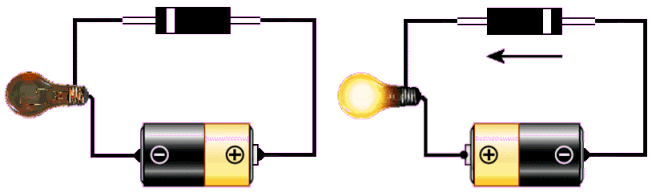
Tip of the Month February 2020

Diodes in our kits

We use diodes in many of our circuits, for a variety of purposes.

How a diode works

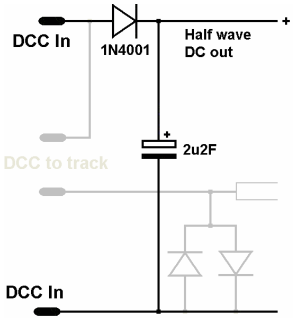
A diode allows an electric current to pass in one direction (called the diode's forward direction), while blocking it in the opposite direction (the diode's reverse direction).
This simple illustration shows which way round a diode allows or prevents current flow.

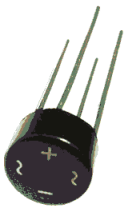


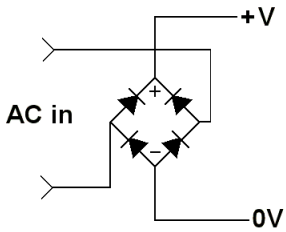
Here are examples of the use of diodes in our Pocket Money kits.

Voltage rectification

All Pocket Money are designed to work with a 12V DC supply.
A common use of diodes is to obtain a DC voltage output from an AC source.
A single diode can be placed in series with the output of an AC transformer and this will result in a not-too-satisfactory DC output (Google *'half-wave rectification'*). It is tolerable for circuits that consume little current and have large smoothing capacitors (as in **PMP7** shown here).





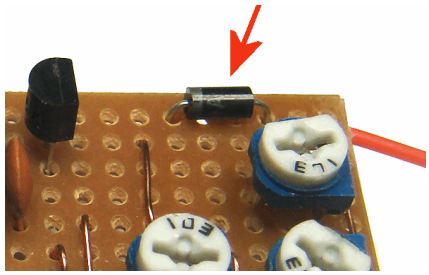


Some loco controllers have an auxiliary 15V or 16V AC output and the **PMP6** kit takes this output and converts it to a more beefy 12V 1A DC supply.
It uses a *'Bridge Rectifier'* which is just four diodes inside a single case.
It produces twice the power of a single diode (Google *'full-wave rectification'*).

Circuit protection

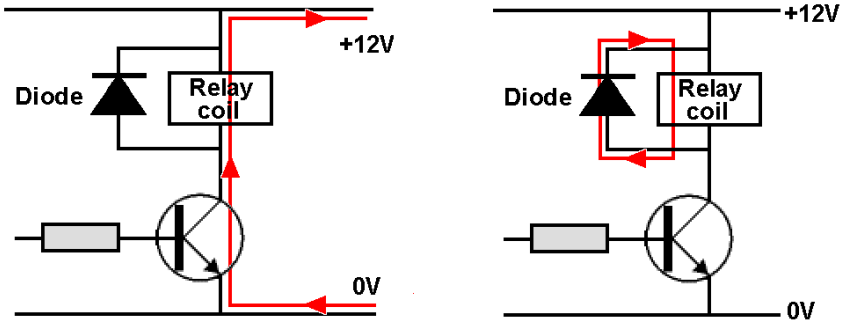
Idiot diode

It is very easy to connect the power to a module the wrong way round, often with catastrophic results for the module.
A previous Tip Of The Month covered *'reverse current protection'* diodes, often referred to as *'idiot diodes'* (I wonder why?). It prevents current flow if you mistakenly connect the power in reverse. The module will not work but there will be no damage.
It only adds about 1p to the cost of a kit and can save a lot of grief.
The image shows it being used in **PMP18**, the EzyPoints kit.



Relay protection diode

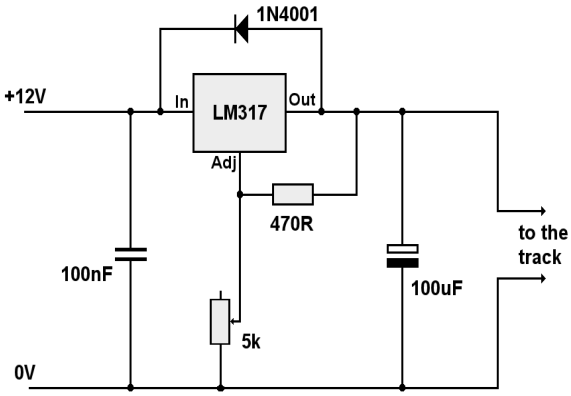
The PMP4 (Shuttle) and PMP28 (AutoStop) kits have a diode wired across their relays. This is usually referred to as a *'flyback diode'* and is used to protect the electronics. The illustration on the left shows the current flow when the transistor is switched on, from 0v through the transistor and the coil up to +12V. The relay creates a magnetic field to operates its switches.



When the transistor is switched off, the magnetic field round the relay coil collapses and induces a high voltage in the opposite direction. Without the diode this reverse voltage could damage the rest of the circuit. The illustration on the right shows the effect of adding the diode; it provides a safe discharge path.

Reverse bias protection

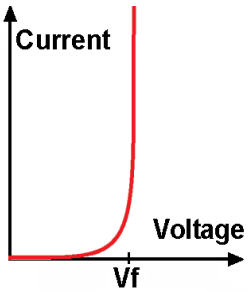
The **PMP10** (Speed Controller) kit places a diode across the LM317 chip, which is an adjustable voltage regulator.
While the module is powered, the voltage on the LM317's input pin is greater than that on its output pin (i.e. the LM317 is '*forward biased*').
If the voltage on the output pin ends up greater than that of the input pin, it is *'reverse biased'* and this could damage the regulator.
This could occur when the power to the module is switched off and the 100uF is still fully charged (the voltage on the small 100nF capacitor will dissipate much quicker than that on the 100uF capacitor)



Or the back emf from the motor might produce reverse voltages on the output pin that are greater than that on the input pin.
In these situations, the *'feedback diode'* transfers the voltage from the output to the LM317's input, preventing any damage.

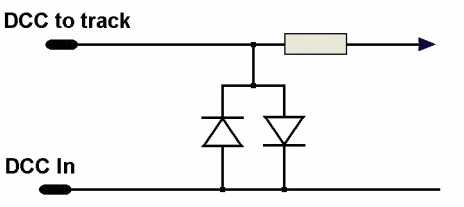
Using diodes for detection

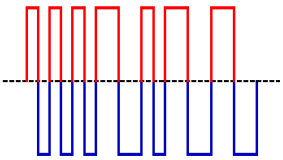
When a diode is connected to be forward biased , it does not allow much current to flow until it reaches a critical point known as the *'forward voltage'*. It is shown as Vf in the illustration. At that point, the diode is forward biased.
For a standard diode, the value of Vf (sometimes called the *'cut-in voltage'*) is around 0.7V.
So, for example, if you have an idiot diode in series with a 12V supply, the module actually gets 11.3V.



In fact, for all voltages greater than the forward voltage, the diode will always drop 0.7V across it. This is true even with a very small current flowing in the circuit.

PMP7 (The DCC Train Detector) makes use of this property.
A section of track is isolated and only gets its DCC through this module. The DCC signal passes through two diodes as shown in this illustration.





A DCC signal is bi-polar, constantly changing polarity and placing two diodes in the DCC path allows the DCC signal to always pass through regardless of the polarity
If there is no load on the isolated section, no current flows through the diodes. However, if a loco is in that track section, current will flow and voltage pulses will develop across the diodes. This is true whether the loco is moving or stationary, as even the small current drawn by the decoder is sufficient to develop these pulses. The rest of the circuit uses the positive going pulses to detect the presence of the loco.

This kit makes use of a special type of diode, known as a *'Schottky'* diode.
It has two benefits over a standard diode.

- It has a low Vf of only 2.2V, instead of 0.7V
- It it is much better at handling the fast switching switching speed of the DCC signal

Other types of diodes

We use *'Light Emitting Diodes'* in many of the kits and we use a Laser diode in **PMP22**. There are many other varieties of diode types from the commonly used Zener diode to exotic and rarely found types.

If your module does not have an idiot diode fitted, why not add one in series with the power lead