Electronic materials and components-A component review

Through-hole components

We start our review of components by looking at those designs with leads that are intended to be soldered into through-holes on boards. With the exception of integrated circuits with very high lead counts, most types of device are (or have been) available in the through-hole format. Whilst larger than surface mount parts, through-hole components have the advantage for simple designs of being able to be used to create crossovers. They are also still surprisingly cheap, because the manufacturing methods are well tried, and the production equipment fully amortized and often transferred to low-cost areas of manufacture.

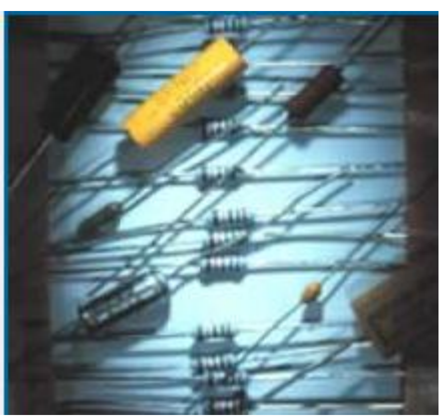
Axial and radial formats

Pin-through-hole discrete components are defined as 'axial' or 'radial', depending on the relationship between the direction of the leads and the major axis of the component:

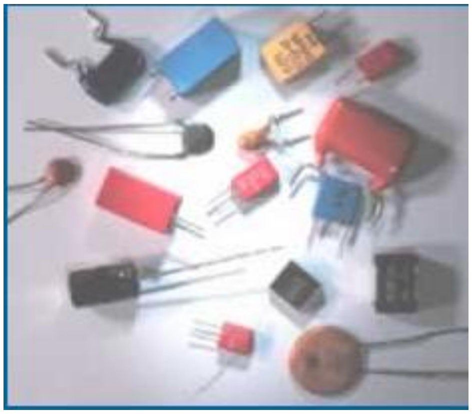
'axial' types have the leads running in opposite directions and parallel to the major axis

'radial' parts have the leads running in the same direction but normal (at 90°) to the major axis.

Whilst there has been some standardisation (for example, pin spacings tend to be multiples of 0.1 inch), there are many variations: in particular, pin length, diameter and location on the body all vary.



A selection of axial components



A selection of radial components

Leads are generally neither sufficiently accurately positioned nor stiff enough to allow machine insertion unless components have been 'taped'. Radial formats use a tape with single sprocket holes (Figure 1); axial formats a pair of tapes on standard centres (Figure 2); both taping styles provide handling protection to the leads and are stored either on reels or 'ammo packs', where the 'bandolier' of components is folded in zigzag fashion.

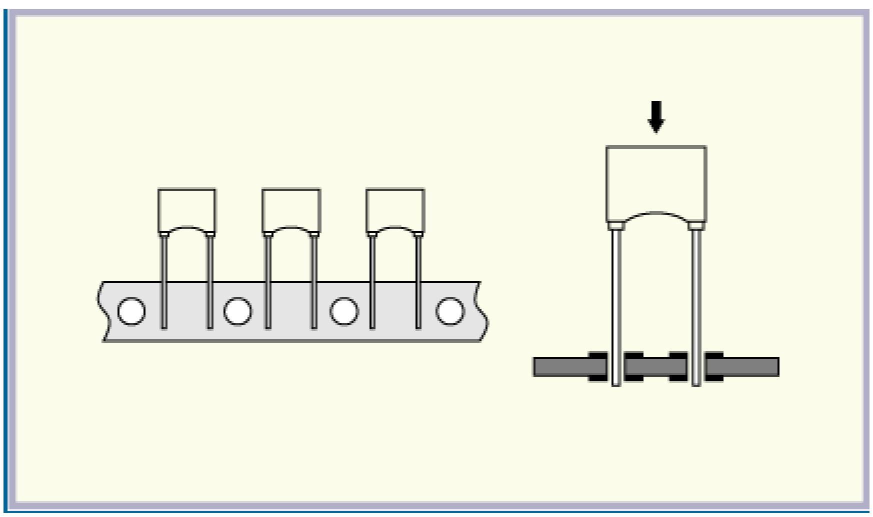
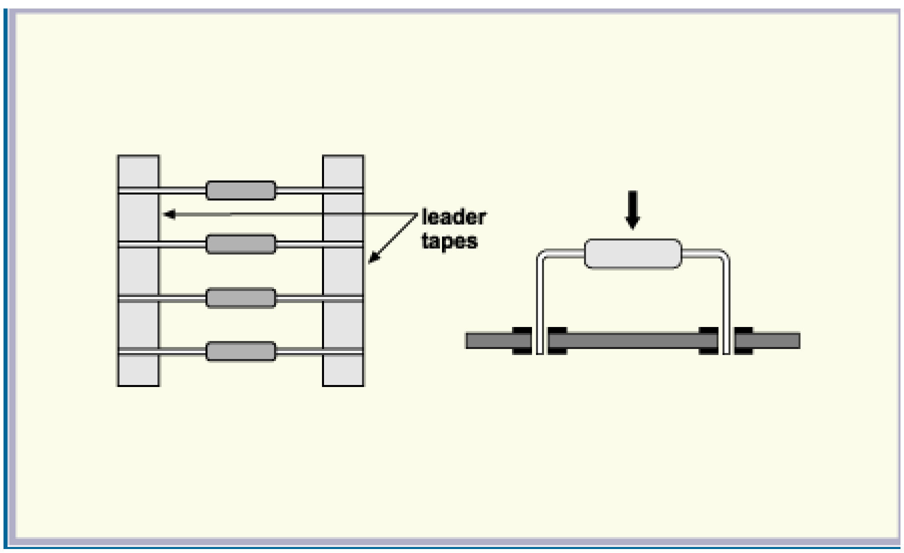


Figure 1: Presentation and insertion of radial components

Radial components on tape

Figure 2: Presentation and insertion of axial components



Diodes are most frequently found as axial components, but transistors are typically radial parts. Some designs have leads in a single plane, and can be presented on tape. However, such pin-outs are close together, so it is more common to have the central lead offset (‘joggled’) in order to have leads on 0.1 inch centres. In this the current plastic package mimics the earlier TO-18 styles, which had hermetic packages and glass-to-metal seal construction.

Components with joggled leads can be taped, but also are to be found handled as loose items. Note particularly that those devices which start with a planar lead frame, and have the central pin joggled, are available in both directions of joggle, so can be specified with two different pin sequences. This is another area where errors can occur.

Dual-in-line format

The quest for improved transistor performance led to silicon planar technology, from which the monolithic integrated circuit (IC) was a natural development. Both transistors and ICs need to be packaged, and in Semiconductor packages we'll be explaining more about how this is done. At this stage, all you need to know is that, the more internal active elements, the greater the number of external leads required, and that the development of ICs led to an ever-increasing number of lead-outs from the component package.

Many multi-leaded packages were devised during the 1960s, but the high cost of some constructions, the difficulty of assembly, and lack of standardisation soon left only two main contenders, the dual-in-line (DIL) package (DIP) and the flat-pack.

Both had leads along two opposite edges. The flat-pack (Figure 3) was the smaller, with leads at 0.05 inch pitch in the same plane as the package. However the package has to be held in contact with the circuit board during soldering.

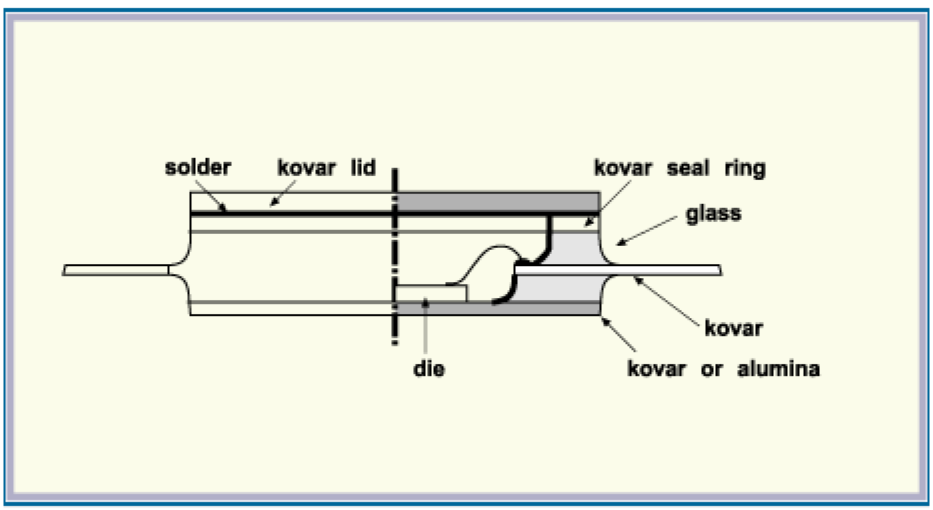


Figure 3: Flat-pack construction (glass-metal seals)

The leads of a DIP (Figure 4) are on a 0.1 inch pitch and, after assembly, project at right angles to the body. By design, the leads on most DIPs are initially formed outwards at a slight angle, so that when inserted into through-holes in the board they are self-retaining during pre-soldering handling.

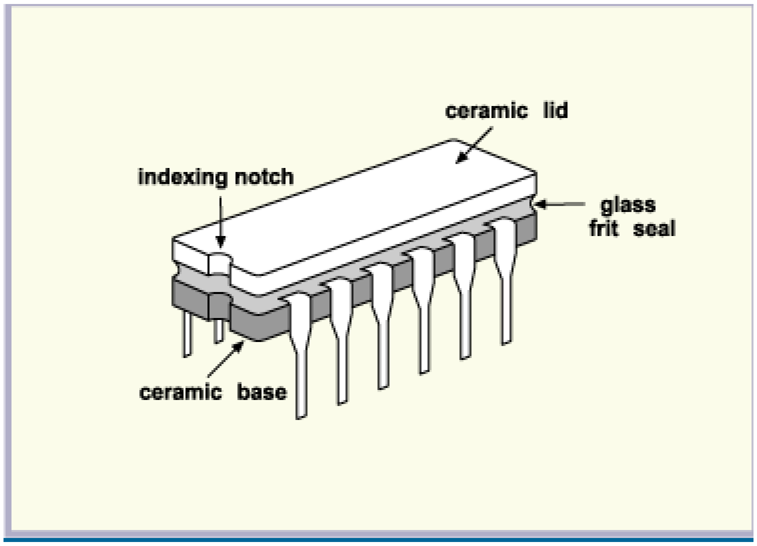
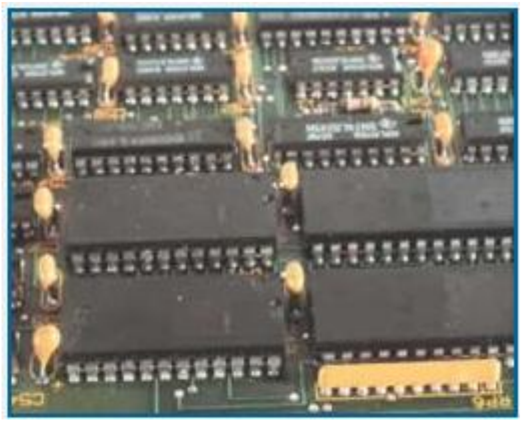


Figure 4: Dual-in-line package construction (CerDIP)

For reasons of reliability and operating temperature range, 1970s military users preferred packages in which the die was hermetically sealed within a cavity filled with dry air. The packages shown achieved this in one of two ways: using glass-to-metal seals (Figure 3), or using a lead-frame sandwiched between ceramic components bonded together with glass (Figure 4). In this second generic style of package, the CerDIP (Ceramic Dual-In-line Package), the final seal made after die and wire bonding uses glass containing a high percentage of lead oxide, which will melt and seal at low temperature.

Early attempts at making plastic-encapsulated equivalents were of limited reliability, but success eventually came from a combination of improved die passivation and reduced ionic impurities in the encapsulant resin. This type of DIP was not only lower cost, but was more compatible with the automated insertion equipment being developed. These machines made fast and reliable board assembly possible, and established the plastic DIP as the most widely accepted IC package: by the mid 1980s it accounted for 80% of all integrated circuits used in the electronics assembly industry.



DIL integrated circuits, an SIL resistor network and bead tantalum capacitors (c.1991)

Single-in-line format

Single-in-line formats are to be found mostly with resistor networks and ceramic filters, often with one end-pin as a common connection to the internal elements. As with the dual-in-line package, pins tend to be on 0.1 inch spacing: whilst 0.05 inch spacing is possible, this is usually achieved by joggling alternate pins in opposite directions, so as to create 0.1 inch spacing between pin centres.

Hermetic components

The original semiconductors were ‘hermetic’ components, that is the internal parts of the device were sealed from the environment. Typically this was carried out by placing the active element within a metal enclosure, making electrical connections through pins sealed into the structure using glass: both glass and metal are not permeable to gases such as water vapour. Hermetic components can also be achieved using ceramic and glass, as with the CerDIP package shown in Figure 4.

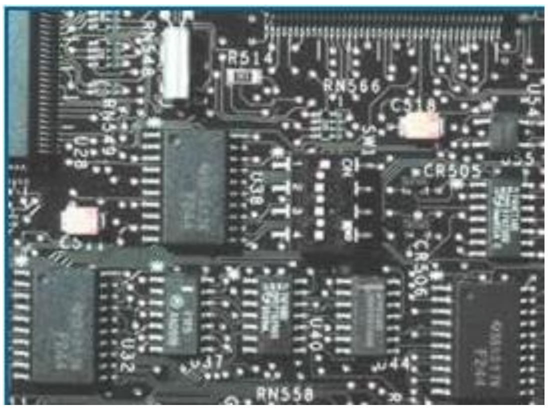
Hermeticity comes only at substantial expense, so few integrated circuits are now made with this kind of encapsulation. However, you will still see hermetic structures used for quartz crystals, because the active elements are extremely sensitive to moisture. Metal-can power transistors also have a hermetic construction, the final lid seal being generally carried out by welding.

Mechanical components

A very wide range of mechanical components is in use, of which connectors and switches are arguably the most common. Care has to be taken to ensure that the spacing of holes on the board is correct for the part – unfortunately some metric standard pitches are very close, but not close enough to Imperial measures. For example, the first few pins on a 2.5 mm pitch connector may fit well into a set of holes designed for a 0.1 inch part, but the 0.04 mm difference on each lead interval quickly turns from snug fit to force fit to no fit at all!

The surface mount transition

The demands of higher packing density drove the transition to surface mount, but the current widespread use of this technology has been driven more by component supply and by the reduced cost of manufacture. In this next section we are looking at the structure and format of some of the key components.



A surface-mount assembly (c.1995)

Chip components

The rationale behind the development of chip components has been that:

conventional axial and radial devices are not suited to surface mounting;

encapsulated parts have a relatively large amount of wasted volume;

for some types of passive device, in particular ceramic capacitors and chip resistors, avoiding the need to have leads has enhanced reliability;

the reduced materials content and improved ability to automate the manufacturing process have both reduced costs.

The miniaturisation of passive components is most pronounced with ceramic capacitors and chip resistors. These components are generally manufactured in set sizes which have become common approved standards. The size designation often used derives from the length and width of the component expressed either in hundredths of an inch (where the USA/UK 0805 size is approximately 0.08 × 0.05 inch) or in millimetres (so that the Japanese equivalent to a USA/UK 0805 is confusingly referred to as a 2012).

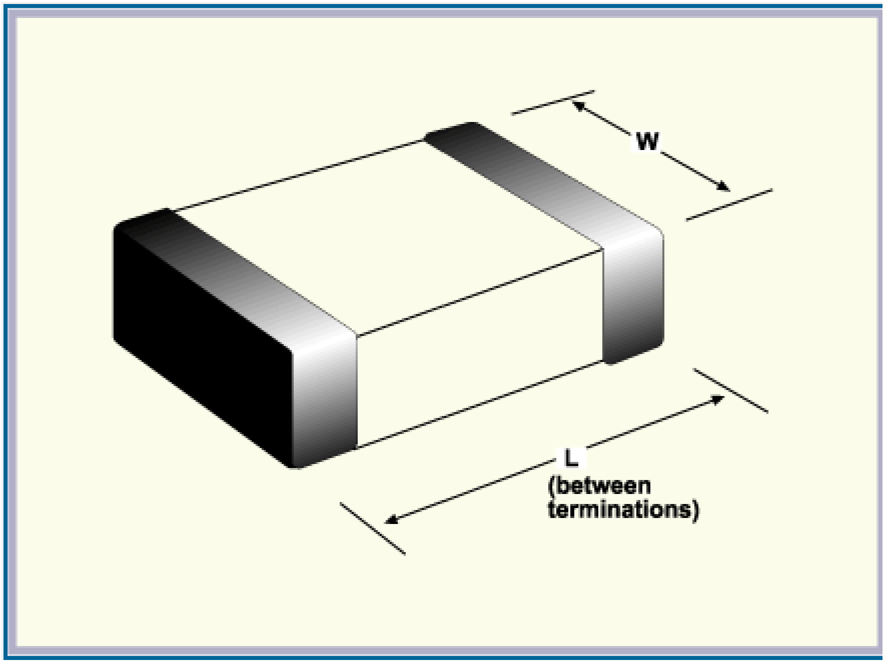


Figure 5: Dimensioning of a chip component

Dimensions

Table 3 gives nominal dimensions for the most common sizes of component. Note that:

There are differences between manufacturers2, especially in relation to dimensional tolerances for capacitors, which depend on the manufacturing technology used

Resistors are usually thinner than capacitors, and thus need different placement machine settings

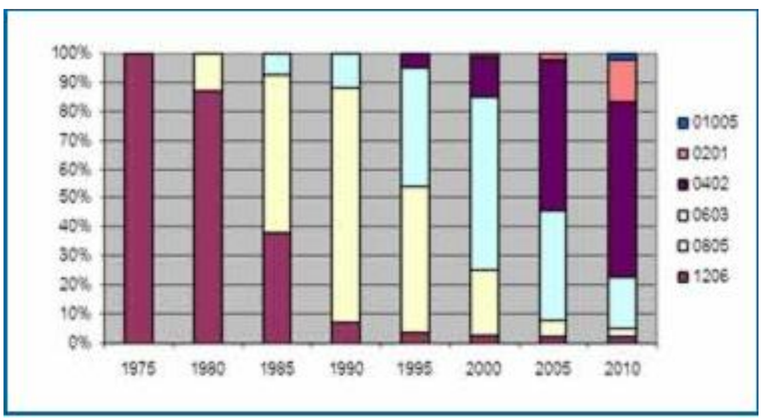
Larger components are available, but these are more reliable when mounted on matched-TCE substrates such as ceramic.

2 The differences between manufacturers are particularly marked with the smaller sizes, with substantial variations in thickness reported. Why not check this out for yourself, by searching Google with [“chip capacitor” dimensions 0201] – this will give about 50 hits.

Table 3: Typical dimensions of preferred sizes of chip resistors and capacitors

Designation		Length	Width	Thickness (mm)	
inch	metric	(mm)	(mm)	Resistors	Capacitors
0201		0.6 ±0.05	0.3 ±0.05	0.18-0.28	0.09-0.21
0402	1005	1.0 ±0.1	0.5 ±0.1	0.30-0.40	0.45-0.55
0603	1608	1.6 ±0.1	0.8 ±0.1	0.35-0.65	0.7-0.9
0805	2012	2.0 ±0.2	1.25 ±0.15	0.40-0.70	0.5-1.35
1206	3216	3.2 ±0.2	1.6 ±0.15	0.50-0.70	0.5-1.75
1210	3225	3.2 ±0.2	2.5 ±0.2		0.5-1.8
1812		4.5 ±0.2	3.2 ±0.2		0.5-2.3
2225		5.7 ±0.25	6.35 ±0.25		0.5-2.3

There is a strong trend towards smaller sizes: in 1988 the 0805 was the most frequently used multi-layer ceramic capacitor, and the 0603 is the 'workhorse' at the present time, but there are many applications for which 0402 is now demanded. Be careful, though, because using too small a component may well increase manufacturing costs, because of higher unit prices and lower yields, with more rework.



Trends in passive component chip sizes

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Source: http://www.ami.ac.uk/courses/topics/0237_acr/index.html