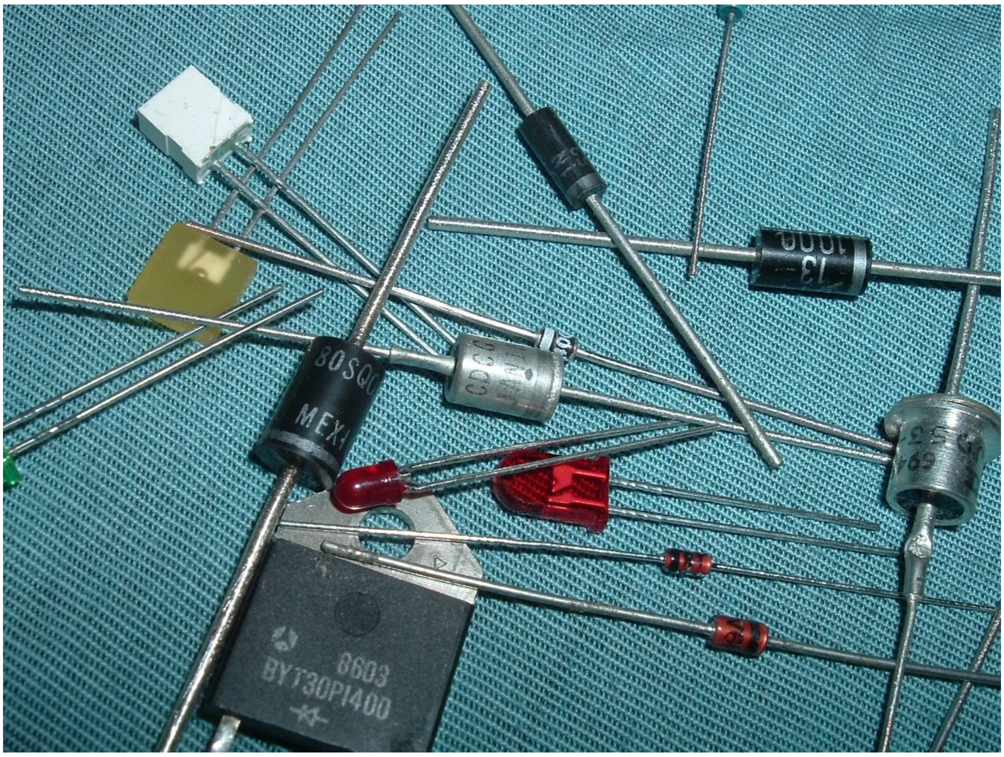
# Diodes

Diodes and rectifiers are the simplest devices in the ***semiconductor*** family. Diodes are ***Polarised*** components, which means that they must be fitted into circuit the correct way. Until you are able to complete a soldered joint quickly, it's advisable to use a heat shunt whilst soldering any semiconductor, especially germanium diodes. Just grip the lead out wire with a pair of pliers between the component and the joint, so that heat travelling up the leadout wire gets absorbed into the metal of the pliers.



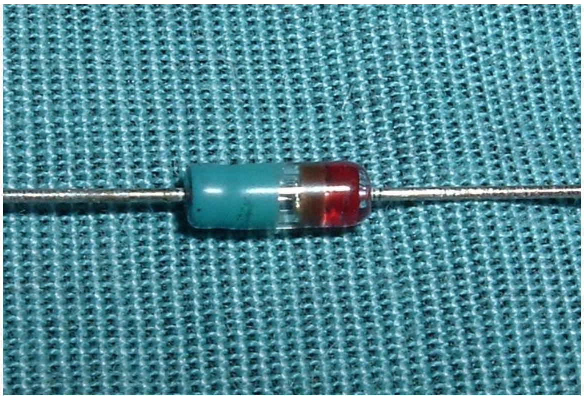

The main action of a diode is to allow current to flow in one direction only – they will block a current of the incorrect polarity. The polarity of a diode is marked on the case – either a pictorial symbol or a coloured band at one end of the diode's body indicates the negative lead.

Pictured left is a selection of various types of diodes, including rectifiers, Light Emitting diodes (LEDs) and small signal devices.

In general, all diodes perform much the same task. Those that handle currents greater than an Ampere are known as "Rectifier" diodes.

Most diodes today are made from silicon, although some are still made from germanium.

Germanium diodes (photograph right) are almost obsolete now, but they still have their uses. Their forward voltage drop is lower, and they start to conduct at a lower voltage than most silicon types. They are to be found mostly in radio circuits as a "detector" stage, and pieces of Amateur Radio equipment (SWR meters and RF probes for example). Note the red band indicates the polarity of the device.

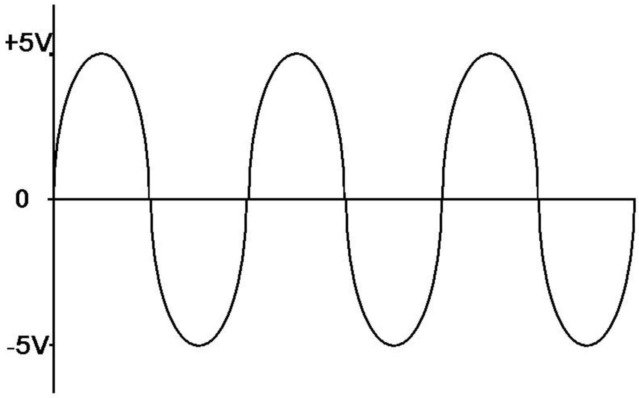


All diodes have a voltage drop across them and they only start to conduct when their forward voltage is around 0.6V (for a silicon diode). This voltage drop can be put to good use, allowing a voltage sensitive device (such as the Z80A CPU) that requires a 5V supply to be powered from a 6V source. Several diodes in series can also be used to give a voltage drop of several volts.

# Rectifier Diodes

Diodes only allow current to pass through them in one direction only, so an ***alternating current*** (AC) is converted into a ***direct current*** (DC) by removing the negative half of the waveform. This process is known as "Rectification" and as the name "Rectifier diode" suggests, this type of diode is designed primarily to "rectify" an AC voltage, be it a low voltage signal or a high current power line

A good example of where to look for a rectifier is in power supply units.




Consider the graph left – it represents an AC waveform. The voltage level rises from zero volts, to a peak of +5 Volts, and then drops down to zero volts again. Then the voltage drops below zero to a negative value of 5 Volts. A diode conducts the upper positive going voltage but blocks the negative going part of the cycle.

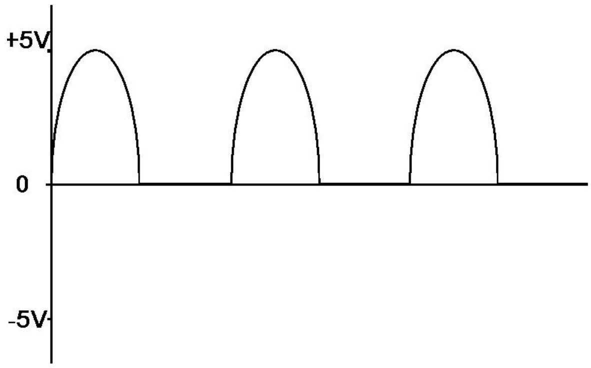
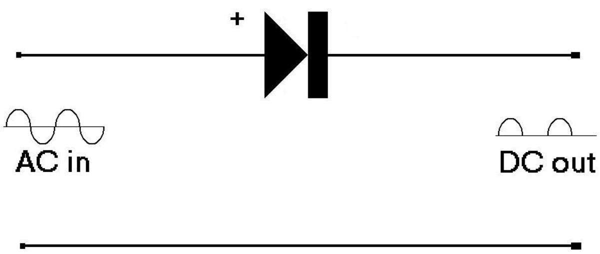
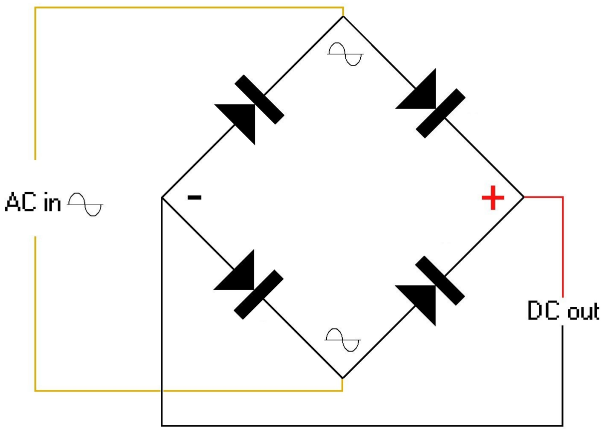



Diagram right – the same waveform as above but with the negative going portion of the cycle removed by a diode. The resulting waveform is a positive pulsed DC. This is know as "Half Wave Rectification" since only half of the waveform is used.

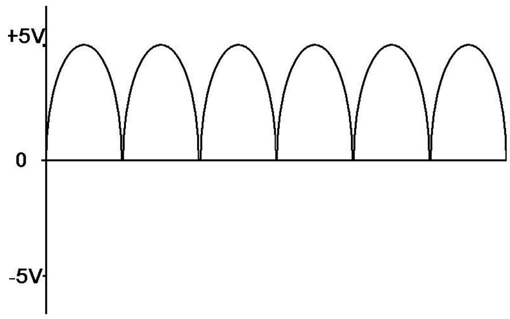



Half wave rectification results in a pulsed direct current output. Whilst this is fine for some things, since the voltage is missing 50% of the time, it isn't very efficient and is a "noisy" source of current. If you could "hear" pulsed DC, it would sound like a buzz. We could use a large value electrolytic capacitor to help smooth things out, but such a capacitor would be large and expensive. It's better to use a diode network that "steers" the negative going cycles into a positive ones, so although the output is still pulsed, both halves of the waveform are used. A capacitor to smooth things out would therefore need to be only half the value of one used in a half wave rectified circuit.

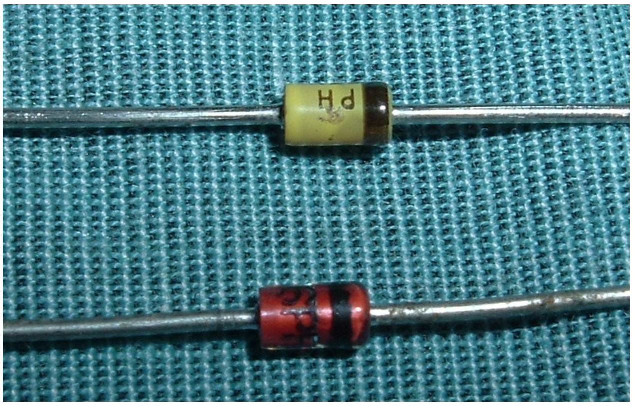



Consider the diagram left. This diode configuration is known as a "Bridge" and is available as a ready made module, known as a "Bridge Rectifier".

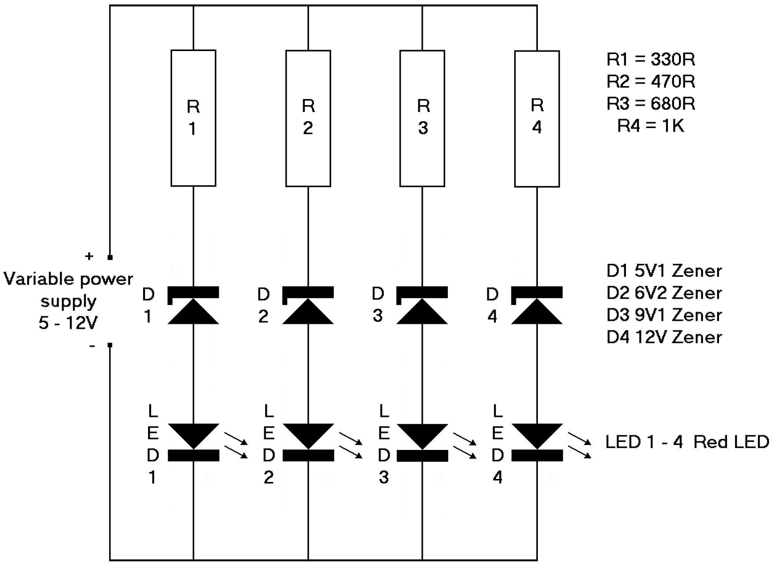
The output of the bridge rectifier is shown right. Regardless of the polarity of the input voltage, a bridge rectifier "steers" the polarity of the voltage so that the positive side of the supply is always in the same place at the output of the bridge. You will almost certainly find many examples of these devices in power supplies – be it as a single module or in its native four diode configuration.



# Zener Diodes



Normally a diode will conduct in one direction only. There are diodes that are specially designed to break down and conduct a current in the reverse direction, and these are called “Zener” or “Avalanche” diodes (photograph right). Avalanche diodes are often called Zener diodes – they are different but have the same effect. So named because at a set reverse voltage (known as the “Zener” or breakdown voltage), the diode will avalanche into conduction, thereby maintaining the voltage across it at this set Zener voltage. As the voltage increases, so the Zener diode conducts more heavily to maintain this voltage, and therefore Zener diodes are used mostly in power supplies or in parts of circuits that require a stable voltage to perform properly. Until the voltage reaches the threshold (Zener voltage), a Zener diode acts just like a normal diode. The circuit shown in the diagram below illustrates the properties of Zener diodes.




Since a diode conducts current in one direction only, the LEDs wouldn't normally light up, but since Zener diodes that conduct in the reverse direction when the Zener voltage is reached are used, one by one, as their threshold voltages are reached , the LEDs will light up in turn. The Zener diode holds the voltage across each LED constant too. The series current limiting resistor (R1 to R4) does not need to be altered, thus proving that even though there may be 12V available, LED1 still only needs a limiting resistor suitable for 5V operation. The Zener diode must therefore be limiting the voltage to it's nominal 5.1 Volts.

Like resistors, Zener diodes have a power rating. Too high a voltage, or try to draw too much current through them, the magic smoke escapes. Most normal types are rated at 400mW, whilst some are rated higher. The size of the component is the key to working out the power rating of a Zener diode assuming the type number printed on the case is unreadable. Else, a quick search on Google will usually reveal all.

# Light Emitting Diodes

This tutorial is only concerned with small LEDs, such as those used in normal electronics. Lighting applications will therefore not be covered in any great detail.

Often used as a replacement for indicator bulbs, they are true diodes still and allow current to pass in one direction only. Most projects in this guide use an LED of some type to indicate something to the user. They have a limited amount of current they can handle, exceed it and the LED will quickly burn out. Most normal LEDs are designed to work at a maximum safe current of around 20mA (0.02 Amperes). Given the voltage of the power source you intend to use, and the maximum current is around 20mA, it's an easy task to work out a suitable series resistor using Ohms Law.

| **Supply voltage** | **Resistor value** |
|---|---|
| 3V | 56R |
| 4V | 100R |
| 5V | 150R |
| 6V | 220R |
| 7V | 270R |
| 8V | 330R |
| 9V | 390R |
| 10V | 470R |
| 11V | 470R |
| 12V | 560R |

The formula is:  R (resistor value) = (supply voltage – LED voltage) divided by the current

For a normal red LED, the LED voltage is around 2V.
Assume a supply voltage of 9V for this example...
Current through the LED is 20mA or 0.02A
LED voltage = 2 Volts

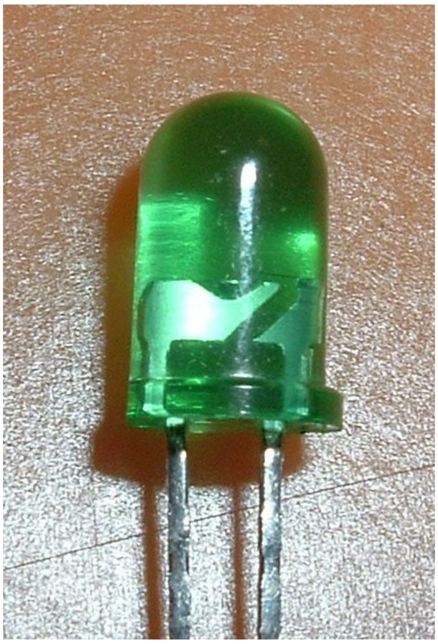
Therefore, R=(9-2) divided by 0.02
R=7/0.02
R=350 Ohms

The E12 series of preferred resistor values is given in the resistors section.  When you have to choose a "nearest value" resistor for an LED series resistor, always choose the closest higher value to protect the LED from too much current.  350 Ohms is not a preferred value, the closest higher value is 390R. The table above gives **minimum** resistor values for voltages from 3V to 12V.

Some LEDs are designed to handle larger voltages and higher currents – especially those intended for lighting applications.

LEDs are available in just about any colour and shape you choose, including invisible parts of the light spectrum such as Ultra Violet and Infra Red.  You can even get "Rainbow" LEDs which have a small IC built into their resin case and cycle the LED through every colour in the rainbow.  Gone are the days when only Gallium Arsenide (GaAs) red LEDS were available.

LEDs also work in reverse, generating minute amount of electrical currents when exposed to light.  Something exploited in photodiodes, solar cells and phototransistors.  See the projects section for a demonstration of an infra-red (IR) LED and  phototransistor.



The polarity of an LED can usually be identified by a flat part moulded into the resin case.  Some LEDs don't seem to have this though, especially those that are not the normal round standard type.  LEDs also usually have one leadout wire longer than the other to indicate polarity – usually the positive connection, but not always.  There seems to be no fixed standard for this.  One quick way to tell is to hold the LED up to a light source, and look at the internal metal parts.  The larger of the two sections – usually next to the flat moulding in the resin case is the negative side of the component.

Either one of the continuity testers described in the projects section will reveal all though.  If you test the unknown LED, the test device will light up when the probes are connected the right way around – the red probe indicating the positive lead of the test device.  The simple continuity tester's LED will also light, the advanced one will stay silent since the voltage drop across the test device unbalances its potential divider circuit, proving that the test device is NOT a short circuit.

One final note regarding diode polarity is the term "Anode" and "Cathode".  So far I have described the polarity of these devices in terms of "positive" and "Negative".  Correctly, polarity should be expressed in terms of Anode (A) and Cathode (K).  Current flows in the direction of the arrow – from positive to negative.