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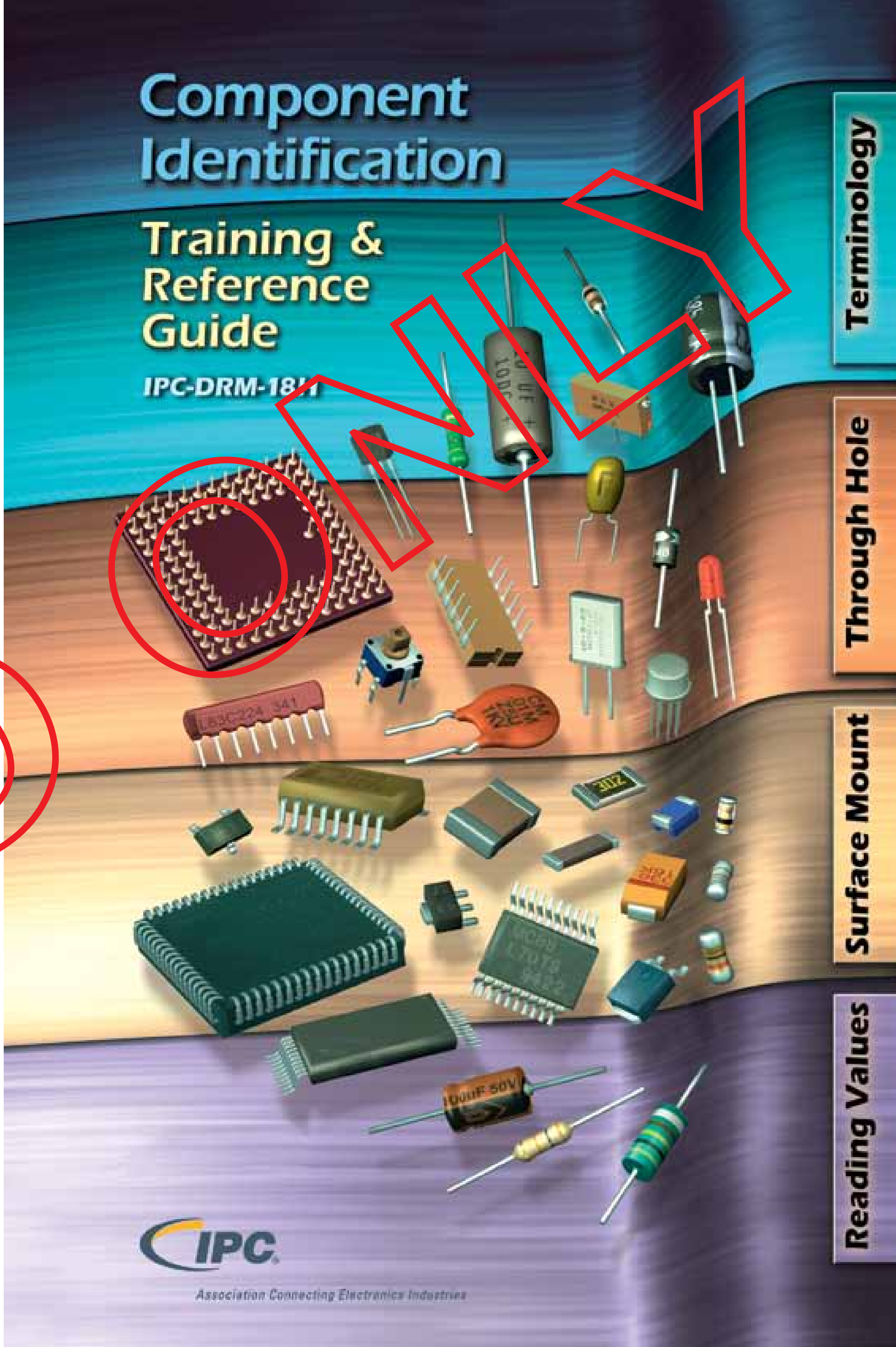


# Table of Contents

## Introduction

### Components

An electronic component is any device that handles electricity. These devices come in many different configurations, shapes and sizes. Different components have different electrical functions and are used for a great variety of purposes. For example, some components may be used to slow electricity, and others may be used to store it.

### Understanding Electricity

Electricity basically consists of voltage, measured in volts, and current, measured in amperes, or amps. Voltage is the electrical pressure, or force of electricity through a circuit. This is similar to the water pressure in a garden hose. Current is the amount of electricity that goes through the circuit.

### Active vs. Passive

Some components are active — meaning they can amplify or interpret a signal. Active components include diodes, transistors and integrated circuits, also called ICs. Other components are passive — meaning that they cannot change an electrical signal — except to reduce it in size or delay it. Passive components include resistors, capacitors and inductors.

### Discrete vs. Integrated

When a component is packaged with only one or two functional elements, it is called a discrete component. An example of a discrete component is a resistor that performs the simple function of limiting the electrical current that flows through it. On the other hand, an integrated circuit is a group of interconnected elements assembled into a single package that performs multiple functions. A well-known example of a complex IC is the microprocessor found in computers.

### Electronic Assemblies

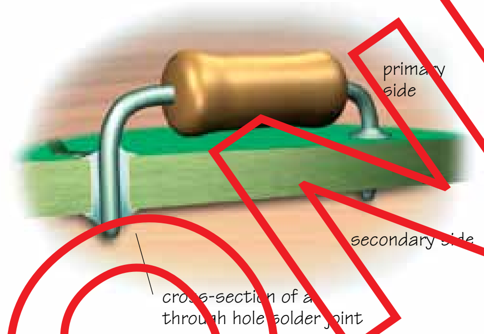
When a group of components are placed together on a printed circuit board to perform some function, it's called an electronic assembly. Circuit board assemblies are created by attaching and soldering the components by hand, or by machine.





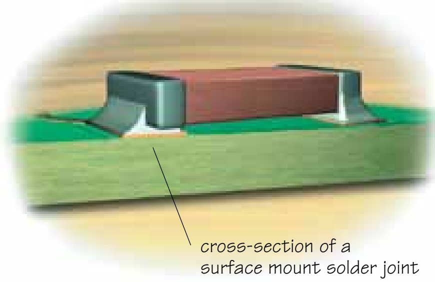
## Through Hole vs. Surface Mount

There are two primary types of components, the difference being how they are attached to the circuit board.

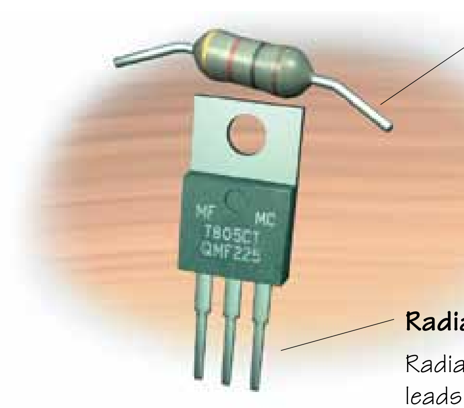



One group is called **through hole.** Through hole components have leads that are inserted through mounting holes in the circuit board.

The other type is called **surface mount.** Surface mount components are designed so they are placed directly onto lands that serve as mounting points on the surface of the board.




## Through Hole Leads



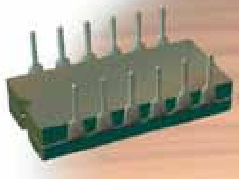
### Axial Leads = Arms

Axial leaded components have two leads — with one lead extending from each side of the component, like arms. Axial components need to have their leads bent so they can be inserted through the holes of a circuit board.

### Radial Leads = Legs

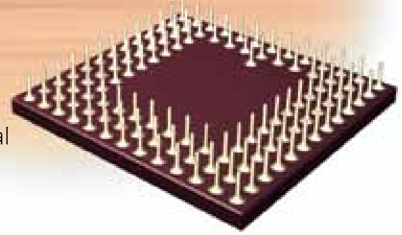
Radial leaded components have two or more leads extending from the bottom of the component, like legs.

**Single In-line Packages** or **SIPs**, are through hole components that have a row of leads in a single, straight line.

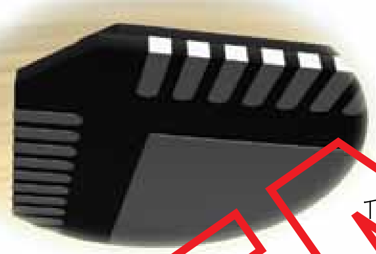
**Dual In-line Packages** or **DIPs**, are components that have two rows of leads in parallel straight lines.

**Pin Grid Arrays** or **PGAs**, are **ICs** that have several rows of round pins extending from the bottom of the component.



## *Surface Mount — Leadless*

Leadless means there are no metal leads sticking out of the component body. These types of components are attached to a circuit board using some type of metallized termination.

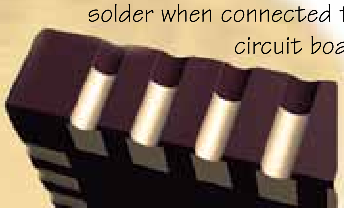


This **QFN** has **terminals**.

**Chips & MELFs** use **terminations** on opposite ends of the component's body.

**Ball Grid Arrays,** or **BGAs,** consist of rows of tiny **balls of solder** on the bottom of the component. These solder balls are connected to matching rows of lands on the circuit board.

**Castellations** are half round metallized recesses in the side of a component that are filled with solder when connected to the circuit board.







## *Surface Mount — Leaded*

Leaded surface mount components usually have one of the following lead styles: gull wings, J-leads, L-leads, flat leads or I-leads.

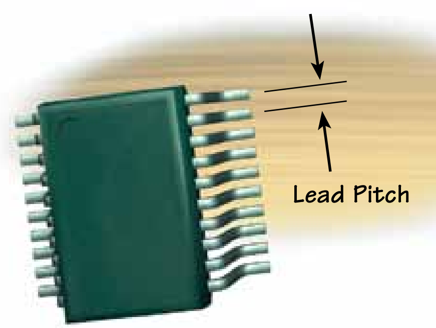
**Gull Wing Lead:** The gull wing lead is a metal lead that bends down and away — similar to a seagull's wing.

**J-Lead:** The J-lead is a metal lead that bends down and underneath a component in the shape of the letter J.

**L-Lead:** The L-lead is inward formed underneath a component.

**Flat Lead:** The flat lead protrudes directly out from the body of a component.

**I-Lead:** The I-lead, or butt lead, is actually a through hole lead that has been cut short for surface mounting. Because the connection is not very strong or stable, the I-lead is not considered suitable for high reliability assemblies.




**Lead Pitch**

An important characteristic of some leaded surface mount components is lead pitch. Pitch is the distance between the center or one lead to the center of the next. When a component has fine pitch it means the leads are spaced very close together (less than 25 mils).

# Component Packaging

Component packaging refers to the way component manufacturers package their product for use by electronics assemblers. See *Introduction to Electronics Assembly*, IPC-DRM-53, for more about the assembly process. Through hole and surface mount components are packaged in one of four ways: on tape and reel, in tubes, in waffle trays or in static-safe bags. The packaging method depends on the component type and whether the component will be assembled onto the circuit board by machine or by hand. most component packages are made to protect the components from electrostatic discharge, or ESD, which could damage them.

### Tape and Reel

Tape reels are used for axial leaded through hole components and the smaller surface mount components. Automatic insertion machines cut through hole components off tape reels and insert them into the board. Surface mount assembly machines, called "pick and place", pick surface mount components from tape reels and place them onto the board.

### Tubes

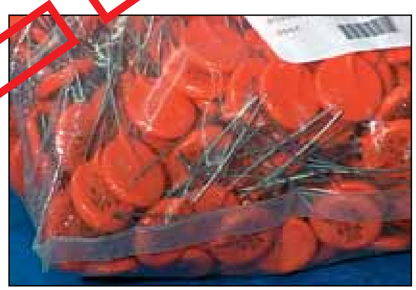
Tubes are used to keep components straight and ready to drop into auto-insertion or auto-placement machines.

### Waffle Trays

Waffle trays are used for many of the larger surface mount components. They are stackable on pick and place machines. Trays also provide protection for fragile leads during storage and handling.

### Static-Safe Bags

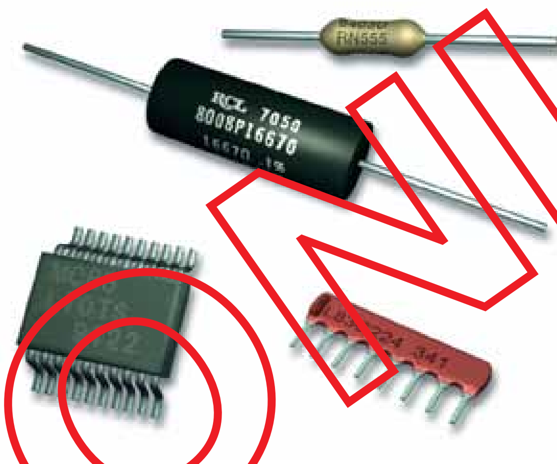
Some components are simply packaged loose in static-safe bags. These components are usually simple through hole axial and radial devices that are too large or unusually shaped to be inserted by machine.



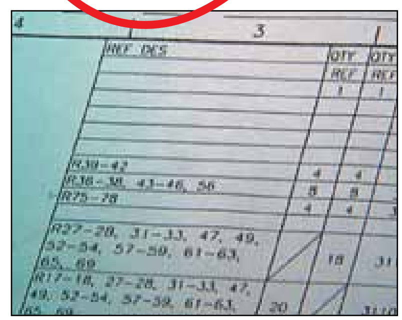




# Identifying Components



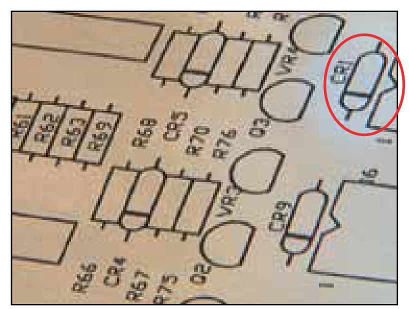
Every component has a manufacturer's part number. This number is either marked on the component itself, or on the packaging.



The bill of materials

And every assembly to be manufactured comes with an assembly drawing and a parts list, also called the bill of materials, or BOM.

The BOM lists the components by part numbers, quantities and reference designators.



The assembly drawing with a diode circled in red

The assembly drawing shows the location of each component.


PCB reference designator for a diode

## Lead-Free Components

With the industry transitioning to lead-free soldering processes, components will have either tin-lead or lead-free terminations and leads. It is very important to know whether a component is lead free.


When tin-lead components are used on lead-free assemblies, there will be *cross contamination.* Cross contamination *may* create unreliable solder connections. There have been studies that show that contaminated solder joints can develop cracks and other types of physical instabilities. But the *biggest* problem with mixing tin-lead and lead-free alloys is that it will make our electronic assemblies and electronic products non-compliant with European Union standards. Companies that are found non-compliant will not have their products accepted.

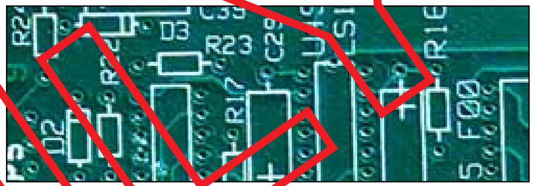
Lead-free components may be marked with the words "lead-free", or with the lead-free symbol. When there are no markings, the packaging and accompanying documentation should be checked to verify that a component is lead free, or RoHS compliant.






## Component Reference Designators

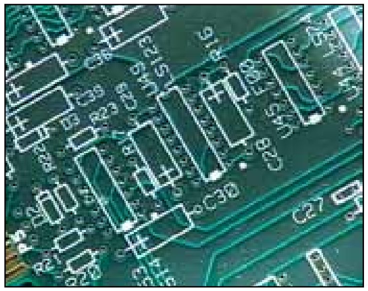
Most of the PCBs made today have a **component legend** silkscreened onto them.



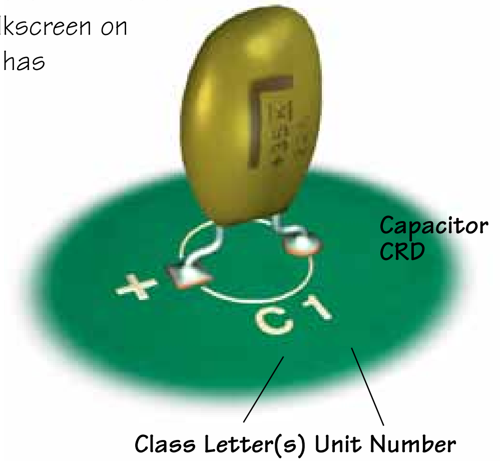

Close-up of a component legend printed on a through hole PCB

These letters and numbers identify the component to be placed in the holes or onto the lands next to each designation.

Also called the **silkscreen** or **Component Reference Designator (CRD)**, this legend is placed on the **component mounting (primary) side** of the PCB. The other side of a through hole board, like the one shown, is often referred to as the **solder (secondary) side**.



The silkscreen may also indicate the direction (for orientation or polarity) the component is to be placed on the board. SMT boards may have the silkscreen on both sides of the board, if it has components on both sides.




For more definitions of reference designators, see **ANSI Y32.16/ IEEE Std 200.**

For more definitions of component class letters, see **ANSI Y32.2/ IEEE Std 315, section 22.**

## Common Class Letters for CRDs

| | ANSI/IEEE | IEC | Other |
|---|---|---|---|
| Amplifier | AR | A | |
| Capacitor | C | | |
| pack or network | C | | CP or U |
| polarized | C | | "+" (by the lead) |
| variable | C | | C VAR, C ADJ |
| Connector | J or P | | |
| Crystal | Y | B | |
| Delay Line | DL | | D --- |
| Diode | D or CR | V | |
| Light Emitting Diode | DS (Display) | E | LED, D, DIS, CR |
| Voltage Rectifier | D or CR | V | VR |
| Zener Diode | D or VR | V | |
| Filter | FL | Z | |
| Fuse F | | | |
| Header | J or P | | |
| Inductor, Choke | L | | |
| Integrated Circuit | U | | IC |
| Insulated Jumper | W or P | | JP |
| Jumper | W, P or R | | JMP, J |
| Microprocessor | U | | IC, MC, CPU |
| Oscillator | Y (crystal) or G (other) | G | OS |
| Relay | K | | |
| Resistor | R | | |
| pack or network | R | | RN, RP, U |
| Potentiometer | R | | VR, POT |
| Thermistor | RT | | R |
| variable | R | | VR, VAR, VRN, ADJ |
| Varistor | | | R, VAR |
| asymmetrical | D or CR | | |
| symmetrical | RV | | |
| Socket | X. XAR, XU, XQ, etc. | | TS, S |
| Switch | S | | SW |
| Test Point or Pin | TP | | TST or J |
| Transistor | Q | V | U |
| Transformer | T | | X, TR |
| Voltage Regulator | VR | | U |



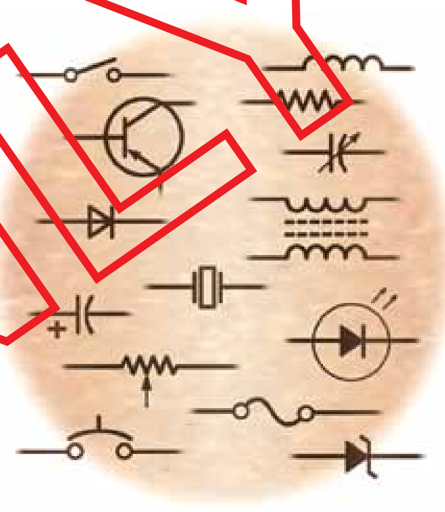


## Schematic Symbols

Along with the assembly drawing and BOM, schematic diagrams are also used to specify assemblies.

Each discrete component has an associated symbol that is specified in IEEE (Institute of Electrical and Electronics Engineers) Standard 315 and 315A (ANSI Y32.2).

Components with multiple functions, such as an integrated circuit, do not use a specific schematic symbol but are often represented by a block in the schematic diagram. This includes ICs packaged as DIPs, SOICs, QFPs, PLCCs, PGAs or BGAs.

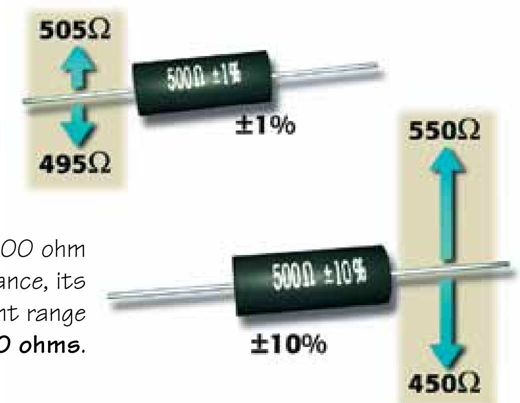


## Value and Tolerance

Some components will have a value and tolerance associated with them. The value is a numerical quantity given to the component. This value is usually assigned a tolerance which is the amount of variation allowed from that value.

If a 500 ohm resistor has a **1%** tolerance, its acceptable measurement range would be **495 to 505 ohms**.

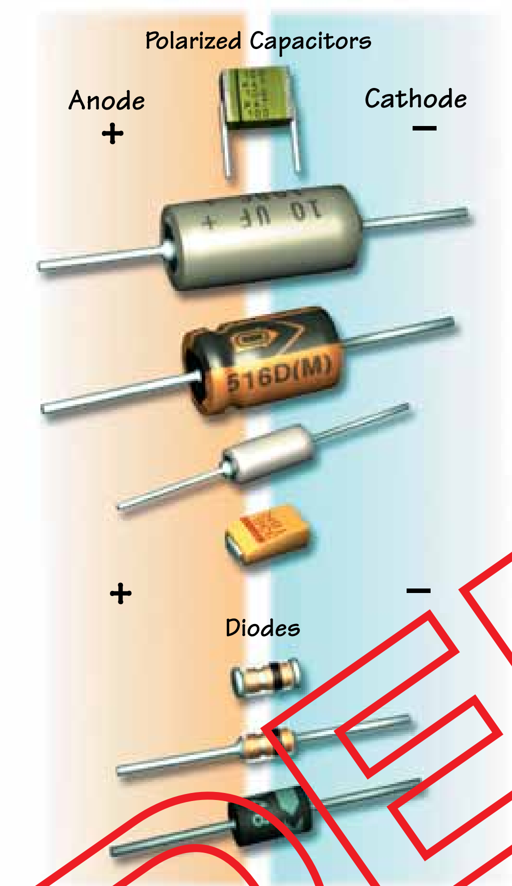
But, if the same 500 ohm resistor has a **10%** tolerance, its acceptable measurement range would be **450 to 550 ohms**.




Reading component values and tolerances is described in detail in the last section of this manual.

# Polarity = Positive & Negative

Each component placed on a PCB or "board" has a specific function. Some components have a positive and negative connection to the board and so must be placed on the board in the correct orientation. This means that the correct lead — positive or negative — is in the correct hole, or on the correct land with surface mount components.




Components with this positive and negative connection are said to have **polarity**.

**Anode & Cathode**

The **positive** lead is called the **anode**.

The **negative** lead is called the **cathode**.

Polarity can be indicated on parts in a variety of ways.

The symbol for a positive lead is the plus sign (**+**), although many components will not have this marking.

The symbol for the negative lead is the minus sign (**–**).

Markings and symbols for either the anode or cathode leads can take many shapes and forms. Markings on the PCB include a square land or pad, a "**+**" symbol, or a diode symbol silkscreened to the board to show the correct orientation.





# Orientation = Position

Component **orientation** refers to situations when a component must be installed on the PCB a certain way, whether or not it has polarity. Orientation marks or symbols on a component's body include:

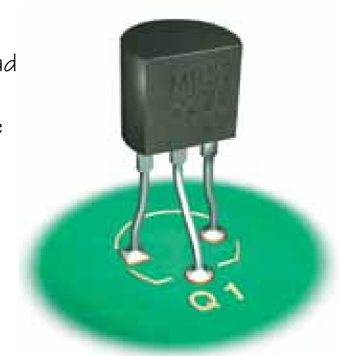

With multi-pin components, such as ICs, these orientation symbols indicate where "pin one" of that component is located so that pin may be mated with the corresponding pad or land on the PCB. Many ICs have tens to hundreds of I/O (input/output) connection points. These may be pins, leads or terminations.

Also, matching orientation marks may be found on the PCB. These often include silkscreened symbols identical to markings on the component body (notch, dimple, wedge, etc.) and/or a square pad or land on the board, especially for multi-pinned components.

# The Square Land / Pad

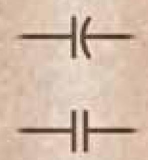
The square land/pad is a common way to designate polarity or orientation. The square land is most often used by PCB designers to show where the marked lead or pin one of a multi-pinned component should be placed. Matching pin one of the component to the correct land or pad on the PCB is critical for the proper function of the component.

For components that have the positive or anode lead marked, like polarized capacitors, the square land typically indicates where the positive lead should be placed. For components which have the negative or cathode lead marked, such as diodes or LEDs, the square land indicates where the marked (negative) lead should be placed.



Square land/pad shows pin one orientation

**Note: Always verify the polarity against any drawings, schematics, silkscreen markings (or any other documentation from your board and component suppliers) as this may vary.**

## Capacitor *(Non-Polarized)*

**Description:** Capacitors store and discharge electricity. They consist of two metal plates, or conducting surfaces, separated by a insulating material called a dielectric. After a sufficient buildup in one plate, the charge is felt in the opposite plate. There are four basic types of non-polarized capacitors:

- Ceramic disc-radial
- Dipped mica-radial
- Mylar-radial, usually round or oval bodies
- Glass-packed axial, easy to mistake for diode or resistor.

**Class Letter:** C (non-polarized)

**Prefix:** None

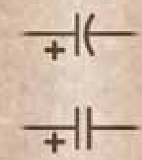
**Value Code:** Measured in microfarads (**μF**), nanofarads (**nF**) or picofarads (**pF**). The value is printed on the capacitor body using some form of abbreviation. Also specified is the operating voltage for the capacitor. These two values determine the physical size of the component.

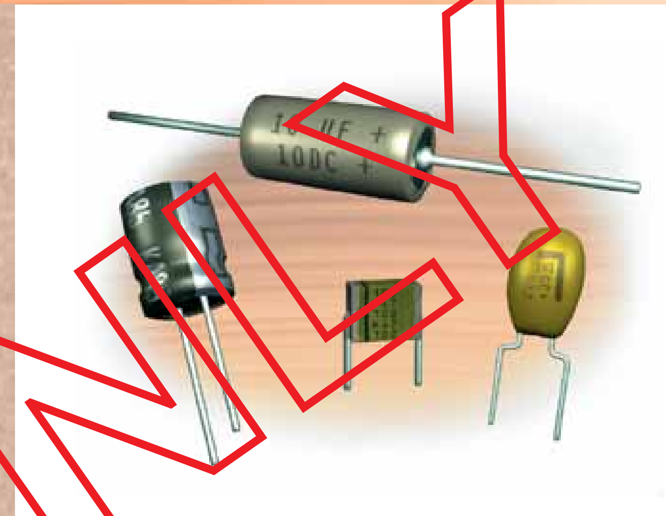
**Tolerance:** Printed as percentage (example: ±5%) or as letter scheme.

**Orientation:** None









## Capacitor *(Polarized)*

**Description:** Polarized capacitors function in the same way as non-polarized capacitors (see page 13).

**Class Letter:** C

**Other:** "**+**" (by the lead)

**Prefix:** None

**Value Code:** Measured in microfarads (**μF**), nanofarads (**nF**) orpicofarads (**pF**). The value is printed on the capacitor body using some form of abbreviation. Also specified is the operating voltage for the capacitor. These two values determine the physical size of the component.

**Tolerance:** Printed as percentage (example: ±5%) or as letter scheme.

**Orientation:** By polarity. A **Square land** on the PCB may mark where the positive lead (anode) is to be inserted.

**Polarity:** Polarized capacitors can be both axial or radial and will have one lead marked as postive (+). This positive lead can be marked or formed in several ways:

**Symbols:**

**Plus (+)**; marks positive lead
**Dot (•)**; marks positive lead
**Band**; marks positive lead
**Line**; the line can have pluses (**+**) leading to the positive leg or minuses (**–**) leading to the negative leg.
**Arrows**; arrows down the side lead to the negative end.

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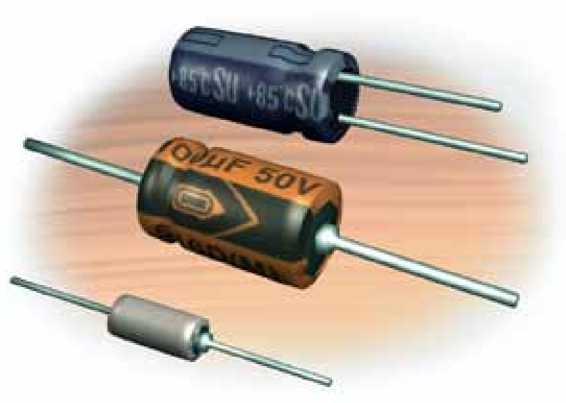


## Capacitor (Polarized)

Continued:

**Colors:**
- **Silver square;** marks positive lead
- **Colored end;** marks positive lead

**Shapes and forms:**
- **Ridge or bevel;** marks positive lead
- **Groove;** marks positive lead
- **Bubble;** marks positive lead *(if both ends have a bubble, the larger one is positive)*

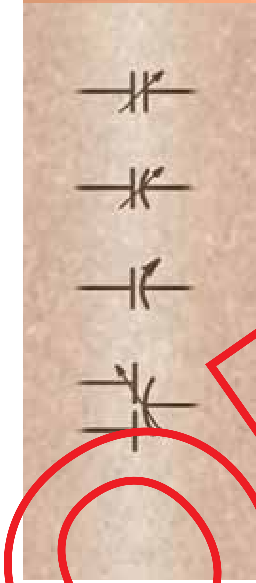
**Larger lead;** the PCB holes are sized to match the larger lead.

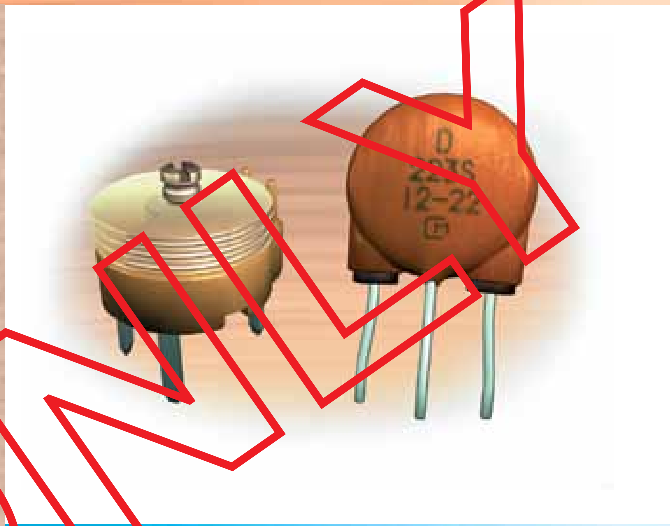
Aluminum electrolytic capacitors

Another type of polarized capacitor is the *aluminum electrolytic capacitor*. These capacitors have a larger capacitance per unit volume than other types, making them valuable in relatively high-current and low-frequency electrical circuits — such as power supply filters. The dielectric is a thin layer of aluminum oxide.









## Variable Capacitor

**Description:** These capacitors can change capacitance by turning a screw that causes the plates to move closer or farther apart. The closer the plates, the higher the capacitance.

**Class Letter:** C

**Other:** C VAR, C ADJ

**Prefix:** None

**Value Code:** Measured as a range, such as 27-200 μF.

**Tolerance:** None

**Orientation:** Non-symmetrical lead pattern allows it to be installed only one way.

**Polarity:** None

## *Crystal Oscillator*

**Description:** Crystal Oscillators usually have metal bodies and produce a consistent electrical pulse. They are typically used as clocks, controlling the timing of events in digital circuits.

**Class Letter:** Y

**Other:** B

**Prefix:** None

**Value Code:** Measured in megahertz (**MHz**), or kilohertz (**kHz**).

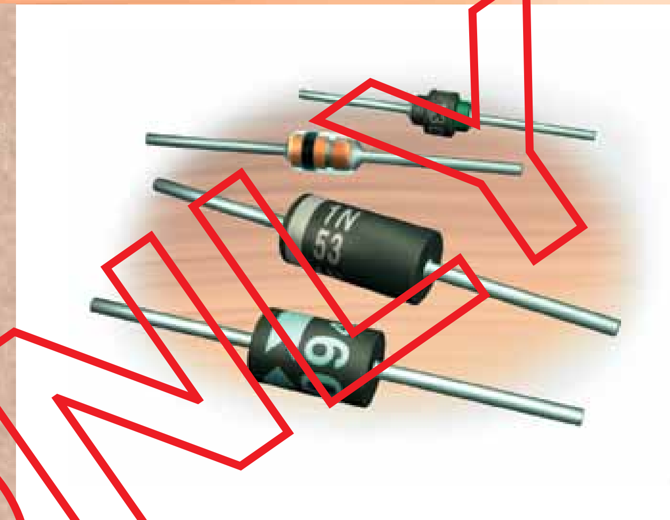
**Tolerance:** None

**Orientation:** Angled corner or dot

**Polarity:** None





## *Diode*

**Description:** Diodes are semiconductors that only allow current to flow in one direction — like a one way street. They can convert alternating current to direct current. A zener diode acts as a voltage limiter for DC voltages. A diode's part number is usually specified by the prefix 1N, followed by two to four digit numbers. Examples include 1N53, 1N751 and 1N4148.

**Class Letter:** D or CR

**Other:** V

**Prefix:** 1N

**Value Code:** None

**Orientation:** By polarity.

**Polarity:** Polarity is usually indicated by colored ring or up to three rings near the negative (cathode) end of axial diodes. An arrow may also point to the negative end. The PCB is marked with a stripe, line, or arrow symbol showing where the cathode end of the diode should be placed.

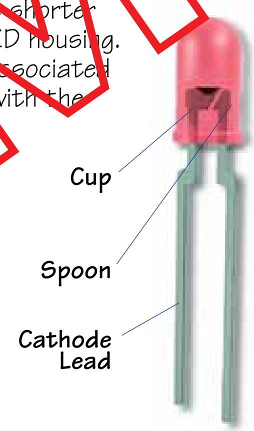
A **Square Land*** may also mark where the cathode end is inserted.

* See page 13, "The Square Land/Pad"


## *Light-Emitting Diode*

**Description:** Also known as LEDs, these components emit light.
**Class Letter:** DS
**Other:** E, LED, D, DIS, CR
**Prefix:** None
**Value Code:** None
**Tolerance:** None
**Orientation:** By polarity.
**Polarity:** LEDs are typically radial leaded, and polarity is indicated by a short lead, a flat side to the component housing, or position of the cup and spoon.

The cathode is usually identified by the shorter lead, or by a flat side (if any) to the LED housing. The cup inside the lens is sometimes associated with the cathode lead, and the spoon with the anode, but this may vary with some manufacturers.

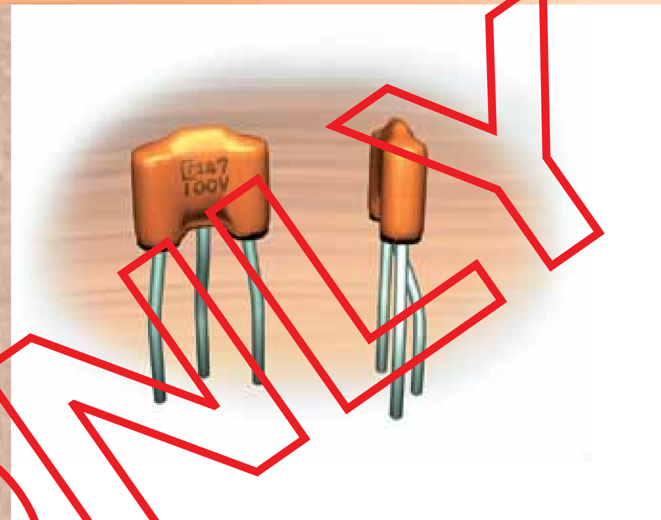



**Square Land:**
The PCB may also be marked with a square land showing where the cathode end is inserted and/or a silkscreened outline of the component body with a flat edge to indicate polarity.

**See page 13, "The Square Land/Pad"**

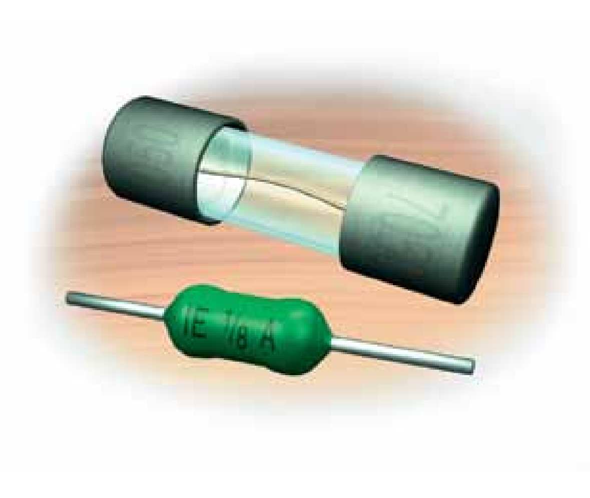


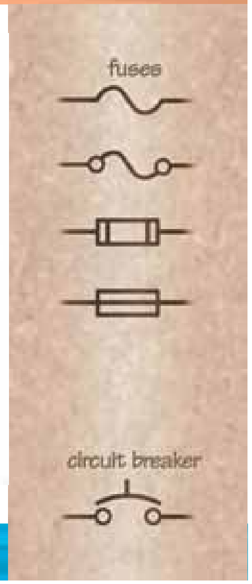




## *Filter*

**Description:** Filters are used to pass one frequency or frequency band while blocking others. They are often used to filter electrical noise in a circuit.
**Class Letter:** FL
**Other:** Z
**Prefix:** None
**Value Code:** None
**Tolerance:** None
**Orientation:** The installation of filters is usually by lead configuration. The pattern of holes or lands on the PCB means there is only one way to insert the filter.
**Polarity:** None




## *Fuse / Circuit Breaker*

**Description:** Fuses consist of a wire with low melting point metal. When current passing through the wire exceeds a prescribed level, the wire melts and opens the circuit, protecting equipment from damage.

**Class Letter:** F

**Prefix:** None

**Value Code:** Measured in amps

**Tolerance:** None

**Orientation:** None

**Polarity:** None

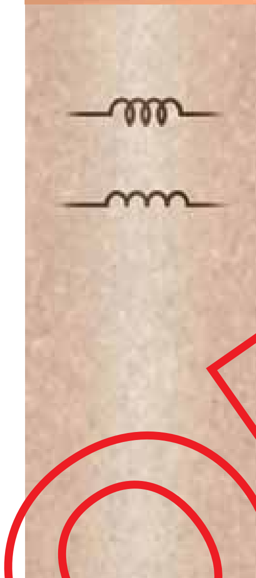
**A circuit breaker** is a device that when exposed to excess current will "trip" or become electrically open and can be reset.

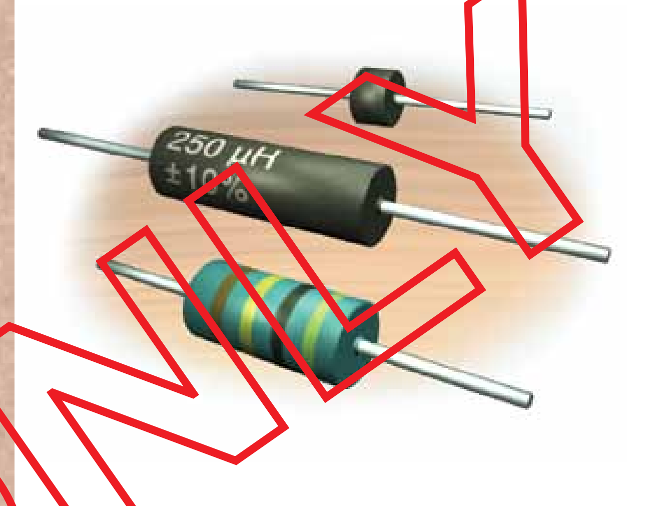
**Class Letter:** CB

A Circuit Breaker Panel like the one in your home.








## *Inductor / Coil*

**Description:** Inductors consist of a coil of wire that creates a magnetic field when current flows through the coil. Transformers, Coils and Toroids are related to inductors (see Transformers). The toroid choke consists of a coil wound on a toroid, or doughnut of magnetic metal. The metal core increases the inductance of the coil.

**Class Letter:** L

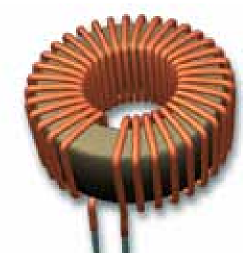
**Prefix:** None

**Value Code:** Measured in microhenry (**µH**) or millihenry (**mH**). The value is either printed on the inductor body or calculated by decoding 4 of 5 colored bands on the inductor body into numbers.

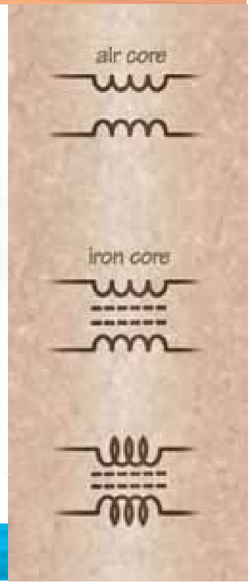
**Tolerance:** Printed as last of five-band color band system.

**Orientation:** None

Choke



Coil




## Transformer

**Description:** Transformers are related to inductors. Transformers basically consist of primary and secondary coils wound on a common core of ferromagnetic material.
When alternating current flows through the primary coil, the resulting magnetic field induces an alternating voltage across the secondary coil. The induced voltage can cause current to flow in an external circuit.

**Class Letter:** T

**Prefix:** None

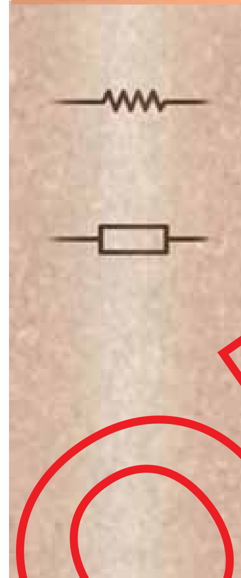
**Value Code:** Measured in microhenry (µH) or millihenry (mH). The value is printed on the body.

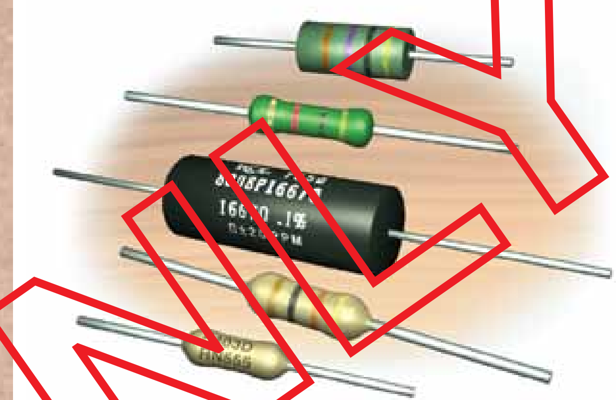
**Orientation:** Many transformers have non-symmetrical leads which only allow it to be installed one way.

Transformer mounted on a board









## Resistor

**Description:** Resistors limit the flow of electrical current in a circuit. This is like a highway narrowing from six lanes to a two-lane road. Fixed resistors are usually made of metal film. The bigger the metal film resistor, the greater its wattage rating (wattage is a measure of electrical power). Resistors can also be made of hot molded carbon.
In addition, there are wire wound power resistors.

**Class Letter:** R

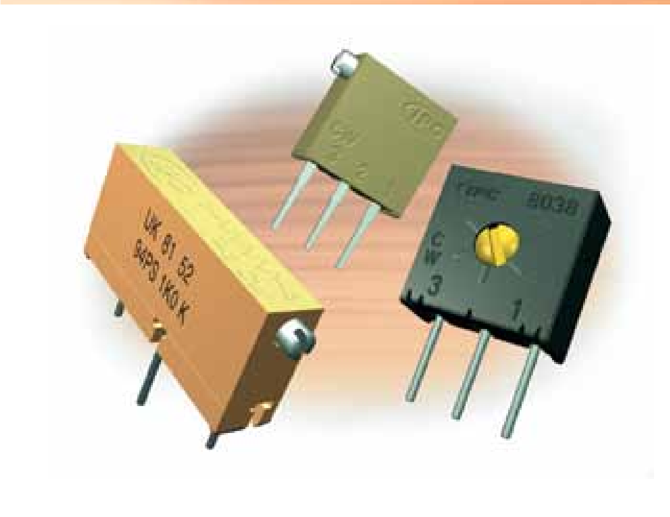
**Prefix:** RC = color coded
RN = metal film
RCL = wire wound

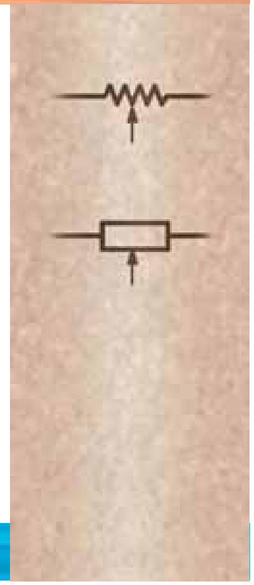
**Value Code:** Measured in ohms (Ω). The value is either printed on the resistor body or is calculated by decoding 3 to 5 colored bands on the resistor body into numbers.

**Tolerance:** Printed on body or as part of color band system.

**Orientation:** None

**Polarity:** None





## Variable Resistor

**Description:** Also called a potentiometer, trimpot or trimmer, a variable resistor is a resistor whose value can be changed by turning a shaft, screw or sliding a contact.

**Class Letter:** R

**Other:** VR, VAR, VRN, ADJ

**Prefix:** None

**Value Code:** Measured in a range in ohms. Maximum value is usually molded into component body. Example: 20 MΩ.

**Tolerance:** None

**Orientation:** Non-symmetrical lead pattern only allows it to be installed one way. Pin one is usually identified.
A square land may also mark where pin one is inserted.*

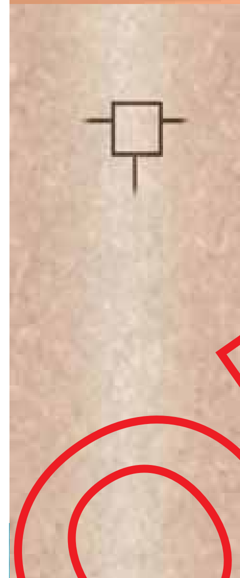
**Polarity:** None

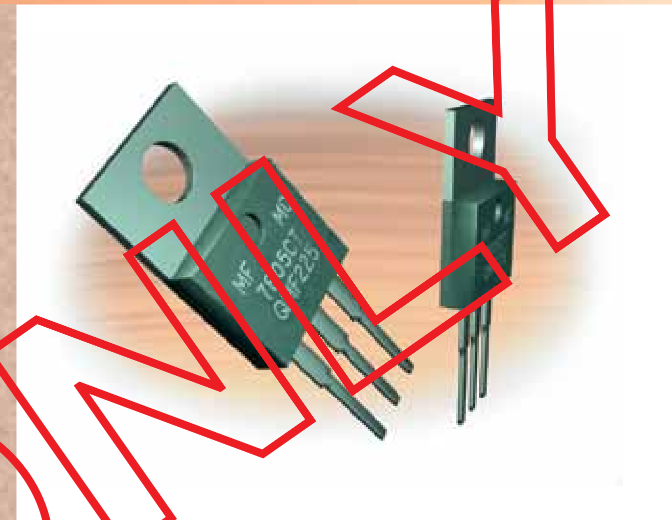
* See page 13, "The Square Land/Pad"











## Voltage Regulator

**Description:** Voltage regulators keep output voltage constant during variations of the output load or the input voltage.
The package configuration often looks like a TO-220.

**Class Letter:** VR

**Other:** U

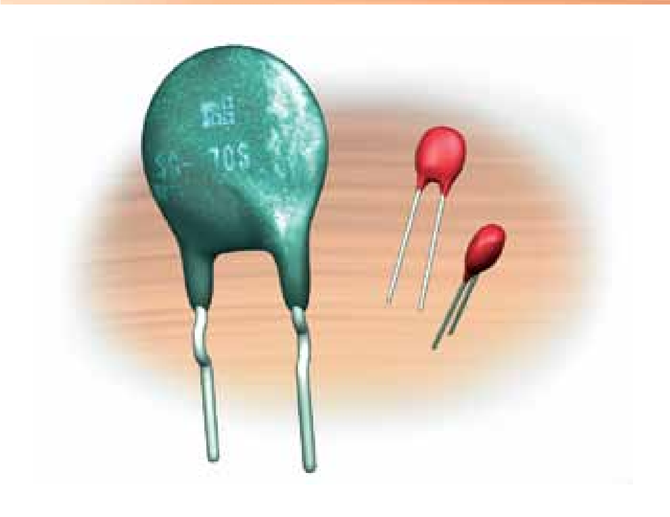
**Prefix:** None

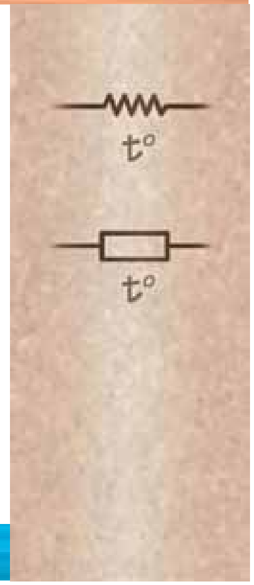
**Value Code:** None

**Tolerance:** None

**Orientation:** Angle on the body or indented dot.

**Polarity:** None





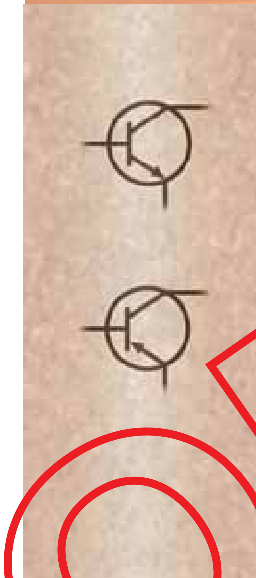

## Thermistor

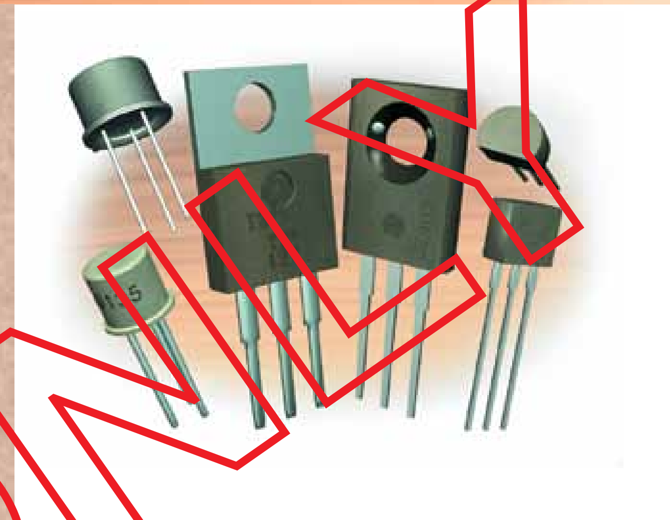
**Description:** Resists current flow based on temperature. Often looks like a disc capacitor.
**Class Letter:** RT
**Other:** R
**Prefix:** None
**Value Code:** None
**Tolerance:** None
**Orientation:** None
**Polarity :** None









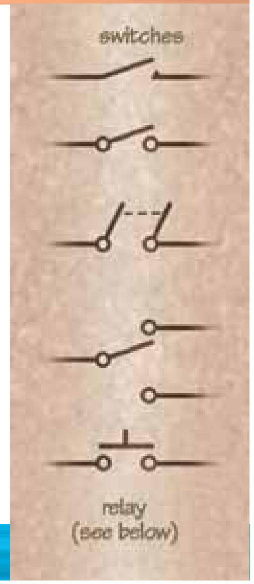


## Transistor



**Description:** Transistors are semiconductors that can amplify, oscillate and provide switching action on electrical signals. Like diodes, transistors do not utilize units of measurement. Instead, their component type is usually specified by the prefix 2N or 3N, followed by two to four digit numbers. Examples include 2N50, 2N701 and 2N2222A.
**Class Letter:** Q
**Other:** V or U
**Prefix:** 2N
**Orientation:** Indicated by one of several methods:

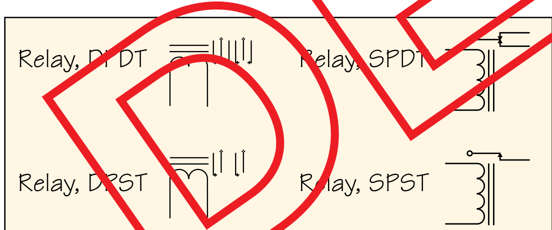
- **Pin Numbers** or pin names which match to the PCB silkscreen.
- **Tab** on the transistor "can". When looking down on the component from the top, pin one is either to the right of, or directly underneath the tab. The pins count counterclockwise from pin one.
- **Matching** component shape with PCB silkscreen outline: Outline on PCB includes the tab — align the tab. Outline on PCB includes the flat side of the transistor — align the flat side. Pattern of through holes on PCB means there is only one way to insert the transistor.

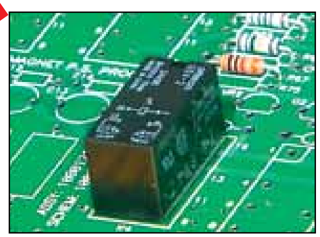



## *Switch / Relay*

**Description:** **Switches** open and close a circuit.
**Class Letter:** **S**
**Other:** **SW**
**Prefix:** None
**Value Code:** May have value rating for maximum current in amps. Example: **10 A**. May also have mechanical information such as **DPDT**; "double-pole, double-throw" printed on it.
**Tolerance:** None
**Orientation:** Dot or notch
**Polarity:** None

**Description:** **Relays** are switches that open and close when actuated by an applied signal.
**Class Letter:** **K**

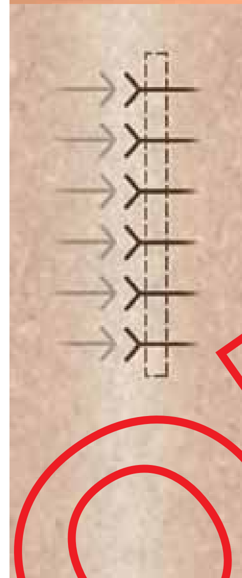


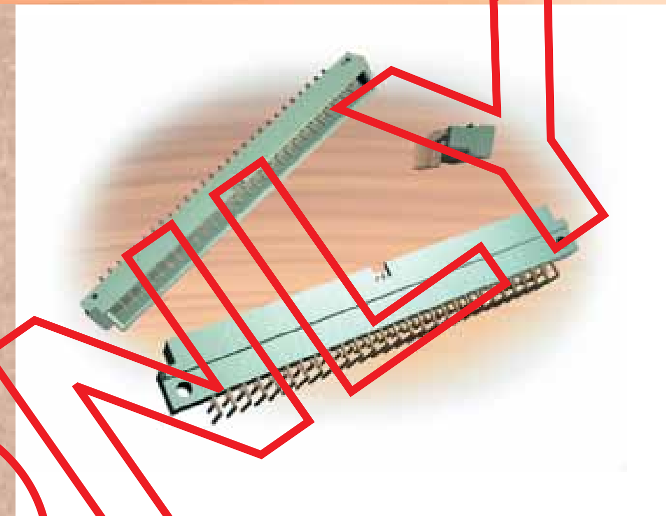



A Relay on a partially assembled PCB



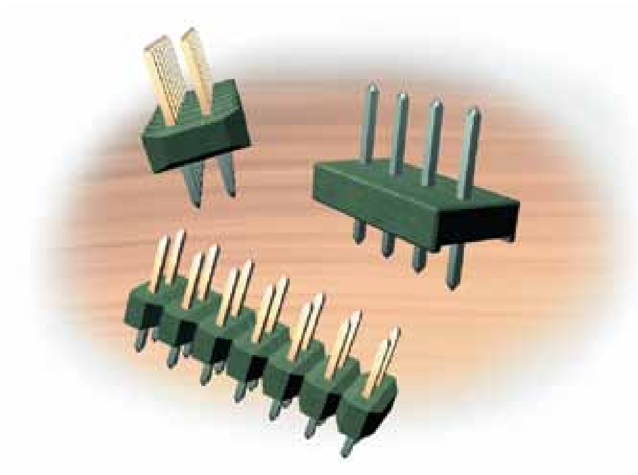






## *Connector*

**Description:** Connectors are placed on a PCB so that wires, cables and other outside connections can be made to the PCB. They usually have a housing around their pins.
**Class Letter:** **P** for MALE PLUG connector, or **J** for FEMALE JACK / RECEPTACLE connector.
**Orientation:** Bevel, notch or pin number molded into the package.
**Polarity:** None



## Header

**Description:** Headers, like connectors are placed on a PCB so that outside connections can be made. Headers usually do not have a housing around their pins.

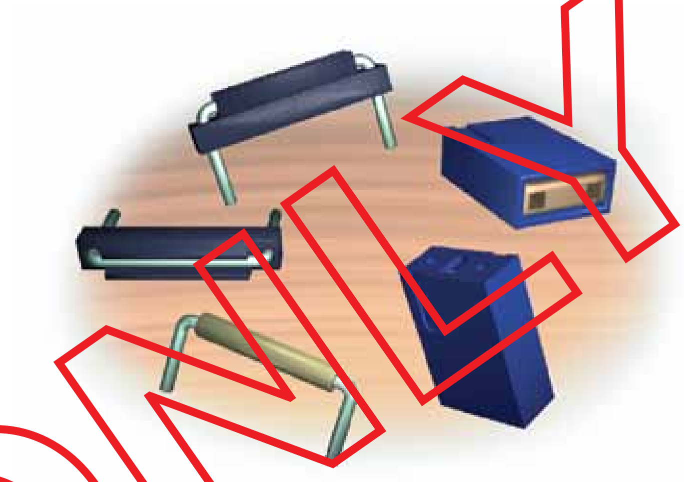
**Class Letter:** J or P

**Orientation:** Usually none. Often has alignment or locking tabs for the connector which mates with it. Correct orientation of this tab is important.

**Polarity:** None







## Jumper

**Description:** Also called jumper configuration, jumper wire or head pin configuration. Jumpers connect two pins on the assembly together, providing an electrical path between those points. Jumpers are sometimes used to solve circuitry errors in the PCB itself. Other times they are used to provide a way to change the assembly's configuration for different applications.

**Class Letter:** **W**, or **E** for insulated piece of conductor (wire); or **P**, for a plug.

**Other:** JP

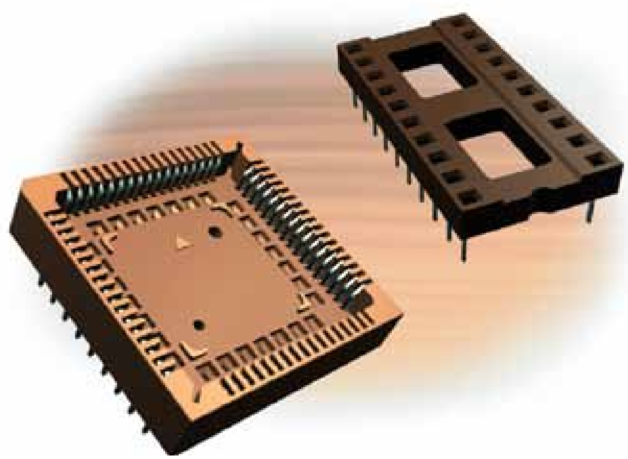
**Prefix:** None

**Value Code:** None

**Tolerance:** None

**Orientation:** Jumper goes into header socket

**Polarity:** None



## *Socket*

**Description:** Sockets are soldered onto circuit boards so that an IC can be plugged into the socket and not soldered directly to the board. This makes removing or upgrading the part much easier. Sockets are sometimes used for components that cannot be soldered in place because of heat sensitivity.

**Class Letter:** **X**, **XAR**, **XU**, **XQ**, *etc.*

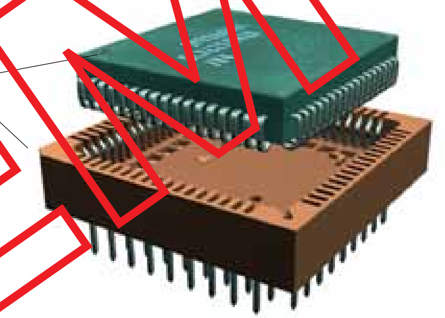
**Other:** **TS**, **S**

**Prefix:** None

**Value Code:** None

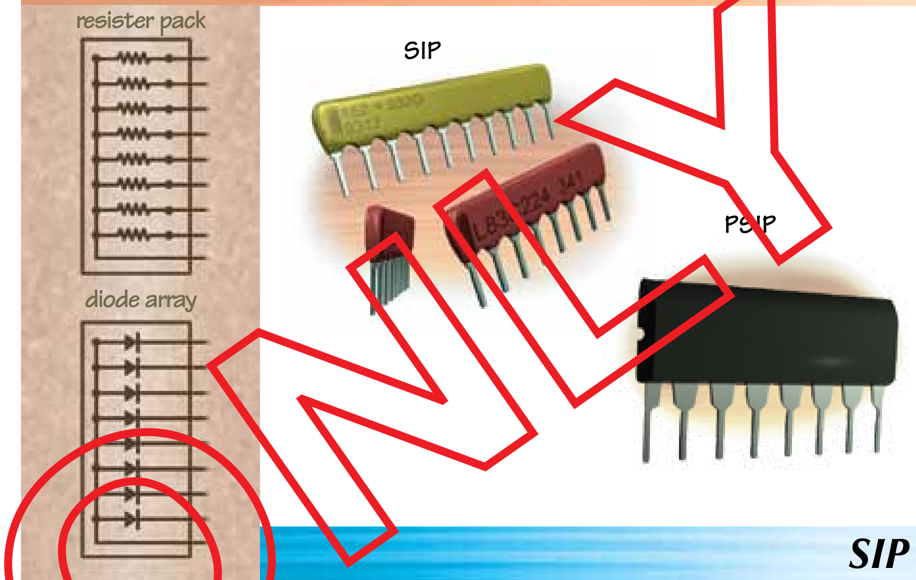
**Tolerance:** None

**Orientation:** Sockets usually have a dot or a notch to indicate orientation to the PCB. Once installed, a socket may cover the PCB orientation mark, so it's important to place the socket correctly.










## *SIP*

**Description:** **S**IP stands for **S**ingle-**I**n-line-**P**ackage. SIPs are often resistor networks (or packs) diode arrays, power converters and power regulators. **PSIP** stands for a **P**lastic **SIP**.

**Class Letter:** **R** for resistor networks, **D** or **CR** for diode array, etc

**Other:** **RP**, **RN**

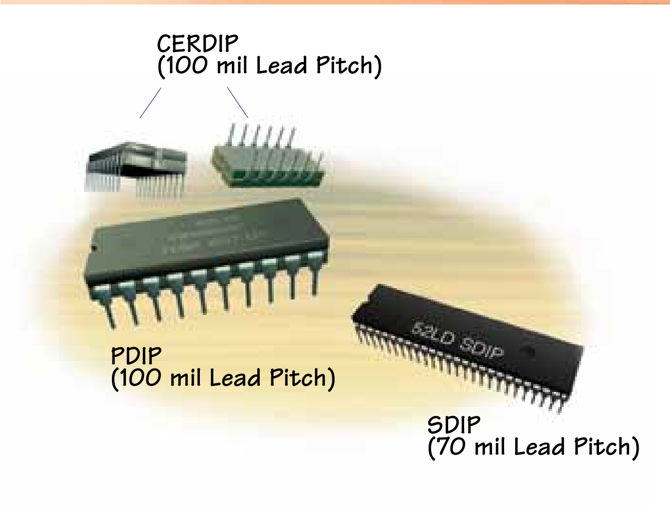
**Prefix:** None

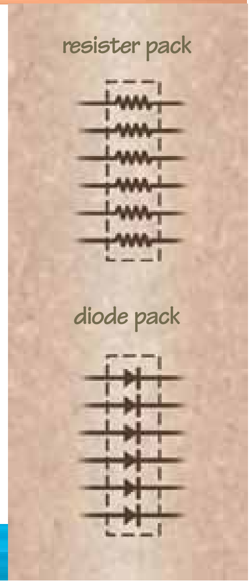
**Value Code:** SIP packages sometimes include banks of passive components. Those values may be marked on the component package. For example, eight 2K resistors would have the value: "8x2K."

**Tolerance:** None

**Orientation:** Determined by the location of lead one. A SIP IC's leads are numbered to ensure proper placement of the component on the circuit board or into a PCB-mounted socket. The orientation marking on most SIPs is usually right over lead one. The remaining leads are counted from lead one.

**Lead One Markings:** The most common markings for orientation on SIPs are numbers, a stripe or a dot.




## DIP

**Description:** **D**IP stands for **D**ual-**I**n-line-**P**ackage. DIPs are usually made of plastic (called **PDIPs**) or ceramic (called **CERDIPs**). They may include hundreds, or thousands of various components. Also includes Shrink DIPs (**SDIPs**).

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Prefix:** None

**Value Code:** DIP packages sometimes include banks of passive components. Those values may be marked on the component package. For example, eight 2K resistors would have the value: "8x2K."

**Lead Pitch:** 100 mils DIPs and 70 mils SDIPs

**Orientation:** Determined by the location of lead one. A DIP IC's leads are numbered to ensure proper placement of the component on the circuit board or into a PCB-mounted socket. The orientation marking on most DIPs is usually either right over lead one or on the end at which lead one is found. The remaining leads are counted counterclockwise from lead one.

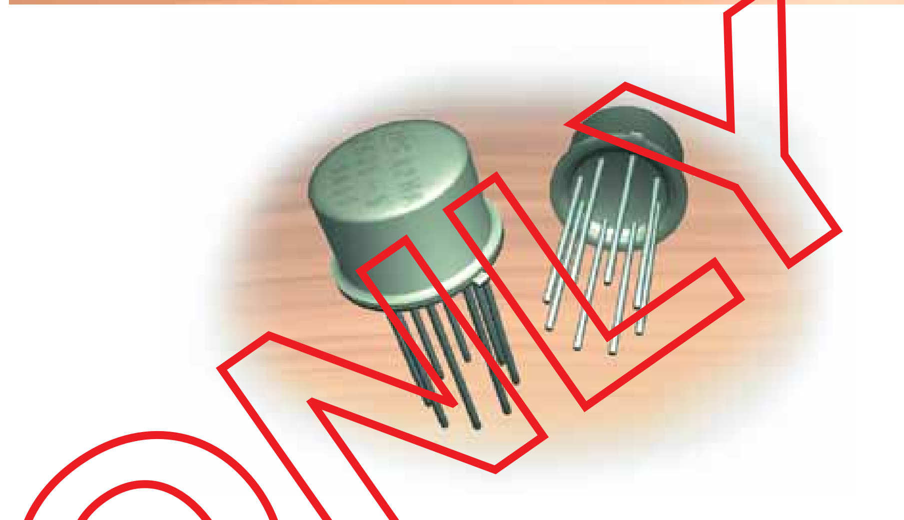
**Lead One Markings:** The most common markings for orientation on ICs are:

- notch
- numbers
- stripe
- dimple
- wedge

**Square Land:** The square land is used to show the location of lead one on the PCB. Aligning lead one of the IC with the square land on the board ensures proper installation of the component.







## IC Can

**Description:** IC Cans are often transistors or voltage regulators.

**Class Letter:** U general IC, Q for transistor, AR amplifier, etc.

**Other:** IC

**Prefix:** None

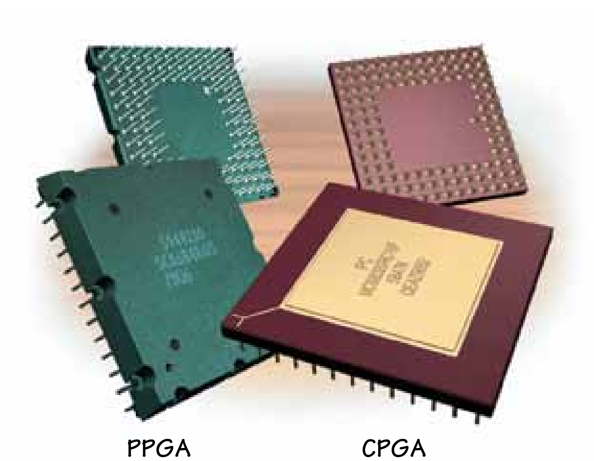
**Value Code:** None

**Tolerance:** None

**Orientation:** Determined by the location of lead one. An IC Can's leads are numbered to ensure proper placement of the component on the circuit board or into a PCB mounted socket.

The orientation marking on most IC Cans is usually a tab in the rim of the can over the highest numbered pin, or between pin one and the highest pin.

The pins are counted counterclockwise starting from the right of the tab when looking down on the top of the can.




## PGA

**Description:** PGA stands for **P**in **G**rid **A**rray. PGAs have several rows of leads or pins extending from the bottom of the IC. The rows make up a grid of connection points. PGAs come in plastic packages (**PPGA**) and ceramic packages (**CPGA**).

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Prefix:** None

**Value Code:** None

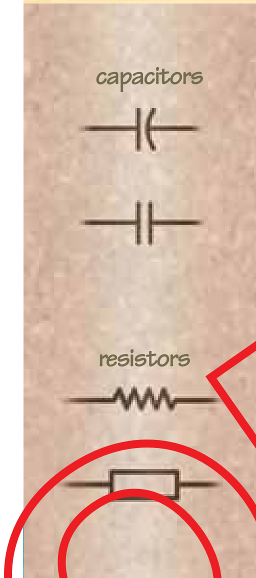
**Tolerance:** None

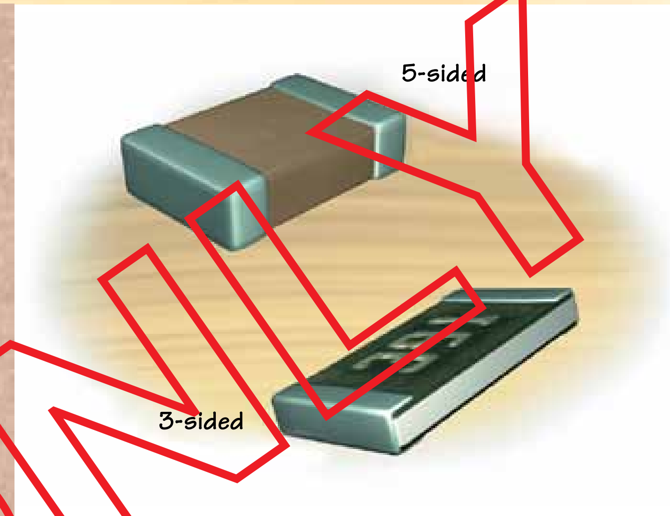
**Orientation:** Usually determined by the location of a notch in the package right over pin one. A corresponding mark on the PCB or socket provides proper alignment. Sometimes also by a missing pin on the component, or a missing hole on the board.
**Square Land:** A square base to one lead among the leads in a PGA is also used to show orientation. Aligning that lead with a matching square land on the board ensures proper installation of the component.












## Chip Components

**Description:** Chip components are usually ceramic-bodied packages with metal connections called terminations at either end. The most common types of chip components are ceramic resistors and capacitors. Five-sided chip components have a solderable surface on five sides of its terminal contact. The terminal contact is the area where the component is attached to the surface of the PCB.
Three-sided components have a solderable surface on three sides of its terminal contact.

### Chip Resistors

**Class Letter:** R

**Value:** Measured in ohms (Ω).

**Orientation:** None

**Polarity:** None

### Chip Capacitors

**Class Letter:** C

**Value:** Measured in microfarads (**µF**) or picofarads (**pF**).

**Orientation:** None

**Polarity:** None (Note: See Tantalum Capacitors)

Continued on the next page


# Chip Components / Resistor

**Reading Chip Resistor Value Codes**

Sometimes the numeric value (Ohms) may be printed on the chip resistor body. More frequently, this value code is printed on the label of the reel in which the chips are packaged. This is because the component itself is too small or will not allow for printing on the resistive element.

The code is a three- or four-digit number. With three-digit codes, the first two numbers are value numbers, and the third is the multiplier. For example **102**, where **1** and **0** are attached to **2** zeroes to equal **1000** Ohms.

With four-digit codes, the first three numbers are the value numbers, and the fourth number is the multiplier. For example: **1501**, where **1**, **5**, and **0** are attached to **1** zero to equal **1500** Ohms.

For either code, a "**0**" (zero), in the multiplier position means don't add any zeros. Example: **150**, where **1** and **5** are attached to no zeros to equal **15** Ohms.

A letter **R** in either code means to "place a decimal point at this spot."
Example: **49R9** = **49.9** Ohms.

## *Tolerance Letter Codes*

| | |
|---|---|
| B = ± .1%<br>C = ± .25%<br>D = ± .5%<br>F = ± 1%<br>G = ± 2%<br>J = ± 5%<br>K = ± 10%<br>M = ± 20%<br>Z = + 80% / -20% | For some manufacturers, chip resistors with 3-digit codes are assumed to be 5% tolerance, and 4-digit chips are assumed to be 1%.<br><br>Tolerance can be decoded from this chart when letter codes are used. |





# Chip Components / Capacitor

**Reading Chip Capacitor Value Codes**

Depending on the size of the chip capacitor, the value code may be printed on the body of the component, or on the label of the reel in which they're packaged. The code for a chip capacitor is a three-digit number expressing a value, usually in picofarads (**pF**).

As with chip resistor three-digit codes, the first two numbers are value numbers, and the third is the multiplier. Example: **221**, where **2** and **2** are attached to **1** zero to equal **220 pF**.

A "**0**" (zero) in the multiplier position for capacitors means no zeros are added to the value. A letter **R** is a decimal point holder. Tolerance comes in many varieties and may be shown with letter codes using the key chart at the bottom of the previous page.

## *Chip Component / Size Codes*

A chip's size, in inches or millimeters, is described by a 4-digit code:

| Size Codes (inches) | |
|---|---|
| 0402 | .04" x .02" |
| 0603 | .06" x .03" |
| 0805 | .08" x .05" |
| **1005** | .10" x .05" |
| 1206 | .12" x .06" |
| 1210 | .12" x .10" |
| 1812 | .18" x .12" |
| 2225 | .22" x .25" |

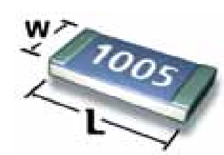
It is important to be certain of which measurement system a size code is in.

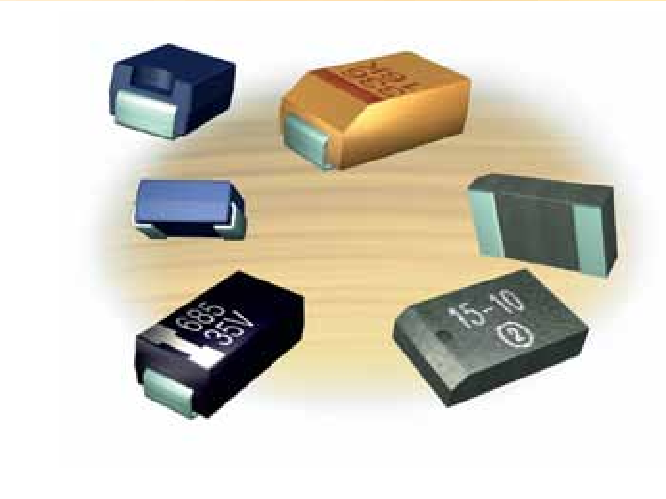
**(inches or millimeters)**

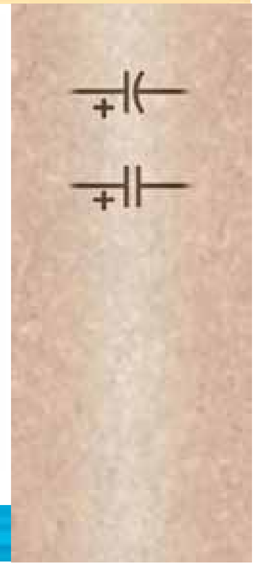
| Size Codes (metric) | |
|---|---|
| **1005** | 1.0 x 0.5 mm |
| 1508 | 1.5 x 0.8 mm |
| 2012 | 2.0 x 1.2 mm |
| 2512 | 2.5 x 1.2 mm |
| 3225 | 3.2 x 2.5 mm |
| 4532 | 4.5 x 3.2 mm |
| 5664 | 5.6 x 6.4 mm |

The first 2 digits are **the length**.

The second 2 digits are **the width**.







## *Tantalum Capacitor*

**Description:** Molded Tantalum Capacitors are polarized chip capacitors with *inward formed L-leads*. These leads almost touch the body of the component. Inside are metal plates which store and discharge electricity.

**Class Letter:** C

**Prefix:** None

**Value Range:** 0.001 **µF** to 1000 **pF**, 4 to 100 V dc

**Tolerance:** None

**Orientation:** By polarity.

**Polarity:** Line, **+** or **A** on anode end. Beveled top on anode end.

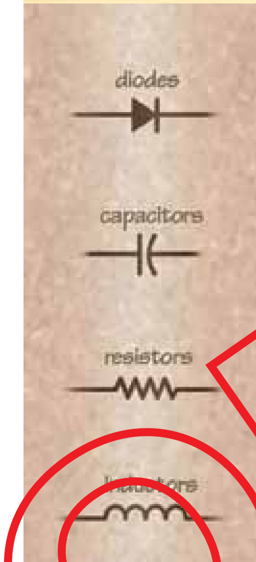
**Size Code:** A tantalum capacitor's size is described by one of four letters: **A**, **B**, **C**, or **D**. These four size codes stand for metric footprints of length and width.

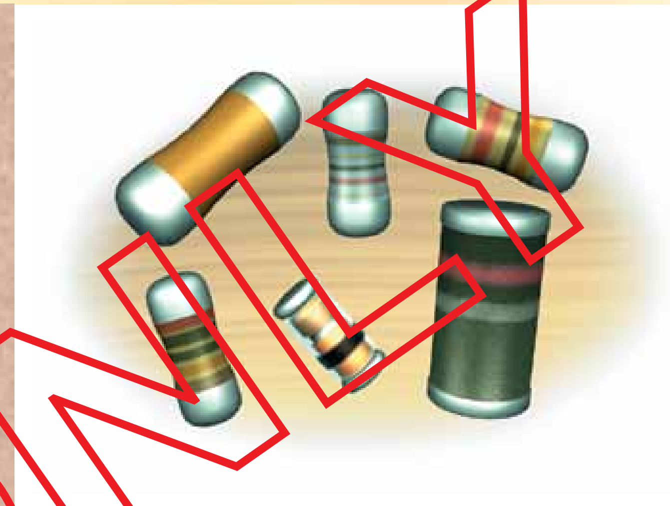
**Tantalum Capacitor Size Codes**

A = 3.2 x 1.6 mm
B = 3.5 x 2.8 mm
C = 6.0 x 3.2 mm
D = 7.3 x 4.3 mm







## *MELF*

**Description:** **M**etal **EL**ectrode **F**ace (**MELF**) leadless components have metallized terminals at both ends of a cylindrical body. Typical MELF components include diodes, resistors, capacitors and inductors. Polarity, value coding and CRDs are the same for these components as for their surface mount chip and through hole counterparts. The smallest of the MELFs are called "mini-MELFs" and "micro-MELFs."

**Class Letter:** Depends on component type.

**Prefix:** None

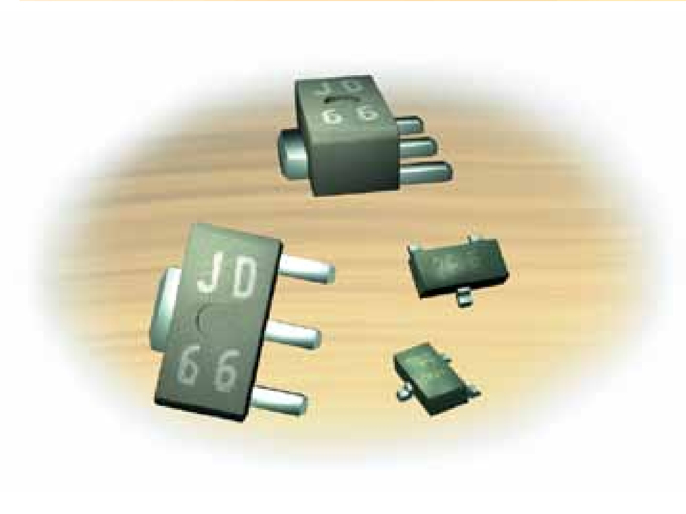
**Value Code:** Resistors have 4 or 5 bands which convey their value.

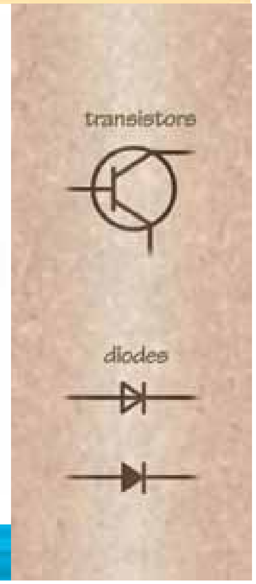
**Tolerance:** Resistors have a tolerance band.

**Orientation:** By polarity.

**Polarity:** MELF diodes have a band at the cathode end.

**Sizes:** MELF resistors are designed to fit same footprints as chip resistors, such as the 0805 (.08 x .05 inches) and the 1206 (.12 x .06 inches).






## SOT / SOD

**Description:** **S**mall **O**utline **T**ransistors (**SOTs**) and **S**mall **O**utline **D**iodes (**SODs**) are rectangular transistor or diode packages with three or more gull wing leads. The most popular size is the SOT23. Other package sizes include the SOT89, SOT143 and SOT 223. SOTs have 3 or 4 gull wings on two sides of their package.

**Class Letter:** **Q** for transistor packages; **D** or **CR** for diode packages.

**Prefix:** None

**Value Code:** By package size.

**Tolerance:** None

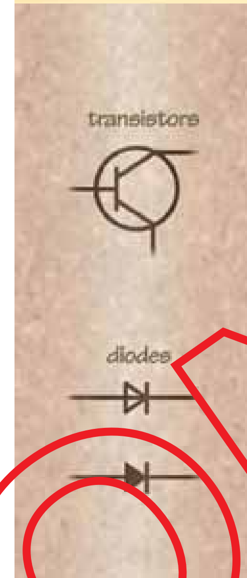
**Orientation:** Determined by lead pattern, or number one lead.

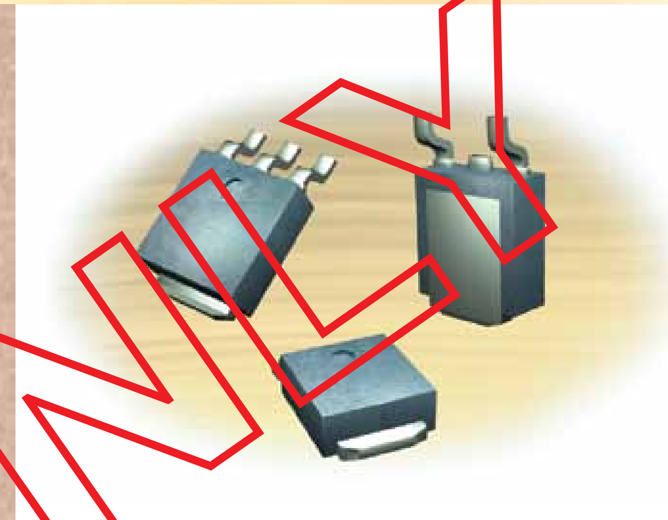
**Polarity:** None









## DPAK

**Description:** **DPAKs** are **D**iode **Pack**ages, which accommodate higher powered groups of transistors and diodes. D2PAKs are the largest surface mount transistor made and include a heat sink mounting pad. DPAKs have a termination on one side of the package, and 2 or 3 gull wings on the opposite side.

**Class Letter:** **Q** for transistor packages; **D** or **CR** for diode packages.

**Prefix:** None

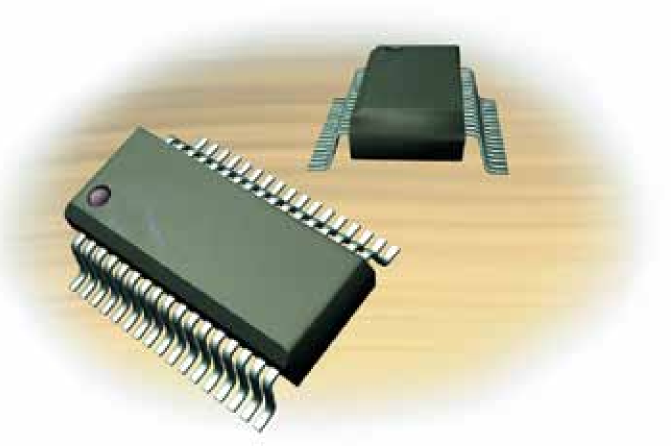
**Value Code:** Determined by package size.

**Tolerance:** None

**Orientation:** Determined by lead pattern.

**Polarity:** None

**Sizes:** SOTs and DPAKs are designed to fit the same footprint as their through hole cousins. For instance, a D2PAK is designed to fit the TO220 through hole transistor.



## *SOIC / SOP*

**Description:** **S**O**IC** stands for **S**mall **O**utline **I**ntegrated **C**ircuit, and **SOP** stands for **S**mall **O**utline **P**ackage. These two abbreviations are used interchangeably. The SOIC (SOP) family is made up of variety of dual in-line (leaded on 2 sides) rectangular body sizes, several lead pitches and lead styles. The SOIC started out in the English system (mil), but as the family grew and the pitches decreased from 50 mil, the new packages were standardized in the metric (mm) system. The number of leads on each package can change and the maximum is determined by the body length and the lead pitch. The actual individual SOIC package is referred to by its abbreviation which rarely includes an "IC" at the end. This makes for some confusion as the same package may be called by more than one name by different companies. For instance, a **SOL** and a **SOLIC** are both names for the same IC — a **S**mall **O**utline **L**arge **IC**.

**# of Pins:** 5-96

**Body Width:** Various

**Lead Type:** Gull Wing, J-lead, flat and I-lead

**Lead Pitch:** From 1.27 mm (50 mils) to 0.40 mm

**Class Letter:** U

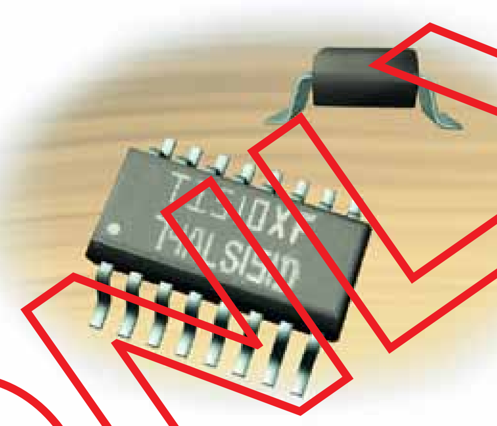
**Other:** IC or **AR**, **C**, **Q**, **R**, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.







## *SO*

**Description:** **SO** stands for **S**mall **O**utline. This is the original narrow body SOIC.

**# of Pins:** 4-16

**Body Width:** 49 mils (1.25 mm), 63 mils (1.60 mm), 154 mils (3.90 mm), 173 mils (440 mm)

**Lead Type:** Gull Wing

**Lead Pitch:** 50 mil (1.27 mm), 1.25 mm, 0.95 mm

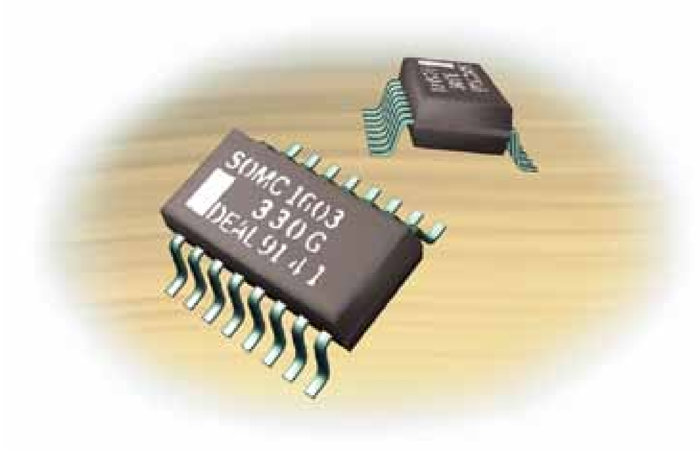
**Class Letter:** U

**Other:** IC or **AR**, **C**, **Q**, **R**, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.

**Polarity:** None



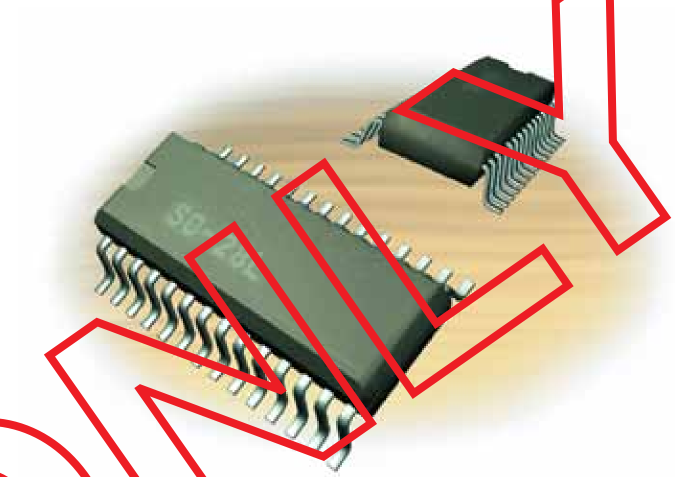

## *SOM*

**Description:** SOM stands for Small Outline Medium (body width). Commonly used for resistor networks.
**# of Pins:** 8-16
**Body Width:** 220 mils (5.60 mm)
**Lead Type:** Gull Wing
**Lead Pitch:** 50 mil (1.27 mm)
**Class Letter:** U
**Other:** IC or AR, C, Q, R, etc.
**Value:** None
**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.
**Polarity:** None









## *SOL / SOW*

**Description:** SOL stands for Small Outline Large, and SOW stands for Small Outline Wide. These two abbreviations are used interchangeably.
**# of Pins:** 14-70
**Body Width:** 209 mils (5.30 mm), 295 mils (7.50 mm), 300 mils (7.62 mm), 330 mils (8.40 mm), 350 mils (8.90 mm), 390 mils (9.90 mm), 440 mils (11.20 mm), 500 mils (12.70 mm), 525 mils (13.30 mm)
**Lead Type:** Gull Wing
**Lead Pitch:** 50 mil (1.27 mm), 1.00 mm, 0.80 mm
**Class Letter:** U
**Other:** IC or AR, C, Q, R, etc.
**Value:** None
**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.
**Polarity:** None

## SOJ / SOL-J

**Description:** SOJ stands for Small Outline J-lead and SOL-J stands for Small Outline Large- J-lead. These two abbreviations are used interchangeably.

**# of Pins:** 24-70

**Body Width:** 300 mils (7.62 mm), 350 mils (8.90 mm), 400 mils (10.16 mm), 500 mils (12.70 mm), 630 mils (16.00 mm)

**Lead Type:** J-lead

**Lead Pitch:** 50 mil (1.27 mm), 1.00 mm, 0.80 mm

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

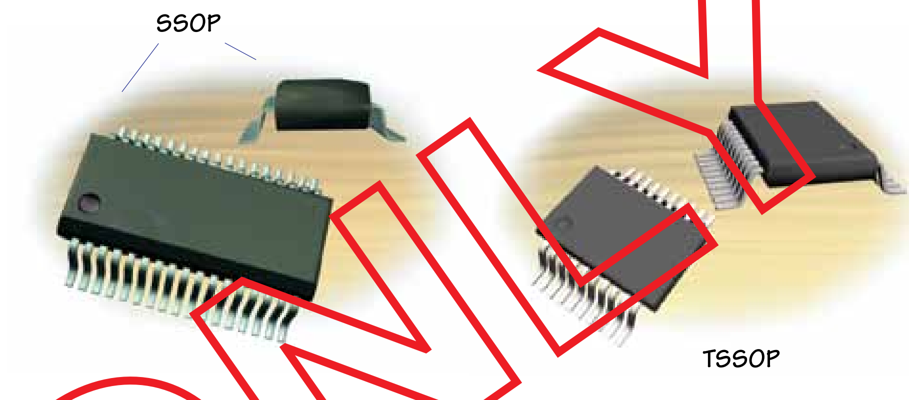
**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.

**Polarity:** None








## SSOP / VSOP / TSSOP

**Description:** SSOP — which stands for Shrink Small Outline Package — and VSOP — which stands for Very Small Outline Package — are used interchangeably. These are higher density (pitch) gull wing leads. TSSOP stands for Thin Shrink Small Outline Package. These packages are thinner versions of the SSOP where the package profiles are only allowed to have a total height of 1.00 mm

**# of Pins:** 8-68

**Body Width:** 154 mils (3.90 mm), 4.40 mm, 209 mils (5.30 mm), 6.10 mm, 8.00 mm

**Lead Type:** Gull Wing

**Lead Pitch:** 0.65 mm, 0.50 mm, 0.40 mm

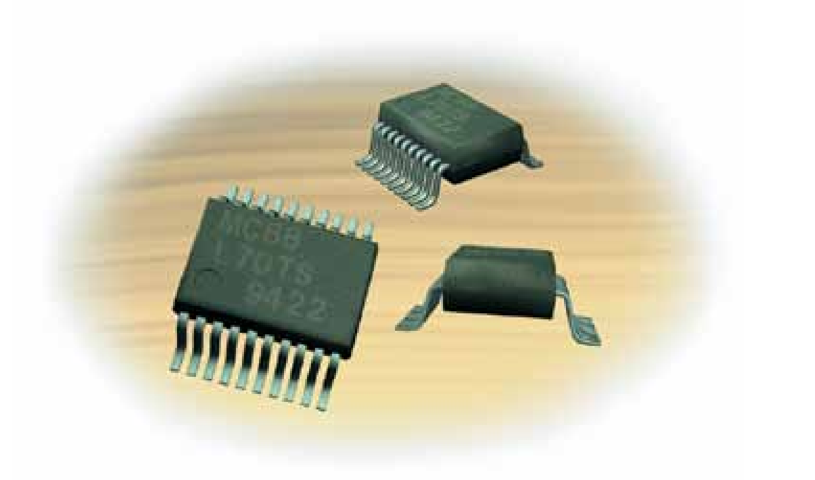
**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.

**Polarity:** None



## QSOP

**Description:** *QSOP* stands for **Q**uarter **S**mall **O**utline **P**ackage. This is the same as the **SO** except it only has 25 mil pitches instead of 50. These are higher density (pitch) gull wing leads.

**# of Pins:** 14-64

**Body Width:** 154 mils (3.90 mm), 300 mils (7.62 mm)

**Lead Type:** Gull Wing

**Lead Pitch:** 25 mils (0.65 mm)

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

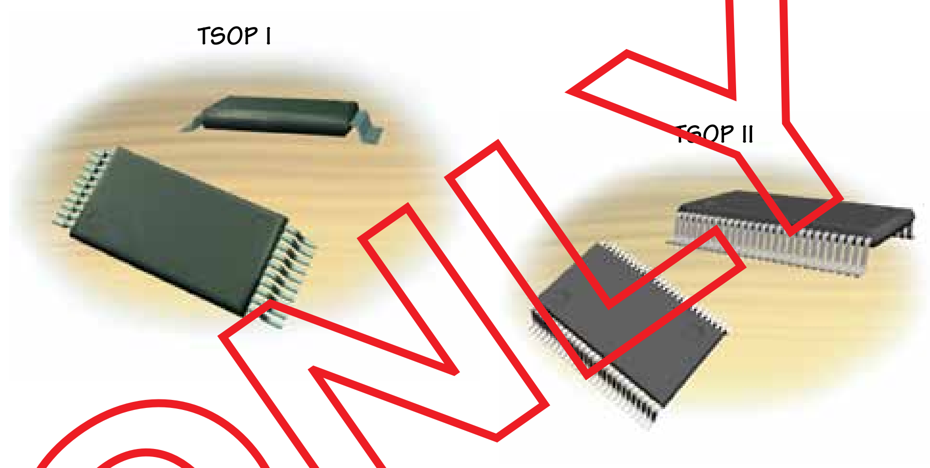
**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.

**Polarity:** None












## TSOP

**Description:** **TSOP** stands for **T**hin **S**mall **O**utline **P**ackage. They come in two types. The **Type I** package has leads on the short sides of the rectangular component. **Type II** has leads on the long sides, just like all other **SO** packages. TSOPs are typically used for memory applications, such as DRAM and Flash memory. These thin profile packages are only allowed to have a total height of 1.00 mm

**# of Pins:** Type I: 24-56, Type II: 20-100

**Body Width:** Type I: 6.00 mm, 8.00 mm, 10.00 mm, 12.00 mm, 14.00 mm

Type II: 300 mil (7.62 mm), 400 mil (10.16 mm), 500 mil (12.70 mm), 630 mil (16.00 mm)

**Lead Type:** Gull Wing

**Lead Pitch:** Type I: 0.50 mm and 0.55 mm

Type II: 1.27 mm, 0.80 mm, 0.65 mm, 0.50 mm, 0.40 mm

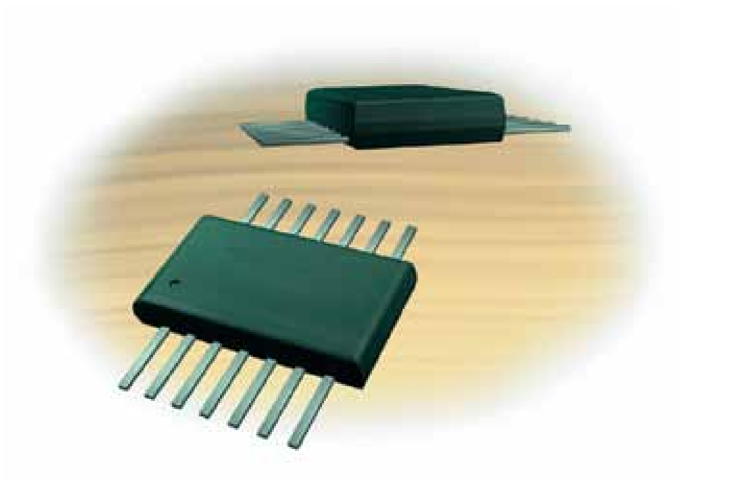
**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.

**Polarity:** None



## Flat Lead Small Outline and Quad Package

**Description:** Flat lead packages have leads that extend from the bottom plane of the component — normally from two sides — so they are most often Small Outline (SO). There are times when a Flat lead may have four sides (QUAD).

**# of Pins:** 4-28

**Body Width:** Various sizes, but the most popular are 209 mils (5.30 mm) or the 300 mils (7.62 mm) SO.

**Lead Type:** Flat

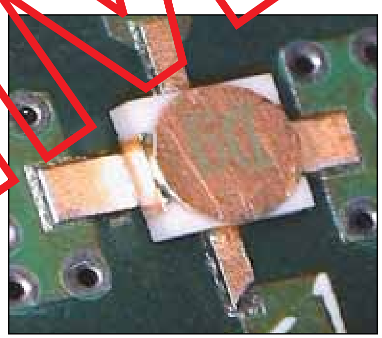
**Lead Pitch:** 50 mil (1.27 mm)

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.



Shown here is the Flat Lug Lead, another type of flat lead device.






## PLCC

**Description:** PLCC stands for Plastic Leaded Chip Carrier, which is a peripheral leaded QUAD family with J-bend type leads. The family has both square and rectangular configurations. PLCCs can either be put into sockets or soldered directly on to circuit boards. The ceramic version of this IC package is called a **CLCC** (**C**eramic **L**eaded **C**hip **C**arrier). This family is sometimes confused with **LCCC** (**L**eadless **C**eramic **C**hip **C**arrier) which is a leadless component

**Lead Type:** J-lead

**# of Pins:** Square: 20-100; Rectangular: 18-32

**Body Width:** Square: .390", .490", .690", .990", 1.190" & 1.300"
Rectangular: .322" x .462", .328" x .528", .390" x .590", & .490" x .590"

**Lead Pitch:** 50 mil (1.27 mm)

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.


## QFP / MQFP / FQFP / CQFP

**Description:** **QFP** stands for **Q**uad **F**lat **P**ack, **MQFP** stands for **M**etric **Q**uad **F**lat **P**ack, and **FQFP** stands for **F**ine **P**itch **Q**uad **F**lat Pack. This family was developed during the time that surface mount packages were evolving from English to Metric dimensioning. These are peripheral leaded QUAD (4-sided) packages with gull wing lead types that are all metric pitches. The family has both square and rectangular configurations. QFPs have higher lead counts than PLCCs and have finer pitches from a high of 1.00 mm to a low of 0.40 mm. MQFPs have pitches of 1.00 mm, 0.80 mm and 0.65 mm while FQFPs have pitches of 0.50mm and 0.40 mm. A ceramic body, internal multilayer version of the QFP is called a **CQFP**.

**# of Pins:** Square: 36-376; Rectangular: 64-128

**Body Width:** Square: 10, 12, 14, 20, 28, 32, 36 & 40 mm
Rectangular: 20 x 14 mm

**Lead Type:** Gull Wing

**Lead Pitch:** 1.00 mm, 0.80 mm, 0.65 mm, 0.50 mm and 0.40 mm

**Class Letter:** U

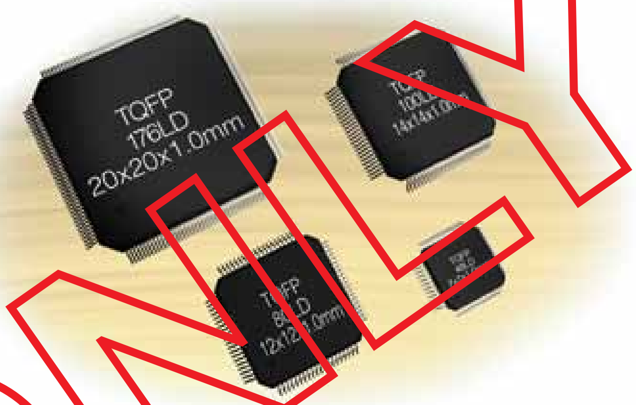
**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.








## LQFP / TQFP

**Description:** **L**QFP stands for **L**ow Profile (1.2 mm maximum) **Q**uad **F**lat **P**ack and **TQFP** stands for **T**hin Profile (1.00 mm maximum) **Q**uad **F**lat **P**ack. This family was developed during the time that surface mount packages were evolving from English to Metric dimensioning. These are peripheral leaded QUAD (4-sided) packages with gull wing lead types that are all metric pitches. The family has both square and rectangular configurations. The LQFP and TQFP share the same body sizes, pitches, and lead counts with the exception that the 28 x 28 mm bodies are only made using the LQFP body thickness.

**# of Pins:** Square: 20-256; Rectangular: 64-128

**Body Width:** Square: 4, 5, 7, 10, 12, 14, 20, 24, & 28 mm
Rectangular: 20 x 14 mm

**Lead Type:** Gull Wing

**Lead Pitch:** 1.00 mm, 0.80 mm, 0.65 mm, 0.50 mm and 0.40 mm

**Class Letter:** U

**Other:** **IC** or **AR**, **C**, **Q**, **R**, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silk screened at the pin one location.


## PQFP / BQFP

**Description:** **PQFP** stands for **P**lastic **Q**uad **F**lat **P**ack. The **PQFP** was the first QFP published by JEDEC as a package outline standard, and was a fine pitch gull wing version of a PLCC. The bumpers on the end of the package were there to add mechanical protection for the fine pitch gull wings during handling and assembly. Sometimes these packages were called **BQFP** which would have been **B**umpered **Q**uad **F**lat **P**ack. PQFPs are built with true inch measurements of their lead pitch. The 25 mil lead pitch version when converted to metric is .635, which is not a hard metric pitch and is not used in the industry. PQFPs are all square-bodied packages.

**# of Pins:** 44-132

**Body Width:** (Square): .390", .490", .690", .990" & 1.190"

**Lead Type:** Gull Wing

**Lead Pitch:** 25 mil

**Class Letter:** U

**Other:** IC or **AR**, **C**, **Q**, **R**, etc.

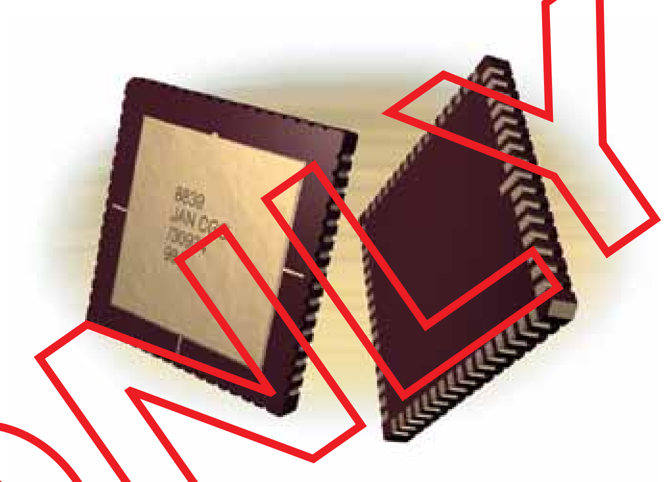
**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silkscreened at the pin one location.









## LCC / LCCC

**Description:** **LCC** stands for **L**eadless **C**hip **C**arrier which is a peripheral leadless Dual and Quad family with bottom terminal pads and edge castellations. The family has both square and rectangular configurations. LCCs can either be put into sockets or soldered directly on to circuit bonds. They are most commonly used in aerospace, flight, military and other high reliability applications. The ceramic version of this IC package is called a **LCCC** (**L**eadless **C**eramic **C**hip **C**arrier).

**# of Pins:** Square: 16-304; Rectangular: 4-32

**Body Width:** Square: .300", .350", .400", .450", .560", .650", .750", .950", 1.150", 1.350", 1.650", & 2.050";
Rectangular: .150" x .220", .170" x .245", .290"x .500", .290" x .425", .450" X.550", .350" x .550", .285" x .350", and .285" x .425"

**Lead Type:** Solderable bottom terminal pads and castellations.*

**Lead Pitch:** Square: 50 mil (1.27 mm), 40 mil (1.02 mm), 25 mil (.635mm) and 20 mil (.508 mm); Rectangular: 50 mil (1.27 mm)

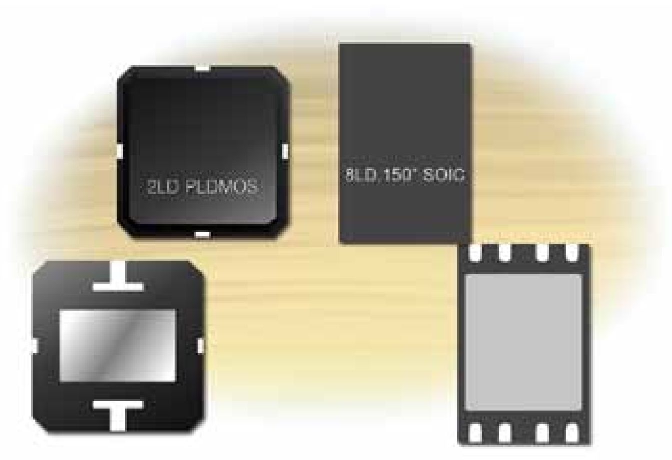
**Class Letter:** U

**Other:** IC or **AR**, **C**, **Q**, **R**, etc.

**Value:** None

**Orientation:** Terminals or castellations are counted counterclockwise from number one. The PCB often has a square silkscreened at the number one location.

***See bottom of page 4.**




## DFN

**Description:** DFN stands for Dual Flat No lead, which are peripheral leadless dual packages with bottom terminal pads and possible edge castellations. The family has both square and rectangular configurations. DFNs are intended to be soldered directly on to circuit boards. Reference marketing names include **MLF** and **MLP**.

**# of Pins:** Square: 2-18; Rectangular: 4-28

**Body Width:** Square: 1.50 mm, 2.00 mm, 3.00 mm, 4.00 mm & 5.00 mm; Rectangular: Numerous sizes from as small as 1.50 x 1.00 mm to as large as 10.00 x 15.00 mm

**Lead Type:** Solderable bottom terminal pads.

**Lead Pitch:** Square: 0.95 mm, 0.80 mm, 0.65 mm, and 0.50 mm

**Class Letter:** U

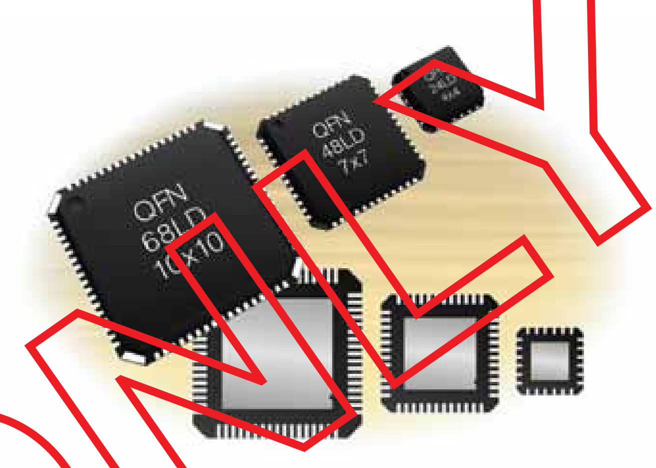
**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silk screened at the pin one location.








## QFN

**Description:** QFN stands for Quad Flat No lead which are peripheral single row leadless quad packages with bottom terminal pads and possible edge castellations. The family has both square and rectangular configurations. QFNs are intended to be soldered directly on to circuit boards. Reference marketing names include **MLF** and **MLP**.

**# of Pins:** Square: 4-108; Rectangular: 8-40

**Body Width:** Square: 2.00 mm, 3.00 mm, 3.50 mm, 4.00 mm, 5.00 mm, 6.00 mm 7.00 mm, 8.00 mm, 9.00 mm, 10.00 mm and 12.00 mm; Rectangular: Numerous sizes from as small as 3.50 x 4.50 mm to as large as 7.00 x 9.00 mm

**Lead Type:** Solderable bottom terminal pads.

**Lead Pitch:** Square: 0.80 mm, 0.65 mm, 0.50 mm and 0.40 mm

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one lead, or an end notch or stripe on the IC. Leads are counted counterclockwise from the number one lead. The PCB often has a square silk screened at the pin one location.


## *QFN / Multiple Rows*

**Description:** **Q**FN stands for **Q**uad **F**lat **N**o lead and sometimes has multiple rows, which are peripheral two or three row leadless quad packages with bottom terminal pads and the outer row having possible edge castellations. These packages were created to take advantage of the QFN technology, but the applications required larger pin counts therefore additional rows where added. The family currently has square configurations. QFNs are intended to be soldered directly on to circuit boards. Reference marketing names include **MLF** and **MLP**.

**# of Pins:** 44-396

**Body Width:** Square: 5.00 mm, 6.00 mm, 7.00 mm, 8.00 mm, 9.00 mm, 10.00 mm, 11.00 mm, 12.00 mm, 13.00 mm, 14.00 mm and 15.00 mm

**Lead Type:** Solderable bottom terminal pads

**Lead Pitch:** 0.65 mm, 0.50 mm and 0.40 mm

**Class Letter:** U

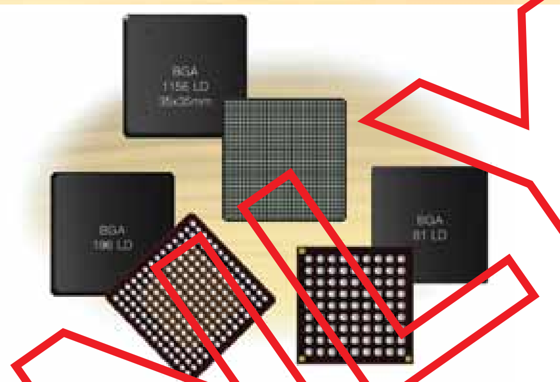
**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one pad, or an end notch or stripe on the IC. Terminal pads are counted counterclockwise from the number one lead. The PCB often has a square silk screened at the lead one location.








## *BGA / CBGA / PBGA / CCGA / LGA*

**Description:** **BGA** stands for **B**all **G**rid **A**rray, which is an array family with balls as the bottom terminations. When the BGA has a ceramic substrate, it is called a **C**eramic **B**all **G**rid **A**rray (**CBGA**). When the BGA has a tape or laminate substrate, it is called a **P**lastic **B**all **G**rid **A**rray (**PBGA**). When a **C**eramic Grid Array has Columns rather than balls, it is called a **C**eramic **C**olumn **G**rid **A**rray (**CCGA**). When a BGA or CGA is sold without balls or columns attached, it is called a **L**and **G**rid **A**rray (**LGA**). The families have both square and rectangular configurations. All BGAs, CGAs and LGAs can either be put into sockets or soldered directly on to ciruict boards.

**# of Pins:** Ball or Ball Land: Square: 9-2404; Rectangular: 119-744; Column or Column Land: Square: 225-2916; Rectangular: 300-1230

**Body Width:** Ball or Ball Land: Square from 7.00 mm to 50.00 mm; Rectangular: from 10.00 mm x 18.00 mm to 25.00 x 32.50 mm; Column or Column Land: Square from 25.00 mm to 45.00 mm; Rectangular: from 25.00 mm x 32.50 mm to 32.50 mm x 42.50 mm

**Lead Type:** Solderable ball or lands.

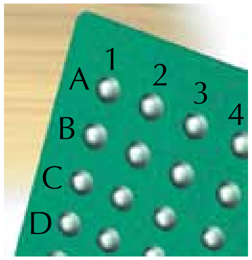
**Lead Pitch:** 1.50 mm, 1.27 mm (50 mil) and 1.00 mm

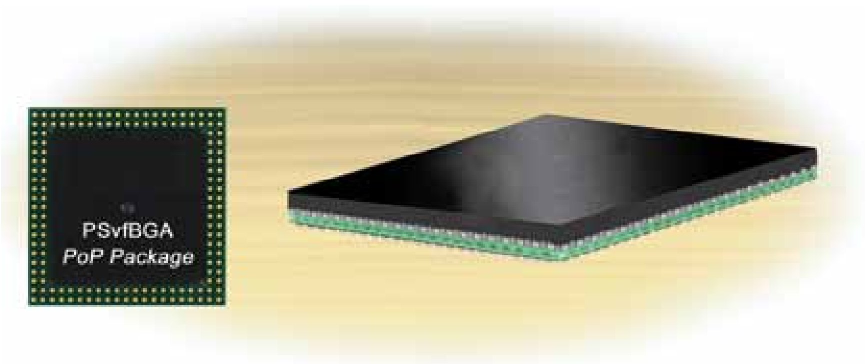
**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the A1 lead, or an end notch or stripe on the IC. Leads are counted using a grid system, starting with the A1 lead. The PCB often has a square silkscreened at the A1 location.






## PoP

**Description:** PoP stands for Package on Package. This packaging concept was developed to provide flexibility to meet the increasing challenges for size and cost reduction while increasing signal processing performance and memory capabilities. The PoP in it simplest form has a bottom package which is normally the logic package and the upper package contains the memory components. The bottom package is a FBGA with FBGA lands on the top side. The top package is a FBGA with balls that are intended to be mounted to the bottom package top side lands. The PoP maybe shipped completed with the two package assembled or shipped separately and assembled at the final manufacturing location. All PoPs can either be put into sockets or soldered directly on to circuit boards.

**# of Pins:** Bottom Ball or Ball Land (Bottom Package) from 304-841; Top Ball Land (Bottom Package) and Ball Top Package: from 96-216

**Body Width:** 10.00 mm, 11.00 mm, 12.00 mm, 13.00 mm, 14.00 mm and 15.00 mm

**Lead Type:** Solderable ball or lands.

**Lead Pitch:** Bottom Ball or Ball Land (Bottom Package) 0.50 mm; Top Ball Land (Bottom Package) and Ball Top Package: 0.80 mm, 0.65 mm and 0.50 mm

**Class Letter:** U

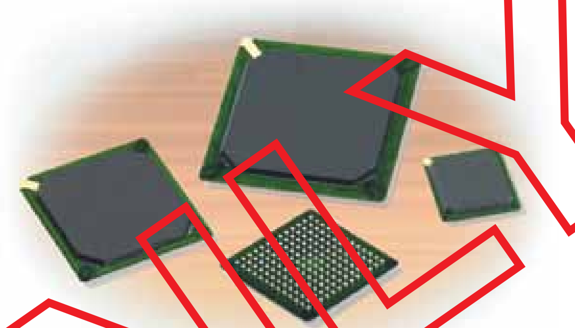
**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the A1 lead, or an end notch or stripe on the IC. Leads are counted using a grid system, starting with the A1 lead. The PCB often has a square silkscreened at the A1 location.







## CSP / FBGA / DSBGA / FLGA / DSLGA

**Description:** CSP stands for Chip Scale Package, which is an array with balls or lands as the bottom terminations. A CSP is intended to be the actual component die size or no more than 1.2 times larger than the component die size. The CSP has four different package styles in the family.

**FBGA** is a **F**ine **P**itch **B**all **G**rid **A**rray whose body size (length and width) is defined without regard to a specific die size. The body dimensions are intended to accommodate assembly of die with various sizes, and usually will not change as a result of future die shrinks for a specific device function. It is fine pitch so they are packages with pitches below 1.00 mm.

**DSBGA** is a **D**ie **S**ize **B**all **G**rid **A**rray is whose body size is defined to coincide as closely as possible with a specific die size. This package is sometimes called a “real chip-size” BGA or CSP. The dimensions of the package body accommodate assembly only of a die with a specific size, and these body dimensions will normally change as a result of future changes in die size. It is fine pitch so they are packages with pitches below 1.00 mm.

**FLGA** is a **F**ine **P**itch **L**and **G**rid **A**rray, which has the same characteristics as a FBGA, except the balls are removed and it is shipped with lands as the termination.

**DSLGA** is a **D**ie **S**ize **L**and **G**rid **A**rray, which has the same characteristics as a DSBGA, except it has lands as the termination instead of balls.

The families have both square and rectangular configurations. All FBGAs, DSBGAs, FLGAs and DSLGAs can either be put into sockets or soldered directly on to circuit boards.

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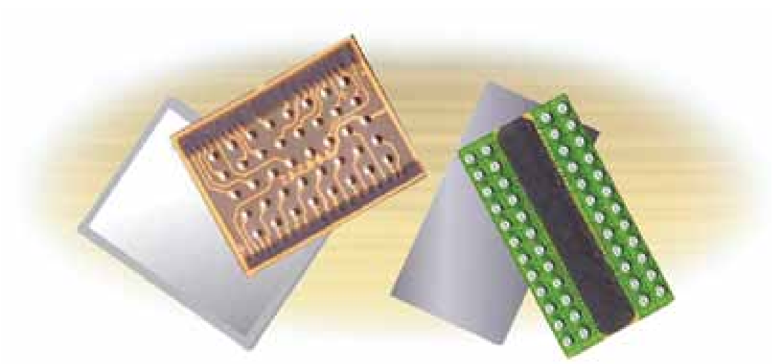


## CSP / FBGA / DSBGA / FLGA / DSLGA *(continued)*

**# of Pins:** FBGA (ball) or FLGA (lands): Square: 9-1681; Rectangular: 54-425; DSBGA (ball) or DSLGA (lands): Rectangular: 4-96

**Body Width:** FBGA (ball) or FLGA (lands): Square 2.00 mm to 22.00 mm; Rectangular: from 5.50 mm x 13.00 mm to 9.00 mm x 13.00 mm; DSBGA (ball) or DSLGA (lands): Rectangular: 0.95 mm x 1.35 mm to 12.50 mm to 21.00 mm

**Lead Type:** Solderable ball or lands.

**Lead Pitch:** FBGA (ball) or FLGA (lands): 0.80 mm, 0.65 mm and 0.50 mm; DSBGA (ball) or DSLGA (lands): 0.80 mm, 0.75 mm, 0.65 mm, 0.50 mm and 0.40 mm

**Class Letter:** U

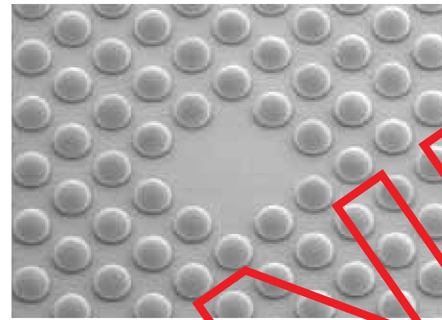
**Other:** IC or AR, C, Q, R, etc.

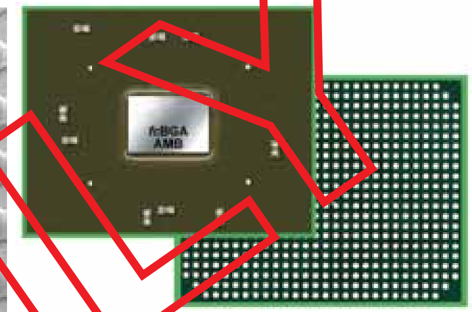
**Value:** None

**Orientation:** Indicated by a dot or a beveled edge over the number one termination, or an end notch or stripe on the IC. Terminations are counted counterclockwise from the number one position. The PCB often has a square silk screened at the number one location.










## COB / Bare Die / Flip Chip

**Description:** **C**OB stands for **C**hip **O**n **B**oard which is an array area or peripheral component chip that is mounted and connected directly to the PC board. The two main types to this family are Bare Die and Flip Chip.

**Bare Die** is a component chip that was designed to be wire bonded into a component package. Instead of packaging the chip, it is die attached (chip pads up) directly to the circuit board and then wire bonded from the chip to the board to provide electrical connection. The wire bonded die is then encapsulated by glob topping the die and wires with a protective material. This process could be as simple as one single chip, or as complex as a "stacked die" combination as shown. The application and the pitch of the chip pads will determine the complexity of the process and the accuracy of the mounting / wire bonding equipment required.

**Flip Chip** is a chip that was designed to be directly attached to a package substrate and finished as a component package. The package is normally a Plastic Ball Grid Array (BGA) type package. The chips are made of two different types. One is designed from the beginning as a flip chip with the terminations coming directly from the Flip Chip balls, bumps or lands. The second type is a wire bonded chip that is changed by adding layers to redistribute the chip pads to create a Flip Chip pattern. Both the Flip Chip types have a wide variety of ball, bump and land metallurgies depending on the end application.

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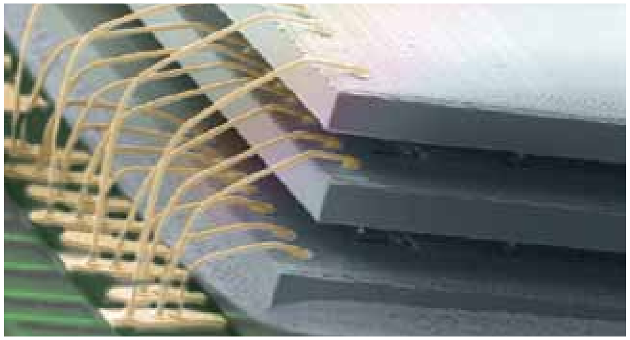


3-Die Stack

## COB / Bare Die / Flip Chip *(continued)*

The two types of Flip Chips come in both array area and peripheral patterns. Instead of packaging the Flip Chip, it is inverted and directly attached to the circuit board. The mounted Flip Chip is then under filled and encapsulated by glob topping. The application and the pitch of the Flip Chip pattern will determine the complexity of the process and the accuracy of the mounting / bonding equipment required. It is possible that the COB application would require the use of both Bare Die and Flip Chip component chips.

**# of Chip Pads:** 4-3000

**Lead Type:** Balls, bumps or lands.

**Chip Connection Pitch:** Bare Die: Single row peripheral 30 microns minimum, Dual or Triple row peripheral 35 microns minimum; Flip Chip: Single row peripheral 30 microns minimum, area array 120 microns minimum

**Class Letter:** U

**Other:** IC or AR, C, Q, R, etc.

**Value:** None

**Orientation:** Bare Die or Flip Chip termination #1 is indicated chip. Chip pads are counted counterclockwise from the number one pad. The PCB often has a square silk screened at the pin one location.





Many components use color bands or number codes to specify value and tolerance. You may see these component values abbreviated.

For example, a **2,000 Ω** resistor is often identified as **2K Ω** — with the letter **K** representing one thousand. Similarly, a **5,000,000 Ω** resistor may be abbreviated as **5M Ω** — with the letter **M** representing one million.


## Axial Resistor Values

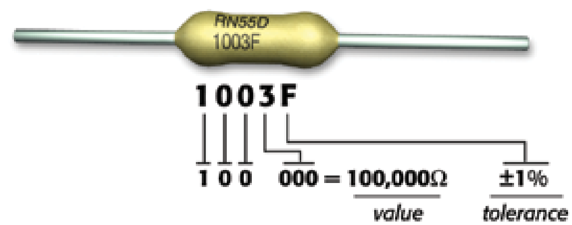
The value of a resistor is expressed in a unit of electrical resistance called ohms (Ω).

Axial resistors will often have 4 or 5 color bands which are "read" using a **Resistor Band Color Code Chart**, **page 71**.

Axial resistors will sometimes have their wattage and tolerance values printed on them in number codes.

### Numbered Resistors

The example below shows how to read the value and tolerance when a number and letter code system is used. You are provided with the value and multiplier numbers, such as the **1003** example where the **100** is attached to **3** zeros to equal **100,000Ω**




**Tolerance Letter Codes**

Tolerance is shown with letters using these codes:

| |
|---|
| **F = ±1%** |
| G = ±2% |
| J = ±5% |
| K = ±10% |
| M = ±20% |
| Z = +80/-20% |

## 4-band Resistors

**Value Bands:** The first two color bands on 4-band resistors are read as actual numbers.

**Multiplier Band:** The third band on 4-band resistors is called a multiplier, or "decade" band because that color's number on the color chart shows how many zeros to add to the end of the numbers from the first two bands.

**Tolerance Band:** The last band is the tolerance, or the range of actual value above or blow the calculated resistance in Ohms.

## 5-band Resistors

**Value Bands:** The first three color bands on 5-band resistors are read as actual numbers.

**Multiplier Band:** The fourth band on 5-band resistors is the multiplier band or "decade" band because that color's number on the color chart shows how many zeros to add to the end of the numbers from the first three bands.

**Tolerance Band:** The last band is the tolerance.

**Military 5-Band:** A fifth, white band in a military 5-band resistor means that the resistor has Military Solderable Leads. Ignore the fifth band, and read as a 4-band resistor. They function the same as a 5-band resistor.

## 6-Band Resistors

There are also 6-band resistors. They function the same as a regular 5-band resistor, but have an extra, 6th band that is the temperature coefficient. This rates the relative change of resistance as the temperature varies —measured in parts per million per degree centigrade (PPM/C). Brown is the most common color designation (at 100 PPM/C), and will work fine for typical operating environments. Other values are intended for extreme or critical temperature applications.

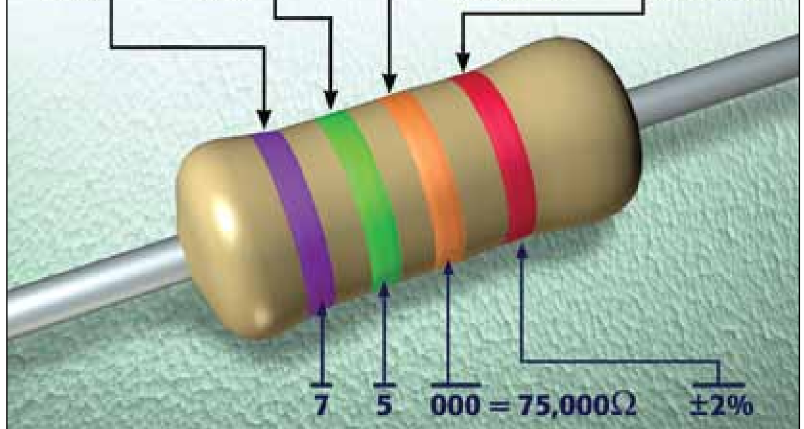
> NOTE:
> **If there is any confusion as to how to read specific component color bands, or if you have trouble distinguishing between value, multiplier and tolerance color bands, contact the component vendor for clarification.**





## RESISTOR Band Color Codes

| 4 - BAND: Band 1 VALUE | Band 2 VALUE | Band 3 MULTIPLIER | Band 4 TOLERANCE |
|---|---|---|---|
| **5 - BAND: Band 1 VALUE** | **Bands 2 & 3 VALUE** | **Band 4 MULTIPLIER** | **Band 5 TOLERANCE** |
| | BLACK 0 | BLACK x1 or no zeros | |
| BROWN 1 | BROWN 1 | BROWN x10 or +1 zero | BROWN ±1% |
| RED 2 | RED 2 | RED x100 or +2 zeros | RED ±2% |
| ORANGE 3 | ORANGE 3 | ORANGE x1k or +3 zeros | |
| YELLOW 4 | YELLOW 4 | YELLOW x10k or +4 zeros | |
| GREEN 5 | GREEN 5 | GREEN x100k or +5 zeros | GREEN ±.5% |
| BLUE 6 | BLUE 6 | BLUE x1M or +6 zeros | BLUE ±.25% |
| VIOLET 7 | VIOLET 7 | | VIOLET ±.1% |
| GREY 8 | GREY 8 | GOLD x.1 | GOLD ±5% |
| WHITE 9 | WHITE 9 | SILVER x.01 | SILVER ±10% |
| VALUE | VALUE | MULTIPLIER | TOLERANCE |



## Capacitor Values

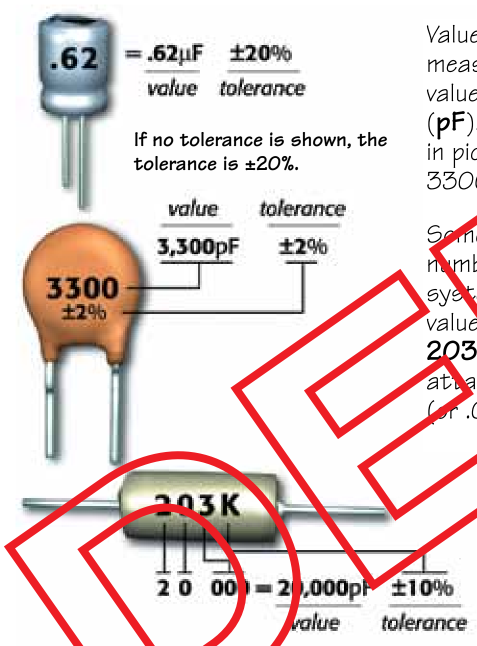
The value of a capacitor is expressed in a unit of electrical capacitance called farads. A capacitor will have the value and tolerance marked on its body. There are three units of measurement for capacitors, using farads:

- picofarads **pF**, The smallest unit of measurement.
- nanofarads **nF**, The middle range unit of measurement.
- microfarad **µF**, The largest unit of measurement.

The values on capacitors are usually printed in picofarads. The chart below will help you convert from picofarads to nanofarads to microfarad:

| picofarads — pF | | nanofarads — nF | | microfarad — µF |
|---|---|---|---|---|
| 100,000,000 | = | 100,000 | = | 100 |
| 10,000,000 | = | 10,000 | = | 10 |
| 1,000,000 | = | 1,000 | = | 1 |
| 100,000 | = | 100 | = | .1 |
| 10,000 | = | 10 | = | .01 |
| 1,000 | = | 1 | = | .001 |
| 100 | = | .1 | = | .0001 |
| 10 | = | .01 | = | .00001 |
| 1 | = | .001 | = | .000001 |
| .1 | = | .0001 | = | .0000001 |

## Numbered Capacitors




Values beginning with a decimal are usually measured in microfarads (**µF**), all other values are assumed to be in picofarads (**pF**). Four-digit values are also measured in picofarads, but without a multiplier. (see 3300 cap shown left).

Some capacitors are coded with a three-digit number which is similar to the color-band system, except you are provided with the value and multiplier numbers, such as the **203** example below where the **2** and **0** are attached to **3** zeros to equal **20,000 pF** (or .02 **µF**).

**Tolerance Letter Codes**

Tolerance is shown with letters using these codes:

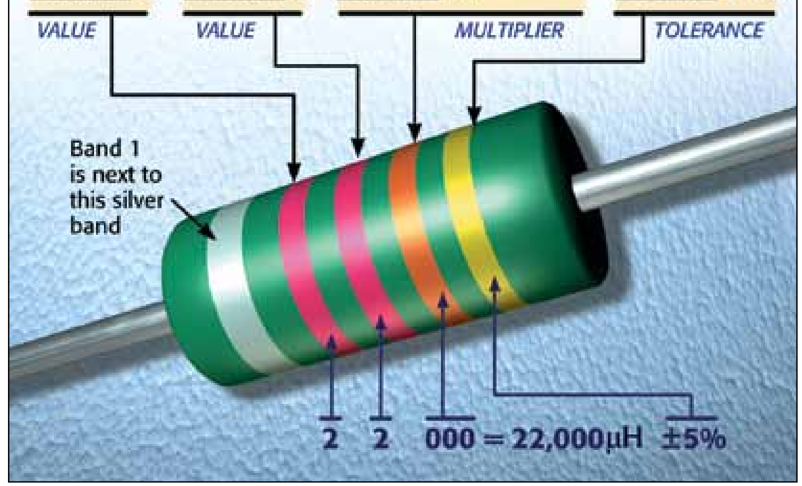
| |
|---|
| F = ±1% |
| G = ±2% |
| J = ±5% |
| **K = ±10%** |
| M = ±20% |
| Z = +80% / -20% |





## INDUCTOR Band Color Codes

| Band 1 VALUE | | Band 2 VALUE | | Band 3 MULTIPLIER | | Band 4 TOLERANCE | |
|---|---|---|---|---|---|---|---|
| | | BLACK | 0 | BLACK | x1 or no zeros | | |
| BROWN | 1 | BROWN | 1 | BROWN | x10 or +1 zero | BROWN | ±1% |
| RED | 2 | RED | 2 | RED | x100 or +2 zeros | RED | ±2% |
| ORANGE | 3 | ORANGE | 3 | ORANGE | x1k or +3 zeros | | |
| YELLOW | 4 | YELLOW | 4 | YELLOW | x10k or +4 zeros | | |
| GREEN | 5 | GREEN | 5 | GREEN | x100k or +5 zeros | GREEN | ±.5% |
| BLUE | 6 | BLUE | 6 | BLUE | x1M or +6 zeros | BLUE | ±.25% |
| VIOLET | 7 | VIOLET | 7 | | | VIOLET | ±.1% |
| GREY | 8 | GREY | 8 | GOLD | x.1 | GOLD | ±5% |
| WHITE | 9 | WHITE | 9 | SILVER | x.01 | SILVER | ±10% |




Inductors are valued in microhenries. The symbol for microhenries is µH. The value for an inductor may be printed on the component body, or it may be printed with color bands, much in the same way as a resistor.

This training & reference guide does not take precedence over, or replace in any way, the requirements in any IPC Standard or Specification. This guide is intended for use as an illustrated support document to assist in the training of component identification.

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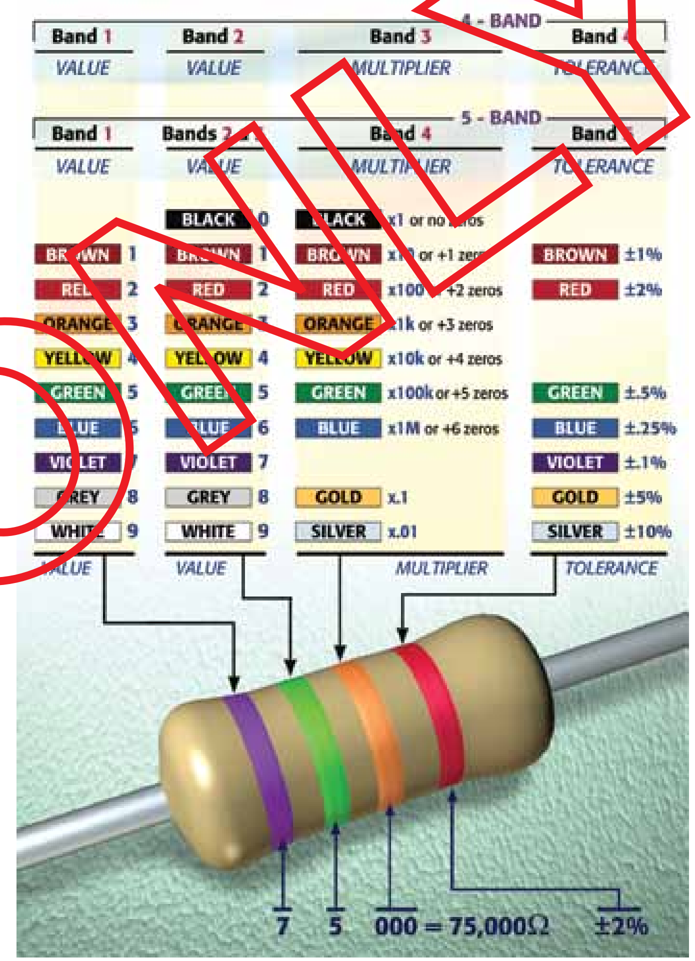
revision F - 8/01 - 5m
revision E - 8/00 - 5m
revision D - 7/99 - 5m
revision C - 7/98 - 5m
revision B - 2/97 - 5m
revision A - 4/96 - 5m
1st printing - 9/95 - 1m


## Resistor Color Code Chart

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