

Printed wiring boards —

Part 20: Guide for the assembly of printed wiring boards

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- Electronic Components Industry Federation
- Electronic Engineering Association
- ERA Technology Ltd
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Foreword

This British Standard has been prepared under the direction of the Electronic Components Standards Committee.

This Part of BS 6221, together with Parts 3 and 21, supersedes BS 5370 which is withdrawn.

The text of this Part has been submitted to the International Electrotechnical Commission (IEC) for consideration as an International Standard.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 6221 provides guidance on the assembly of components on printed wiring boards irrespective of their method of manufacture.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 6221, the definitions given in BS 6221-3 apply, together with the following.

2.1

taped components

components attached to continuous tapes

2.2

screen printing

a process for transferring an image on a surface by forcing a suitable media through a stencil screen with a squeegee

3 Handling of components prior to assembly

3.1 Static

3.1.1 It is necessary to safeguard certain types of components and devices against possible damage which can be caused by an electrostatic discharge (ESD).

The susceptibility of devices to static damage can vary considerably, but generally those devices constructed with thin oxide and extremely thin conducting paths only a few micrometres wide are most susceptible.

Table 1 below gives some typical values of static discharge to which devices are reported susceptible.

Table 1 — Devices sensitive to static discharge

Device type	Range of ESD volts
VMOS	30 to 1 800
EPROM	100 max.
MOSFET	100 to 200
GaAsFET	200 to 300
JFET	140 to 17 000
SAW	150 to 500
OP-AMPS	190 to 2 500
CMOS	250 to 2 000
Schottky diodes	300 to 2 500
Film resistors	300 to 3 000
Bipolar transistors	380 to 7 000
ECL (hybrid, PB level)	500 to 1 500
SCR	680 to 1 000
Schottky TTL	1 000 to 2 500

It is considered that, for practical purposes, if static potentials in the working environment can be held at less than 100 V, static problems will be greatly reduced.

3.1.2 When considering the handling of static sensitive devices, the following two general rules should be observed:

- all work areas, manual or automated in which static sensitive devices are handled should be static safeguarded areas;
- static sensitive devices/components or assemblies require the use of static protected containers during transport or storage.

3.1.3 In the assembly area, conductive items of equipment including tools, work stations, machinery and personnel can be grounded by a variety of methods obtainable from specialist suppliers. A resistance to ground of less than 1 G Ω is considered sufficient to discharge to a safe level in less than 1 s; however, a minimum of 1 M Ω is necessary to limit current flow to a safe level.

Table 2 shows the maximum allowable resistances and discharge times for static safe operations involving personnel, bearing in mind the capacitive effects of the human body.

Table 2 — Static resistance and acceptable discharge times

Maximum tolerable resistance from operator to ground via:	Acceptable discharge time
Floor mat: 1 G Ω	1 s
Table mat: 1 G Ω	1 s
Wrist strap: 100 M Ω	0.1 s

3.1.4 Shielding of components sensitive to static should be carried out from the receipt of component stage. The protection supplied by the device supplier should be maintained as long as practicable. Where dual in-line (DIL) packages are supplied in static shielded shipping tubes, these can interface directly to automatic insertion equipment and the devices need not be handled.

3.1.5 The likelihood of static damage is reduced but not eliminated once components are assembled to the printed board.

Assembled boards should be transported or stored in suitably grounded conductive containers, and boards with edge connectors should be fitted with contact shunting shrouds to maintain constant board voltage levels.

3.1.6 Where boards are to be packaged in plastics bags or containers, the materials of the bag or container should be capable of preventing a static charge existing across the package.

Generally, metallized film materials are more satisfactory as they provide true electrostatic shielding.

NOTE For more detailed information on the handling of electrostatic sensitive devices, see BS 5783.

3.2 Edge connectors

3.2.1 Edge connectors formed as part of a printed board (integral) or provided as a wired on (discrete) plug end are generally plated with a precious metal on the contact area.

It is important that the surface of the contact area is protected from damage or contamination during assembly processes.

3.2.2 Where the edge connector is integral with the board, it will be necessary to protect the contact area with a heat-resistant tape or shield during the mass soldering process.

Typically, a stainless steel shield may be employed to surround the edge contacts and prevent solder wetting. However, this should be combined with a tape or heat-resistant plastics shroud that protects the contact area from flux creepage. Any tape used for this purpose should have a non-transferable adhesive. Specialist tapes are available but should be checked for adhesive transfer before use.

3.2.3 After processing any tape, etc. should be removed from the contacts before the board is cleaned.

3.2.4 Subsequent to cleaning operations the edge connector should be protected preferably with a slip-on moulded plastics shroud that combines protection with easy availability for test, etc.

The shroud should be of a shape that clips onto the board beyond the contact zone. To prevent the scratching of the contact zone by grit that may have contaminated the shroud, the shroud should be pushed on to the board from the side.

NOTE Only plastics with stable plasticizers should be used to prevent transfer of plasticizers onto edge contacts.

3.2.5 Discrete edge conductors, not subject to mass soldering, should be protected either as in **3.2.4** or by a tape having adhesive edges and a clear centre section positioned over the contacts.

4 Stoving

4.1 General. Boards should be placed in an air circulating oven such that there is free circulation of air round each board and stoved at $120 \pm 5^\circ\text{C}$ for a maximum of 2 h.

4.2 Double-sided printed wiring boards. In order to minimize blow holes in joints of mass soldered plated-through hole double-sided printed boards, it is advisable to stove before assembly and within one week of the soldering operation.

4.3 Stoving multilayer and flexible printed wiring boards. It is recommended that multilayer and flexible printed wiring boards be stoved before being soldered. This action is necessary to drive out slowly the absorbed moisture and promote any gassification that may otherwise result in delamination or outgassing during mass soldering.

NOTE Specifications for multilayer circuits and flexible circuits normally require specimens to be stoved at $125 \pm 5^\circ\text{C}$ for a minimum of 1 h before testing interlaminar bond using thermal shock.

5 Mounting of components

5.1 Fitting

5.1.1 General. Horizontally mounted, non-polarized components should be oriented so that component marking and colour codes may be “read” in the same direction. Vertically mounted, non-polarized components should preferably be mounted so that the markings can be read from top to bottom. All polarized components should be oriented so that their positive (+) or negative (–) symbols are visible.

Components should be mounted on only one side of the board, generally opposite the major circuit pattern, unless otherwise permitted by design, e.g. surface mounted components.

The projection of the outline of the component on the board should not extend over the edge of the board or interfere with board mounting. It should preferably be a minimum of 1.5 mm from the edge of the board and board guide or mounting hardware.

5.1.2 Accessibility. The placement of any component on the board should not prevent the insertion or removal of any hardware (tool clearance included) used to mount the assembly, unless the assembly is considered disposable and is not intended for repair.

5.1.3 Centring. The body of the component should be approximately centred between the lead span, whenever possible and practical.

5.1.4 Horizontal placement of axial-lead components. Axial-lead components should be mounted so their axis is parallel to the mounting base. Unless otherwise specified by the user, components may have a portion of the body in direct contact with the printed wiring board.

5.1.5 Components mounted over conductors. Components should not be placed in contact with more than one conductor unless the board surface is suitably protected from moisture traps.

NOTE This recommendation applies to components with or without sleeving.

Care should be taken when mounting metal-cased components to ensure the casing does not come in contact with the conductive pattern. Sleeving may be used to insulate metal-cased components. The sleeving should be sufficiently transparent so that the identification markings remain visible and legible. Sleeved components should not be mounted over or in contact with sharp solder connection points.

Adhesive pads of insulating material may also be placed under the component instead of sleeving but it is not good practice to rely on a solder resist film in this context.

Thermal degradation of components may result from contact with conductors on lands during mass soldering; adhesive pads may also be used as a thermal barrier.

5.1.6 Vertical component mounting. Axial-lead components mounted perpendicular to printed wiring boards should be installed with a minimum of 0.4 mm and a maximum of 3.0 mm clearance between the end of the component body and the surface of the circuit board to prevent entrapment problems. There should be no strain on the component lead when a spacer is used.

Vertically mounted radial-lead components should have their leads parallel to each other and perpendicular to the edge of the component-mounting base. Such components should have their vertical axis within 15° of the plane that is perpendicular to the component-mounting base, unless otherwise restricted by design.

5.1.7 Moulded or encapsulated ceramic or plastics components. Moulded or encapsulated ceramic or plastics components should be mounted so that the coating or sealing material does not enter the solder joint area. Components installed in plated-through holes should maintain a minimum clearance of 1.5 mm between the surface of the board and the end of the lead coating. When the holes are non-plated-through holes, the minimum clearance can be reduced to 0.75 mm.

5.2 Lead forming. The purpose of preforming parts for retention to the board is to combine the advantages of labour reduction achieved in straight through leads and the mechanical reliability of the clinched lead. Simple forms are used only to hold parts of the board prior to soldering; complex forms can be used for mechanical strength.

The forming of leads can be from a minimum of a simple offset to a complex compound form. The major factors affecting the forming of leads are board thickness, lead diameter, lead material, hole size, and tooling system requirements.

The simple offset method shown in Figure 1 gives the appearance of a straight through lead. The advantages are ease of forming and ease of insertion; the disadvantages are the minimum of retention force, and the resiliency of small or soft component leads.

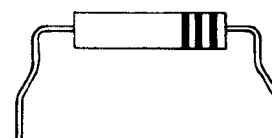


Figure 1 — Simple offset preformed leads

Figure 2 shows examples of dimple preformed leads. This method of preforming increases the retention of the components to the board. Owing to the variation of lead sizes on the board, the main disadvantages are the die sets required to form the leads and the hole size to dimple height requirements.

5.3 Lead bend. The lead should extend approximately straight out from the body of the component a minimum of 1.5 mm prior to the start of any bend, except that when space is limited by high density packing, the minimum may be 1.0 mm. The end of the body in this application is defined to include any coating meniscus, solder seal, solder or weld bead, or any other extension.

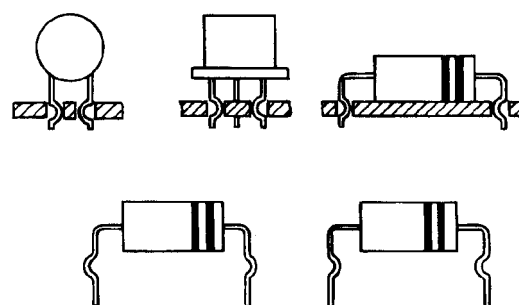


Figure 2 — Dimple preformed leads

It is essential that extreme care be taken when forming bends to prevent nicking or damage to the component leads and damage to the component body or seals. Exposed base metal of component leads should be re-tinned.

5.4 Mechanical stress

5.4.1 General. The shock and vibration to which printed board assemblies are subjected during normal handling and testing can damage the lead terminations and lead-to-component body seals. Where there is a risk of such damage, components should be secured by suitable means.

5.4.2 Clips, clamps and brackets. The following recommendations should be adhered to when components are mechanically secured by clips, clamps or brackets.

- a) All clips, clamps or brackets should be secured to prevent their rotation, e.g. by using two fasteners or one fastener and non-turn device.
- b) Clamps and brackets that require their removal in order to replace the component should be secured with a threaded fastener or other non-permanent fastener, unless the subassembly in which they are used is considered to be disposable or non-repairable.
- c) The use of clips for glass envelope components should be avoided.

5.5 Special considerations

5.5.1 Hermetically-sealed components.

Hermetically-sealed components, such as miniature relays, headers, glass eyelets, glass sealed capacitors, diodes and transformers, should be handled with caution to prevent damage to seals. The seals should not be chipped, cracked or crazed. Leads should not be bent less than 1.5 mm from the seal. Hook and post type terminals sealed to headers should not be bent closer than 1.5 mm to adjacent terminals.

5.5.2 Heat dissipation. All parts dissipating 3 W or more (for epoxide woven glass base material) should be mounted so that the body is not in contact with the board unless a clamp, heat sink, or other means is used to ensure that the maximum allowable operating temperature of the board is not exceeded.

6 Board assembly

6.1 Manual assembly

6.1.1 Simple layout memorization. If the board is of fairly simple design and of relatively low volumes, the operator can be requested to learn the board layout and therefore know which components are placed and where.

Layout memorization is easier if the components to be mounted have easy distinguishing marks and are laid out on the board by the designer such that a sequence can be singled out. Reference points such as silk screened legends or positioning marks will aid the operator.

With this method of assembly it is preferable for components to be arranged in sequence in bins to suit any one operator; however, it has disadvantages. Although the technique requires a low investment, it may cause insertion errors, especially if operators have to memorize the layouts of several boards.

6.1.2 Stage assembly. More complex boards can be assembled efficiently with a memorization technique if they are divided into two or more zones, each of which can be considered as small boards for an operator to memorize. The entire board can be assembled on an assembly line with each operator assembling different zones of the board.

It is generally accepted that in a line of this sort, the last operator carries out a general inspection and that each assembly stage is worked out to take the same amount of time.

To assist operators when the same line is used for assembling several different types of board, a template can be placed over the board area in which the operator should not insert components. With each board type change, the operator's template set has to be changed.

The assembly line can be designed in such a way that each change of template provides for the corresponding components being offered from a gravity fed magazine or provides a visual indication against the relevant component bin.

6.1.3 Sequence assembly. Where it is possible to identify a logical sequence that forms a serial path touching all the components on a board, a rapid method of accurate insertion can be applied.

A fixed board holder is used with as many bins as components, arranged in the same sequence as that identified on the board with the bins in a closed loop chain.

The operator works through the board sequence taking sequentially from each bin (the bins may be stationary or presented to the operator by a drum, wheel system or linear transport system), until the entire board is completed.

Board changes can be accommodated by making the bin conveyor quickly interchangeable.

Where a sequence is not readily obvious on a board, an alternative sequence placing system can be applied.

A closed loop hopper chain is used to carry the boards and present them one at a time to the operator. The boards should be horizontal for this process and the mechanism is generally motor indexed but under the operator's control.

Component bins can be either fixed or on an adjacent mobile arrangement.

The operator takes one component type at a time and loads the first board in all the appropriate positions, keeping to the same component type. The operator then indexes and loads every board. When all boards are loaded with that component, the operator selects a second type and repeats the operation.