible, rigid-flex combinations or with high-density microvia dielectric material combinations.		
PCB Printed Circuit Board Rigid, Flex, PC Card A printed board that provides both point-to-point connections and printed components in a predetermined arrangement on a common base.	PWB Printed Wiring Board Rigid, Flex, PC Card A printed board that provides point-to-point connections, but not printed components in a predetermined arrangement on a common base.	HDB High Density Board Single/Multichip, High Density A printed board that consists of microvias and fine-line point-to-point interconnections, in a predetermined arrangement, on a common passive or active PCB/PWB core.
PCA Printed Circuit Assembly An assembly that uses a printed circuit board for component mounting and interconnecting purpose.	PWA Printed Wiring Assembly An assembly that uses a printed wiring board for component mounting and interconnecting purposes.	HDA High Density Assembly An assembly that uses a high density board for component or microcircuit (bare die) mounting and interconnecting purposes.
HDCB High Density Circuit Board A printed circuit board core that provides microvia connections and fine-line point-to-point connections, in a predetermined arrangement on one or both sides of the printed circuit board core.	HDWB High Density Wiring Board A printed wiring board core that provides microvia connections and fine-line point-to-point connections, in a predetermined arrangement on one or both sides of the printed wiring board core.	HDMB High Density Microcircuit Board A high density circuit or wiring board intended to be used as the mounting substrate inside an electronic component, to become the redistribution layer from one or more bare die to the component package I/Os.
HDCA High Density Circuit Assembly An assembly that uses a high density circuit board for prefabricated and embedded or printed electronic component mounting and interconnecting purposes.	HDWA High Density Wiring Assembly Density wiring board for prefabricated electronic component mounting and interconnecting purposes.	HDMA High Density Microcircuit Assembly (Single Chip Module) An assembly that uses a high density microcircuit board as the redistribution layer for bare die/dice mounting and interconnecting purposes.

Ceramic Pin Grid Array (CPGA) – A pin grid array package (PGA) made of a ceramic material, hermetically sealed by metal, with leads formed on a grid extending from the bottom of the package.

Ceramic Dual-Inline-Package (CERDIP) – A dual-inline-package that has a package body of ceramic material and hermetically sealed by a glass; (see also “Dual-Inline-Package”).

Chip Carrier – A low profile, usually square, surface-mount component semiconductor package whose die cavity or die mounting area is a large fraction of the package size and whose external connections are usually on all four sides of the package. (It can be leaded or leadless.)

Chip Component – A component designed for surface mounting with two or more terminations, attachable with solder or electrically conductive adhesive.

Chip-In-Board (CIB) – An electronic component chip is inserted into an opening of a ceramic or glass-epoxy substrate and bonded by wire bonding or TAB techniques. The object of this technique is to reduce the thickness of the Chip-On-Board assembly. A resin may cover the chip after bonding.

Chip-On-Board Assembly – A printed board assembly using a combination of uncased chips and other devices. The silicon area density is less than 30%.

Chip-On-Flex (COF) – Surface mounted chip attached directly onto flexible printed boards.

Chip-On-Glass (COG) – An assembly technology that uses an unpackaged semiconductor die mounted directly on a glass substrate such as a glass plate for liquid crystal display (LCD).

Clinched Lead – A component lead that is inserted through a hole in a printed board and is then formed in order to retain the component in place to make metal-to-metal contact with a land prior to soldering. See also “Partially-Clinched Lead.”

Clinched-Wire Through Connection – A connection made by a bare wire that has been passed through a hole in a printed board and subsequently formed (clinched) and soldered to the conductive pattern on each side of the board (see Figure 1-3).

Coined Lead – The end of a round lead that has been formed to have parallel surfaces that approximate the shape of a ribbon lead.

Conductive Paste – A conductive material used for thick film circuits that is a creamy mixture of metal powders and a vehicle material. A conductor is produced by screen printing the paste on a base material and heat curing.

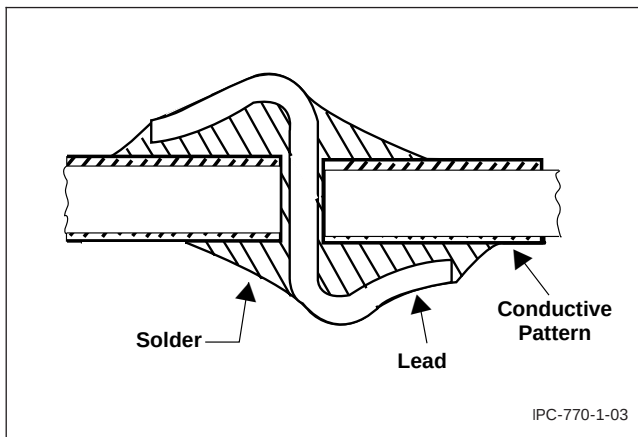


Figure 1-3 Clinched Wire Through Connection

Conductive Pattern – The configuration or design of the conductive material on a base material. (This includes conductors, lands, vias, heatsinks and passive components when these are an integral part of the printed board manufacturing process.)

Controlled Collapse Bonding (CCB) – A bonding technique that makes termination by reflowing the solder bump on a chip and connecting it to the land on the printed board.

Controlled Collapse Soldering* – A technique for soldering a component (i.e., flip chip, chip scale package, BGA) to a substrate, where the component connection surface tension forces of the liquid solder supports the weight of the component and controls the height of the joint.

Component Lead – The solid or stranded wire or formed conductor that extends from a component to serve as a mechanical or electrical connector, or both.

Component Pin – A component lead that is not readily formable without being damaged.

Coplanarity – The distance in height between the lowest and highest leads, terminations or bumps when the component is in its seating plane.

Design for Reliability (DfR) – Design procedure to assure long-term reliability of electronic assembly.

Die – The uncased and normally leadless form of an electronic component that is active or passive, discrete or integrated.

Die Pad – A land on which the integrated circuit die is mounted during the assembly process using adhesives.

Dual-Inline Package (DIP) – A basically-rectangular component package that has a row of leads extending from each of the longer side of its body that are formed at right angles to a plane that is parallel to the base of its body.

Eyelet – A short metallic tube, the ends of which can be formed outward in order to fasten it within a hole in material such as a printed board.

Face Down Bonding – A type of integrated circuit bonding wherein the die circuitry faces the substrate or the lead frame.

Face Up Bonding – A type of integrated circuit bonding wherein the back of the die is attached to a base material.

Fine Pitch QFP – A quad flat pack package with the lead pitch less than 0.625 mm.

Fisheye (Prepreg)* – A localized area of the reinforcement where the resin coverage is significantly diminished although intact, forming a circular depression, much like a hollow volcano.

Flat Pack – A rectangular component package that has a row of leads extending from each of the longer sides of its body that are parallel to the base of its body.

Gull Wing Leads – An SMT lead form. Leads extending horizontally from the component body centerline, bent downward immediately past the body and then bent outward just below the bottom of the body, thus forming the shape of a gull's wing.

Heat Absorption Coefficient – The degree to which various materials absorb heat or radiant energy.

Humidity Aging – The exposure to a humid environment as a preconditioning before testing components, printed boards, or assemblies.

Inner Layer – See “Internal Layer.”

J-Leads – The preferred surface mount lead form used on PLCCs, so named because the lead departs the package body near its Z axis centerline, is formed down then rolled under the package. Leads so formed are shaped like the letter “J.”

Land – A portion of a conductive pattern usually, but not exclusively, used for the connection and/or attachment of components.

Land Pattern – A combination of lands that is used for the mounting, interconnection and testing of a particular component.

Land Grid Array (LGA) – A square or rectangular package with termination lands located in a grid pattern on the bottom of the package.

Large-Scale Integrated Circuit (LSI) – An integrated circuit with over 100 gates.

Lead Extension – Part of a lead or wire that extends beyond a solder connection.

Lead Frame* – The metal frame on which the integrated circuit die is mounted and bonded during the assembly process.

Lead Fingers – The interior ends of the lead frame leads to which the bond wires from the integrated circuit are connected.

Leadless Chip Carrier (LCC) – A chip carrier whose external connections consist of leads that are around and down the side of the package; (see also “Leadless Device”).

Leadless Device – See “Die” and “Leadless Surface Mount Component.”

Leadless Surface-Mount Component – A surface-mount component whose external connections consist of metallized terminations that are an integral part of the component body; (see also “Leaded Surface-Mount Component”).

Leaded Surface-Mount Component – A surface-mount component for which external connections consist of leads that are around and down the side of the package; (see also “Leadless Surface-Mount Component”).

Least Material Condition (LMC) – The condition in which a feature of size contains the least amount of material within the stated limits of size.

Locating Accuracy – The accuracy in the positioning of a component described by the amount of displacement (i.e., diameter of true position) from the desired position.

Manufacturing Exposure Time (Component) – The time after bake that the component manufacturer requires to process the components prior to bag seal, including a default amount of time to account for shipping and handling.

Maximum Material Condition (MMC) – A drawing defining certain characteristics of the printed board, such material within the stated limits of size.

Metal Electrode Face (MELF) – MELF leadless components have metallized terminals at both ends of a cylindrical body.

Migration (Pressure Sensitive Tape) – The movement over a long period of time of an ingredient from one component to another when the two are in surface contact. May occur between tape components or between the tape and the surface to which it is applied.

Mixed Component Mounting Technology – A component mounting technology that uses both through-hole and

surface-mounting technologies on the same packaging and interconnecting structure.

Molded Interconnection Device (MID) – A combination of molded plastic substrate and conductive patterns that provides both the mechanical and electrical functions of an electronic interconnection package.

Mounting Tack Time – The interval of time required for mounting one component or all components in the solder paste on a printed board.

Multichip Module (MCM)* – A multichip module consisting primarily of closely-spaced integrated circuit dice that have a silicon area density of 30% or more.

Multichip Module-Ceramic (MCM-C) – Multichip modules where the materials of the mounting structure are ceramic or glass-ceramic alternatives; (see also “Multichip Module”).

Multichip Module-Deposited (MCM-D) – Multichip modules where unreinforced dielectric and conductive materials are added sequentially to form an interconnect structure on a substrate; (see also “Multichip Module”).

Multichip Module-Laminate (MCM-L) – Multichip modules primarily using printed board manufacturing processes and materials; (see also “Multichip Module”).

Package Cracking – Cracks in a plastic integrated circuit package caused by stress that results from exposure to reflow solder temperature. These cracks may propagate from the die or die pad to the surface of the package, or only extend part way to the surface or lead fingers.

Planar Resistor – An etched or deposited resistive element incorporated within or on the surface of the printed board.

Plastic Ball Grid Array (PBGA) – A polymer based package with interconnects formed of tin-lead solder spheres. The solder interconnects are located in an array area on the bottom side of package.

Plastic Leaded Chip Carrier (PLCC) – A surface mount family of integrated circuit packages with J-leads extending from all four sides of the package, generally with a 1.27 mm lead-to-lead pitch.

Plastic Quad Flat Pack (PQFP) – A surface mount family of integrated circuit packages with leads exiting from all four sides of the package and formed into “gull-wing” lead format.

Polarized Component – A component wherein the terminations are assigned as positive or negative polarity.

Quad Flat Pack (QFP) – A square component package with leads that are formed in “gull-wing” shape and extend from the four sides of the body.

Quad Flat Pack With Bumpers (BQFP) – A QFP package with guarding bumpers at the four corners to protect the leads from damage.

Radial Lead Component – A component where the leads are located on the bottom, radially and parallel to the central axis.

Radial Lead – Lead wire extending from the axis of a component or module body at the mounting surface.

Rectangular Lead – A lead form or leg shape whose cross-section is rectangular in shape.

Reflow – The joining of surfaces that have been tinned and/or have solder between them, placing them together, heating them until the solder flows, and allowing the surface and the solder to cool in the joined position.

Seating Plane – The surface of a substrate on which a component rests.

Self-Alignment Effect – A force that pulls an SMD to the center of the land by the surface tension of the solder during reflow soldering.

Shrink Sop (SSOP) – A family of component packages with four sizes, each having the ability to provide lead pitches between 0.68 mm and 0.3 mm.

Single Chip Package (SCP) – An integrated circuit package containing only one semiconductor die.

Single In-Line Package (SIP)* – A component package that terminates in one straight row of pins or leads.

Small Outline (SO) – See page 46 of DRM-18F for definition.

Small Outline I-Leaded Package (SOI) – A component package of SOP type with the leads shaped like the letter “I.”

Small Outline Integrated Circuit (SOIC) – A surface mount family of integrated circuit packages with two rows of formed leads with 1.27 mm pitch (center-to-center spacing). Lead formation may be “J” or “gull wing.”

Small Outline J-Leaded Package (SOJ) – Small outline package (SOP) with J-leads.

Small Outline Package (SOP) – An integrated circuit package with leads of “gull wing” shape extending from two sides of its body.

Small Outline Transistors (SOT) – SOTs are rectangular transistor or diode packages with three or more gull-wing leads.

Surface Mounting* – The electrical connection of components to the surface of a conductive pattern that does not utilize component holes.

Surface Mount Component – A leaded or leadless device (part) that is capable of being attached to a printed board by surface mounting.

Surface Mount Device – See “Surface Mount Component (SMC).”

Thin Quad Flat Pack (TQFP) – A surface mount family of integrated circuit packages with a thin plastic body.

Thin Small Outline Package (TSOP) – A package that has the same features as the Small Outline Package except that its thickness is reduced to 0.8 mm - 1.2 mm.

Through-hole Mounting – The electrical connection of components to a conductive pattern by the use of component holes.

Transistor Outline (TO) – JEDEC Designation for Transistor Packaging Outline.

Tray – A pallet intended to contain surface mount devices (SMD) designed to make it easy to feed them to an automatic component-mounting machine.

Through Hole – The electrical connection of components to a conductive pattern by the use of component holes.

Very Large Scale Integrated Circuit (VLSI) – Integrated circuits with more than 80,000 transistors on a single die that are interconnected with conductors that are 1 micron or less in width.

Wire Bond Degradation – A weakening of an integrated circuit ball bond due to stress caused by exposure to reflow soldering temperatures resulting in possible reduction of component reliability.

Zigzag In-Line Package – A package with in-line leads on one side that is arranged in zigzag fashion.

2 APPLICABLE DOCUMENTS

There are many other resources to where designers may wish to refer. While some of these may be outdated or even cancelled, there is still good support information found in them.

2.1 IPC¹

IPC-DRM-18 Component Identification Training & Reference Guide

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

IPC-SC-60 Post Solder Solvent Cleaning Handbook

IPC-SA-61 Post Solder Semi-Aqueous Cleaning Handbook

IPC-AC-62 Post Solder Aqueous Cleaning Handbook

IPC-CH-65 Guidelines for Cleaning of Printed Boards

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

IPC-D-325 Documentation Requirements for Printed Boards, Assemblies, and Support Drawings

IPC-D-350 Printed Board Description in Digital Form

IPC-D-356 Bare Substrate Electrical Test Data Format

IPC-A-610 Acceptability of Electronic Assemblies

IPC-HDBK-610 Handbook and Guide to IPC-A-610

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

IPC-CA-821 General Requirements for Thermally Conductive Adhesives

IPC-CC-830 Electrical Insulating Compounds for Printed Board Assemblies

IPC-HDBK-830 Guidelines for Design, Selection and Application of Conformal Coatings

IPC-SM-840 Qualification and Performance of Permanent Solder Mask

IPC-1902 IPC/IEC Grid Systems for Printed Circuits

IPC-2221 Generic Standard for Printed Board Design

IPC-2222 Sectional Standard on Rigid PWB Design

IPC-2223 Sectional Design Standard for Flexible Printed Boards and Assemblies

IPC-2224 Sectional Standard for Design of PWBs for PC Cards

IPC-2225 Sectional Design Standard for Organic Multichip Modules (MCM-L) and MCM-L Assemblies

IPC-2226 Design Standard for High Density Interconnect (HDI) Printed Boards

IPC-3406 Guidelines for Electrically Conductive Surface Mount Adhesives

IPC-3408 General Requirements for Anisotropically Conductive Adhesives Films

IPC-6011 Generic Performance Specification for Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6013 Specification for Printed Wiring, Flexible and Rigid-Flex

IPC-6015 Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures

IPC-6016 Qualification and Performance Specification for High Density Interconnect (HDI) Layers or Boards

IPC-7095 Design and Assembly Process Implementation for BGAs

IPC-9501 PWB Assembly Process Simulation for Evaluation of Electronic Components (Preconditioning IC Components)

IPC-9502 PWB Assembly Soldering Process Guideline for Electronic Components

IPC-9503 Moisture Sensitivity Classification for Non-IC Components

IPC-9504 Assembly Process Simulation for Evaluation of Non-IC Components (Preconditioning Non-IC Components)

1. www.ipc.org

IPC-9701 Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments

2.2 Joint Industry Standards²

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

IPC-HDBK-001 Handbook and Guide to Supplement J-STD-001

J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

J-STD-003 Solderability Tests for Printed Boards

J-STD-004 Requirements for Electronic Soldering Fluxes

J-STD-005 Requirements and Test Methods for Solder Paste

J-STD-006 General Requirements and Test Methods for Electronic Grade, Soft 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-020 Handling requirements for Moisture Sensitive Components

J-STD-026 Semiconductor Design Standard For Flip Chip Applications

J-STD-033 Standard for Handling, Packaging, Shipping and Use of Moisture Reflow Sensitive Surface Mount Devices

J-STD-035 Acoustic Microscopy for Non-Hermetic Encapsulated Electronic Components

2.3 Electronic Industries Association³

RS-471 Symbol and Label for Electrostatic Sensitive Devices

2.4 EOS/ESD Association Documents⁴

ANSI/ESD-S8.1 ESD Awareness Symbols

ANSI/ESD-S-20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment

2.5 JEDEC⁵

Publication 95 Mechanical Outlines of Solid State and Related Products

Publication 95-1 Design Requirements for BGA and FBGA

3 GENERAL GUIDELINES

The component mounting technique, the mounting sequence and the resultant assembly configuration all impact the soldering techniques that can be applied to the interconnection of components, printed boards and the resultant quality of the solder joints.

Excessively large clearances can result in draining of the solder. Lead extension through the hole must be adequate to ensure opportunity for a good solder joint and subsequent inspection but not so long as to cause interference with tooling for subsequent processes or shorting to adjacent runs or assemblies.

Component and board considerations, independent of type that impact soldering should be considered.

3.1 Design Options and Considerations When first considering assembly options some basic decisions have to be made. Decisions such as whether to use solder or adhesives for component attachments, whether to surface mount, through board mount or use a mixture of both, whether even newer techniques such as chip-on-board should be considered. Selections of placement methods and equipment and choices of solder material form lead to questions about material application methods and equipment.

The type of component used is normally dependent on the type of assembly. For example, single-sided assemblies often use through-hole components only, whereas double sided/multilayer assemblies often use surface mounted or intermixed components. In the former case, the through-hole components are frequently wave soldered. In the latter case, the surface-mounted components may be reflow soldered, or those surface-mounted components on the underside of the board may be attached with adhesives and then wave soldered.

If the printed board structure is complicated, or only a small number of assemblies are to be made, then manual assembly techniques are often used. However, if the printed

2. www.ipc.org

3. www.eia.org

4. ESD Association, 7900 Turin Road, Bldg. 3, Ste. 2, Rome, NY 13440

5. www.jedec.org

board structure is simple, or the number of assemblies required is large, then the set-up time and monetary investment for automated component mounting and assembly may be worthwhile.

In either case, component mounting on double sided or multilayer printed boards is more complicated than single-sided boards because the former use plated-through holes for the through-board components. These plated-through holes require greater tolerances because plating builds up in the holes. This may restrict component mounting.

The joining techniques used may also influence the assembly process. Although this document deals primarily with component mounting, not the joining process, the two cannot be separated in intermixed assemblies. In some sequential manufacturing operations, certain parts must be secured or permanently attached before other components are mounted.

The assembly process itself often influences component placement. For example, singular (one at a time) or multiple (several at a time) component placement affects tool-head clearances for automatic placement equipment, set up procedures, and other manufacturing steps.

The entire sequence of events in the assembly/joining process affects component placement. Previously mounted components must not interfere with other components mounted in a second step and secondary-joining techniques, such as soldering, must not damage components previously placed and joined.

In some cases, simply selecting a different assembly/joining procedure cannot solve problems in assembly. Perhaps the problem cannot be “solved” at all, but it can be prevented through careful design. To prevent problems and create a board that can be manufactured, the designers of printed board assemblies must take into account all of the fabrication assembly steps necessary to complete the electronic assembly.

3.1.1 Leadless Component Terminations This geometry provides no compliance and results in a very rigid, small lap solder joint depending on the reflowed solder material system providing desired mechanical properties. Visual inspection of the joint is limited to fillet appearance on any castellation and pad extension. Cleaning is more difficult with this geometry than with the leaded termination.

3.1.1.1 Lead/Land Relationships The leadless and leaded terminations provide different solder joint geometries and the stress distribution is different in each case. If leads are too short to protrude through the printed board or

if the surface mount lands are too small, soldering may become difficult. Printed board hole diameters must be considered for the type product to be used.

Costs and problems can be reduced if the designer selects his devices prior to printed board design and then designs the proper hole or land size, etc. “Nonstandard” holes and land patterns increase costs by making “nonstandard” devices mandatory.

3.1.2 Leaded Component Terminations This geometry results in a narrow solder fillet. It provides compliance that can compensate for some degree of mismatch in expansion between the component package and the substrate. Visual inspection of solder joints is somewhat easier with this geometry. Cleaning operations are aided by this geometry since it provides clearance between the bottom of the component and the substrate. Excess solder fillets on this geometry can stiffen the lead and reduce any compliance advantage.

3.1.2.1 Lead/Hole Relationships Hole and land requirements for intermixed assembly are identical to those requirements in through hole and surface mounted land pattern configurations. No special requirements are necessary and implementation of the proper land pattern into the design provides the appropriate solder joint after placement.

3.1.3 Spacing Proper spacing can greatly increase automatic, semiautomatic and manual speed of component placement. If possible, features should be placed in straight-line patterns rather than random ones. They should also be placed so that readjustment of the board to the product is unnecessary. Additional considerations:

- Tooling holes should be placed as far apart as possible.
- No premounted components should interfere with the proper machine installation of those devices to be subsequently installed.
- Printed board holes may be “non” plated or “through” plated, drilled or punched, depending on the device that is eventually used and the quality required in the final printed board.

As a general rule, a drilled hole is more consistent in size and is advised where a hole will eventually be plated through. Punched holes in multilayer printed boards are not recommended since the internal conductors may be damaged.

3.1.4 Part Type Mass soldering of assemblies is usually done with either a solder wave or a reflow process with hot air, radiation (infrared), condensation heat transfer or conductive plate. Many leaded devices such as DIPs and

are currently not considered appropriate for wave soldering and must be soldered with the reflow process. These devices may appear on either side of the board. However, if processing includes a wave-solder operation, SMT components on the solder destination side should be reflowed. Surface mounted devices with fewer leads such as resistors, capacitors and small outline (SO) devices can be assembled with solder waves but the orientation of the parts becomes important. Passive chips, SOTs, SOICs and other components that can tolerate immersion in the molten solder of a wave soldering machine may be mounted on the “solder source” side of printed wiring assemblies.

Through-hole mounted parts have the potential of resultant lower quality solder joints if insulation material, potting compound or other material is allowed to protrude into the hole. Another characteristic of these devices is their tendency to “rise” during the fluxing/wave soldering process if not clinched or mechanically retained. For wave soldering, the through hole mounted devices should be mounted on the “solder destination” side of the board. These devices may not be compatible with reflow processes. The component mass is another factor to be reviewed. Heavy mass components require longer soldering times due to their heat sinking characteristics.

3.2 Assembly Considerations

3.2.1 Component Preparation All lead extension and forming requirements for parts to be mounted on printed board structures are identical to the techniques described for through hole and surface mount component mounting and positioning.

Sometimes it is necessary to modify a component so that it can be mounted in a different manner. For example, forming the leads of a through-hole component so that it could be surface mounted. This could result in the elimination of a wave soldering process.

Figure 3-1 shows taking a standard flatpack that is usually surface mounted and forming the leads to mount the component in the through hole. This practice would be used when only several flatpacks are present on an otherwise all through-mounted board assembly.

Sockets are sometimes used so surface mount components may be placed in through-hole assemblies.

When components designed for through hole are converted to surface mount, there are additional steps necessary in lead forming. Axial leaded parts that are normally mounted through hole would have their leads coined as shown in Figure 3-2. These parts could then be surface mounted. In addition, some manufacturers have started to use the concept of a dual-in-line package (DIP) with I beam leads. In

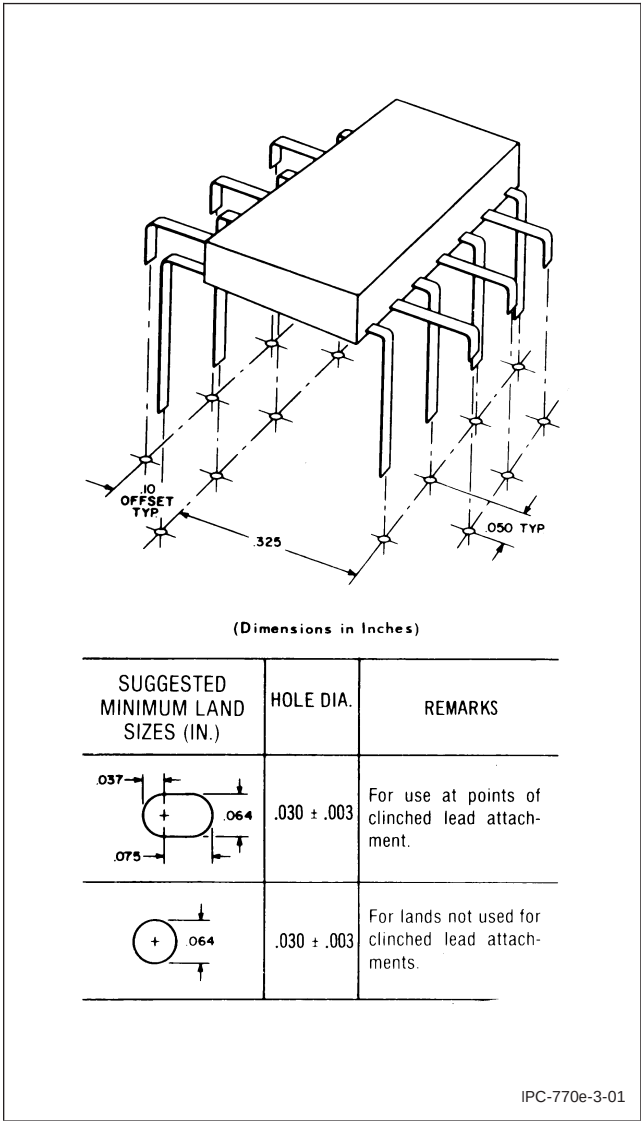


Figure 3-1 Staggered Hole Pattern Mounting “MO” Flatpack Outline Drawing (Only Inches Shown)

this technique, the DIPs have their leads trimmed and are surface mounted to the board in the manner shown in Figure 3-3. Special care must be taken to insure that the components do not move during the soldering operations. Usually the solder paste is sufficient to hold a dual inline package in place prior to reflow soldering. This method is not acceptable for Class 3 assemblies.

3.2.2 Lead Forming When component leads require forming, the leads should be formed with a bending tool. The component leads should be formed to the final configuration before assembly or installation (except for the final crimp, where required). When being bent, a suitable tool should firmly hold the welded leads on the side of the weld away from the component body. Lead forming should not nick the lead. Care must be taken so that energy (mechanical shock) from the bending action is not transmitted into the component.

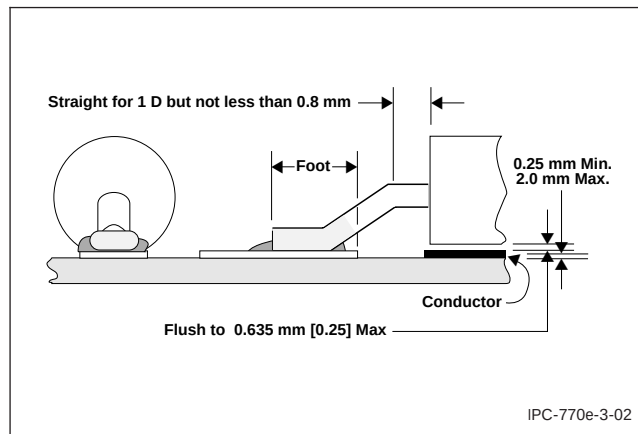


Figure 3-2 Component Modifications for Surface Mounting Applications

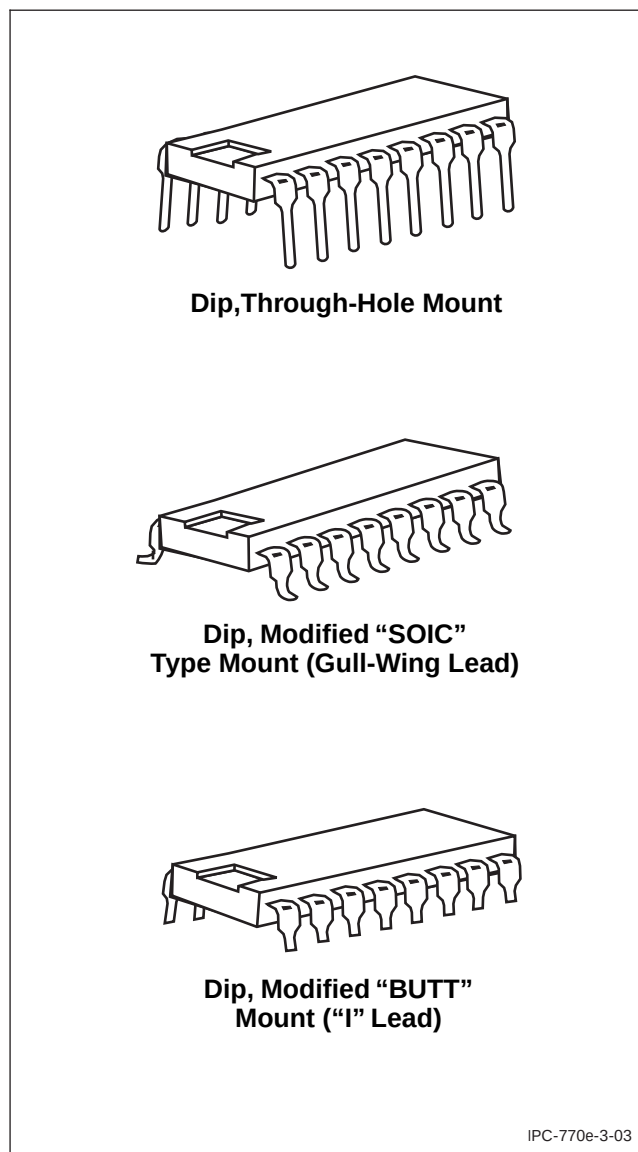


Figure 3-3 Modifying DIP for Surface Mounting

Lead forming tools and forming tolerances have significant impact on maintaining functional quality of components. Considerations must be given to lead material and hardness when designing tooling. Component body materials (glass, elastomers, metal case, plastic) react differently to forming strains. Stresses from gripping and close bending may damage protective cases.

Nicks, cuts or other cross-section reduction to leads during the gripping and forming process can provide failure mechanisms and change electrical characteristics. Care should be exercised in tool design and materials. Following specific guidelines on closeness of bend and minimum bend radii is necessary.

3.2.3 Component Placement Sophisticated tooling is available, both for the placement of axial leaded components and the placement of surface mounted components. Figure 3-4 shows an example of the sequencing used for placing two leaded axial parts and a tape used to place chip components between the parts. Also, machine head clearances must be considered.

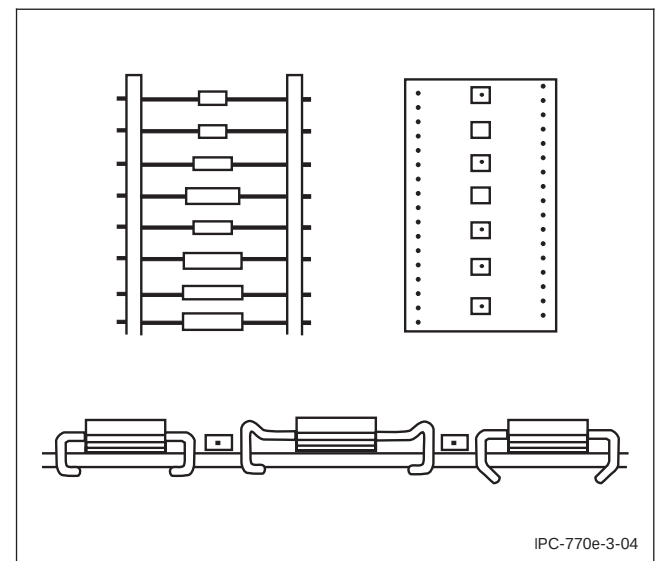
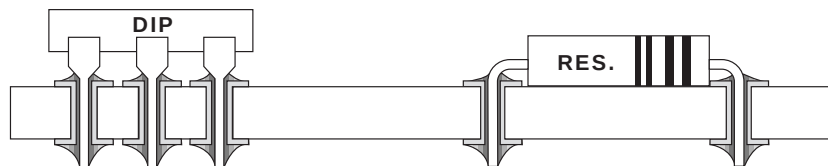


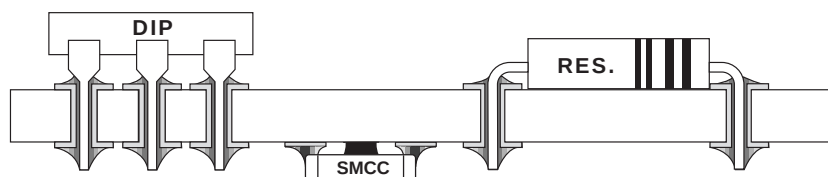
Figure 3-4 Placement Machine Considerations

In the example shown, the chip resistors would be placed first and probably attached through reflow soldering. The design must provide adequate clearances for the machine that assembles and clinches the leads for the axial leaded components. Without proper knowledge of machine clearances or considerations included into the design, manufacturers would have to insert components semiautomatically or use manual techniques.

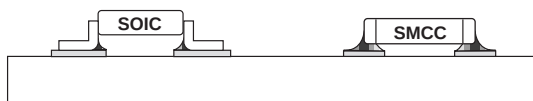
3.2.4 Mixed Assemblies In the example shown in Figure 3-5, the chip resistors would be placed first and probably attached through reflow soldering. The design must provide an adequate clearance for the machine.



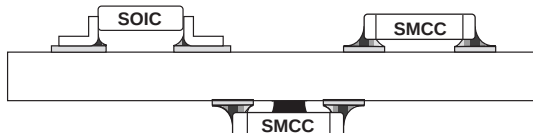
Type 1A Simple Through-Hole



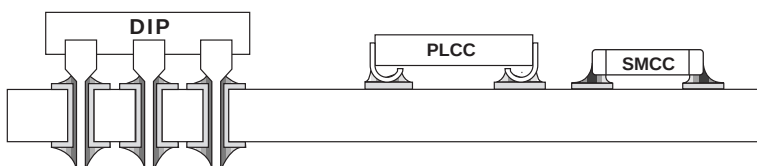
Type 2C Simple Mixed Through-Hole & Surface Mount



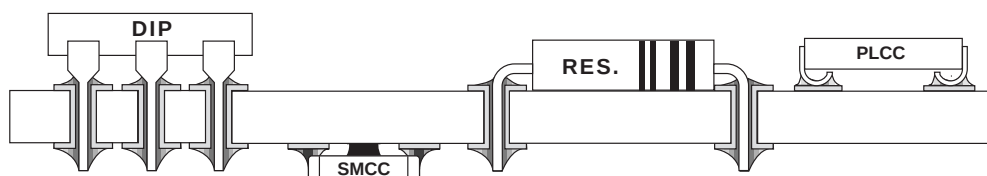
Type 1B Simple One Side Surface Mount



Type 2B Simple Surface Mount on Two Sides



Type 1C Simple Mixed Through-Hole & Surface Mount on One Side



Type 1A Simple Mixed Through-Hole & Surface Mount on Two Sides

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Figure 3-5 Mixed Assemblies

3.2.5 Component Securing Forming of leads for through-hole mounting components serves many purposes. These include retaining the component in the substrate during subsequent handling prior to soldering or providing a standoff. Such bends or loops are provided by tooling with some forming machines and/or can be introduced by hand forming. Care must be exercised such that stresses are not introduced to the component, leads or solder joint during solidification.

The shock and vibration to which printed board components are subjected during normal handling, environmental testing and use can damage the lead terminations and lead-to-component body seals. For this reason, many components should be mechanically secured to the mounting base.

The component securing methods most commonly used are clips, clamps, and brackets, wire and elastic straps, adhesives and integral mounting provisions.

Most circuit malfunctions in a severe vibration environment are caused by cracked solder attachments, cracked seals, or broken electrical lead wires. These failures are usually due to dynamic stresses that develop because of relative motion between the electronic components and the board. This relative motion is generally most severe during resonant conditions.

Since shock and vibration vary widely with each specific application, it is not possible to provide solutions to all component-mounting problems. This document suggests some general guidelines that, if observed, provide reasonable assurance that the components and assemblies survive shock and vibration within their intended use.

The extent to which the user wishes to implement these guidelines may ultimately be validated by actual tests of the assembled printed board in its intended shock and vibration environment.

The ultimate ability of components to survive in shock and vibration environments depends upon the degree of consideration given to the following factors:

- Worst case levels of shock and vibration environment for the entire structure in which the printed board assembly resides and the ultimate level of this environment that is actually transmitted to the components mounted on the board. Particular attention should be given to equipment that is subjected to random vibration.
- Method of mounting the board in the equipment to reduce the effects of this environment, specifically the number of board-mounting supports and their interval and complexity.
- Attention given to the mechanical design of the board; specifically its size, shape, type of material, material thickness and degree of resistance to bowing and flexing.

- Shape, mass, and location of the components mounted on the board.
- Component lead wire strain relief design as provided by its package, lead spacing, lead bending, or a combination of these with the addition of restraining devices.
- The attention paid to workmanship during board assembly to ensure that component leads are properly bent, not nicked.
- Components are installed in a manner that minimizes component movement.

Techniques for shock and vibration mounting of intermixed assemblies do not vary dramatically from techniques previously described for boards that have only through hole components or are all surface mounted.

One aspect of the intermixed assembly is that although components can take the shock of the final assembly, certain components and their joints may not take the shock of a secondary assembly operation. For example, if chip components are mounted on the underside of the board and attached using some form of adhesive, the next assembly operation should not impart additional shocks to the assembly so that the parts that have been secured to the underside are dislodged.

The characteristic of shock from secondary assembly operations is even more important when parts that have previously been mounted are attached using soldering techniques. Now the shock and vibration is not just on the part itself, shock and vibration can also affect the reliability of the soldered joint.

Special fixturing should normally be provided during the assembly operation to insure that no damage is imparted to those parts that have been previously mounted or attached.

3.2.5.1 Clips, Clamps and Brackets The following list describes the basic guidelines for components mechanically secured by clips, clamps and brackets (see Figure 3-6):

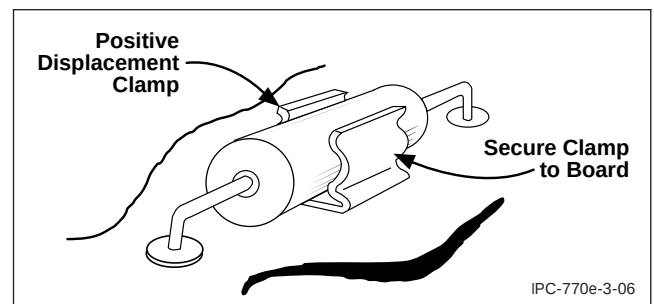


Figure 3-6 Clip-Mounted Component

- All clips, clamps or brackets should be secured using two fasteners or one fastener and a nonturn device to prevent rotation.
- Clamps and brackets that require their removal in order to replace the component should be secured with a nonturn device.

fastener or other nonpermanent fastener, unless the subassembly in which they are used is considered to be disposable or nonrepairable.

- Spring type clips that need not be removed during component replacement may be secured with permanent type fasteners such as rivets or eyelets.
- Twist-type lugs, ears, or clips with glass envelope components should be avoided.

3.2.5.2 Strapping Devices When using wires and elastic straps for mechanical securing, the strap is wrapped over the component body and passed through holes in the mounting base. When wire is used, it is clinched and soldered in the same manner as component leads to lands. When wire is used with heat sensitive or fragile components, the part of the wire on the component should be covered with a suitable sleeving.

The elastic strap is secured by being stretched to reduce its cross-section below that of the hole, and then returned to its larger-than-hole size by relieving the tension after it has been passed through the hole. The resiliency of the strap holds the component in place (see Figure 3-7).

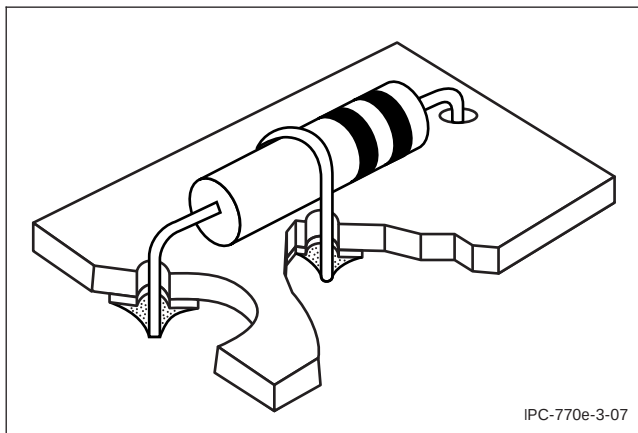


Figure 3-7 Strap Securing

3.2.5.3 Component Securing Devices The shock and vibration to which printed board components are subjected during normal handling and environmental testing can damage the lead terminations and lead-to-component body seals. For this reason, many components, especially those weighing more than 7.09 g per lead, should be mechanically secured to the mounting base prior to lead termination and during assembly usage.

The more commonly used component-securing methods are clips, clamps, and brackets; wire and elastic straps; adhesives and integral mounting provision.

3.3 Materials All soldering processes are only capable of achieving optimum process yields if the materials used in those processes are not substandard. Regardless of the particular soldering process (dip, wave, and reflow), all solder

processes follow the same basic steps: flux, preheat and soldering. Some newer technologies use other materials such as adhesives either in conjunction with or in replacement of soldering. Adhesive attachment of components is particularly attractive with temperature sensitive devices, and for securing surface mount devices. The various types of alternative solder materials are discussed here.

3.3.1 Solder Metal alloys with melting points in the range of 150°C to 400°C. Alloys below this temperature range are commonly called fusible alloys while above this range they are called brazes. Tin-lead alloys are most common, although more complex compositions have been developed for special applications.

For electrical soldering, alloys near the eutectic composition (63% tin - 37% lead) have the required combination of properties. Although compositions either side of the eutectic composition have higher liquidus (completely melted) temperatures desirable for higher ambient temperature applications, the initial melting point when solder softens is 183°C; the same for all tin-lead alloys with compositions between 20% and 98% tin. There is no benefit of service temperature unless the tin content is less than 20% or greater than 98%.

The range of properties of tin-lead alloys can be varied by adding other metals such as bismuth or indium to lower the melting point, or antimony, silver, etc., to increase hardness and fatigue resistance. Alloys containing less than 10% tin are used for applications involving temperatures below -40°C. As mentioned earlier, the choice of the soldering flux depends primarily on the solderability of the base material. Solder pastes and alloys should be agreed upon for composition and purity. Solder paste is defined in J-STD-005; solder alloys are defined in J-STD-006.

3.3.2 Flux Must have properties to chemically remove the surface oxide or tarnish and keep the surface clean until the solder has melted and flowed over the fluxed surface.

Soldering fluxes have been divided into three general categories. The traditional flux specifications classify fluxes on the basis of their chemical make-up or flux base (rosin base fluxes, for example, are classified as R, RMA or RA ROLO ROL1 etc.).

J-STD-004 utilizes a unified approach to flux classification based on fundamental, intrinsic corrosive and conductive properties of flux and flux residues, rather than specifying the flux base.

Flux are specified according to one of the following three types of flux/flux residue activity per J-STD-004:

- L = Low (or none)
- M = Moderate
- H = High

Inorganic fluxes are not permitted for electronics soldering. The flux and the cleaning process (or lack thereof) are directly interdependent.

3.3.2.1 Rosin Flux Many common fluxes use natural rosin as a base. This product, derived from the gum of pine trees, is a mix of abietic acid and numerous dehydrogenation products.

Rosin is a glassy, noncrystalline mixture of organic acids which are inert up to their softening point and only assume an acidic nature when molten. After melting and solidifying, the hard glassy properties render the residue once again inert. Residues from other added chemical activator compounds usually become encapsulated in the rosin residue, which renders them noncorrosive. The effectiveness of this safeguard, however, depends on the quantity and nature of the activator used.

The acidity of pure rosin alone is usually insufficient to clean surfaces to be soldered, so rosin fluxes are usually enhanced by a variety of chemicals called activators. Common activators are inorganic halides, organic halides, carboxylic acids, amines and halogenated amines. The degree of activation achieved by the various chemicals depends upon the compound and the quantity. The overall activity developed is often a synergistic product of more than one activator. Activation is usually quantified not by formulation alone but rather by some secondary property. Examples include the ability of the residue extract to dissolve a copper from the "Copper Mirror Test" or the chemical's ionic conductivity. The level of activator affects the rate of wetting.

3.3.2.2 Organic Acid (Water Washable) Fluxes These fluxes are significantly more active and aggressive than rosin fluxes in removing oxides from the surfaces to be soldered. They use strong organic acids and salts to achieve these properties. They are more forgiving of poor solderability characteristics of the soldered surfaces.

The increased activity yields flux residues that are more corrosive than the residues of rosin fluxes. Because of their characteristics it is necessary to completely remove the residue with a post soldering cleaning operation to prevent early failure of the soldered assembly.

3.3.2.3 No Clean Fluxes (Low Residue/No Residue) This family of fluxes includes both rosin or modified rosin fluxes and nonrosin fluxes. The activators used are generally weak organic dicarboxylic acids.

The low solids rosin/resin based fluxes leave small amounts of residue after soldering which may interfere with bed of nails testing or other post-soldering operations or operating characteristics. They generally have no deleterious impact on reliability and do not need to be removed from the assembly with a post solder defluxing operation.

Other no clean fluxes, leaving no residue, are formulated with no rosin and utilize a mixture of one or more weak dicarboxylic acids and wetting agents to provide the activation needed to enhance soldering. These fluxes leave little or no residue and do not need to be removed from the assembly with a post solder defluxing operation.

An inert gas atmosphere, such as nitrogen, is often used to enhance the soldering process when using these more benign fluxes.

3.3.3 Cleaning Agent In addition to removing grease, oil, wax, dirt, flux and other debris, cleaning agents should also remove flux residue, ionic, ionizable nonpolar and particulate contaminants. The cleaning agent should not degrade the materials and parts being cleaned. Trichloroethylene and some other chlorinated solvents should not be used on glass-silicone resin laminated material. Delamination and surface/component damage may result with their use.

3.3.4 Adhesive Used for securing components in place during soldering should not degrade the solderability of nearby interconnection sites or lead to corrosion or unacceptable insulation resistance properties of the assembly. Insulation testing of adhesives is described in IPC-CA-821.

3.3.4.1 Anisotropic Conductive Adhesive Conducts electricity in one direction only, the Z-axis (between parallel traces). A film of anisotropic adhesive can be placed between the circuit and the components. Heat and pressure are simultaneously applied so that component terminations press down into conductive particles and, in turn, press the particles against the lands. The adhesive holds the component in place upon cooling. Heat may be applied to certain component leads (such as larger gull-wing types). Conversely, convection or direct transfer may heat the circuit. Liquid thermoset adhesive materials are processed differently. The material is coated or printed onto the circuit. The entire board can be covered. Components are conventionally placed and heating them cures the adhesive. Electrical contact is made between the circuit and the components. The conductive particles in the unpopulated areas remain dispersed within the resin so that it serves as an insulating coating.

Caution: Use only with manufacturer's approved component and land surface finishes. Other finishes may lead to reliable connections (see IPC-3406 and IPC-3408).

3.3.5 Components Should be compatible with all solders, process chemicals, and temperatures used to manufacture the assembly. Components that do not meet these requirements must be given special handling.

3.3.6 Printed Boards Should be in accordance with the requirements of the applicable design and performance specification (see 1.2.3 and Table 1-1).

3.3.7 Board & Lead Finishes Should be uniform and of specified thickness. They should be thoroughly cleaned of all residues, capable of adequate storage life times, and impart solderability to the lead or termination that they cover.

Gold or palladium finishes that could cause embrittlement of the solder connection must be carefully evaluated. Finishes such as immersion gold are viable if the thickness is controlled.

3.3.8 Solderability To achieve acceptable solder connections the surfaces to be joined must be solderable. This is known as solderability.

Good solderability can improve production rates, increase reliability, lower costs and improve joint appearance. Production rates increase significantly if board solder joints do not have to be reworked or touched up. Manual touch ups can damage printed boards and impact long-term reliability.

The solderability of both component leads and printed boards is important. Degradation of either part impedes the formation of good solder joints. The emphasis of the control of solderability has been placed on component leads rather than on printed boards due to the following component characteristics:

- Longer storage times
- More rigorous processing during manufacturing
- Lower cost compared to cost of reworking the PWB

3.3.8.1 Solderability Testing Considerable work on solderability control has been applied to printed boards. This includes both testing for solderability and improving the surfaces to be soldered. Testing solderability is required to successfully handle solderability problems. In the last ten years, many tests have been devised for component leads, terminals and printed boards.

J-STD-002 and J-STD-003 list the current requirements and test methods to be used in accordance with the customers' needs for component leads and wires and printed boards:

3.3.9 Coating

3.3.9.1 Conformal Coating Considerations A thin layer of insulating material that is applied to a printed board assembly. This material closely follows the contours of the board and components. It "conforms" to the shape of the assembly, and produces a film of consistent thickness over the entire assembled printed board. Assembled printed boards are frequently given a conformal coating to assist them in functioning under certain environmental conditions. Correctly chosen, and carefully applied, conformal

coating helps to protect the assembly from the following hazards:

- Humidity
- Dust and dirt
- Airborne contaminants - e.g., smoke, chemical vapors
- Conducting particles - e.g., metal chip, filing
- Accidental short circuit by dropped tools, fasteners, etc.
- Abrasion damage
- Vibration and shock (to a certain extent)

Conformal coating is not a substitute for good design, or the selection of adequate components and materials. It does, however, assist the designer in producing equipment that performs under hostile conditions. The conformal coating should be compatible with any solder resist used on the assembly. Conformal coatings protect the electrical characteristics of the assembly by doing the following:

- Preventing contamination of the dielectric surface by field soil, which in humid environments can cause electrical leakage.
- Inhibiting the growth of fungus, thereby protecting the electrical characteristics. Even nonnutrient surfaces can support fungus growth when contaminated with field soils such as oil vapor.
- Suppressing electrical flashover between conductors at high altitudes.

The secondary function of conformal coating is to help support the components, relieving the solder joints from carrying the entire mass of the component. Properties to be considered in quality test and/or evaluations:

- Appearance
- Thickness
- Fungus resistance
- Adhesion
- Shelf life
- Pot life
- Abrasion resistance
- Solvent resistance
- Flammability
- Dielectric withstanding voltage
- Moisture resistance
- Thermal shock resistance
- Thermal humidity aging
- Fluorescence
- Resonance

For additional information on conformal coating see IPC-CC-830 and IPC-HDBK-830.



Documents

Document Sharing Hub

3.4 Handling and Storage This section discusses handling and storage issues such as electrical overstress (EOS), electrostatic discharge (ESD) and storage methods designed to reduce moisture impact on solderability, component cracking/delamination (popcorning) and board damage.

Care must be taken during acceptability inspections to ensure product integrity at all times.

Moisture sensitive component (as defined by IPC/JEDEC J-STD-020 or equivalent documented procedure) must be handled in a manner consistent with J-STD-033 or an equivalent documented procedure.

The following general rules should be practiced when handling printed board assemblies:

- Keep workstations clean and neat.
- Do not eat or drink in the work area. This prevents contamination of the board assemblies.
- Avoid handling the board edge contacts.
- Do not use hand creams and lotions containing silicone since they can cause solderability problems. Lotions formulated specially for use in solder assembly areas are available.
- Do not stack board assemblies. This prevents physical damage to components. The special racks normally provided in assembly areas can create contamination; therefore, changes should be made as frequently as necessary.
- Perform all handling and assembly at an antistatic workstation. Electrostatic discharge may damage sensitive components.

Caution: Cleaning agents may damage certain substrates and unsealed components such as switches, power modules, adjustable devices, etc. Care must be taken to identify and protect these types of components through the cleaning process.

3.4.1 EOS/ESD Electrostatic Discharge (ESD) is the rapid discharge of electrical energy created from electrostatic sources. Electrical energy can cause damage if it comes in proximity of or in contact with sensitive components. Electrostatic Discharge Sensitive (ESDS) components are affected by these high-energy surges. The relative sensitivity of a component to ESD is dependent upon its construction and materials. As components become smaller and operate faster, their sensitivity increases.

Electrical Overstress (EOS) is the internal result of an unwanted application of electrical energy that results in damaged components. This damage can come from many different sources, such as electrically powered process equipment or the handling or processing of components. ESDS components can fail to operate or change in value as a result of improper handling or processing. These failures

can be immediate or latent. Additional testing, reworking, or even scrapping can result from immediate failures. The consequences of latent failure are the most serious. Even though the product may have passed inspection and functional testing, it may fail after the customer receives it. Build protection for ESDS components into circuit designs and packaging is important. In the manufacturing and assembly areas, work is often done with unprotected electronic assemblies (such as test fixtures) that are attached to the ESDS components. Removing ESDS items from their protective enclosures only at EOS/ESD safe workstations within Electrostatic Protected Areas (EPA) is another important consideration. This section discusses the safe handling procedures of these unprotected electronic assemblies.

Information in this section is intended to be general in nature. Additional information can be found in ANSI/ESD-S-20.20 and other related documents. This section covers the following subjects:

3.4.1.1 Electrical Overstress (EOS) Damage Prevention Unwanted electrical energy from many different sources could damage electrical components. ESD potentials can cause this unwanted electrical energy. Another source are electrical spikes caused by the tools such as soldering irons, soldering extractors, testing instruments or other electrically operated process equipment. Some devices are more sensitive than others, depending on the design of the device. In general, devices that are smaller or have higher speeds are more susceptible than their slower, larger predecessors are. The purpose or family of the device also plays an important part in component sensitivity. This is because the design of the component can allow it to react to smaller electrical sources or wider frequency ranges. EOS is a more serious problem than it was even a few years ago. It is even more critical in the future.

The susceptibility of the most sensitive component in the assembly must be considered. Applied unwanted electrical energy can be processed or conducted just as an applied signal would be during circuit performance.

Before handling or processing sensitive components, tools and equipment need to be carefully tested to ensure that they do not generate damaging energy, including spike voltages. Current research indicates that voltages and spikes less than 0.5 volt are acceptable. However, an increasing number of extremely sensitive components require that soldering irons, solder extractors, test instruments and other equipment must never generate spikes greater than 0.3 volt.

As required by most ESD specifications, periodic testing may be warranted to preclude damage as equipment performance may degrade with use over time. Maintenance programs for process equipment are also necessary to ensure they do not cause EOS damage.

EOS damage is similar in nature to ESD damage, since both result from undesirable electrical energy.

3.4.1.2 Electrostatic Discharge (ESD) Damage Prevention The best ESD damage prevention is a combination of preventing static charges and eliminating static charges if they do occur. All ESD protection techniques and products address one or both of these issues.

ESD damage is the result of electrical energy generated from either applied or approximate static sources to ESDS devices. The degree of static generated is relative to the characteristics of the source. To generate energy, relative motion is required. This could come from contacting, separation, or rubbing the material. Most of the serious offenders are insulators since they concentrate energy where it was generated or applied rather than allowing it to spread across the surface of the material. Common materials such as plastic bags or Styrofoam containers are serious static generators and as such are not to be allowed in processing areas; especially in static safe/Electrostatic Protected Areas (EPA). Peeling adhesive tape from a roll can generate 20,000 volts. Even compressed air nozzles that move air over insulating surfaces generate charges (see Table 3-1).

Table 3-1 Typical Static Charge Sources

Environment	Source
Work surfaces	Waxed, painted or varnished surfaces Untreated vinyl and plastics Glass
Floors	Sealed concrete Waxed or finished wood Floor tile and carpeting
Clothes and personnel	Non-ESD smocks Synthetic materials Non-ESD Shoes Hair
Chairs	Finished wood Vinyl Fiberglass Nonconductive wheels
Packaging and handling materials	Plastic bags, wraps, envelopes Bubble wrap, foam Styrofoam Non-ESD totes, trays, boxes, parts bins
Assembly tools and materials	Pressure sprays Compressed air Synthetic brushes Heat guns, blowers Copiers, printers

Destructive static charges are often induced on nearby conductors, such as human skin, and discharged into conductors on the assembly. This can happen when a person, having an electrostatic charge potential, touches a printed board assembly. The electronic assembly can be damaged as the discharge passes through the conductive pattern to an ESDS component. Electrostatic discharges may be too low (less than 3500 volts) to be felt by humans, and still damage ESDS components.

Typical static voltage generation is included in Table 3-2.

Table 3-2 Typical Static Voltage Generation

Source	10-20% Humidity (Volts)	65-90% Humidity (Volts)
Walking on carpet	35,000	1,500
Walking on vinyl	12,000	250
Worker at a bench	6,000	100
Vinyl envelopes (Work Instructions)	7,000	600
Plastic bag picked up from the bench	20,000	1,200
Work chair with foam pad	18,000	1,500

3.4.1.3 ESD Damage Prevention - Warning Labels

Warning labels are available for posting in facilities and placement on devices, assemblies, equipment and packages to alert people to the possibility of inflicting electrostatic or electrical overstress damage to the devices they are handling. Examples of frequently encountered labels are shown in Figure 3-8.

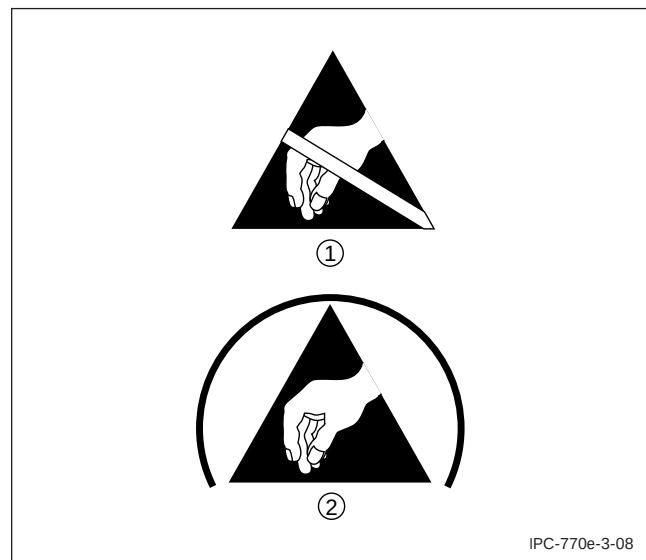


Figure 3-8 Frequently Encountered EOS/ESD Warning Labels

Symbol (1): ESD susceptibility symbol. A triangle with a reaching hand and a slash across it. This symbol indicates that an electrical or electronic device or assembly is susceptible to damage from an ESD event.

Symbol (2): ESD protective symbol. This differs from the ESD susceptibility symbol in that it has an arc around the outside of the triangle and no slash across the hand. This symbol identifies items that are specifically designed to provide ESD protection for ESD sensitive assemblies and devices. Symbols (1) and (2) identify devices or an assembly as containing devices that are ESD sensitive, and must be handled accordingly. These symbols are provided by

the ESD association and are described in EOS/ESD standard S8.1 as well as the Electronic Industries Association (EIA) in EIA-471 and IEC/TS 61340-5-1.

Note: The absence of a symbol does not necessarily mean that the assembly is not ESD sensitive. When doubt exists about the sensitivity of an assembly, it must be handled as a sensitive device until it is determined otherwise.

3.4.1.4 ESD Damage Prevention - Protective Materials ESDS components and assemblies must be protected from static sources when not being worked on in static safe environments or workstations. This protection could be conductive static-shielding boxes, bags or wraps.

ESDS items must be removed from their protective enclosures only at static safe workstations.

It is important to understand the difference between the three types of protective enclosure materials: (1) static shielding (or barrier packaging), (2) antistatic packaging material and (3) static dissipative materials.

- **Static Shielding Packaging** – Prevents an electrostatic discharge from passing through the package and into the assembly causing damage.
- **Antistatic (Low Charging) Packaging Materials** – Provides inexpensive cushioning and intermediate packaging for ESDS items. Antistatic materials do not generate charges when motion is applied. However, if an electrostatic discharge occurs, it could pass through the packaging and into the part or assembly, causing EOS/ESD damage to ESDS components.
- **Static Dissipative Materials** – Have enough conductivity to allow applied charges to dissipate over the surface relieving hot spots of energy. Parts leaving an EOS/ESD protected work area must be overpacked in static shielding materials, which normally also have static dissipative and antistatic materials inside.

Note: Do not be misled by the color of packaging materials. It is widely assumed that black packaging is static shielding conductive and that pink packaging is antistatic in nature.

While that may be generally true, it can be misleading. In addition, there are many new clear materials now on the market that may be antistatic and even static shielding. At one time it could be assumed that clear packing materials introduced into the manufacturing operation would represent an ESD hazard. This is not necessarily the case now.

Caution: Some static shielding, antistatic materials and topical antistatic solutions may affect the solderability of assemblies, components, and materials in process. Select only noncontaminating packaging and handling materials in-process assemblies and use them with regard for the vendor's instructions. Solvent cleaning of static dissipative or antistatic surfaces can degrade their ESD performance.

Follow the manufacturer's recommendations for cleaning.

3.4.1.5 EOS/ESD Safe Workstation/EPA An EOS/ESD safe workstation prevents damage to sensitive components from spikes and static discharges while operations are being performed. Safe workstations should include EOS damage prevention by avoiding spike generating repair, manufacturing or testing equipment. Soldering irons solder extractors and testing instruments can generate energy of sufficient levels to destroy extremely sensitive components and seriously degrade others.

For ESD protection, a path to ground must be provided to neutralize static charges that might otherwise discharge to a device or assembly. ESD safe workstations/EPAs also have static dissipative or antistatic work surfaces that are connected to a common ground. Provisions are also made for grounding the worker's skin, preferably via a wrist strap designed to eliminate charges generated on the skin or clothing. Provisions must be made in the grounding system to protect the worker from live circuitry as a result of carelessness or equipment failure. This is commonly accomplished through resistance in line with the ground path, which also slows the charge decay time to prevent sparks or surges of energy from ESD sources. Additionally, a survey must be performed of the available voltage sources that could be encountered at the workstation to provide adequate protection from personnel electrical hazards.

For maximum allowable resistance and discharge times for static safe operations see Table 3-3.

Table 3-3 Maximum Allowable Resistance and Discharge Times for Static Safe Operations

Reading from Operator Through:	Maximum Tolerable Resistance	Maximum Acceptable Discharge Time
Floor mat to ground	1000 megohms	Less than 1 sec.
Table mat to ground	1000 megohms	Less than 1 sec.
Wrist strap to ground	100 megohms	Less than 0.1 sec.

Note: The selection of resistance values is to be based on the available voltages at the station to ensure personnel safety as well as to provide adequate decay or discharge time for ESD potentials. Examples of acceptable workstations are shown in Figures 3-9 and 3-10. When necessary, air ionizers may be required for more sensitive applications. The selection, location, and use procedures for ionizers must be followed to ensure their effectiveness.

Keep workstation(s) free of static generating materials such as Styrofoam, plastic solder removers, sheet protectors, plastic or paper notebook folders, and employees' personal items.

Periodically check workstations/EPAs to make sure they work. EOS/ESD assembly and personnel hazards can be caused by improper grounding methods or by ionizers.

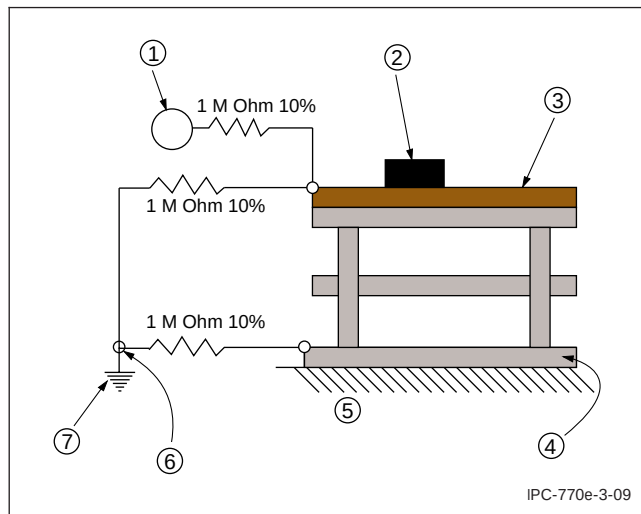


Figure 3-9 Series Connected Wrist Strap

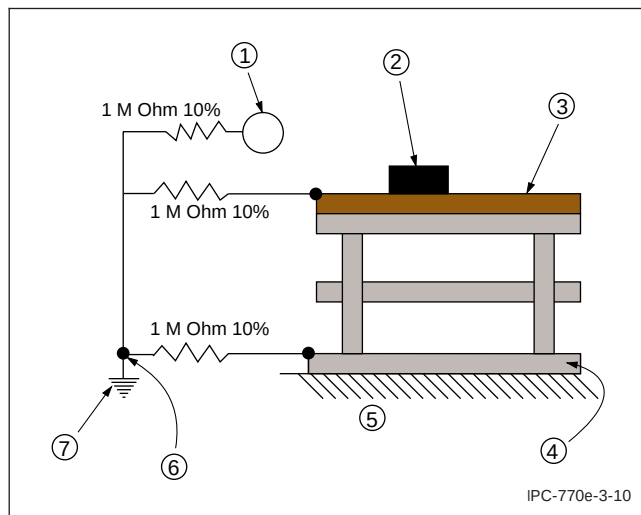


Figure 3-10 Parallel Connected Wrist Strap

build-up on grounding connectors. Tools and equipment must be periodically checked and maintained to ensure proper operation.

Note: Because of the unique conditions of each facility, particular care must be given to “third wire” ground terminations.

Frequently, instead of being at workbench or earth potential, the third wire ground may have a “floating” potential of 80 to 100 volts. This 80 to 100 volt potential between an electronic assembly on a properly grounded EOS/ESD workstation/EPA and a third wire grounded electrical tool may damage EOS sensitive components or could cause injury to personnel. Most ESD specifications also require these potentials to be electrically common. The use of ground fault interrupter (GFI) electrical outlets at EOS/ESD workstations/EPAs is highly recommended.

3.4.2 Moisture Sensitivity Plastic bodied components are susceptible to absorption and retention of moisture. Component manufacturers should assign components to a

moisture sensitivity level using IPC/JEDEC J-STD-020A. This level of sensitivity determines the method of preservation required assuring that the components do not crack or delaminate (popcorn) during the manufacturing process. IPC/JEDEC J-STD-035 provides a test method for determining if damage has occurred during the manufacturing process. IPC-9501, 9502, 9503, and 9504 provide guidance on conditioning of components prior to assembly. IPC/JEDEC J-STD-033 provides detail instruction on handling moisture sensitive devices.

Printed circuit boards are also susceptible to moisture absorption and can exhibit damage as a result of that moisture during the assembly process. Because of the complexity and variables associated with boards, the user needs to determine the specific storage or baking time and temperature requirements.

3.4.3 Storage The preservation of solderability and the protection of parts and assemblies from handling and ESD damage should be a vital control aspect of the manufacturing process of printed board assemblies. Printed boards should be protected before shipping or transportation to the destination where they are received and assembled.

3.4.3.1 Storage Material Care should be exercised to assure that packaging materials do not contain additives or surface treatments that deteriorate solderability or degrade the insulation properties of components, boards or assemblies.

3.4.3.2 Bags One of the most common forms of protection for bare boards is an antistatic bag wrapped with a moisture barrier and then cushioning material.

Ensure the boards are thoroughly cleaned before being packaged and that the atmosphere in which the boards are packed is reasonably dry. Sealing moisture or a contaminated environment within a bag can affect the solderability and moisture content of the boards.

Printed boards, components and hardware are frequently placed in their original containers and put on a shelf until they are required. Some consideration should be given at this point to the packing material in use. If the manufacturer did not provide a protective material, it is advisable to repackage.

Parts should not be stored in open containers exposed to environment that may cause the parts to oxidize (for example, dust and air pollutants).

Inventory control should carefully handle the parts with a “first in-first out” policy.

Components and boards should not be left exposed overnight or over weekends. This causes dust and debris from the atmosphere to accumulate.

3.5 Material Movement Systems

3.5.1 Transporters One method of providing material to the production stations is accomplished by means of the transporter system controlled by a central dispatch area. Typically the transporter consists of two levels. The upper level dispatches the work while the lower level returns completed work. Strategically placed photocells on the return conveyer read bar code labels on the tote box to provide automatic work-in-progress (WIP) status to a central computer. Static-free conveyer belts and the grounding of machinery should provide protection for ESD sensitive components.

Personnel must use ESD protection at all times when touching devices or assemblies.

3.5.2 Racks and Carriers Store assembled boards between component mounting and soldering. When storing the assembled boards, covering the racks with an approved material to keep them out of the way of dust and debris is recommended.

Frequently, problems due to improper storage lead to future failures. These may show up in the final assembly testing operation or in the form of field failures.

4 COMPONENT GUIDELINES

This section contains a general introduction to the kinds of components that are discussed in detail in the following chapters. Common characteristics of components, component selection and general issues are considered here.

Components are selected for electrical, thermal, or mechanical characteristics determined by the requirements of the contents of the package. The material composition, finish and configuration of both the body and the terminations of a component must be considered in the choice of assembly methods.

All components must be qualified for the assembly processes to be used. The physical dimensions of the component must adequately mate with the physical handling devices of the placement equipment. Soldering or other high temperature processes used must not degrade the parts, physically or electrically. Also, the parts must be able to tolerate exposure to the chemicals used in adhesive bonding, soldering, cleaning or any other chemical processing.

Electronic components come in a great variety of package styles and shape. This relates not only to the electrical functions that the components perform but sometimes the same function is available in different packaging configurations.

Component selection should consider the following factors when applicable:

- Electrical Characteristics
- Electrical Performance
- Mating Forces
- Environmental Requirements
- Durability
- Repairability
- Manufacturing Methods
- Mechanical Requirements
- Thermal Requirements
- Electrical Environment
- Placement/Attachment Equipment
- Polarization
- Cleaning
- Corrosion
- Part Identification/Verification
- Special considerations (heat sensitive, unsealed, etc.)

4.1 Component Characterization and Classes There are two classes of components:

- Through Hole (see Figure 4-1)
- Surface Mounted (see Figure 4-2)

Note: Components listed in Figures 4-1 and 4-2 are not all-inclusive, and not intended to represent all types of components.

4.1.1 Axial-Leaded Components Discrete axial-leaded devices are two-leaded board mounted components that have the leads exiting from the ends of the component along the axis of the components. They are considered suitable for automatic component insertion. The most common axial-leaded devices are resistors, capacitors and diodes. Detailed description of axial leaded components is contained in Section 2.

4.1.2 Radial-Leaded Components Two or more-leads that exit from one side of the component. Sometimes this side is on the perimeter of the package and sometimes it is the bottom of the component. The body shapes vary from simple disc-shaped capacitors to transistor outline (TO) shapes (can) to parallel-leaded devices such as dual or single in-line packages. Generally, active semiconductor devices or arrays of two terminal devices can be packaged in multileaded radial configurations. The details of multileaded radial components are contained in Section 2.

4.1.3 Chip Components Comprise a wide variety of two-terminal devices for surface mount attachment. Some of the chip components have formed metal leads for attachment but most are simple ceramic devices with plated or solder dipped terminations that are integral to the body of the component. Chip components are categorized by the

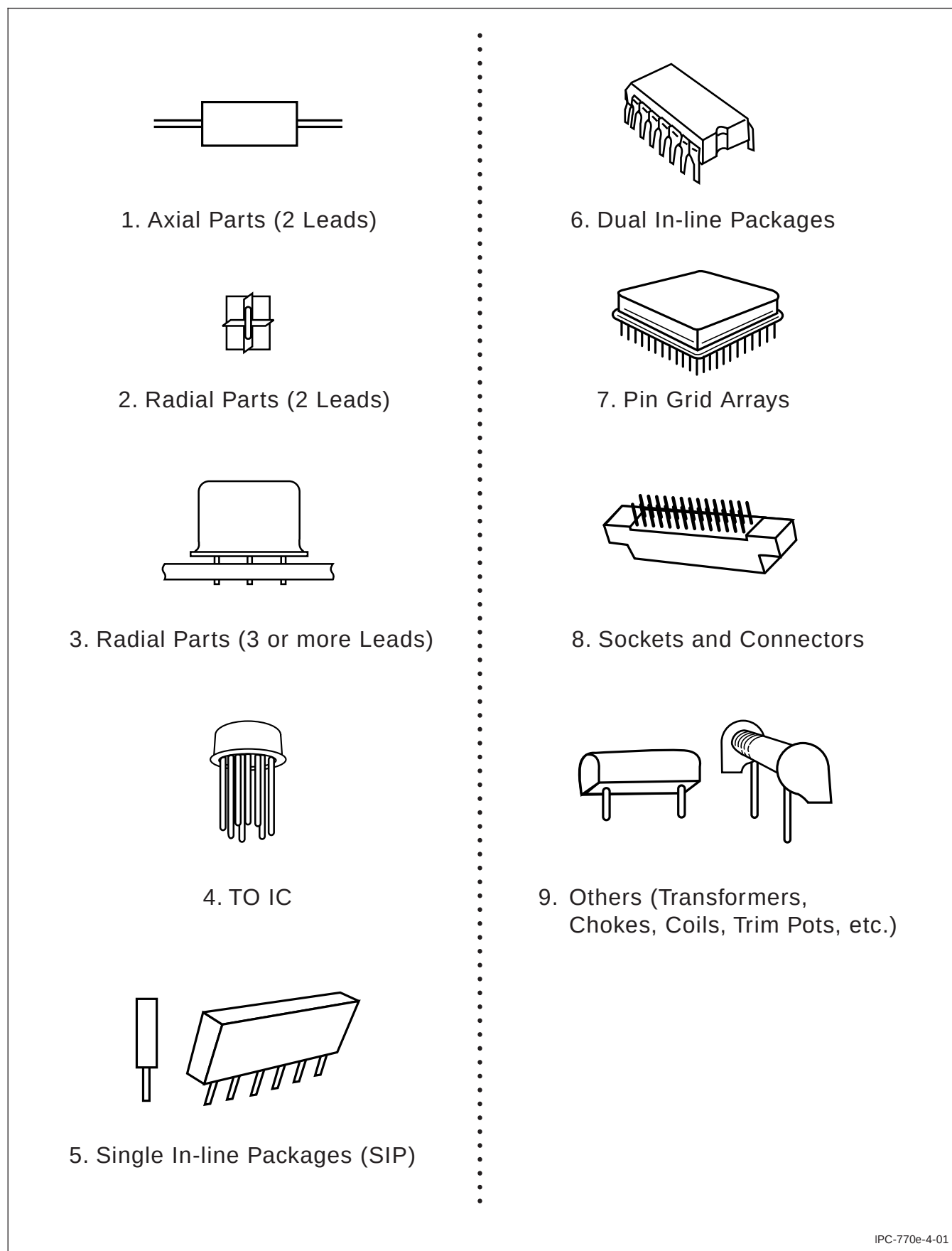
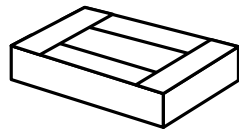
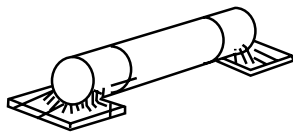


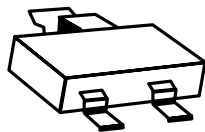
Figure 4-1 Through-the-Board Component Types



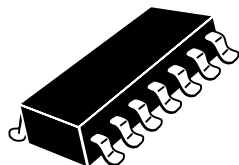
10. Chip Component, Rectangular or Square



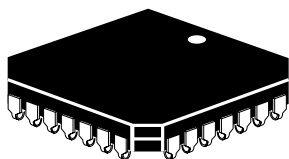
11. Cylindrical End Cap - Metal Electrode Leadless Face (MELF)



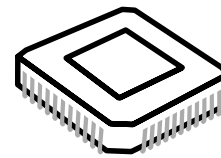
12. Small - Outline Transistors (SOT)



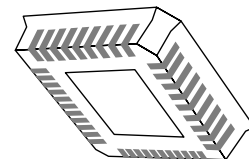
13. Small - Outline IC (SOIC)



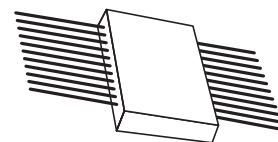
14. Plastic Leaded Chip Carrier (PLCC)



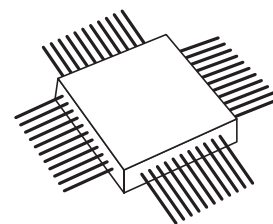
15. Ceramic Leaded Chip Carrier (CLCC)



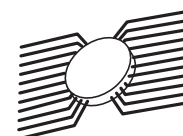
16. Ceramic Leadless Chip Carrier (LCCC)



17. Flat Pack



18. Quad Pack



19. Other

IPC-770e-4-02

Figure 4-2 Some Surface Mount Component Types

designed and packaged for automatic component handling. The details of chip components are contained in Section 12 *Component Characteristics Surface Mount*.

4.1.4 Small Outline Components (SOs) A family of two or more lead plastic post-molded components intended for surface mount attachment. Details of SO components are contained in Section 12.2.1.5.

4.1.5 Multiple-Ribbon-Lead Components Ribbon-leaded components (flat-pack, gull-lead, and J-lead) have flat wire ribbon leads that are arrayed around the perimeter of the component. They are frequently used to package integrated circuits. Ribbon-leaded component details are contained in Sections 12 and 14.

4.1.6 Chip Carriers Currently the most common multi-leaded surface mount package. The terminations are arrayed around the perimeter of the rectangular body. They can come as either formed metal leads or pads that are integral to the body of the component. For printed board mounting, most chip carrier leads are located on 1.27 mm centers, but newer designs are considering 0.635 mm and smaller spacing between leads. The small lead spacing and the large number of leads can require special assembly procedures. Chip carrier package details are contained in Section 14.

4.1.7 Unpackaged Semiconductors This type of component includes all semiconductor devices that are not in individual discrete packages. They may consist of individual semiconductor dice that have termination bonding pads or they may be semiconductor dice bonded to flexible substrates, such as TAB, to aid in their handling and interconnection. These components are used primarily with chip-on-board technology as described in Section 18.

4.1.8 Tape Automated Bonding (TAB) Involves the automated bonding of semiconductor devices (dies) to a flexible lead frame in tape and reel format. The devices are delivered to the assembly operation on tape where the individual devices and part of the interconnecting lead frame are excised, the leads formed and the devices directly mounted to a printed board structure. TAB devices are frequently encapsulated after mounting to the printed board structure.

4.1.8.1 PGA Pad Grid Arrays Also known as Land Grid Arrays, these are surface mount packages where the interconnections are distributed in an area array on the bottom of the package. The interconnections are typically solder columns connecting lands on the bottom of the package to a matching set of lands on a printed board structure beneath it. Details of Pad Grid Arrays are contained in

Section 15, *Guidelines for High Pin Count Area Array Component Mounting*.

4.1.8.2 Pin Grid Arrays Form a class of very high input/output (I/O) through board mount integrated circuit package. The leads are arranged in a solid area-filling array across the bottom of the package, frequently with space left free under the chip mount area. Details of Pin Grid Array packages are contained in Section 15.

4.1.9 Area Array Components The area array package for semiconductors adapts a metallized circuit pattern applied to a dielectric structure. To this structure, the semiconductor die (a) is attached either to the top or bottom surface. On the underside of the dielectric is an array pattern of metallized lands that will provide a means for both mechanical and electrical interface between the package body and a mating feature such as a printed board. The surface of the dielectric that contains the die may be encapsulated by various techniques to protect the semiconductor. Refer to IPC-7095, Design and Assembly Implementation for Ball Grid Arrays.

4.1.9.1 The Ball Grid Array (BGA) The ball grid array is a surface mount package that utilizes alloy spheres and reflow solder processing to provide a mechanical and electrical interface between the package and the circuit structure. Six contact pitch formats have been established for BGA; 1.50 mm, 1.27 mm, 1.00 mm, 0.80 mm, 0.65 mm and 0.50 mm. Contact spacing of less than 1.00 mm is defined as fine-pitch BGA (FBGA).

4.1.10 Connectors Form the means to interconnect between a printed board structure and another level of interconnection with a separable connection. Connectors between printed boards and cables, backplanes and special printed board structures are common. Frequently connectors consist of a molded plastic housing that contains formed metal contacts. Connectors can be either through board or surface mount assembled. Connector details are contained in Section 14.

4.1.11 Sockets Form of connector used to make separable contact between a printed board structure and the terminations (leads) of a component. Sockets are frequently assembled with the same technologies used for components. Details of sockets are contained in Sections 11 and 14. (Press fit components are not addressed in this series of documents.)

4.1.12 Electromechanical and Interconnect Components Other board mounted components, such as pins, wires, terminals, and mechanical hardware comprise a wide set of parts that are assembled to printed wiring products to enhance the interconnection capabilities and reliability.

with housings, supports, test equipment and other peripheral structures. The details of these special components are contained in Section 15.

4.2 Component Packaging/Delivery Systems There are a variety of component packaging methods. These include tape and reel, waffle trays, and tubes, as well as bulk pack. The sectional documents address unique guidelines for specific component types.

4.3 Lead/Termination Finishes Finishes on the leads of leaded component packages and on the metallized terminations of leadless packages, whether for through-hole or surface mounting, preserve and assure the solderability of the interconnection surfaces without decreasing the assembly yield or the attachment reliability. Frequently, solder joints cannot be visually inspected because of their sheer numbers and are physically inaccessible. The large number of solder joints makes it imperative that the solderability of the component I/Os be positively assured prior to assembly. The lead finish that accomplishes this is fused or reflowed tin or solder. The solder coating can be obtained either by solder dipping or tin/lead plating with a subsequent reflow process. It might be necessary to remove excess solder, which could interfere with the assembly or socketing process, with a hot air knife or similar method.

Gold and silver form brittle intermetallics with the tin in solder causing solder joint reliability problems. It is important to know the amount of precious metal plating on the leads as provided by the supplier. It may be necessary to reduce the gold or silver thickness through a tinning operation to assure reliability of the connection.

Caution should be used when leads are coated with tin or tin/lead plating without reflowing prior to assembly because the plating does not always assure solderability. Organic materials that are sometimes co-deposited during the plating process can also cause poor solderability.

In addition, some user specifications require fusing of the tin plate to eliminate the possibility of tin whisker growth.

The foregoing considerations are more critical for surface mounting than for through-hole mounting. Through-hole mounting provides considerable margin because of the mechanical anchoring of the leads and the larger solder volumes.

5 PACKAGING AND INTERCONNECTING (PRINTED BOARD) STRUCTURES

Printed board structures include conventional and modified organic printed boards, inorganic ceramic printed boards, and supporting plane/core structures. Design requirements for printed board structures are described in the IPC-2220 Series, and performance requirements are described in the IPC-6010 Series.

Many different board types can be used to mount intermixed assemblies. The material used to manufacture the printed board plays a large role in the component mounting techniques that may be used to place parts on the printed board structure or board. Printed board design is detailed in the IPC-2220 Series.

5.1 Printed Board Characterization and Classes There are three basic types of printed circuit (printed wiring) boards, all of which can be manufactured with rigid or flexible materials in a variety of methods (see 1.2.3). The three types are listed below in ascending order of interconnection wiring and component density:

- Single-sided with conductors on only one surface of a dielectric (insulating) base.
- Double-sided with conductors on both sides of a dielectric base, usually interconnected by plated-through or otherwise reinforced holes.
- Multilayer-boards with three or more conductor layers separated by dielectric material, usually interconnected by plated-through interlayer holes.

The single-sided board is used for relatively unsophisticated circuitry. They are applicable when circuit types and circuit speeds do not demand unusual electrical characteristics.

Double-sided boards are required for more complex, denser circuit types requiring interconnecting layers.

The requirements for high speed circuits in computer and space industries, with a requirement for a still further increase in package density, has led to the development of multilayer boards.

All printed boards have an insulating base often referred to as the dielectric or laminate. Laminate bases for single-sided, double-sided or multilayer printed boards can be either “rigid” or “flexible.”

5.1.1 Rigid Laminate Boards The boards are selected according to physical, thermal and electrical requirements. Some base materials are “punchable,” enabling low-cost hole formation, thus making them popular for single-sided board use. However, their dimensional stability is unsuitable for making plated-through-hole boards. The more expensive glass-epoxy laminates have good dimensional stability, usually making them the choice for plated-through-hole, double-sided and multilayer boards. Glass-epoxy is not as “punchable” as the other laminate types; therefore, holes are usually drilled. Other laminate types are available for high temperatures, high frequencies and other special requirements.

5.1.2 Flexible Laminate Boards When flexible printed board types are used for surface mounting, through hole mounting or intermixed assemblies, the component-mounting task may become more difficult, depending on

the structure of the detailed assembly. Usually, stiffeners or other rigid sections of the flexible board are provided to insure the proper surface for component mounting. In addition, flexible printed boards usually take many different shapes and special fixturing may be required in order for the component assembly equipment to adequately mount and attach electronic parts.

5.1.3 Metal-Core Boards These types of products, due to their mechanical rigidity, make the component-mounting task somewhat easier. However, the thermal characteristics of the interconnection structure require that the soldering or attachment technique consider the impact that the thermal mass has on the solder joint solidification. Tables 5-1a-d provide a comparison of the advantages and disadvantages of many of the available printed board structures.

5.2 Supporting-Plane Printed Board Structures Supporting metallic or nonmetallic planes can be used with conventional printed boards or with customer processing to enhance printed board properties. Depending on the results desired, the supporting plane could be electrically functional or not. It could also serve as a structure stiffener, heatsink and/or CTE constraint.

5.2.1 Printed Board Bonded to Support Plane (Metal or Nonmetal) This is a conventional thin printed board that has been fabricated and bonded with a rigid adhesive insulation to a supporting plane such as metal (Figure 5-1) or graphite-fiber resin composite. It can create a printed board structure with controlled thermal expansion in the X and Y-axes. Depending on its properties, the supporting plane can improve rigidity, thermal conductivity, etc. However,

Table 5-1a Packaging and Interconnecting Structure Comparison

Organic Based Substrates	Major Advantages	Major Disadvantages	Comments
Epoxy Fiberglass	Substrate size, weight, reworkable, dielectric properties, conventional board processing.	Thermal conductivity, X, Y and Z axis CTE.	Because of its high X-Y plane CTE, limited to environments and applications with small changes in temperature and/or small packages.
Polyimide Fiberglass	Same as Epoxy Fiberglass plus high temperature Z axis CTE, substrate size, weight, reworkable, dielectric properties.	Thermal conductivity, X and Y-axis CTE, moisture absorption.	Same as Epoxy Fiberglass.
Epoxy Aramid Fiber	Same as Epoxy Fiberglass, X-Y axis CTE, substrate size, lightest weight, reworkable, dielectric properties.	Thermal conductivity, X and Y-axis CTE, resin microcracking, water absorption.	Volume fraction of fiber can be controlled to tailor X-Y CTE. Resin selection critical to reducing resin microcracks.
Polyimide Aramid Fiber	Same as Epoxy Aramid Fiber, Z-axis CTE, substrate size, weight, reworkable, dielectric properties.	Thermal conductivity, X and Y-axis CTE, resin microcracking, water absorption.	Same as Epoxy Aramid Fiber.
Polyimide Quartz (Fused Silica)	Same as Polyimide Aramid Fiber, Z-axis CTE, substrate size, weight, reworkable, dielectric properties.	Thermal conductivity, X and Y-axis CTE, Z-axis CTE, drilling availability, cost, low resin content required.	Volume fraction of fiber can be controlled to tailor X-Y CTE. Drill wear out higher than with fiberglass.
Fiberglass/Aramid Composite Fiber	Same as Polyimide Aramid Fiber, no surface microcracks, Z-axis CTE, substrate size, weight, reworkable, dielectric properties.	Thermal conductivity, X and Y-axis CTE, water absorption, process solution entrapment.	Resin microcracks are confined to internal layers and cannot damage external circuitry.
Fiberglass/Teflon Laminates	Dielectric constant, high temperature.	Same as Epoxy Fiberglass, low temperature stability, thermal conductivity. X and Y-axis CTE.	Suitable for high speed logic applications. Same as Epoxy Fiberglass.
Flexible Dielectric	Light weight, minimal concern to CTE, configuration flexibility.	Size.	Rigid-flexible boards offer trade-off compromises.
Thermoplastic	3-D configurations, low high-volume cost.	High injection-molding setup costs.	Relatively new for these applications.

Table 5-1b Packaging and Interconnecting Structure Comparison

Nonorganic Based Substrates	Major Advantages	Major Disadvantages	Comments
Alumina (Ceramic)	CTE, thermal conductivity, conventional thick film or thin film processing, integrated resistors.	Substrate size, rework limitations, weight, cost, brittle, dielectric constant.	Most widely used for hybrid circuit technology.

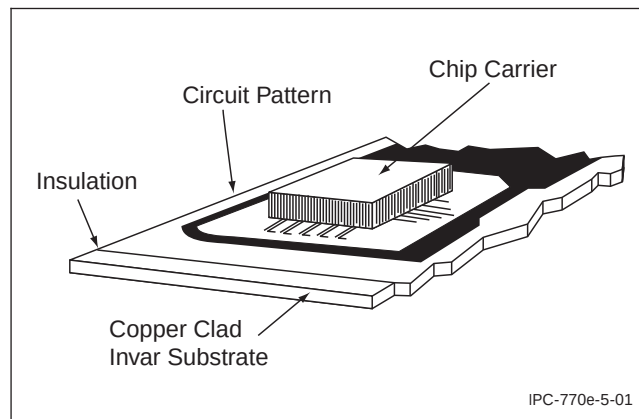
Table 5-1c Packaging and Interconnecting Structure Comparison

Supporting Plane	Major Advantages	Major Disadvantages	Comments
Printed Board Bonded to Plane Support (Metal or Nonmetal)	Substrate size, reworkable, dielectric properties, conventional board processing. X-Y axis CTE, stiffness, shielding, cooling.	Weight.	The thickness/CTE of the metal core can be varied along with the board thickness, to tailor the overall CTE of the composite.
Sequential Processed Board with Supporting Plane Core	Same as board bonded to supporting plane.	Weight.	Same as board bonded to supporting plane.
Discrete Wire	High-speed interconnections, good thermal and electrical features.	Licensed process. Requires special equipment.	Same as board bonded to two-expansion metal support plane.

Table 5-1d Packaging and Interconnecting Structure Comparison

Constraining Core	Major Advantages	Major Disadvantages	Comments
Porcelainized Copper Clad Invar	Same as Alumina.	Reworkability, compatible thick film materials.	Thick film materials are still under development.
Printed Board Bonded With Constraining Metal Core	Same as board bonded to supporting plane.	Weight, internal layer registration.	Same as board bonded to supporting plane.
Printed Board Bonded to Low Expansion Graphite Fiber Core	Same as board bonded to low expansion metal cores, stiffness, thermal conductivity, low weight.	Cost.	The thickness of the graphite and board can be varied to tailor the overall CTE of the composite.
Compliant Layer Structures	Substrate size, dielectric properties, X-Y axis, CTE.	Z-axis CTE, thermal conductivity.	Compliant layer absorbs difference in CTE between ceramic package and substrate.

the printed board must be thin enough to preclude warping of the assembly or else the board should be bonded to both sides of the plane (see 5.3.2). The printed board portion of the printed board structure can be either unpopulated or completely assembled and tested prior to being bonded. However, components can only be mounted to one side of the printed board. Also, the support is not normally electrically connected to the printed board.

**Figure 5-1 Printed Board Bonded to Supporting Plane**

5.2.2 Sequentially-Processed Structures with Metal Support Plane High-density, sequentially processed, multilayer printed board structures are available with organic dielectrics of specific thickness, ultrafine conductors, and solid plated vias for layer-to-layer interconnections with thermal lands for heat transfer, all connected to a low-CTE metal support heatsink. Thus, this technology combines laminating materials, chemical processing, photolithogra-

phy, metallurgy, and unique thermal transfer innovations, such that it is also appropriate for mounting and interconnecting bare integrated circuit chips, as shown in Figure 5-2.

The major advantage of this system is that the vias can be as small as 0.20 mm square and conductor widths can range from 0.12 to 0.20 mm for high interconnection density. Thus, most applications can be satisfied with two signal layers with additional layers for power and ground.

5.2.3 Discrete-Wire Structures with Metal Support Plane Discrete-wire printed board structures have been developed specifically for use with surface mounted components, as shown in Figure 5-3. These structures are usually built with a low-expansion metal support plane that also offers good heat dissipation.

The interconnections are made by discrete 0.06 mm diameter insulated copper wires precisely placed on a 0.03 mm grid by numerically-controlled machines. This geometry results in a low-profile interconnection pattern with excellent high-speed electrical characteristics and a density normally associated with thick-film technology.

The wiring is encapsulated in a compliant resin to absorb local stresses and dampen vibrations. Copper vias 0.25 mm in diameter provide electrical access to the conductors. The small via size can be accommodated in the component-attachment land, thus eliminating the need for fan-out patterns when using components with terminals on centers as close as 0.6 mm, and allowing very-high packaging densities.

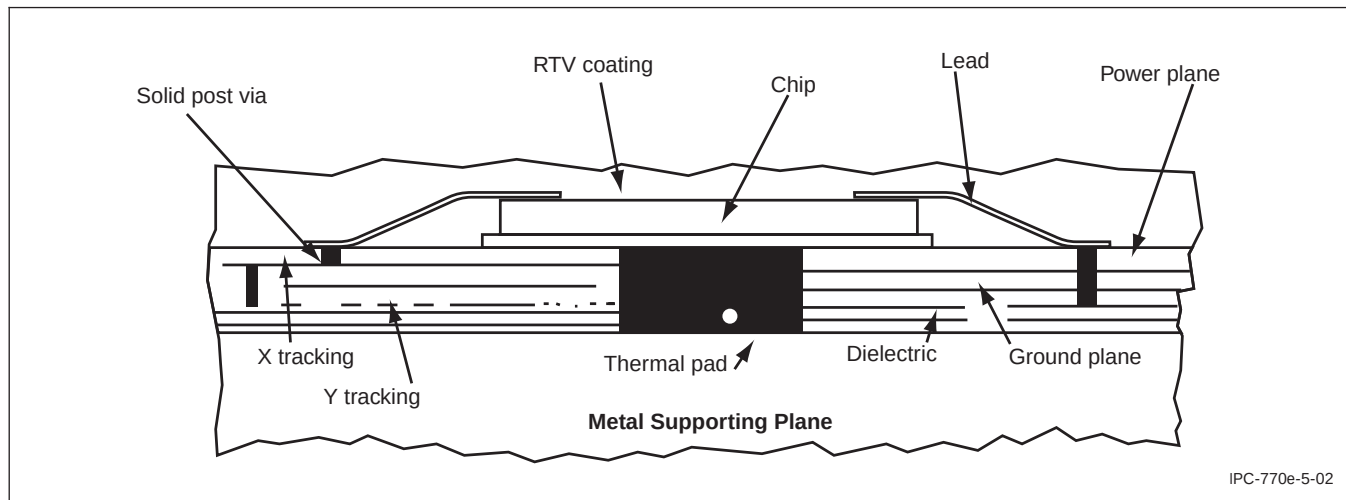


Figure 5-2 Sequentially Processed Structure with Supporting Plane

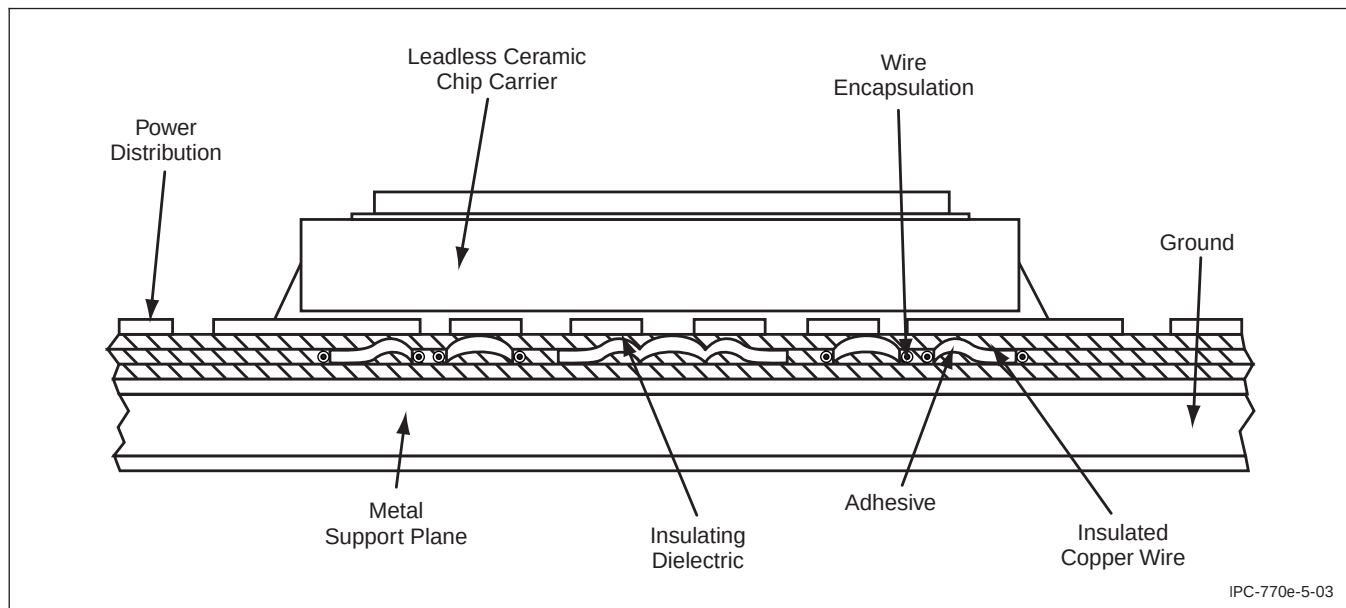


Figure 5-3 Discrete-Wire Structure with Low-Expansion Metal Support Plane

5.2.4 Flexible Printed Board with Metal Support Plane

Another arrangement for a printed board structure with leadless components involves conventional fine-line polyimide flexible printed wiring, as shown in Figure 5-4. These assemblies can be constructed in multilayer form while retaining the low-modulus feature that reduces residual strain at the solder joints. Furthermore, lasers can drill very fine holes in the thin printed wiring laminate. These holes can be plated-through or filled with solid copper, as required.

To retain inherent flexibility while dissipating heat from the solder joint, cutouts in the flexible circuit accommodate pillars from the metal heatsink support plane. Although this appears to be heavy and cumbersome, if the heatsink baseplates are made from thin sheets of aluminum, the resulting density of the combined circuit/heatsink assembly might actually be less than other constructions.

5.3 Constraining Core Printed Board Structures As with supporting-plane printed board structures, one or more supporting metallic or nonmetallic planes can serve as a stiffener, heatsink, and/or CTE constraint in constraining core printed board structures.

5.3.1 Porcelainized-Metal (Metal Core) Structures An integral core of low-expansion metal (e.g., copper-clad Invar) can reduce the CTE of porcelainized-metal printed board structures so that it closely matches the CTE of the ceramic chip carrier. Also, the printed board structure size is virtually unlimited. However, the low melting point of the porcelain requires low-firing-temperature conductor, dielectric and resistor inks.

A number of composite printed board structures use leadless components. An integral material with a lower CTE than that of the printed boards controls the CTE of these structures.

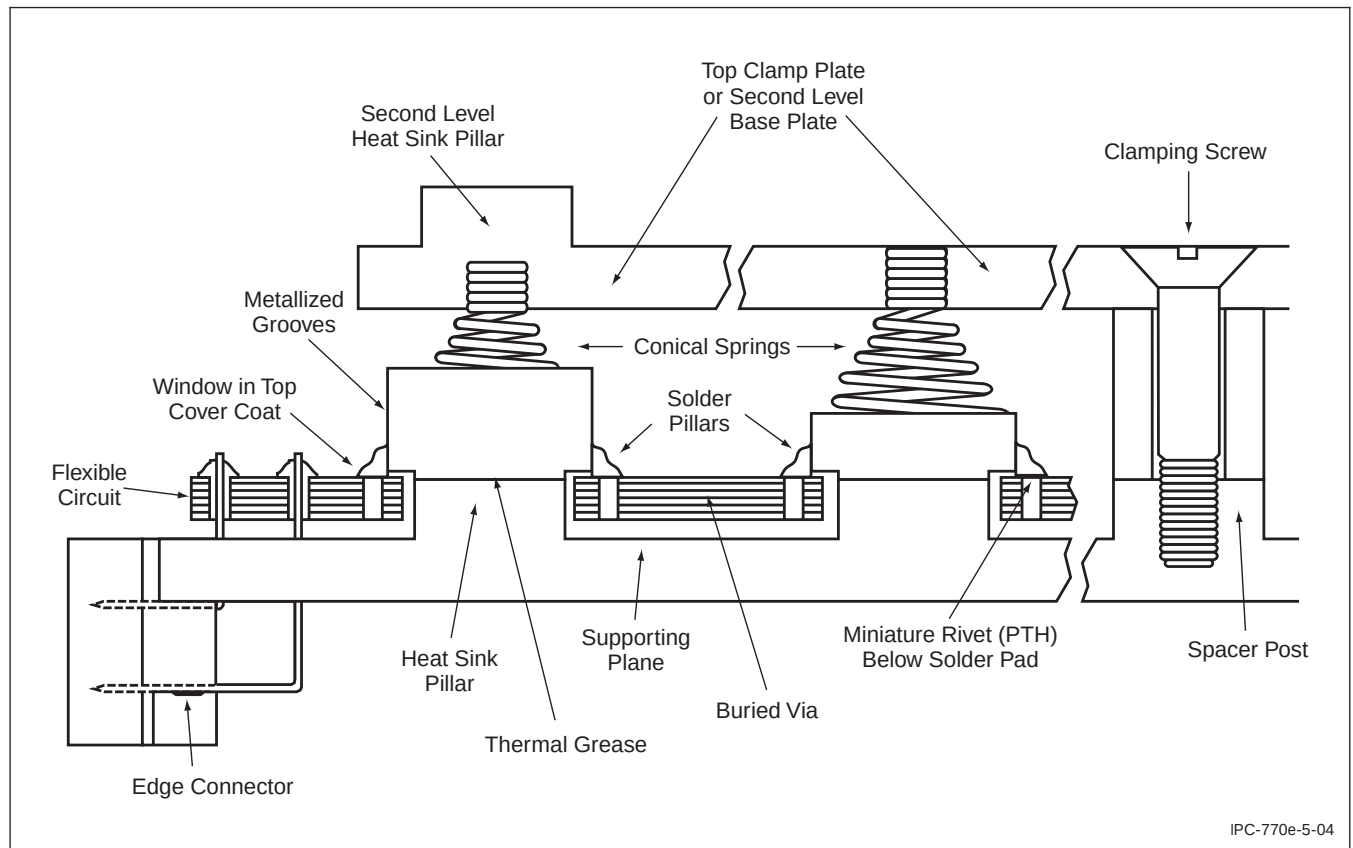


Figure 5-4 Flexible Printed Board with Metal Support Plane

5.3.2 Printed Board with Constraining (Not Electrically Functioning) Core Can be used for high-density, low-warpage printed board structures. The core acts as a heat-sink, but in this case is not electrically functional. For optimum density with this approach, use a multilayer construction with a centrally located predrilled, low-CTE core (see Figure 5-5). The holes in the core are filled with a compatible resin prior to lamination and the printed board structure completed with conventional fabrication techniques.

Molybdenum can be used as the core in these printed board structures for special applications that require inherent stiffness in extreme environments. However, molybdenum and copper-clad Invar are difficult materials to fabricate using conventional processes. Graphite can be used where thermal conductivity per unit of weight is important.

5.3.3 Printed Boards with Electrically-Functional Constraining Cores More conventional multilayer printed boards can be made as printed board structures with thin, 0.1 to 0.25 mm, copper-clad Invar as electrically-functional ground and power planes. After the planes have been pre-drilled they are located in a symmetrical arrangement within the lay-up and subsequently laminated as an integral part of the multilayer printed board structure (Figure 5-6). Varying the composition and thickness of the planes can tailor the overall CTE of the structure.

5.3.4 Printed Board with Constraining Core A constraining fiber resin composite internal plane in a conventional printed board can modify thermal expansion in the X and Y-axes improve rigidity and improve thermal conductivity, depending on the properties and location of the supporting plane. These constraining fibers can be graphite, Kevlar, quartz, etc. The very high modulus of these materials requires a balanced construction to prevent bowing or twisting (see Figures 5-7 and 5-8 for typical construction). Graphite's high cost is justified if low weight is critical. Graphite is conductive; therefore via holes must be drilled oversize and then resin filled prior to final via hole drilling. Graphite allows excellent CTE tailoring. Kevlar and quartz fibers require modified fabrication techniques due to their mechanical properties.

5.4 Other Mounting Structure Materials and Considerations

5.4.1 Heat Sinks Devices used to absorb and/or transfer heat away from heat sensitive parts. Heat sinks come in many styles, shapes, and sizes and may be designed for mounting on printed boards, on a component or a series of components. They can be mounted by riveting/bolting to the component or the circuit board or by clipping to a mounted component. Some common types are depicted in Figure 5-9.

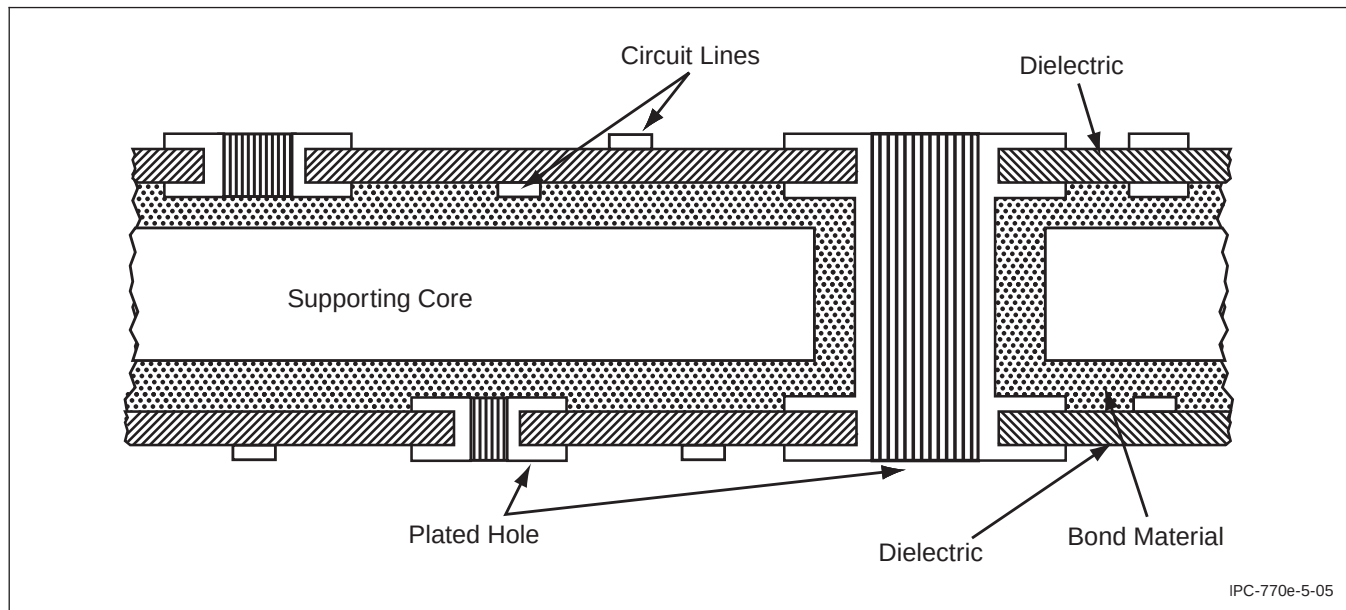


Figure 5-5 Printed Board with Supporting Plane (Not Electrically-Functional Constraining Core)

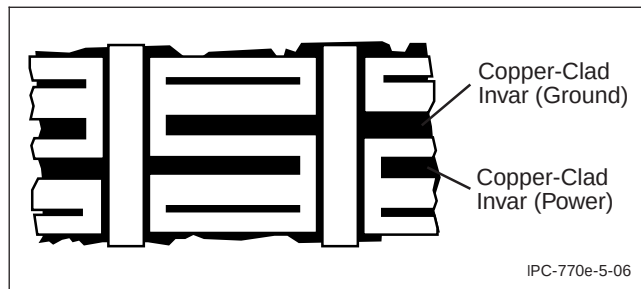


Figure 5-6 Multilayer Printed Board Structure with Copper-Clad Invar Power and Ground Planes (Electrically-Functional Constraining Cores)

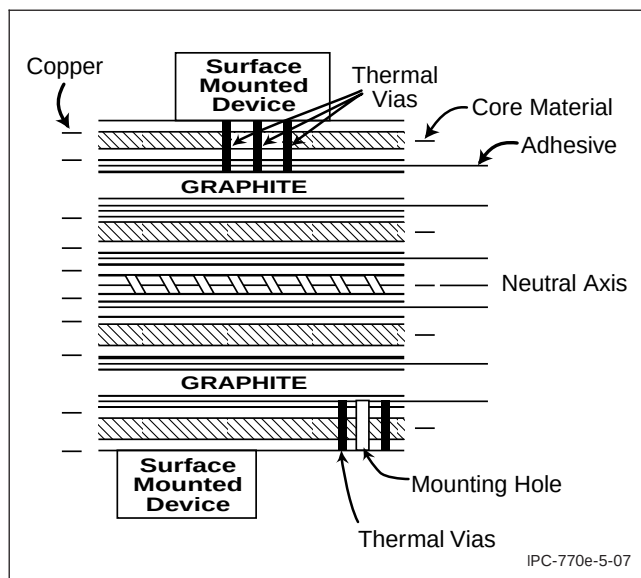


Figure 5-7 Balanced Structure with Constraining Core not at Neutral Axis

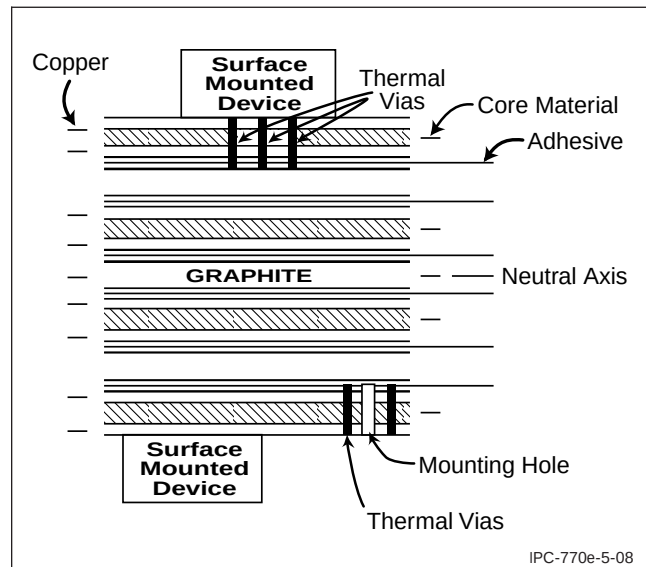


Figure 5-8 Balanced Structure with Constraining Core on Neutral Axis not at Neutral Axis

To facilitate heat sinking of components that must be electrically insulated from heat sinks, chassis, washers, etc., thermally conductive epoxy compounds and adhesives, silicone grease, silicone rubber and other materials are available. The silicone rubber and other sheet material are usually provided in the shape of the various devices. Forced air convection can improve the effectiveness of heat sinks. Heat pipes are also used for heat sinking, spreading hot spots or causing several components to operate at the same temperature. Recently, heat sinks have become available which permit mounting of the active component/heat sink combination. These can then be mounted to the printed board. Some of these heat sinks contain provisions that

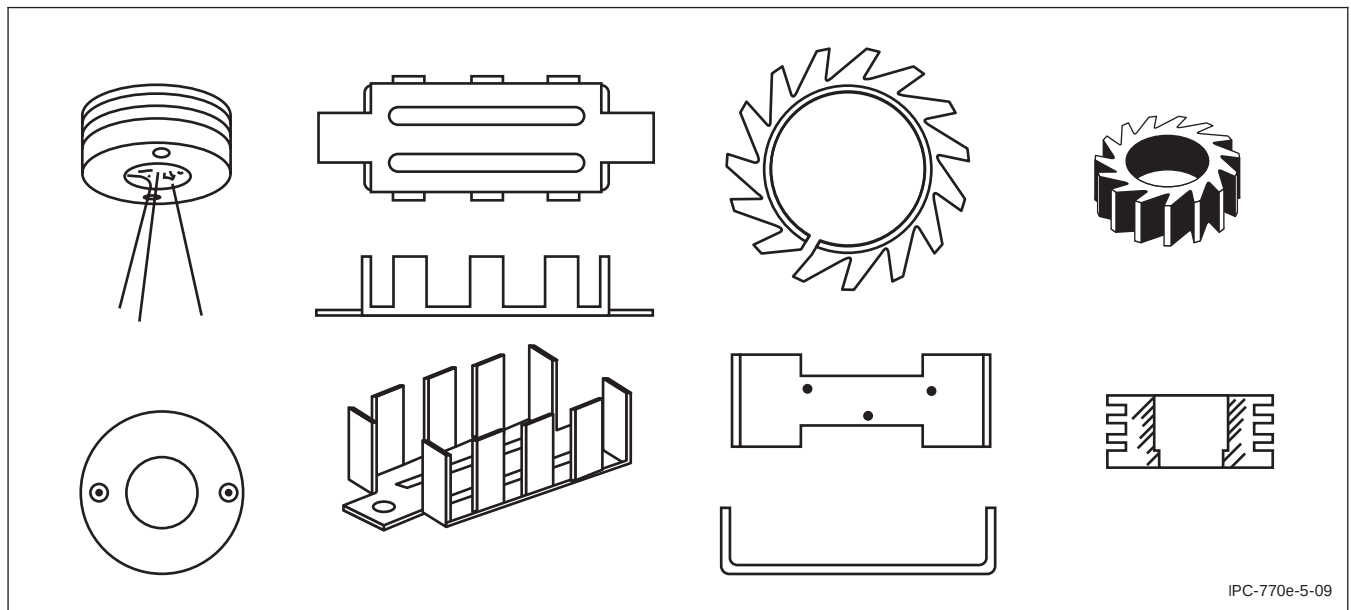


Figure 5-9 Common Component Heat Sinks

permit the heat sink and component leads to be soldered directly to the board.

5.4.2 Spacers Maintain a component above the mounting surface for electrical clearance, increase soldering and cleaning capabilities, improve air flow on heat dissipative parts, provide mechanical support, and facilitate and minimize thermally cleaning-induced stresses.

Spacers are manufactured from nonconductive materials (plastic, nylon, and Teflon), materials that do not dissolve during the cleaning process. Spacers are usually used on multileaded radial devices (three or more leads), such as transistors, or amps, potentiometers, etc. See Figure 5-10 for examples.

5.4.3 Component-Lead Spreaders The use of multiple lead can spreaders, Figure 5-11, serves a similar function for offset can mounting as do spacers for straight-through

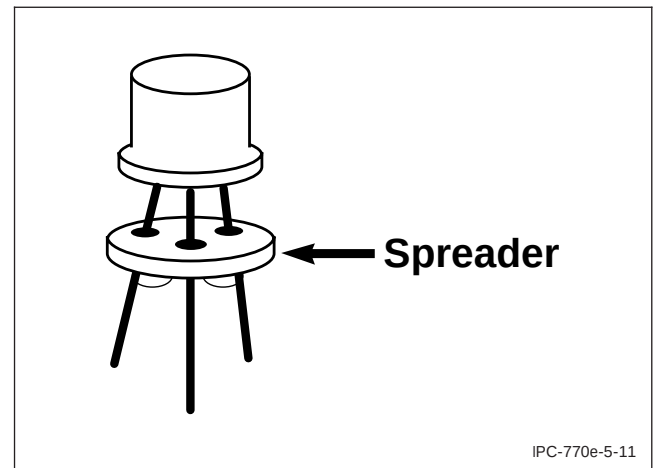


Figure 5-11 Can Mounting Spreader

can mounting. Leads may be terminated in the clinched or unclenched lead method.

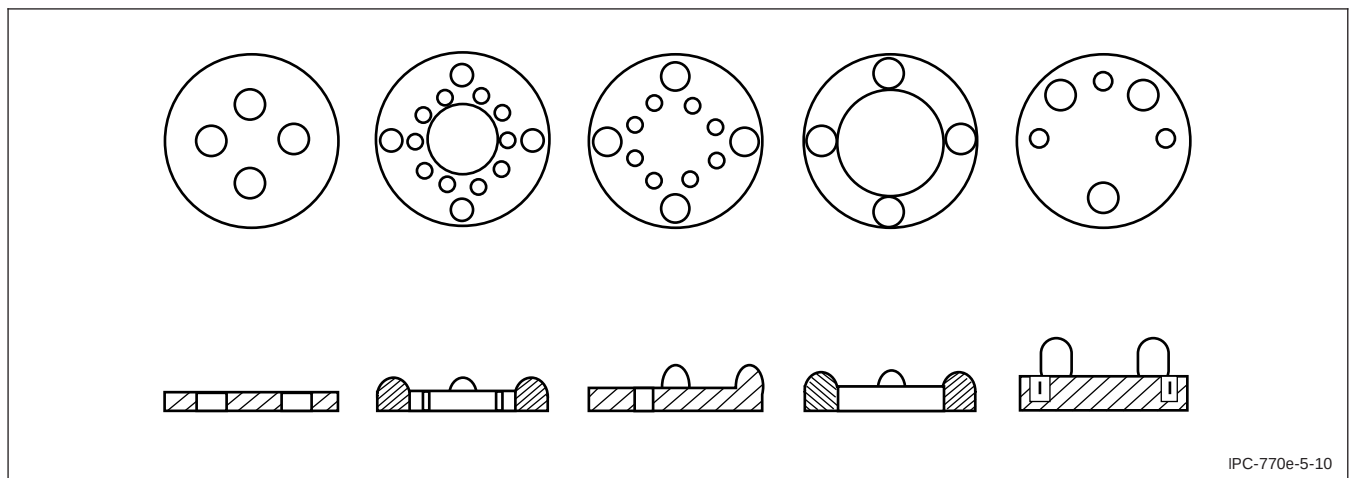


Figure 5-10 Typical Spacers

5.4.4 Thermally Conductive Insulators The most common method of obtaining thermally conductive insulators has been by the use of a silicone grease and mica or plastic film on printed board assemblies which must be cleaned and conformally coated. The use of silicone grease can cause cleaning and coating adhesive problems. Thermally conductive insulators made of silicone rubber and fiberglass cloths are also available in standard package configurations and custom forms. By using these cured silicone insulators, many of the cleaning and coating problems related to silicone grease smear can be avoided (see Figure 5-12).

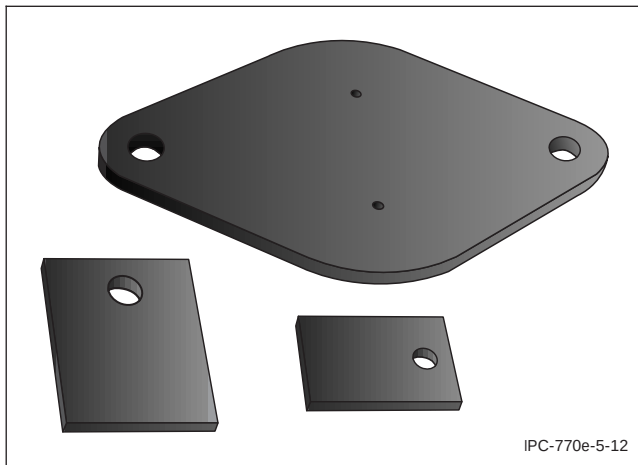


Figure 5-12 Thermally Conductive Insulator

6 ASSEMBLY DESIGN CYCLE

Because of the multistep component mounting operation, the designer of intermixed assemblies must take into account all of the fabrication and assembly steps necessary to complete the electronic assembly. These concerns that take place during the design cycle include:

A. Component Types

- Through Hole
- Leaded SMT
- Leadless SMT

B. Assembly Processes Used

- Single-Sided Assembly
- Double-Sided Assembly
- Component Securing

C. Joining Techniques

- Single-Sided Joining Techniques
- Double-Sided Joining Techniques
- Care Required for Heat-Sensitive Components
- Handling of Unsealed Components

D. Sequence of Events

The last item on the list shown above is usually never considered during the design cycle.

6.1 Types of Assembly Operations Handler capabilities and features vary according to the type of unit and device being accommodated. Automatic units provide throughput rates on the order of 6,000 (and greater) components per hour. Tube adapters are designed to take most tubes currently in use. Automatic assembly machines range from very specific machines that repeat the same task over and over again, to the machines that can be programmed to do several similar processes.

Consideration must be given to complexity, volume of units per run and the product mix to be assembled. Equipment should be selected for high flexibility enabling it to handle a large product mix and short production runs, or chosen for high-speed dedicated equipment that does not allow for much product mix.

The following lists three basic types of equipment available:

- Inline Machines
- Sequential Machines
- Mass Placement Machines

6.1.1 Inline Machines Moderate volume machines that utilize multiple placement heads. These machines can have each head placing a single component or a programmable head that can place a variety of components up to approximately 30,000 components per hour.

6.1.2 Sequential Machines Provide for flexibility of programming placement of components 2,000 to 12,000 per hour. This level of automation allows for some component testing prior to the placement of the board.

6.1.3 Mass Placement Machines Very high volume, fairly dedicated machine used in the matrix of stocks or multiplicity of tapes, which assembles a total circuit with one or more codes of the machine, up to 200,000 components per hour.

6.2 Soldering Operations Either manual or automated. Each of these has several processes.

6.2.1 Manual Soldering Tools and Processes

6.2.1.1 Hot Air Pencils/Heat Guns Both effective and versatile tools for preform soldering. A variety of nozzle shapes are available to localize the heated area. Masks or covers can be used to protect sensitive components. If an inert or reducing atmosphere is required, connecting the intake impeller to a suitable supply of gas can provide this protection.

6.2.1.2 Induction Soldering Confines heating to local areas of a panel or assembly, particularly when unusual shapes or spots are involved. Fast throughput is possible.

using coils uniquely designed for reflow of specific areas of interest. Clad coils prevent inadvertent electrical contact with components.

6.2.1.3 Soldering Irons Another effective and versatile tool for performing manual soldering operations. A variety of tip shapes are available to localize the heated area without damaging adjacent parts. Operator skill is required in order to position the solder iron tip at the correct location and to avoid over-heating the joint or plated through hole.

6.2.2 Automated Soldering Processes The following sections describe the specific details of the most common automated processes used for mass production soldering of electronic assemblies.

6.2.2.1 Wave Soldering The large percentage of through-hole board mounted components are mass wave soldered. Small surface mount components such as passive chip capacitors, resistors and SOTs (small outline transistors) are bonded to the bottom side of the board with an adhesive are also wave soldered extensively.

Wave soldering involves the following sequence of operations:

- Fluxing
- Preheating
- Soldering

The wave soldering process includes a pump located in a tank of liquid solder at a temperature of about 235-250°C. This pump generates a positive pressure causing the solder to flow up a chimney or nozzle where it overflows to form a standing solder wave. This solder wave crests higher than the rim of the solder tank, which performs the solder joining of the components to the metallic surfaces on the circuit board.

The preheated assembly receives the balance of the heat required to raise the joint areas to the soldering temperature, causing the liquid solder to wet those areas to be joined.

The assembly is conveyed, usually up a slope, inclined between 4 - 7°, till its bottom surface contacts the crest of the solder wave where the pads, protruding leads, plated holes and bottom-side surface mounted components are soldered.

The solder only wets to, or forms joints on, solderable metallic surfaces. Consequently, no soldering takes place on the board surface that is nonmetallic and poor soldering can occur on any metallic surfaces that are contaminated or have poor solderability. A common wave for soldering traditional boards with leads in through plated holes is the asymmetrical wave used with an inclined conveyor. The majority of the solder flowing from the nozzle flows

against the direction of travel of the board. The remaining portion of the solder flows as a smooth laminar stream of solder in the same direction as the board. This small amount of solder flows over a weir, often adjustable in vertical position, so that the speed of the solder flowing towards the exit weir is moving at the same speed as the board and the conveyor. With the board and the solder moving in substantially the same direction and at the same speed, the drainage conditions where the assembly separates from the wave are ideal for optimum soldering results.

Various wave configurations have been used including the narrow parabolic wave, the wide wave, the adjustable wide wave and the hollow jet wave. Some are operated with horizontal conveyors and others with inclined types.

To eliminate solder bridges that sometimes form as a board separates from a solder wave, some wave solder machines may have an air knife fed with hot air to sweep any bridges from the joint areas before the solder has had a chance to freeze. When used in a nitrogen wave soldering system, nitrogen is supplied to the hot knife.

For wave soldering of surface mount assemblies where, in addition to the usual leaded components, small chip components have been glued to the bottom of the board, two solder waves are sometimes used. The first solder wave is usually a high, rather narrow wave made turbulent by some mechanical means. This is achieved by pumping the solder through rows of small, fixed or moving holes at the outlet of the nozzle or by means of a unidirectional hollow jet wave, with its flow trajectory usually aimed in the same direction as the board travel direction. This first turbulent wave is followed by an asymmetrical laminar wave as described above.

The turbulent action of the first wave causes the solder to move in and around all the chip components to help ensure that all solder joints get soldered. Those joints that are still not soldered most probably are soldered when contacting the second wave. In some designs a vibrating device is added to produce additional mechanical pressure in the second laminar wave to promote hole filling and to further help reduce solder skips.

With double wave systems, a separate pump for independent wave height control drives each wave and they are usually found in the same solder pot. Some machines have the two waves in separate solder tanks, in which case, it is possible to control the solder waves at different temperatures.

6.2.2.2 Vapor-Phase Soldering Although each of the above techniques can produce acceptable results, vapor-phase soldering is an extremely consistent soldering process because the soldering temperature is maintained constantly at the boiling point of the primary liquid used.

vapor-phase soldering can solder both sides of a printed board structure simultaneously.

The process uses a perfluorinated liquid that is heated to its boiling point, creating a saturated vapor zone. At atmospheric pressure, the temperature of the saturated vapor is the same as the boiling liquid. Typically, a perfluorinated fluid with a working temperature of 215°C is used for eutectic grade solder. Fluids with other boiling temperatures are available for lower or higher solder compositions, in multistep soldering, or for use with pure tin.

The soldering process moves the populated printed board structure into the vapor zone using either a vertically operating baton system or a conveyORIZED in-line system. In either configuration, reflow cycle times of 30 to 60 seconds are common.

The printed board structures come out of the soldering process uniformly soldered and dry. The uniformity results from the inert, oxygen-free conditions in the vapor and the precise maximum temperature limitations of the process.

6.2.2.3 Conduction-Reflow Belt Soldering A conduction-reflow belt system uses conduction to transfer heat through the printed board structure. This is accomplished by a series of heated platens located under a continuously moving belt.

The platen temperature and belt speed is individually controlled so that the reflow profile can be varied for different types of printed board structures, which may have different melting temperatures. Since heat is conducted through the board, a thermal gradient exists across the printed board structure. Increasing or decreasing the flow of air over the belt as the assemblies travel off the end of the final platen can also vary the cooling rate.

Because the conduction of the heat through the printed board structure depends on the contact of the structure to the belt, a weighted fixture is usually used to apply pressure to multiple points on the structure. This pressure is applied from the primary side of the printed board structure and is designed not to interfere with the chip carriers on that side. Universal fixtures are usually designed for multiple printed board structures.

A typical schedule for a three-stage conduction reflow soldering belt system is as follows:

1st platen: 50°C
 2nd platen: 200°C
 3rd platen: 230°C
 Belt speed: 10-11 IPS
 Air flow: As required

The belt speed should be adjusted to allow the solder to reflow for a total of 30 to 60 seconds. In addition, the air-flow should be adjusted so that the solder, when solidified, is shiny and not grayish in color.

6.2.2.4 Reflow Oven Electrically heated air circulation ovens are suitable for batch operations, provided the whole assembly can withstand the soldering temperature. Inert or reducing atmospheres can be used if necessary. For continuous operation, gas or electrical conveyORIZED furnaces may be used and these can also allow the use of controlled atmospheres. Smaller units require careful matching of temperature settings with a thermal pad of product if close control of temperature profiles is required.

6.2.2.5 Heater Bar Reflow Soldering Attaches leaded surface mount devices to printed board conductive land areas. Heat is supplied via electrical resistance heating of the heater bar tip. The tip temperature is controlled by a variable current feedback loop with a thermocouple on the heat bar tip.

The Pulsed Heat Cycle can be either pulsed or constant. The pulsed heat cycle system consists of the following steps:

1. Heater bars are aligned over leads to be soldered.
2. Heater bars descend on top of the leads exerting approximately 0.1 to 0.2 pounds per lead being soldered.
3. Power supplies preset for time at temperature are activated and send variable current to the heater bar tips to reflow solder the leads to the printed board structure.
4. After the soldering cycle time at temperature is completed, the power supplies are deactivated and air jets, directed at the heater bars, are activated. Meanwhile, the heater bars maintain their contact pressure on the leads for a specified dwell time allowing the leads to cool undisturbed.
5. After the solder has solidified, the heater bars are retracted and aligned over the next set of leads to be reflow soldered.

The Constant Heat Cycle consists of the following steps:

1. Heater bar tips are heated to and maintained at a predetermined temperature setting.
2. Heater bars then contact the leads for a specified amount of time, reflow soldering the leads.
3. The heater bars are then removed allowing the joints to cool undisturbed.
4. Both methods have different applications but require the common set up of tinned leads and a predetermined amount of solder paste on the conductive land area.
5. When using a pulsed heat cycle system, take care to properly form the leads. Otherwise, the pressure of the heater bars induces mechanical stress into the joints because the leads are forcibly held in place during cooling. This can cause solder joints to crack during burn-in, thermal and vibration cycling.