



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

IPC-FA-251

Assembly Guidelines for Single-Sided and Double-Sided Flexible Printed Circuits

ANSI/IPC-FA-251

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A standard developed by IPC

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Assembly Guidelines for Single-Sided and Double-Sided Flexible Printed Circuits

Developed by the Flexible Circuit Assemblies Subcommittee
of the Flexible Circuits Committee of IPC

APPROVED SEPTEMBER 9, 1991 BY



AMERICAN NATIONAL STANDARDS INSTITUTE

Users of this standard are encouraged to participate in the
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Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the IPC Flexible Circuits Assemblies Subcommittee of the IPC Flexible Circuits Committee are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Assembly Guidelines for Single-Sided and Double-Sided Flexible Printed Circuits

1.0 INTRODUCTION

This document is intended to provide the designer and manufacturing engineer the key issues related to Flexible Printed Circuit (FPC) assembly techniques; and where appropriate, sections from other IPC documents have been excerpted in order to highlight the concerns and design principles. These guidelines provide information on what type of parts are available, the techniques and processes necessary for their proper use, possible advantages, disadvantages or problems, how to start implementation, and where to find additional information.

1.1 Scope This document provides guidelines for the assembly of components and mounting hardware to single- and double-sided flexible printed wiring. In addition, the guidelines describe the type of materials and processes that may be used to accomplish the proper electronic assembly.

1.2 Purpose The purpose of this document is to guide the user by seeking answers to questions related to accepted, effective methods of assembly processes to FPC. The methods described herein are not standards, since state of the art is constantly changing such that applications and requirements may vary beyond the scope of this publication.

1.3 Classification Three classifications are assigned, based on increasing difficulty and sophistication of assembly. These are,

1. *Class A:* Simple assembly, employing through the board component mounting;
2. *Class B:* Surface mounting, employing all the techniques to make that assembly choice reliable;
3. *Class C:* An intermixing of through the board (through hole) and surface mount methods.

In addition to the three classes of assembly, there are two types of assembly. They are:

1. *Type 1:* Assemblies with components mounted to one side of the finished flexible board.
2. *Type 2:* Components mounted to both sides of a finished flexible board.

Note: These classes and types are not to be confused with the classes and types of IPC-FC-250 which refer to end-item use. All classes of IPC-FA-251 assemblies may apply to any class of IPC-FC-250 circuit.

1.4 Dimensions/Tolerances All dimensions and tolerances are expressed in ISO units with English system equivalents shown in brackets []. Users are cautioned to employ this system and not intermix ISO and English system units. Reference information is shown in parenthesis (). Dimensions and tolerances shall be interpreted in accordance with ANSI Y14.5M.

2.0 APPLICABLE DOCUMENTS

2.1 IPC

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

IPC-SC-60 Post Solder Solvent Cleaning Handbook

IPC-AC-62 Post Solder Aqueous Cleaning Handbook

IPC-CM-78 Guidelines for Surface Mounting and Interconnecting Chip Carriers

IPC-PC-85 Certification of IPC Defined Products Under the NECQ System

IPC-CI-86 Printed Board Manufacturing Capability Identification

IPC-PC-90 General Requirements for Implementation of Statistical Process Control

IPC-MF-150 Metal Foil for Printed Wiring Applications

IPC-FC-231 Flexible Bare Dielectrics for Use in Flexible Printed Wiring

IPC-FC-232 Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring

IPC-FC-233 Flexible Adhesive Bonding Films

IPC-FC-241 Flexible Metal-Clad Dielectrics for Use in Fabrication of Flexible Printed Wiring

IPC-D-249 Design Standard for Flexible Single- and Double-Sided Printed Boards

IPC-FC-250 Specification for Single- and Double-Sided Flexible Printed Wiring

IPC-A-600 Acceptability of Printed Boards

IPC-A-610 Acceptability of Printed Board Assemblies

IPC-TM-650 Test Methods Manual**IPC-CM-770** Component Mounting Guidelines for Printed Boards**IPC-SM-780** Component Packaging and Interconnecting with Emphasis on Surface Mounting**IPC-SM-784** Guidelines for Chip-on-Board Technology Implementation**IPC-S-804** Solderability Test Methods for Printed Wiring Boards**IPC-S-815** General Requirements for Soldering Electronic Interconnections**IPC-SF-818** General Requirements for Electronic Soldering Fluxes**IPC-AJ-820** Assembly and Joining Handbook**IPC-SM-840** Qualification and Performance of Permanent Polymer Coating (Solder Mask) For Printed Boards**2.2 Electronic Industries Association (EIA)****Publication 95** JEDEC Registered and Standard Outlines for Solid State Products**2.3 Military****MIL-STD-202** Test Methods for Electronic and Electrical Component Parts**MIL-STD-810** Environmental Test Methods**MIL-STD-2118** Flexible & Rigid Flex Printed Wiring for Electronic Equipment**MIL-P-28809** Printed Wiring Assemblies**MIL-I-45208** Inspection System Requirements**MIL-STD-45662** Calibration System Requirements**MIL-P-50884** Printed Wiring, Flexible and Rigid-Flex**2.4 Federal****QQ-S-571** Solder, Tin Alloy, Lead-Tin Alloy and Lead Alloy**2.5 American National Standards Institute (ANSI)****ANSI Y-14.5M** Dimensioning and Tolerancing**3.0 GUIDELINES**

3.1 Terms and Definitions Terms and definitions used herein are in accordance with IPC-T-50 except as otherwise specified.

3.2 Materials Since the assumption is made that a Flexible Printed Circuit (FPC) used as a component in an assembly will be designed after consideration of IPC-D-249, and manufactured in accordance with IPC-FC-250, the materials used in the construction of the circuit will conform to one or more of the following specifications:

IPC-CF-150 Metal Foil for Printed Wiring Applications**IPC-FC-231** Flexible Bare Dielectrics for use in Flexible Printed Wiring**IPC-FC-232** Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring**IPC-FC-233** Flexible Adhesive Bonding Films**IPC-FC-241** Flexible Metal-Clad Dielectrics for use in Fabrication of Flexible Printed Wiring**IPC-SM-840** Qualification and Performance of Permanent Polymer Coating (Solder Mask) For Printed Boards**3.2.1 Material Considerations in Assembly****3.2.1.1 Thermal Assembly Process Considerations**

3.2.1.1.1 General Assemblers must be attentive to the susceptibility of damage to FPC materials due to high temperature assembly processes.

The inherent mismatch in Coefficient of Thermal Expansion (CTE) among dielectric, adhesive and conductor can contribute to board failure when exposed to high temperatures. In addition, the tendency of some dielectric films to stress relieve during thermal exposure can increase CTE problems.

The process or manufacturing engineer should minimize thermal exposure and communicate the extremes of the thermal exposure during manufacturing. (The general rule suggests the lowest temperature and shortest dwell time consistent with high assembly yield to be the process goal.)

Because of the variety of dielectrics and adhesives available and suitable for FPC, it is beyond the scope of this document to recommend appropriate temperatures and dwell times for all process/material variations. The user is reminded, however, that despite the significant differences in thermal characteristics (i.e., melting point, glass-transition temperature, etc.) dielectrics, and adhesives (e.g., polyesters vs. polyimides) there are appropriate limits.

temperature combinations which will allow successful thermal assembly without failure.

3.2.1.1.2 Moisture Absorption Flexible dielectrics and adhesives absorb moisture. There are significant differences in absorption characteristics among materials (e.g., aramid fiber vs. fluoropolymers). In addition, the assembler may be forced to confront entrapped solvents which have not been completely withdrawn from FPC during the manufacturing process. It is recommended that the manufacturing or process engineer include a prebake cycle to drive out moisture entrapped or absorbed during storage, manufacture, or handling. The cycle time and temperature will vary with the combination of adhesive and dielectric used. A typical prebake cycle is 121°C [250°F] for 30–60 minutes.

3.2.1.1.3 Cleaning After thermal assembly operations, care must be taken to assure cleanliness of the FPC. Component packaging should be selected and assembly fixtures designed to maximize efficiency of cleaning operations and minimize the potential of chemical entrapment. If possible, inorganic process chemicals should be used since this will minimize the effect of chemical entrapment and fungus growth.

3.2.1.2 Mechanical Considerations

3.3.1.2.1 Clinching The design of an area to which a component will be clinched should allow the metal conductor to absorb the stress imparted to the FPC. Evaluation of clinched joints may be accomplished by pull testing, which should reflect conservative application estimates.

3.2.1.3 Fixturing Consideration must be given to the fragility of FPC in the design and use of fixtures. Fixtures should be designed to minimize stresses that would induce tearing of dielectric materials. It is recommended fixtures

be designed to accommodate stresses on dielectric films which will occur with thermal exposure.

Care should also be taken to design fixtures to support components of significant mass and allow thorough cleaning of the finished assembly.

3.2.1.4 Mechanical Assembly When components are connected to FPC by mechanical means (e.g., screws or rivets), care must be taken to avoid overstressing the FPC. Figure 1 shows a method of reinforcing an area of mechanical assembly.

3.2.1.5 Testing Test methods should insure appropriate exposure to the applicable environment without imparting unnecessary stresses to the assembly. The use of test fixtures which ignore the moisture absorption tear properties, and CTE characteristics of the assembly are to be avoided. Test probes must be designed for adequate electrical contact without damaging the assembly.

3.2.1.6 Packaging and Handling Packaging and handling of FPC should be accomplished without imparting stresses to solder joints and welds, and appropriately support components of significant mass. Handling motions (e.g., twisting or bending), which tend to induce or propagate tearing, should be avoided if possible. Where it is not possible to avoid stressful handling, areas to be stressed should be reinforced.

3.2.1.7 Electrostatic Discharge (ESD) While individual circuits are rarely affected by ESD, a number of components found in typical FPC are susceptible to damage and/or destruction from electrostatic discharge. The use of plastic films in the construction of FPC invites the build-up of static electrical energy, which may be accidentally discharged. The following precautions are recommended:

- Removal of carpeting from assembly areas,

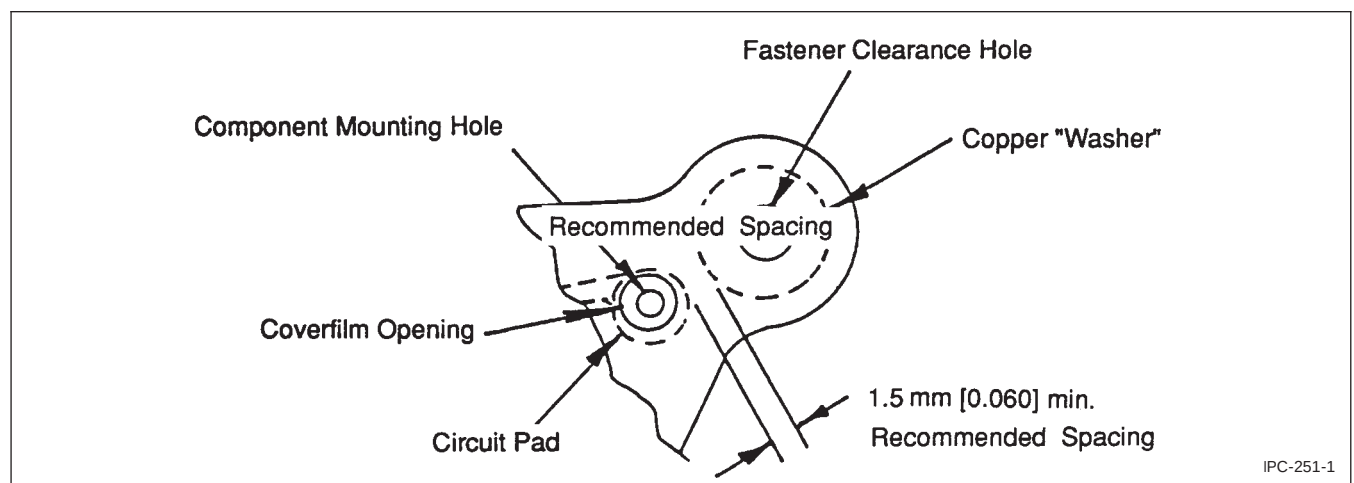


Figure 1 Copper reinforcement for mechanical fastener

- Grounding assembly workers/work area (see Figure 2),
- Use of assembly/component transporters resistant to electrostatic discharge and packaging,
- Limiting access to reduce accidental and casual handling by non-grounded personnel,
- Assembly under “clean room” conditions. Reduce acts like wiping, dusting and mopping which tend to create static potential.

3.3 Assembly Process Considerations

3.3.1 Concepts The designer should review the end product from viewpoints of form, fit and function. The concepts of form, fit and function are defined as follows:

- Form: Physical characteristics such as size, mass and shape;
- Fit: Position or relationship to other components within the assembly;
- Function: The activity or operation unique to the assembly under consideration.

3.3.2 Environmental Considerations Thermal environments which will be experienced by a FPC require the designer's consideration. These environments include those encountered in assembly processes as well as those encountered in operation. In addition, the following factors should receive consideration:

- Coefficient of Thermal Expansion (CTE) mismatch between the FPC and components mounted to the board;
- Dissipation of heat from those components which generate heat during operation;
- Service temperature, and also the extremes of thermal exposure which will be experienced by the assembly during operation.

3.3.3 Shock and Vibration Consideration must be given to the levels of shock and vibration a FPC will experience. Testing to evaluate the capability of a FPC to withstand

shock and vibration is routinely accomplished using MIL-STD-202 and/or MIL-STD-810, or, occasionally, an application specific specification. Here are some typical concerns related to shock and vibration.

- The worst case levels of shock and vibration environment for the entire structure in which the FPC resides, and the ultimate level of this environment that is actually transmitted to the components on the board. (Particular attention should be given to equipment that will be subjected to random vibration.)
- The method of mounting the board in the equipment to reduce the effects of the shock and vibration environment, specifically the number of board mounting supports, their interval, and their complexity.
- The mechanical design of reinforced area: specifically size, shape, type of material, material thickness, and the degree of resistance to bowing and flexing that the design provides.
- The shape, mass and location of the components mounted on the board.
- The component lead wire stress relief design as provided by its package, lead spacing, lead forming, or a combination of these, plus the addition of restraining devices, such as a stiffener.
- Workmanship during circuit assembly, so that the components are installed in a manner that will minimize component movement.
- The selection of components to be mounted on boards subjected to severe shock and vibration should favor, where circuit design permits, the use of components that have low mass, low-profile packages.
- The use of irregularly shaped components, especially those having a large mass and a high center of gravity, should be avoided where practical. If their use cannot be avoided, they should be located in nonconductor or rigidized areas, or where the final package provides support.

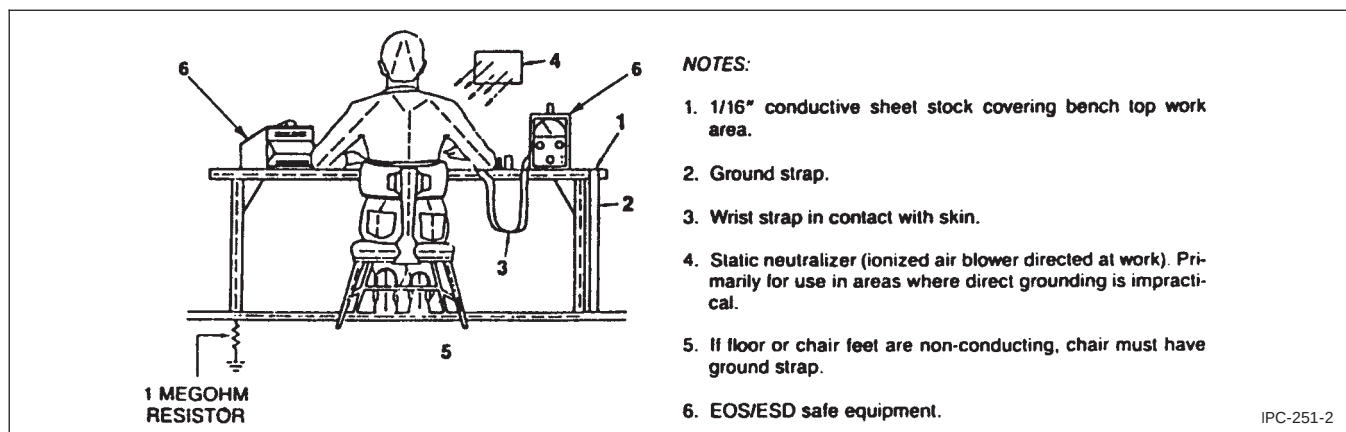


Figure 2 ESD drawing

4.0 COMPONENT ASSEMBLY CONSIDERATIONS

Information for pretreating and handling components prior to assembly can be found in IPC-CM-770 and IPC-SM-780. Table 1 highlights some of the more commonly used flex circuit components.

Table 1 Some Commonly Used Flex Circuit Components

Fig.	Component Type	Auto-Assembly Capability	Assembly Method	Reinforcement	Solder Cycle Sensitivity
3	Axial Leaded	Yes	2,3	Reinforcement recommended	Low
4	Radial leaded	No	2,3	Reinforcement recommended	Low
5	Two-Terminal Chips	Yes	1,2,3,4	Reinforcement not required	Low
6	Sm Outline Transistors (SOT)	Yes	1–4	Reinforcement not required	Low
7	Sm Outline Integrated Cir. (SOIC)	Yes	1–4	Reinforcement recommended	Low
8	Single In-Line Package (SIP)	Yes	2,3	Reinforcement recommended	Medium
9	Dual In-Line Package (DIP)	Yes	1–4	Rigid reinforcement required	Medium
10,11,12	Ribbon Leaded	Yes	1–4	Rigid reinforcement required	Medium
13	Leadless Chip Carrier (LCC)	Yes	1,2,4	Rigid reinforcement required	Medium-high
14	Pin Grid Array (PGA)	Yes	2,3	Rigid reinforcement required	Medium-high
15	PAD Grid Array (PAD)	Yes	1,4	Rigid reinforcement required	Medium-high
16	Plastic Leaded Chip Carrier (PLCC)	Yes	1–4	Rigid reinforcement required	Medium

Assembly methods:

- 1 – Reflow
 - 2 – Wave solder
 - 3 – Hand solder
 - 4 – Conductive adhesives process
- thermal sensitivity

Low – Unrestricted thermal excursion

Medium – Some restriction applies

High – Restricted

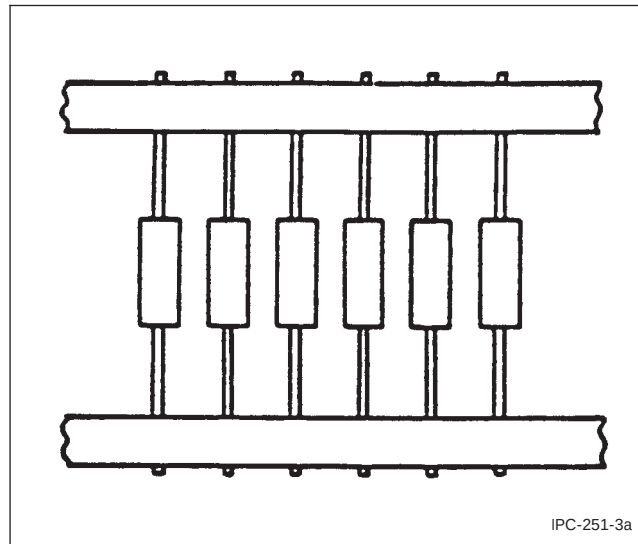


Figure 3a Axial-leaded, auto-assembly package

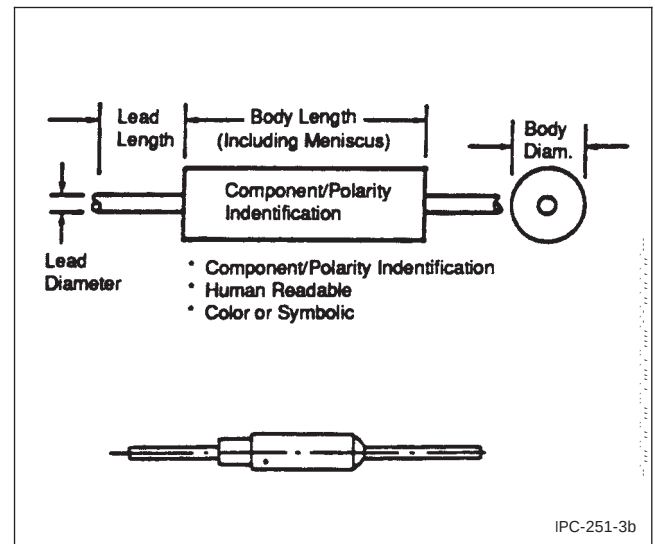


Figure 3b Typical axial-leaded components

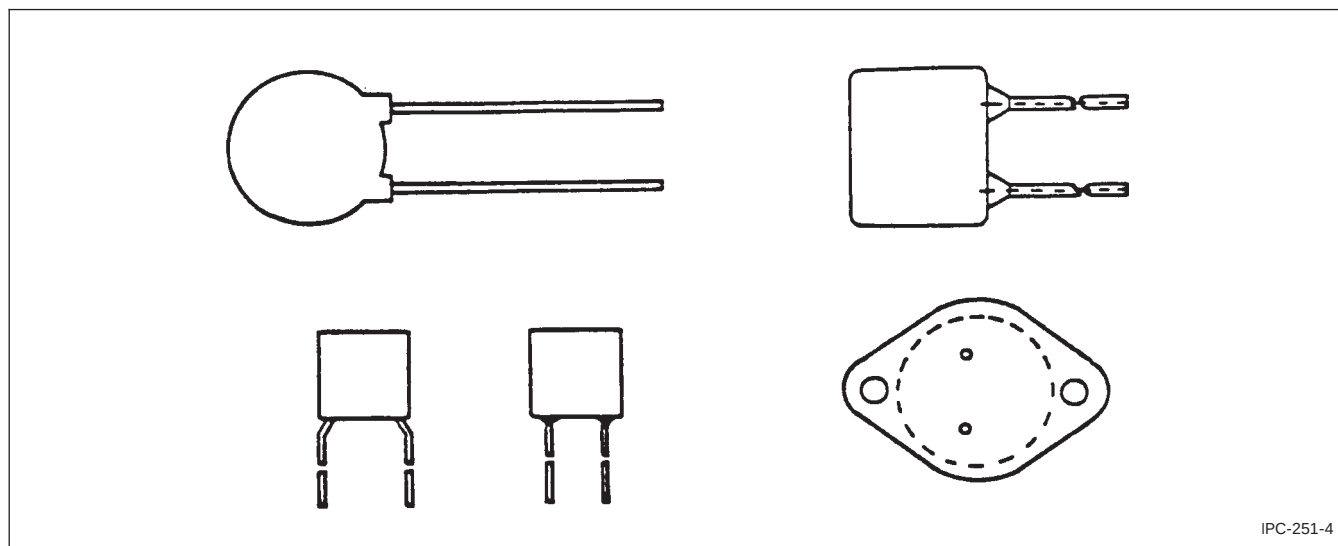


Figure 4 Typical radial-leaded components

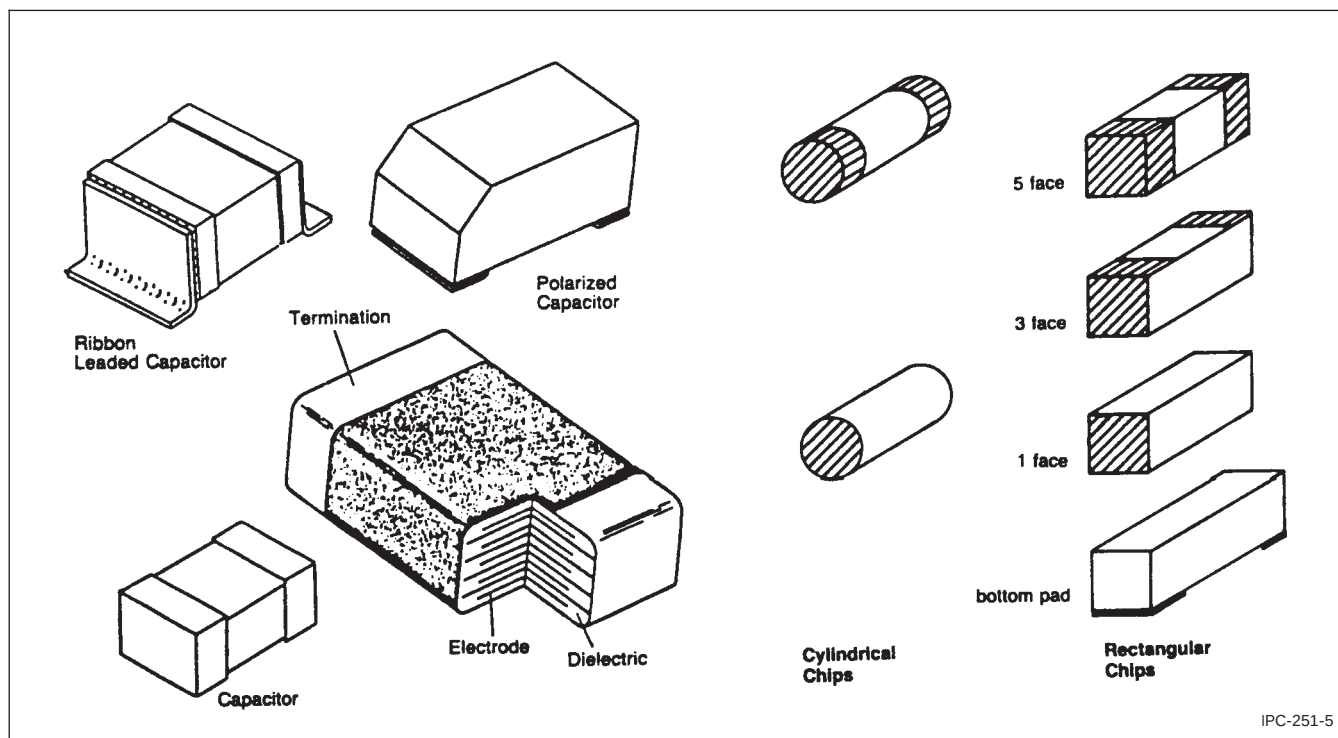


Figure 5 Chip components types

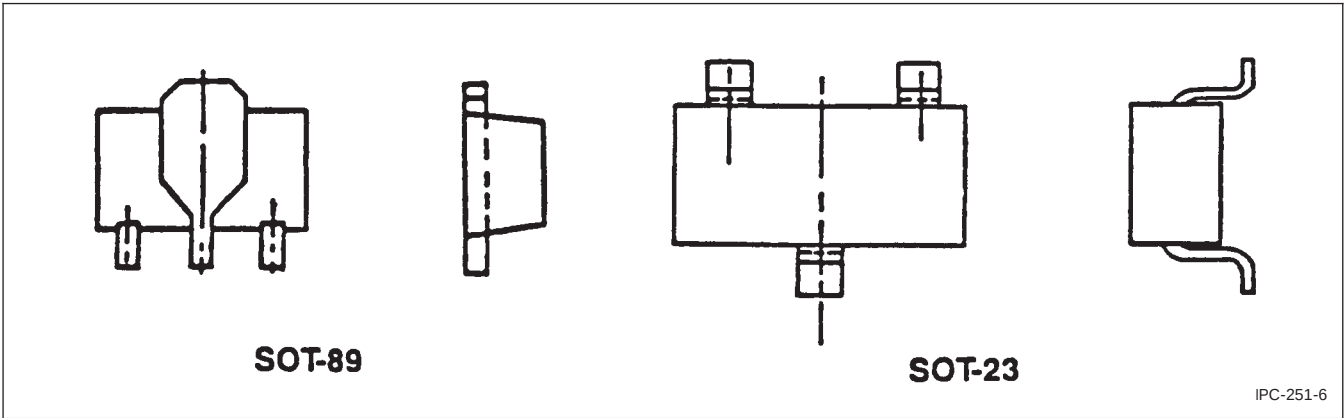


Figure 6 Typical Small-Outline Transistor (SOT) packages

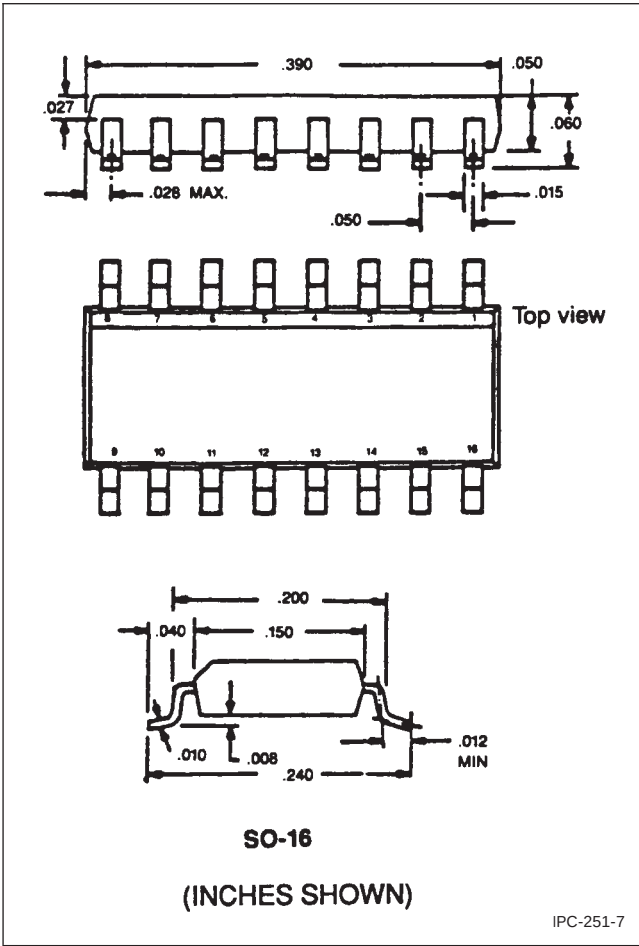


Figure 7 Typical Small-Outline Integrated Circuit (SOIC) package

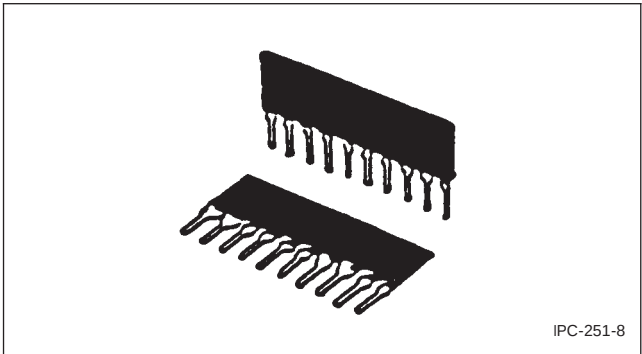


Figure 8 Typical SIP

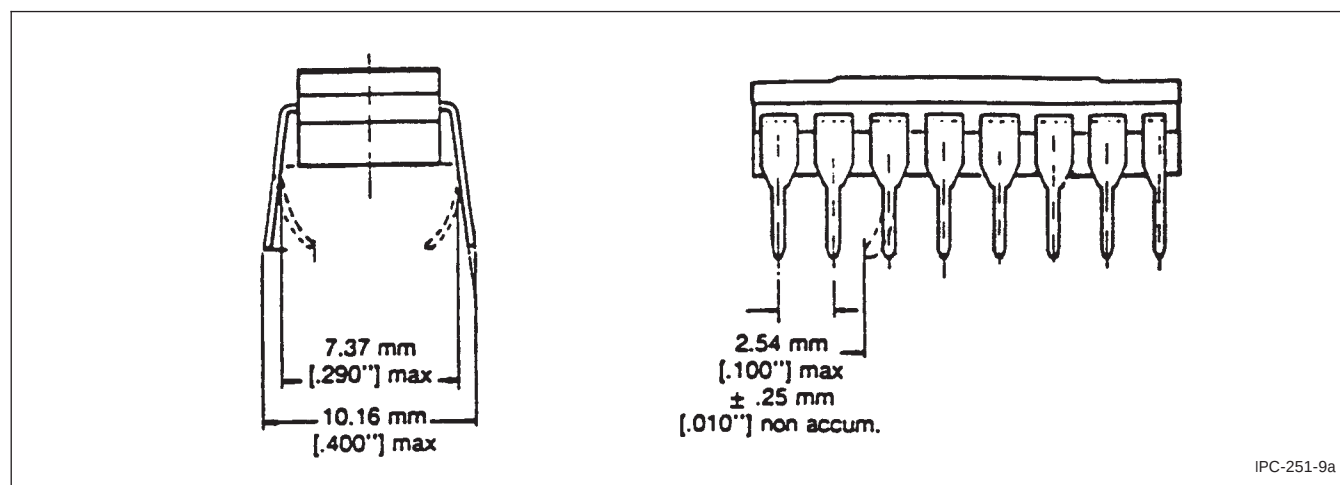


Figure 9a Typical dual, in-line package

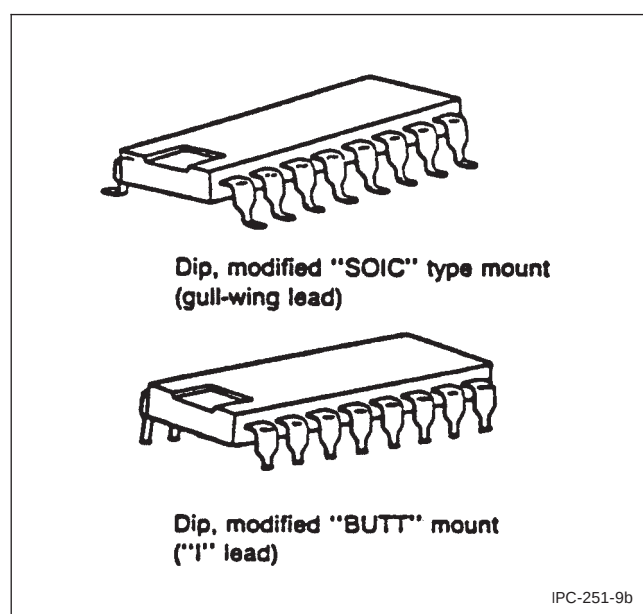


Figure 9b DIP modification for surface mount

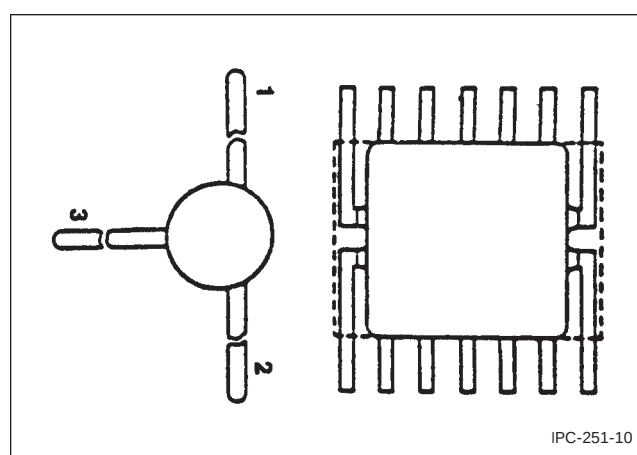


Figure 10 Ribbon-leaded components