



*THE INSTITUTE FOR
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Design and Application Guidelines for Surface Mount Connectors

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A standard developed by the Institute for Interconnecting
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Users of this standard are encouraged to participate in the development of future revisions.

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1.0 INTRODUCTION

1.1 Scope With the present packaging trend in system design moving towards compact, low-power consumption configurations, the use of Surface Mount Technology offers a viable approach toward achieving the desired packaging goals. Sophisticated electronic assemblers, using a variety of interconnection and packaging techniques, employ the best of today's technology, intermixed with the appropriate state-of-the-art component and attachment processes. The degree of advancement in packaging of electronic components is predicated on the type of product being produced; the need for miniaturization and weight savings; plus the off-the-shelf availability of different component types.

The growing popularity of surface mount technology for packaging electronics has raised a need for surface mount connectors to provide a common packaging approach.

This document provides guidelines for the design, selection and application of soldered surface mount connectors for all types of printed boards, rigid, flexible-rigid and back-planes. (It does not cover solderless interconnections, such as those that employ conductive elastomers.)

1.2 Purpose The purpose of this document is to provide information on design and application of connectors for surface mount application in order to aid the designer in effectively interconnecting this package. The connector material, design and mounting characteristics are discussed. Land patterns, solder joint configurations, assembly techniques, rework and repair procedures are also covered.

Adherence to the guidelines set forth in this document will generally assure adequate reliability for the majority of applications; however, more rigid requirements may be appropriate for more critical applications.

The methods listed herein shall not be construed as standards since the state-of-art is constantly changing and applications and requirements may vary beyond the scope of this publication.

1.3 Terms and Definitions The definition of terms used herein shall be in accordance with IPC-T-50 and the following:

1.3.1 Coefficient of Thermal Expansion (CTE) The linear dimensional change of a material per unit change in temperature.

1.3.2 Co-planarity of Leads The measure of variation of planarity of leads from a common reference plane.

1.3.3 Double-sided Assembly A packaging and interconnecting structure with components mounted on both the primary and secondary sides.

1.3.4 Footprint (See preferred term "Land Pattern.")

1.3.5 Land Pattern A combination of lands intended for the mounting, interconnection and testing of a particular component.

1.3.6 Mating Force The force required to mate a connector pair.

1.3.7 Packaging and Interconnecting (P&I) Structure The general term for a completely processed combination of base materials, supporting planes or constraining cores, and interconnection wiring used for the purpose of mounting components.

1.3.8 Primary Side That side of a packaging and interconnecting structure so defined on the master drawing. (It usually contains the most complex or most number of components.)

1.3.9 Secondary Side That side of a packaging and interconnecting structure that is opposite the primary side. (It is the same as the "solder side" in through-hole component mounting technology.)

1.3.10 Single-Sided Assembly A packaging and interconnecting assembly with components mounted only on the primary side.

1.3.11 Solder Tail The portion of a connector contact which is designed for soldering to a printed board.

1.3.12 Thermal Expansion Mismatch (See 1.3.1) The absolute difference in thermal expansion of two components.

1.3.13 Unmating Force The force required to unmate a connector pair.

1.3.14 Vapor Phase Reflow The process of reflow soldering by direct contact condensation heating.

1.4 Applicable Documents

IPC-SM-780 Component Packaging and Interconnecting with Emphasis on Surface Mounting

EIA/IS-47 Contact Termination Finish Standard for Surface Mount Devices

2.0 TECHNOLOGY CONSIDERATIONS

2.1 Surface Mount Versus Through Hole Technology

The trend today is to mount active and passive components on the surface of one or both sides of the boards, rather than use through hole mounting. Among the goals for surface mounting are:

- Reduced applied cost
- Improved reliability
- Greater device integration
- Space and weight savings
- Improved performance
- Greater compatibility with automatic (robotic) placement equipment

Manufacturers are looking to Surface Mounting Technology (SMT) for size, weight and cost benefits. When comparing surface-mount with through hole technology, several things are evident. These are:

- a. It allows a single reflow solder operation which is less expensive than two (or more) required with mixed through hole and SMT assemblies.
- b. Holes in printed boards are an expense. Surface mounting of connector components eliminates the need for these through holes for the electrical connections.
- c. Space on the board is saved by surface mounting components, especially on multilayer boards where it is not necessary to have component lead through holes. This saves space on a multilayer board for conductor routing.
- d. Automatic pick and place equipment is better adapted to surface mount than through hole devices. The problem is that misaligned pins can cause disastrous results with a robotized placement method.
- e. Placement rates 3 to 10 times those for through hole devices mean fewer placement machines and lower unit costs.
- f. An option on using surface mount with other mounting methods is also viable. This is called intermixed technology and consists of using through-hole mounting along with surface mount or chip-on-board technology. It enables the design engineer to increase system density by replacing some through hole components and to move toward surface mounting when all components are not available in surface mount form.

2.2 Connector Types

2.2.1 General Connectors are interconnect devices that provide rapid connect/disconnect service for electrical cable, wire, printed boards and other electronic packages.

Connection systems are generally described by geometric form and significant functional attributes:

- Number of contact positions
- Number of rows
- Center-line spacing
- Staggered or square grid mounting pattern
- Orientation to board plane
- Insertion force class
- Board attachment method

The three most common types of connectors are one-part, such as the card edge connector (Fig. 2-1), two-part, such as the post type header and receptacle (Figs. 2-2 and 2-3), and sockets, such as the chip carrier socket. (Fig. 2-4).

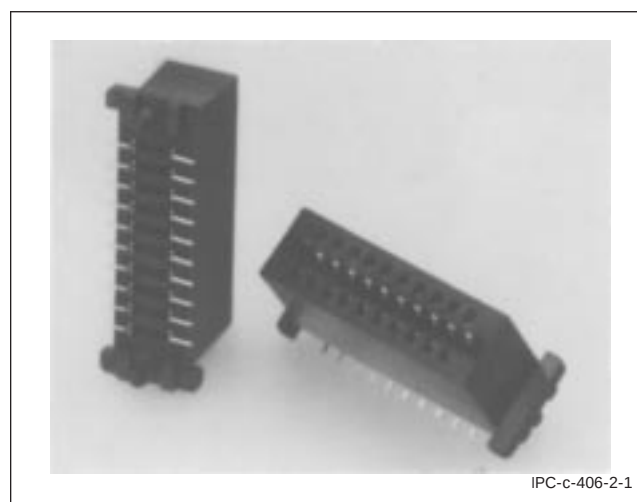


Figure 2-1 Surface Mount Card Edge Connectors

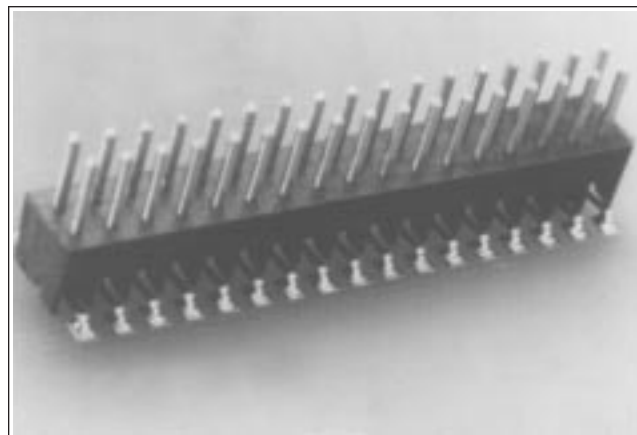


Figure 2-2 Surface Mount Header

The clear difference between a surface mounted connector and a standard leaded connector is in the shape and function of the terminals. Instead of being inserted into holes in the printed board, the terminals of the surface mount connectors are soldered or mechanically attached directly to the substrate surface. When soldered, both the mechanical and electrical performance of the connector is improved.

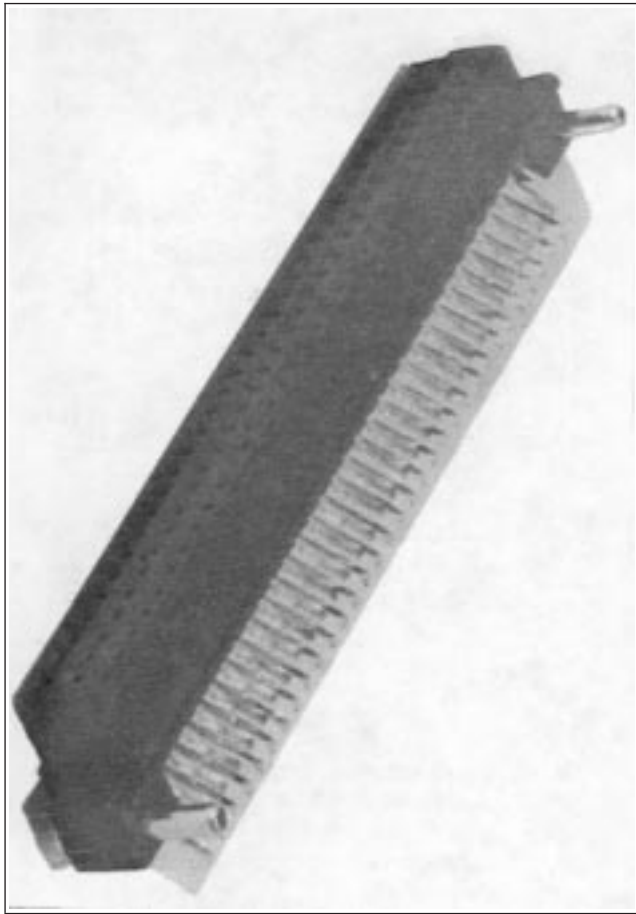


Figure 2-3 Surface Mount Receptacle

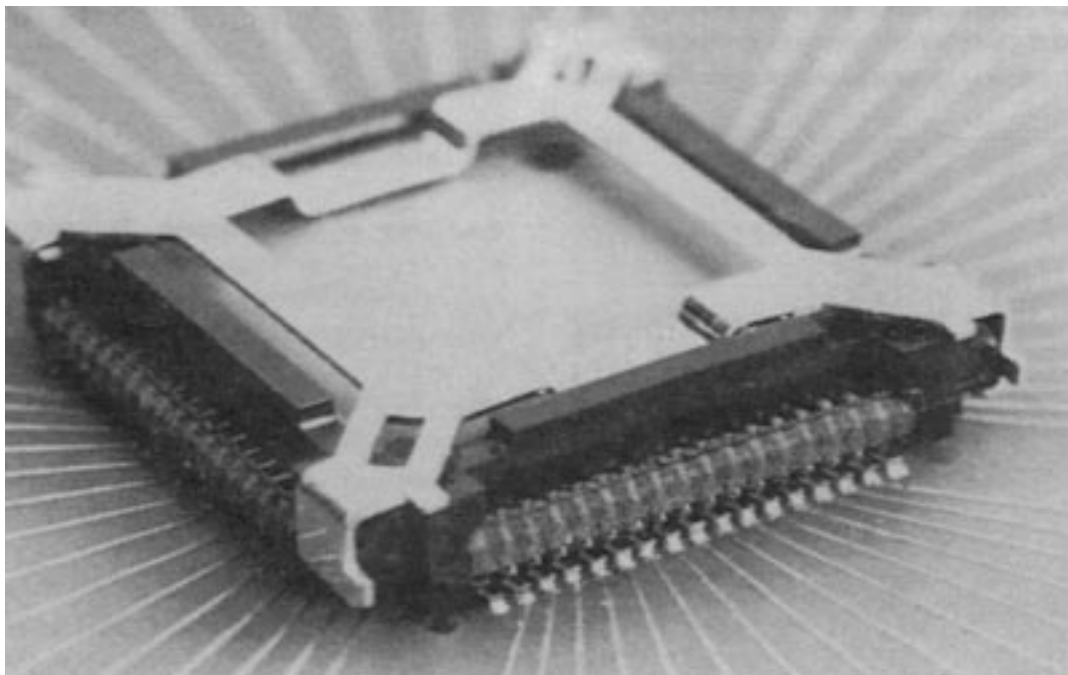
on the integrity of the solder joint. Solder itself is a poor structural material, so care and preparation should go into the production of the joint.

Since the advent of the SMT theme, a host of connector systems are available and are continually evolving.

2.2.2 Solderless or Separable Surface Mounted One type of surface mounted connector maintains electrical contact by means of mechanical pressure between mating surfaces. The inboard connector (Fig. 2-5) is an example of this type of surface mounting. Direct Board Interface (DBI) connectors are another type of surface mount connector. DBIs mate a flexible cable's coiled or etched contact points directly to a rigid printed board.

2.2.3 Solder or Reflow Surface Mounted There are two generic types of reflow-soldered surface mount connectors—partially and fully surface mounted.

2.2.3.1 Partially Surface Mounted Connectors The first is a partially surface mounted type that has the connector body mechanically fixed to the printed board. The solder terminals are surface mounted, but the connector body is bolted or otherwise mechanically attached to the substrate (Figs 2-1, 2-4, 2-6, and 2-7). In this configuration, once the solder joint is made, it minimizes further mechanical loading. All insertion and withdrawal forces are transmitted to the printed board via the mechanical attachment and not



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Figure 2-4 Surface Mounting Socket

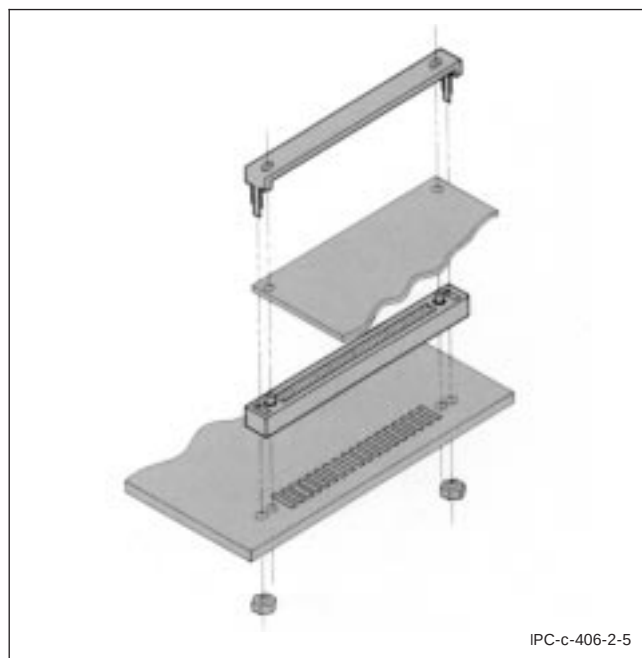


Figure 2-5 Solderless-Mount Connector

the solder joint. This is the preferred configuration where space allows some holes to be drilled in the board and where the service cycle demands a number of matings and unmatings, thermal shock, mechanical shock or vibration.

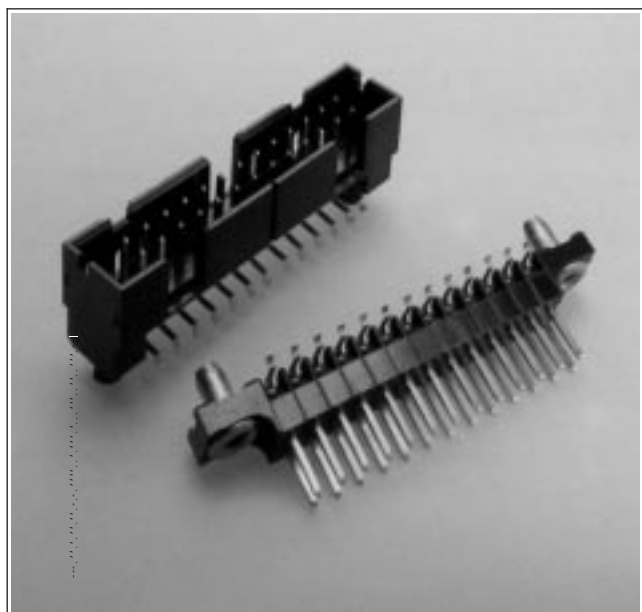


Figure 2-6 Partial Surface Mount Connector

2.2.3.2 Fully Surface Mounted Connectors A fully surface mount connector has the mechanical forces transmitted to the printed board via the solder joints (Figs 2-2 and 2-8). In ceramic boards or where circuit density precludes the use of holes in the printed wiring boards, it will be necessary to adopt the fully surface mount version.

2.2.4 Surface Mount Compatible In many applications, the form factor of several electrical components or the non-

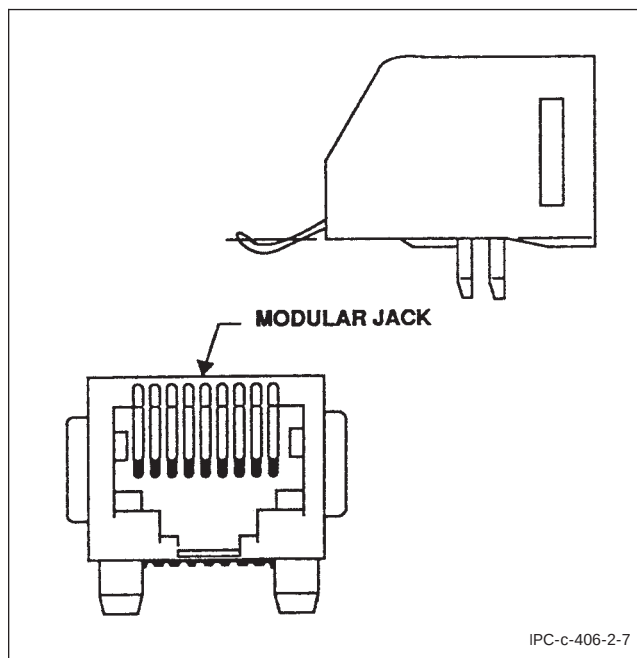


Figure 2-7 Surface Mounted Connector with Mechanical Strain Relief

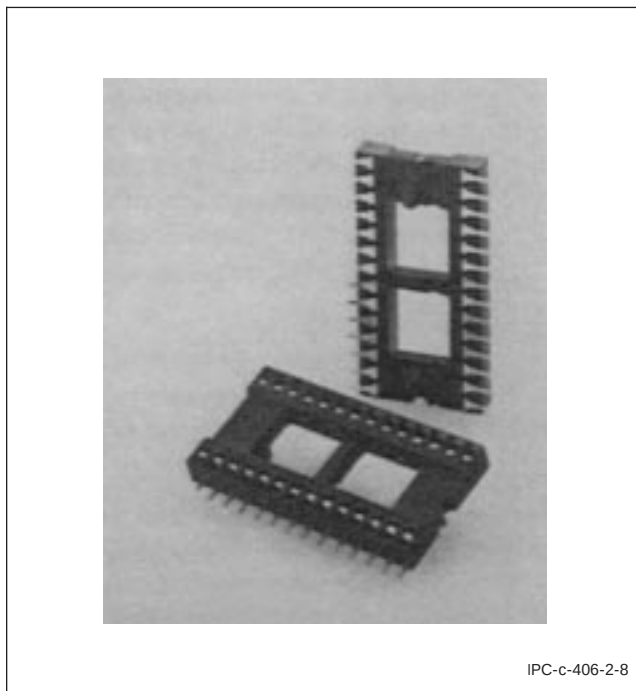


Figure 2-8 Fully Surface Mount Socket with No Supplemental Mechanical Hold Downs

availability of several components in surface mount form dictate that a hybrid SMT and conventional through-hole technology design be utilized. In these applications many users utilize surface mount compatible connectors. These connectors are generally through-hole mount connectors which may have the housing material changed to be compatible with the temperature requirements of the soldering process.

In some cases the contact may be modified to include solder in the form of solder inlays or solder doughnuts.

2.3 Electrical Considerations Information is provided in Appendix A to assist the design engineer in selecting a connector with appropriate electrical characteristics and to assist the connector manufacturer in properly characterizing a connector electrically so as to provide appropriate information to the end user.

2.4 Mechanical Considerations

2.4.1 Mating and Unmating Mating and unmating forces on a functional connector can be as high as 80 pounds. This high mechanical stress should not be absorbed by electrical solder joint connections, particularly when 90° printed board connectors (such as a D-Subminiature connector) are employed. These connectors employ contacts that emerge from the connector rear; the mating force produces a severe moment arm that stresses the solder joints. An auxiliary mechanical means of holding the connector to the printed board must be employed to manage these forces.

In addition, other forces on the printed board lands can cause board warpage, particularly with high pin count, long connectors. A correctly positioned mechanical hold down device is needed to prevent board warpage. For example, a 600 contact connector can produce a 46 pound total normal force with only 35 grams acting per contact; the printed board could easily bow or warp if an improper mechanical hold down is employed.

Various methods including nuts and bolts, rivets, heat stake posts, solder, adhesives, and clamps can be used as hold down devices. Because surface-mount components will usually be placed by robots, the hold down method selected should be compatible with robotic technology. Nuts and bolts are not easily handled with robots.

Rivets, heat stake posts, and clamps can be secured by robots equipped with a proper end-effector that will hold the connector to the board while riveting, staking, or activation occurs. This hold down force exerted by the robot will also deflect solder tails, producing the required force at the tail ends. The above methods require at least two holes in the printed board.

2.4.2 Shock and Vibration Connectors must withstand more varied and severe forces than other surface mounted components. The higher forces result from mating/unmating, mass, misalignment, thermal expansion/contraction, and abuse.

Unmating a vertical surface mounted connector, depending on hold down design, may pull upward on the solder joints generating tensile stresses. In like manner, horizontal

mating/unmating may create shear stresses in the solder joints. The tensile strength of a surface solder joint is determined by lead strength, solder tensile strength, and adhesion of the copper land to the printed board. Typical surface-mount solder joints are weaker than typical through-hole mount joints. Consequently, they often require connector hold down. Coplanarity of connector leads is a factor and is covered in section 3.2.

Vibration standards may include simple harmonic motion up to 2000 Hz at 20 G. Mechanical shock standards may range from 15 to 300 G with pulse duration from 3 to 11 milliseconds.

2.4.3 Thermal Shock-Cycling Connector design and selection must include consideration of the different rates of thermal expansion of the printed board and the connector plastic housing. The coefficient of thermal expansion for a typical glass/ epoxy board is 16×10^{-6} inches/inch/degree Celsius. Values for connector plastics vary considerably and are dependent on the material, filler, and mold flow direction. Consequently, connector attachment legs, etc. need to provide for compliancy. Thermal shock cycling standards may range from -55°C to $\pm 150^\circ\text{C}$.

2.4.4 Solder Joints Solder joints are critical to the performance of surface mount connectors. Successful solder joint formation is dependent on a number of factors including: solder composition, solder land adhesion to the substrate, and terminal to land adhesion. While the terminal must be properly soldered to the land, the solder land must also be properly attached to the substrate. Joint failures can occur at both the terminal/land interface and at land/substrate interface.

In surface mount reflow applications, the gold plating thickness distribution should be carefully evaluated. During reflow, significant amounts of intermetallic can form from the dissolution of gold into solder. Solder may not adhere to nickel surfaced terminals. Tin/lead or tin plate are possible finishes for leads to provide optimum wetting during reflow (EIA/IS-47).

Preliminary research into the relative strength of various connector leads has yielded mixed results. Assuming all the variables can be controlled, post solder visual inspection and batch vertical pull testing to measure joint strength is probably adequate. During shear tests, failure should occur at the terminal/land interface rather than the land/substrate interface.

Solder leads can generally be classified into three types—"I" lead, gull wing and the "J" lead (Figure 2-9 and para 3.2.2).

Solder joint tensile strength decreases and in general becomes less predictable as the height of the lead above the board increases.



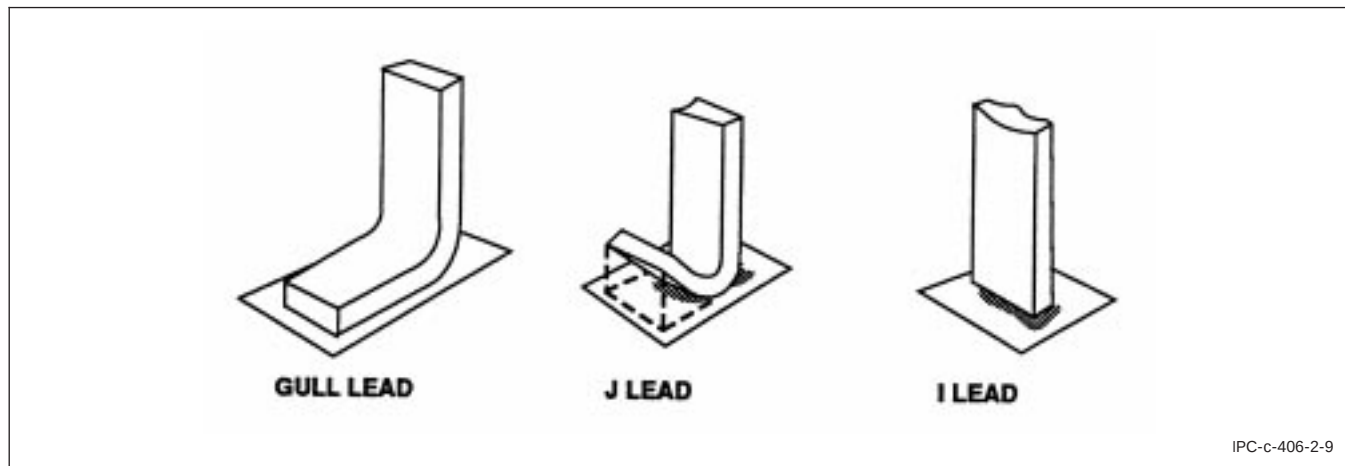


Figure 2-9 I Lead Configuration, J Lead Configuration and Gull Lead Configuration

3.0 CONNECTOR DESIGN CONSIDERATIONS

3.1 Material

3.1.1 Insulator Material Selection The insulator material is the single item most dramatically affected by the surface mount process. The popularity of vapor phase reflow and infrared reflow for soldering has dictated the usage of new materials to withstand temperatures which we never experienced in conventional soldering processes.

In choosing a resin for a surface mount technology (SMT) connector body, there are a number of factors to be considered.

3.1.1.1 Warpage The connector design is the most important consideration. The wall sections should be uniform and kept to a minimum. Uneven walls create differential rates of cooling and shrinkage. Crystalline resins generally exhibit more shrinkage in molding than do the amorphous resins, and are more anisotropic in their shrinkage, the shrinkage in the machine “flow” direction (MD) is less than the transverse “cross flow” direction (TD) which can produce warpage. Glass fibers will reduce shrinkage, but they also cause anisotropic shrinkage. Mineral and glass flake, when added, will tend to reduce the anisotropic shrinkage.

3.1.1.2 Molding Considerations Molded-in stresses, if present in the connector body, can cause warpage at temperatures of infrared and vapor phase soldering. To produce a stress-free part, most crystalline resins should be molded at high mold temperatures. Mold surface temperatures of 240 – 350°F are not uncommon for polyethylene terephthalate (PET), polyetherimide (PEI), and polyphenylene sulfide (PPS). Modified polyarylethers can be molded with mold temperatures of +240 to +300°C. Oil heaters are recommended to reach these mold temperatures.

3.1.1.3 Coefficient of Thermal Expansion SMT connectors are generally secured to the printed board during

soldering by molded-in pins or some other mechanical means of fastening. As the temperature of the package is increased from room temperature to 420°F, the board and connector will expand. Ideally this would occur at the same rate. With a thermoplastic board, that may be possible, but the coefficient of thermal expansion (CTE) of an epoxy board can be one half that of the attached thermoplastic connector. Obviously a smaller connector creates less of a CTE mismatch problem. If the connector is large, the CTE mismatch can cause warpage of the board during soldering.

A high level of glass reinforcement of the resin will reduce the CTE in the connector body, particularly in the direction of flow (length). Glass reinforcement of 20–50% is not uncommon.

3.1.1.4 Creep Resistance Under Load Many connectors have contacts preloaded into plastic. Connector designs that “preload” terminals into plastic connector bodies have internal stresses. Connector performance can be affected significantly if the plastic softens at 215°C reflow temperatures. Considering the connector design, these loads can be balanced and neutralized. In a card edge connector, however, there can be considerable force generated by the preloaded contacts which tend to reduce the card slot width during soldering. This is the effect of creep under load at elevated temperatures. Generally, the higher the heat deflection temperature (HDT) and/or the Modulus of Elasticity of the polymer at the soldering temperature, the lower the distortion or closing of the card slot.

Usually, the higher the glass reinforcement of the polymer the better the resistance to creep. Crystalline polymers can exhibit less distortion at elevated temperatures compared to amorphous resins. Again, higher mold temperatures in processing generally raise the level of crystallinity. The above comments on controlling creep in a card edge connector also apply to contact retention in any connector where the contact is force-fit to the connector body.

3.1.1.5 Solvent Resistance Acid flux and other contaminants are commonly removed by vapor cleaning or through total immersion in boiling saturated and halogenated hydrocarbons. The chemical resistance of the polymer is therefore extremely important. Crystalline polymers usually exhibit better resistance to halogenated hydrocarbons than do amorphous resins.

3.1.1.6 Humidity Aging All of the resins absorb moisture to some degree. This can cause problems during the reflow operation. Since the reflow temperatures are much greater than the boiling point of the water, any moisture rapidly vaporizes and will try to escape, causing blistering, or foaming of the connector body. The magnitude of these effects will be a function of the design of the connector, the amount of moisture the material can absorb, and the resin's modulus at reflow temperatures. Tests should be run on moisture conditioned connectors to insure that this type of failure will not occur after a finished product sits in the field for a given time.

3.1.2 Typical Connector Body Insulation Materials

Several material types are now available which are suitable for SMT. The list that follows describes some of these materials. Since properties vary widely within a material type depending on filler type, filler form, and the effect of combining with other resins, each application must be evaluated against specific performance requirements. The following list is not to be considered all inclusive. Table 3-1 is a partial list of materials available.

3.1.2.1 Polyphenylene Sulfide (PPS) Presently being used for SMT connector bodies. Its chief advantages are ease of flow in thin sections, minimal warpage in molding and good dimensional stability in vapor reflow. Chief draw-backs are low elongation when inserting interference-fit pins and lack of toughness. Users also complain that interaction with the polymers generates high maintenance costs for molds and molding machines.

3.1.2.2 Polyethylene Terephthalate (PET) Found to be acceptable for a wide range of SMT connectors. For optimum dimensional stability in vapor reflow, connectors must be molded in a hot mold (240–280°F) for maximum crystallinity. Chief disadvantages are creep under load in card edge connectors and greater warpage than PEI or PPS in connectors of non-uniform wall design.

3.1.2.3 Polyetherimide (PEI) The chief benefits are low shrinkage and minimal warpage in molding even in connectors with nonuniform walls, and a high elongation for interference-fit pins. Processing temperatures in molding are high (640–800°F) for best part quality.

3.1.2.4 Diallyl Phthalate (DAP) DAP thermoset resins are used in high temperature/high humidity environments

where mechanical and electrical reliability are required. Consequently, they are primarily found in military applications. They have good electrical properties, are dimensionally stable in extremes of temperature and humidity, and have a good CTE match with epoxy board resins. DAP will be difficult to mold into thin-walled connectors. Hence, their usage is expected to be concentrated in high performance applications.

3.1.2.5 Phenolic Little opportunity is seen for this thermoset family of resins in SMT connectors. The material is fairly brittle and difficult to mold in thin sections. However, it does have a low price and has a good CTE match with epoxy boards. In addition, phenolics have good dimensional stability and can be thermally stable up to 400°F.

3.1.2.6 Modified Polyarylethers These resins combine the desirable characteristics of both amorphous and crystalline materials. The amorphous nature imparts close molding tolerances and high warp resistance. The crystallinity provides the necessary solvent resistance. Elongation and toughness are sufficient for mechanical requirements such as interference-fit pin insertion. Though the heat distortion temperatures under pressure are below the soldering temperatures, the modulus of these resins at soldering temperatures is high enough to prevent distortion. Their excellent hydrolytic stability imparts good retention of properties under conditions of high humidity.

3.1.2.7 Liquid Crystal Polymers (LCP) A new class of commercial resins, known generically as thermotropic liquid crystal polymers which achieve the high strength, stability, and low weight of thermoset composite materials with the easy processability of thermoplastic resins.

LCPs allow extremely low molding pressures (1,000 PSI) with excellent material flow properties which in many cases combine to more than offset its current premium material price. LCP's heat deflection temperature of 229°C allows its usage in vapor phase applications.

3.1.3 Contact Material The contact materials are not as dramatically affected as the housing by the processing parameters of surface mount technology (SMT). Many of the standard materials previously utilized in non-SMT applications can be utilized. Care must be exercised so that the contact design is configured such that preplated contact surfaces are not in contact with each other during vapor phase or infrared processing. This would result in a reflow of the solder plating which may not allow the contact to operate as intended.

3.1.3.1 Base Materials Previously, the most common and reliable contact materials used for surface mount connectors have been C51000 (phosphor bronze), C50400 (copper alloy), and C51010 (copper alloy).

Table 3-1 Typical Connector Body Insulator Materials

			Thermoplastics						Thermosets	
			Semi-Crystalline		Amorphous		Cryst./Amorp. Blend	Liquid Crystal Polymer	Diallyl Phthalate	Phenolic
Properties	Units	ASTM Test Method	Polyphenylene Sulfide	Poly Ethylene Terephthalate	Polyetherimide	Polyethersulfone	Modified Polyarylether			
Mechanical										
Tensile strength	kpsi	D-638	17.5	22.0	24.5	18.0	15.9	29.0	12.0	9.0
Elongation at break	%	D-638	0.9%	2.3%	2.7%	3.0%	1.5%	1.9%	0.5%	0.5%
Flexural modulus	Mpsi	D-790	1.70	1.50	1.20	0.86	1.34	2.1	2.1	2.5
Tensile impact strength	ft-lb/in(E2)	D-1822	9				16			
Izod impact strength, 1/8"	ft-lb/in	D-256								
Notched			1.3	1.6	2.0	1.5	1.0	3.0	0.08	0.08
Unnotched			4.5		8.0	8.0	7.8		2.0	2.0
Thermal										
Coefficient of thermal expansion	in/in F	D-696	1.2E-5	1.1E-5	1.1E-5	1.5E-5	1.5E-5	0.9E-5	1.5E-5	1.3E- 5
	in/in C	D-696	0.6656	0.61E-5	0.61E-5	0.83E-5	0.83E-5	0.5E-5	0.83E-5	0.72E-5
Heat deflection temp.										
at 264 psi	F	D-648	500	435	410	420	293	445	400	375
	C		260	224	210	216	145	229	203	190
at 64 psi	F	D-648			414		381			
	C				212		194			
Limiting oxygen index	%	D-2863	46.5	33		40			38	47
UL:										
Thermal Ind., w/Impact	C	UL-764B	200	150	170	180	150		170	180
UL94 Flammability		UL-94	V-O	V-O	V-O	V-O	V-O		V-O	V-O
Thickness	inches		0.028	0.032	0.063	0.017	0.032		0.063	0.063
Electrical										
Dielectric Strgth, 1/8"	V/mil	D-149	450					1100		
Short time			363	430		375	455		400	475
Step-by-step			383				419		400	425
Diel. constant, 60 Hz		D-150	3.9	3.6			3.8		4.1	5.6
1 MHz			3.8	3.6		3.5	3.7	2.9	4.0	5.2
Dissipation factor, 60 Hz		D-150	0.0006	0.0040			0.0089		0.0090	0.0290
1 MHz			0.0014	0.0100		0.0060	0.0086	0.003	0.0130	0.0250
Arc resistance	sec.	D-495	38	117	85		125	137	130	150
Volume resistivity	ohm-cm	D-257	4.5E16	1.0E15	3.0E16	2.0E16	1.6E16	1.0E15	1.0E15	1.0E11
Surface resistivity	ohms	D-257		1.0E14			2.1E16			
General										
Specific gravity		D-1505	1.60	1.67	1.51	1.51	1.47	1.57	1.87	1.75
Mold shrinkage, MD	mil/in	D-955	2	2	2	3	2	0.03	2	2
TD	mil/in		10	9			5			

(cupro nickel tin), C17200 and C17410 (beryllium copper). Each alloy possesses good spring properties coupled with excellent formability. Depending upon temper, the electrical and mechanical properties and cost of these alloys dictate which contact material is selected for a particular design. More recently, copper clad stainless steel has come into use, combining higher strength levels with 100% con-

ductivity copper on the surface. Also of recent interest is spinodal alloy C72900 having very high temperature stress relaxation resistance.

Table 3-2 displays the selection properties for these materials and the tempers commonly used in surface mount designs.

Table 3-2 Typical Contact Base Materials

Alloy and Temper	C72500 Hd. Temper	C51000 Hd. Temper	C51000 Ex-Hd. Temper	C17410 Ht. Temper	C17200 1/4 HM Temper	C17200 1/2 HM Temper	C17200 HM Temper	Cu/SS /Cu HM Temper	C72900 TMO4 Temper
Tensile strength (KSI)	75–90	76–91	88–103	110–130	110–120	120–135	135–150	145–160	115–135
0.2% Yield strength (KSI)	74–79	74–88	85–102	95–125	90–110	100–125	115–135	135–150	105–125
Elastic modulus (MSI)	20	16	16	19	19	19	19	25	19
Electrical conductivity (%IACS)	11	15	15	45–60	20–28 t20–28	20–28	22–25*	8	8
Formability (R/T) Bad way bend 90°	3.0	2.0	4.0	6.0	1.0	2.0	3.0	<0.3	0.5
Stress relaxation—remaining stress (%) 1000 HR @ 105°C Test stress is 75% of .2% Y.S. @200°C	85	80	75	>95	>95	>95	>95	>80	>95
@225°C	**	**	**	80	—	30	—	70	90 80

* Bulk conductivity with 25% Cu

** Not recommended at 200°C

Phosphor bronze and cupro nickel tin alloys display lower electrical conductivities and less resistance to stress relaxation properties. Higher operating temperatures would be experienced with these alloys under high current situations where self heating occurs. This situation coupled with surface mount connector designs sensitive to stress relaxation could jeopardize the long term reliability of the connection.

The beryllium copper alloys display better electrical conductivity and mechanical properties. The recently introduced C17410 alloy has excellent mechanical and electrical properties, but is limited in formability. The limited formability may not permit the use of this material in particular designs. Copper clad stainless steel (Cu/SS/Cu) allows the designer to obtain superior mechanical and electrical properties and increased formability. The spinodal alloy C72900 has high strength and formability and exhibits no distortion when age hardened. Particular product designs will determine what compromises must be made in the material selection. No one material may possess all of the ideal properties for a particular surface mount connector.

Some connector designs use two or more contact materials often welded together allowing the solder tail material to be different from the material used for the active portion; i.e., socket, box, tuning fork, etc. In these applications, high conductivity is most important and stress relaxation is not a concern, for the solder-tail material. Selection should begin in the near pure coppers and low zinc brasses.

3.1.3.2 Lead Surface Finishes Platings or coating systems for leads and for land areas on printed boards must be chosen for reasons other than the initial attainment of good solderability as deposited. Of utmost concern should be the

possibility of deterioration due to intermetallic formations which occur while on the shelf, in transit prior to final soldering and continue even after final soldering. Major variables to be considered are:

- Chemistry of the deposit
- Thickness of the deposit
- Chemistry of the basis metal being plated or coated
- Process by which coating is attached
- The thickness and chemistry of the undercoat layers applied prior to the final coating
- Storage period
- Storage conditions of temperature and humidity
- Protective treatments applied over the surface

In practice, storage conditions can be controlled. Treatments can also be employed on parts immediately after coating to render them less susceptible to atmospheric attack. Treatments such as passivation or application of a resin/alcohol solution can be incorporated. The resin solution will dry as the alcohol is evaporated and provides atmospheric protection in storage but, upon heating during soldering, the dried resin layer acts as a soldering flux.

Deterioration then, as it may occur while parts are protected on the surface, would be due to intermetallic growth between the finish and the base metal. Materials being addressed are those used in the electronics industry. The most common are the copper alloys used as base materials for leads and components and pure copper used as basis land metal material on printed boards. These are the materials

with tin or tin/lead alloy. In many cases noble metal platings are used in place of the tin or tin-lead coatings. This is done for maintaining good electrical characteristics since noble metals do not tarnish or corrode in normal operating environments.

Barrier platings, the underplates beneath the final finish, are recommended as protection against diffusion. Whereas the surface platings are selected for their ability to serve specific needs, the underplate must be selected to protect the surface plating from internal contamination and subsequent characteristic changes. In some cases such as copper component leads it is more desirable to eliminate all platings and hot dip coat in a 60% tin, 40% lead bath to a heavy thickness of 7.5 micron [0.000300 inch] minimum. Since most underplate materials only slow down the rate of diffusion, and in many cases the underplate itself may diffuse, it is practical to employ a very thick hot dip coating which would solder well, is continuous in coverage and would require a very extended time period for any intermetallic, which might form with the base material, to diffuse through the layer and cause any problem.

It is not always possible to use hot dip coatings especially on boards or in situations where thickness control is important. Plating systems are then used. Recommendations for plating systems which would minimize interference from intermetallic formations follow:

- In general, component leads used in solder connections should be with tin/lead alloy.
- Pure tin platings are not recommended unless alloyed with some lead to prevent formation of tin whiskers. Tin whiskers may interfere with board circuitry. If necessary to plate, the plating must be done on absolutely clean surfaces and be capable of being reflowed with no signs of dewetting or nonwetting.
- Platings on brass should be preceded by an undercoat plating; 2.5 micron [0.000100 inch] is recommended. The mobility of zinc in brass causes a build-up of zinc at the surface of the coating by diffusion. The level of diffusion is great enough to cause corrosion by condensed moisture, which in turn interferes with the ease of soldering.
- Nickel or copper underplatings are recommended diffusion barriers. These two metals can form intermetallic compounds with the coating. However, these intermetallics grow more slowly than the zinc intermetallics.
- Coatings of tin/lead alloys give excellent initial solderability and retention of solderability in thicknesses not less than 7.5 micron [0.000300 inch] minimum without nickel or 3.75 micron [0.000150 inch] with nickel underplates. Platings however, must be capable of reflow with no signs of dewetting or nonwetting.
- A 1.25 micron [0.000050 inch] to 2.5 micron [0.000100 inch] nickel underplate on tin/lead plated zinc bearing alloys gives enhanced initial solderability and little perceptible deterioration in storage.
- A 2.5 micron [0.000100 inch] thick copper undercoat generally enhances initial solderability of tin lead platings. In some cases the decrease in solderability with storage time will be greater than with a nickel underplate. This is due to the faster growth rate of the copper/tin intermetallic.
- Gold to solder and pure palladium to solder connections, especially in surface mount applications, are a source for intermetallic formation. They should be studied carefully to insure that concentrations in a solder joint do not reach critical levels. If soldering to thin gold only or palladium plated leads, insure that all gold and palladium is dissolved off the lead during the soldering process.
- Wherever possible only similar platings should be mated to each other for soldering. This affords ease of soldering and eliminates the risk of intermetallic formation.
- Gold platings on brass should always have a copper or nickel diffusion barrier. Gold platings on non-zinc bearing copper alloys may include a nickel underplate to improve wear and to slow down alloying with copper. Gold intermetallics are formed with either nickel or copper, however, diffusion with the nickel intermetallic is slower.
- Noble metal platings alloyed with nickel and underplated with nickel can provide additional protection against intermetallic formation and subsequent contamination. The additional nickel in the alloy provides additional interference. An alloy such as palladium nickel with a gold flash on the surface and a nickel underplate is a good example of this enhanced protection.

3.2 Contact Lead Design

3.2.1 Lead Shape and Size

3.2.1.1 Lead Size The size of a surface mount lead is dependent on the contact density or centerline spacing on the board. Typically connectors and sockets are readily available on 2.54 or 1.27 mm [0.100 or 0.050 inch] centers. Higher contact densities can drive these dimensions to as small as 0.254 mm [0.010 inch]. Dimensions may vary with design. Appendix B lists recommended lead and land sizes.

3.2.1.2 Coplanarity There are a number of connector dimensional tolerances that are important to the printed board mounting process. The main one is the degree of coplanarity of connector lead lengths. Planarity requirements are dictated by a number of factors including solder thickness, warpage in the connector housing, warpage in the board, and amount of contact float. Generally a coplanarity of 0.1 mm [0.004 inch] will provide good solderability.

joint. A coplanarity of 0.05 mm [0.002 inch] less than the solder thickness at installation will provide optimum results.

3.2.1.3 Compliance of Leads Some compliancy in the contact leads is necessary to provide assurance that the lead is embedded into the solder paste prior to reflow and to allow for strain induced by differences in CTE. This feature does, however, produce a residual force normal to the board after reflow which can induce board warpage especially in large pin count connectors.

3.2.2 Lead Shape

3.2.2.1 Gullwing The gullwing design is the easiest to form and provides both compliancy and easy inspectability (Fig. 2–9). It is probably the most common configuration for connectors.

3.2.2.2 “J” Lead The “J” Lead design is slightly more difficult to make than the gullwing (Figure 2–9). It allows the formation of two strong solder fillets. This increase in solder joint surface area will withstand more abuse.

3.2.2.3 “I” Lead In the “I” Lead design the terminals are soldered perpendicularly to the substrate surface (Figure 2–9). It is the joint with the least amount of contact area and generally is used where solder joint strength is not an important factor. (However, a joint with a proper 360° fillet can be very strong.) “I” Lead is sometimes referred to as Butt Lead.

3.2.3 Mechanical Considerations

3.2.3.1 Hold Down Previously published research has defined how reliable individual solder joints can be achieved for connectors. The mechanical aspects of connector design and how they are attached to boards also play a substantial role in successful use of surface mounted connectors.

Although individual solder joints may be perfect, failures of surface mount solder joints can still occur due to other factors. This section will discuss some of these other failure mechanisms, how to prevent them, and also will present some design concepts to permit designers to take full advantage of the potential offered by the combination of surface mounting and reflow soldering.

A. Breaking of Solder Joints—Solder is not mechanically strong. Solder joints can be broken relatively easily by any condition that concentrates force on a particular solder joint. One example is bending of the board away from a rigid connector. (Figure 3–1).

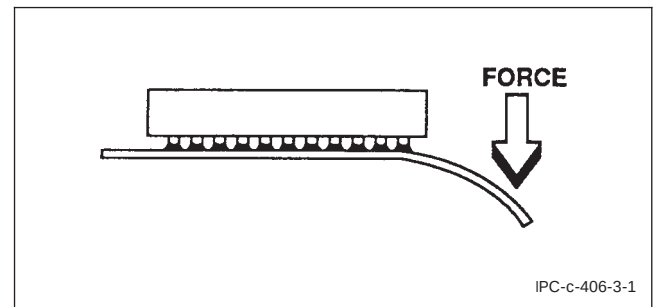


Figure 3-1 Peeling of Board Away From Connector

The longer the connector and the more flexible the board, the more vulnerable the solder joint is to breakage from this mechanism. One solution is to fasten the connector to the board outboard of the solder joints. (Figure 3–2).

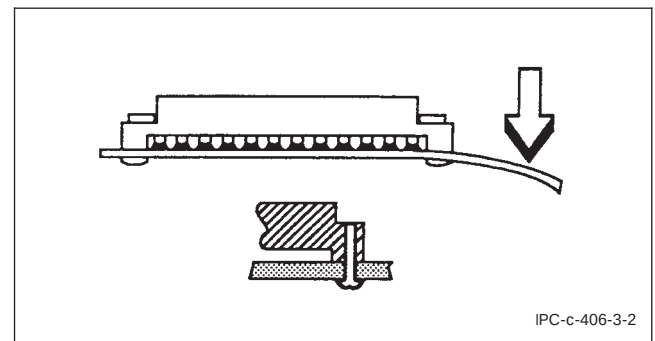


Figure 3-2 End Attachment Protects Solder Joint

This does not totally relieve the solder joints, however, since there will still be deflection of the board between the attachment points. Deflection of the board underneath the connector can occur during routine handling, especially mating and unmating of the connector. Compliant leads can accommodate such board deflection. Vibration, especially if the appropriate harmonic frequency is found, can also cause catastrophic deflection to occur underneath the connector. (Figure 3–3).

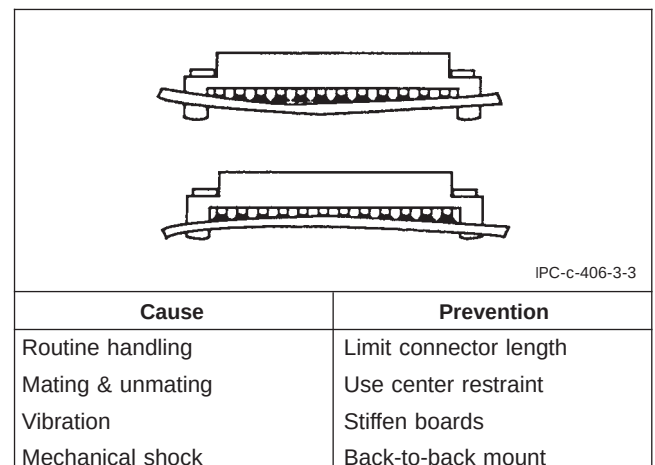


Figure 3-3 Deflection of Board Under Connector

B. Preventing Breaking of Solder Joints—This deflection and its effects can be limited by several simple mechanical means including: Limiting the connector length, limiting the board size, using center pegs on larger connectors, and by using board stiffeners or back-to-back connectors.

Daughter cards can become very effective levers that can be abusive to the solder joints. For parallel “baby cards,” there is a real possibility that someone will unmate the board so that strong torsional forces are transmitted to the solder joints. This can be prevented by designing the assembly to make this unlikely by using mechanical ejectors, using two connectors—one on each end of the baby board, or by providing a lead-in mechanism so that the connector is always mated last and unmated first. (Figs 3–4 and 3–5).

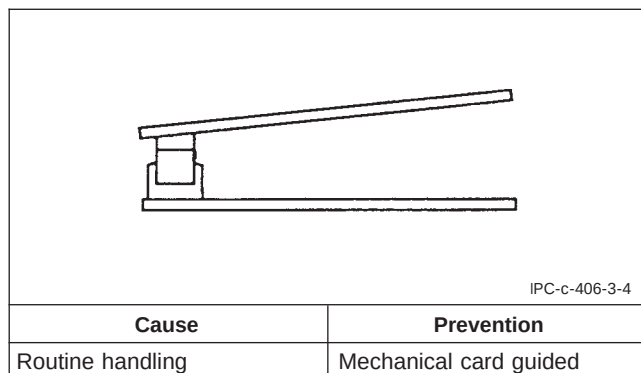


Figure 3-4 Parallel Boards

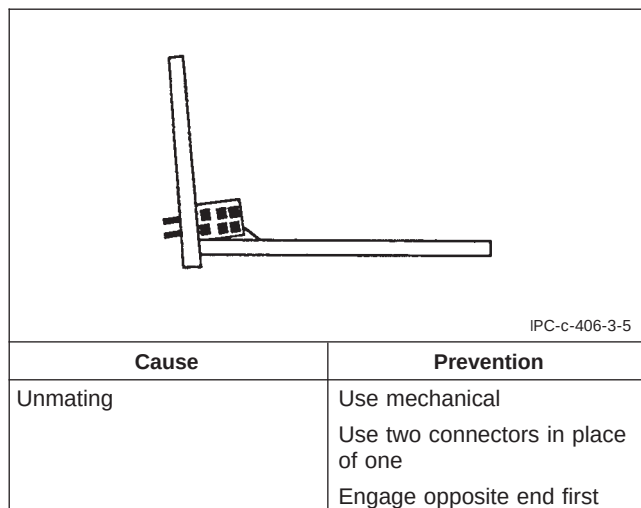


Figure 3-5 Right Angle Boards

C. Connector Design to Relieve Solder Joint Stress—There are some design features of surface mount connectors that can alleviate the causes of solder joint failure by separating the solder joint from stress that affects it.

First, individual terminals can float in the housing cavity. Some connectors have terminals that are permitted

to float as much as 0.125 mm [0.005 inch] in each direction inside the housing cavity.

Second, the longer the lead distance between the solder joint and the plastic body of the connector, the better. Although there is always a trade-off between length of the soldertail and size of the connector, a suitable compromise can normally be found.

Third, the more flexible the soldertail is, the better. This compliance in the soldertail acts to isolate the solder joint from the effects of board flexing, vibration, thermal cycling, and mating/unmating of the connector. Flexibility of this soldertail is obtained through a combination of material selection, soldertail length and width and shape. Needless to say, any connector that uses flexible soldertails also requires mechanical attachment to the printed board.

Hold-down features on connectors provide two functions: Location of the connector and mechanical attachment to the printed board (thus protecting the solder joint). On some connector designs, hold-downs are essential, on others they are optional.

Assuming that hold-down mechanisms are indeed practical and desired, what mechanisms will provide the best results? Choosing the optimal hold-down mechanism is a compromise among:

- Locating accuracy and retention
- Retention forces and insertion forces
- Functionality and cost
- Suitability for automatic placement and suitability for hand placement
- Board real estate

The most attractive hold-down alternative for a connector manufacturer is a peg that is molded as an integral part of the connector body. These pegs can be designed for an interference fit into the printed board (Fig. 3–6) or for insertion and later heat staking for retention. (Fig. 3–7).

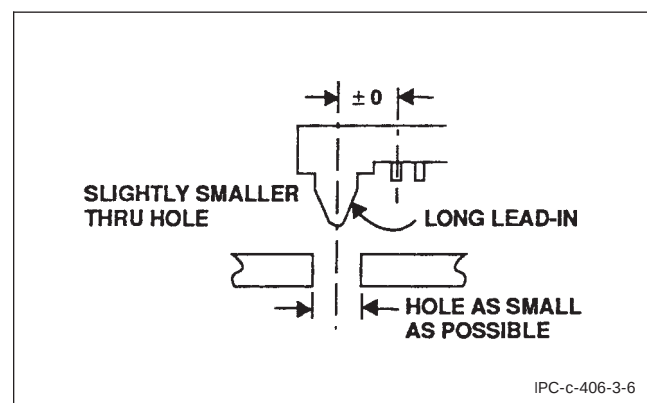


Figure 3-6 Press Fit Pegs



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