

Choosing Transistor Replacements

When repairing a circuit, or even building a new one it is often not possible to find an exact [electronics component](#) - we tell you how to choose a suitable replacement. [Circuit design software](#)

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Transistor Tutorial Includes:

• [basics](#) [Gain: Hfe, hfe & Beta](#) [Transistor specifications](#) [BJT Early Effect](#) [Transistor and diode](#)
 • [g codes](#) [Choosing replacement transistors](#)

• [component data](#): [Transistor component data](#)

Working with electronics equipment, either in electronics circuit design, build or repair, it is sometimes necessary to choose a replacement transistor. Either the type of transistor may not be to hand, or it may not be

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Usually it is normally possible to use a replacement transistor type as there is often a considerable degree of overlap between the specifications of different types of transistor, and by looking at the basic specifications it is possible to choose the correct transistor replacements.

Attention is focussed on bipolar transistors, but it is possible to apply similar logic to other electronic components including field effect transistors to ensure that suitable replacements can be found.



BC547 Plastic leaded transistor

When looking for suitable transistor replacements it is necessary to look at the main specifications for the transistor. Once transistor specifications and parameters have been ascertained, it is possible to check for other different transistor types with similar parameters that will be able to operate within the circuit in question.

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When considering any possible replacement transistors, it is necessary to look at a variety of parameters that affect the operation of the transistor. These will include the basic parameters of the transistor operation and its performance.

It is necessary to look at the environmentally related parameters like the temperature range and the like as these are very important in many instances.

Physical factors like size and package are also very important. With many transistors being available as leaded as well as surface mount devices, these aspects can be very important.

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Fact of the day: It was in this month in 1916 that W Schottky in Germany described the principle of the superhet radio as a powerful and selective amplifier. He never made the receiver to prove his idea and was beaten to this goal by Edwin Armstrong. Also on this day in 1923, Charles Jenkins, an inventor from Dayton, Ohio, who invented a mechanical television system called radiovision and claimed to have transmitted the earliest moving silhouette images.

Quote: *Science can purify religion from error and superstition. Religion can purify science from idolatry and false absolutes.* Pope John Paul II (Karol Wojtyla)

Point to ponder: A photon that takes eight minutes to travel from the Sun to Earth took 100,000 years to get from the centre to the surface of the Sun.

When making a choice about a replacement transistor, it is necessary to take all the various factors into consideration to ensure a new electronic component fits and performs within the electronic circuit design.

Working at the basic transistor parameters

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Many transistors used in electronic circuit design are general purpose types. Their specifications are not very exacting and a variety of general purpose transistors could be used. Today, the performance of even general purpose transistors is exceedingly high and they can be used in a variety of applications.

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A much closer look must be taken at transistors that fulfil a more exacting role. Their specifications need to be checked more closely to ensure that any substitutes will have a similar specification.

When looking for a suitable transistor replacement some of the basic transistor parameters that need to be checked include the following:

Conductor material used: Most transistors will either be germanium or silicon. Other types are normally reserved in very specialist applications.

It is important to know what type the transistor is because there is a difference in the base emitter forward bias voltage drop. For germanium it is around 0.2 - 0.3 volts and for silicon it is around 0.6 volts. The circuit will be designed around a particular voltage drop.

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Transistor type: It is absolutely imperative to find out whether the transistor is either NPN or PNP variety. Install the correct type and it will experience the inverse of all the voltages it would expect and is likely to be destroyed.

Transistor application: Although it is not always necessary to exactly match the intended purpose for the transistor, a variety of areas of its performance will be tailored to its intended applications.

Some application types may include: switching, analogue, low power, RF amplifier, low noise, etc. Put in the correct type and it may not perform well. For example a low power general-purpose transistor is unlikely to work in a switching application even if it has a high current or frequency limit.

Package and pin-out: Transistors have many packages. It is often necessary to match the replacement transistor package as closely as possible to enable the transistor to physically fit. Also the package may give an indication of other parameters.

Power dissipation breakdown: It is necessary to make sure that the transistor is able to withstand the voltages it is likely to experience. Transistor parameters such as V_{ce} , etc need to be checked.

Current gain: The current gain parameter of a transistor normally has a very wide spread. This is normally specified as β or h_{fe} . Although they are slightly different, for all circuit equivalences of this nature these transistor parameters are the same.

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When making a replacement transistor with approximately the same current gain is necessary. Normally it is not a problem to choose a replacement transistor with a higher gain. Often a lower current gain may be acceptable.

Frequency limit: The upper frequency limit for a transistor is normally quoted as its f_t . It is normally important to ensure that the transistor can meet any frequency limits.

Power dissipation: It is necessary to ensure that the replacement transistor can dissipate sufficient power. The package type is a good indication of this.

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QUIZZLY

Take a quick quiz about this page:

What are the main factors to consider when choosing a replacement transistor?

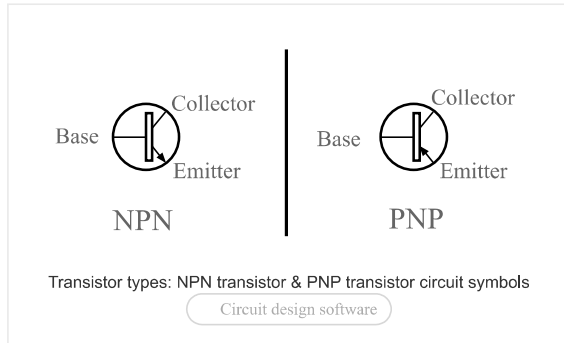
- ☐ Size and package
- ☐ Temperature range
- ☐ Basic transistor parameters
- ☐ All of the above

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are the main parameters that are of importance in most applications, but be on the look out for any other parameters that may need to be included in the selection of the replacement transistor.



Choosing a replacement transistor

Choosing a suitable replacement transistor for use within an electronic circuit, there are several stages that are considered when making the choice. These can be progressed in a logical order to narrow down the choice to the best alternative for the replacement transistor to be made.

Step by step instructions:

Choose a transistor of the same polarity: The first major selection criterion is whether the transistor is PNP or

Choose a replacement transistor of the same material: Most transistors are either silicon or germanium. As technologies and other features are different it is necessary to select a replacement transistor with the same material.

Choose the same functional type of transistor: Transistors are normally given an indication of their application in datasheets. The replacement should have the same application if possible.

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Choose a replacement with the same package: Choosing a replacement transistor with the same package pin-out will facilitate much easier replacement. Differences in the package for small signal transistors is not usually an issue, but for larger ones where there may be heatsinks, etc involved, different packages can cause significant issues.

Where the pin connections are different, care should be taken to ensure that the right pins are taken the right connections. For many transistors the pinout is EBC, but there are other configurations for the pinout that can trap many people.

Choose a replacement transistor with the same breakdown voltage: Ensure that figures for V_{CE0} and V_{CBO} are at least as high as the original transistor.

Choose it can take the current: Ensure that the replacement transistor can pass the required current - it should have an I_{Cmax} greater than or equal to the original transistor.

Choose a transistor with a similar H_{fe} : It is necessary to ensure that the current gain of the replacement transistor is about the same as the original. Current gain values normally vary widely even for transistors of the type so some variation will be acceptable.

Choose a replacement transistor with equivalent F_t : It is necessary to ensure that the replacement transistor is able to operate at the relevant frequencies, so a similar or slightly higher F_t is advisable. Don't go for a transistor with a much higher F_t as this may increase the risk of oscillation.

Choose a transistor with a similar power dissipation : It is necessary to ensure that the replacement transistor can handle the power that it will dissipate within the circuit. Choosing a replacement transistor with a similar package style will often mean that both transistors have a similar power dissipation.

Check for any special features: While ensuring the features above are selected, there may be some additional features that need to be considered. These are normally required when transistors are used in specialist applications.

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Once a choice of replacement transistor has been made, then it can be installed in the circuit, and the performance should be checked. In most cases it will operate satisfactorily, but occasionally there may be a problem. If this is the case, it is

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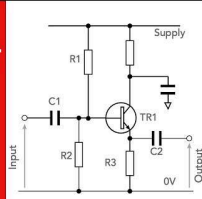
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try to re-visit the way in which the choice of the replacement transistor was made and see if any mistakes have been made or look for other parameters that may affect the operation of the transistor circuit.

covers it.

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What if I can't find the original transistor details?

It is very easy to find out the parameters of a particular transistor as it may be possible to find them on the transistor in a transistor data book. If this is not possible, either because the markings are not visible, or the data is lost, then not all is lost.

It is possible to find out a lot about the transistor from its package and also the circuit in which it is being used. In many cases it is usually possible to find a suitable replacement transistor. The step by step instructions below should help you to find the parameters of the transistor to be discovered. [Circuit design software](#)

Step by step instructions:

The instructions are set out in an approximate order of the most significant parameters first followed by the less significant ones:

Transistor type? This may appear to be an obvious question, but occasionally some devices may appear to be a transistor at first sight. It may be a field effect transistor, a Darlington transistor or even some other form of transistor. Alternatively, sometimes small voltage regulators are contained in packages similar to that of a transistor. Some devices may also appear in what may appear to be transistor packages at first sight. Careful examination of the package will enable this to be verified.

Silicon or germanium: It is important to find out whether the transistor is silicon or germanium. It may be possible to discover this in a number of ways. If the original transistor is still working then this can be discovered by measuring the voltage across the base emitter junction when it is forward biased. This should be about 0.2 volts for a germanium transistor and 0.6 volts for other varieties. Alternatively it may be possible to ascertain the type by looking at other transistors in the circuit. Often the same technology will be used throughout the circuit. This is not always true so beware!

Power dissipation: This is often defined by the package in which the transistor is placed. Look at the packages for other transistors in the same packages and this will give a good guide. Those packages designed for mounting on heatsinks will be more variable because they can often dissipate more power dependent upon the heatsink. It is best to be more cautious with these packages.

Maximum voltage: An idea of the maximum voltage can be gained from the circuit in which it is used. To be on the safe side, ensure the maximum operating voltage of the replacement transistor is at least twice the rail voltage of the circuit in which it is operating.

Current gain: The current gain of transistors is notoriously difficult to specify. High power transistors often offer gains - older power transistor types may be as low as 20 - 50, whereas the smaller transistors may offer anywhere between 50 and 1000.

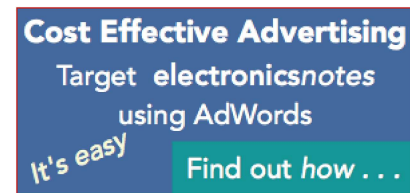
Maximum frequency: It is necessary to make sure that the replacement transistor is able to operate at the required frequency. Look at the components in the circuit and the function of the circuit. It is usually possible to estimate the frequency of operation. Then take this and choose a replacement transistor that can easily operate at the required frequency.

Anything else: Although most of the main points have been covered in the points above, it is always best to be on the look out for other parameters that may affect the choice of transistor replacement. This is particularly true for specialised circuits where some specific performance features may be critical.

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Choosing a replacement transistor is normally quite easy. There is a huge number of transistor types available, and many types of transistor overlap, making the choice of a replacement transistor quite easy in many cases.

It can help to check the stock of local stockists or reputable electronic component distributors. It is often easy to select a transistor that can be obtained quickly and easily. Checking what might be available with a local electronic component distributor will help make the final decision.

Even if choosing a replacement transistor can be very useful if the exact transistor type is not available easily. It is likely that a similar one may be available to hand, or possibly from a local stockist. In either case, it is useful to choose the replacement transistor with a good possibility of it being able to work.



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