Part 1: Some Basic Ideas and Components

Current and Resistance

Resistance in a circuit limits the current which can flow.
Current is measured in Amps.

MORE RESISTANCE means LESS CURRENT

To calculate the resistance of a component:

Resistance = Voltage/Current

$$R = \frac{V}{I}$$

The unit of resistance is the OHM

LEARN THE RESISTOR COLOUR CODE !! Test yourself by using an ohm-meter.

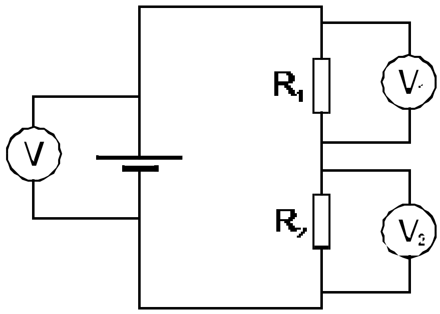
Voltage Divider Circuits

These circuits are often called "potential divider" circuits (because "potential difference" means voltage).

Set up the circuit shown below. Use a voltmeter to verify these two formulae:

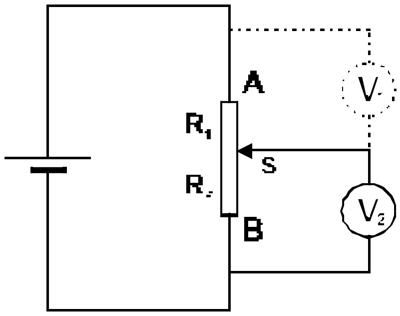
a) $V = V_1 + V_2$

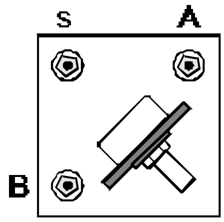
b) $\frac{V_1}{V_2} = \frac{R_1}{R_2}$



Variable Potential Divider Circuit

We can make a variable potential divider using a rheostat (also called a variable resistor). In this case we have a circuit similar to the previous one but now the two resistors R_1 and R_2 are *two parts of the same component*. This is useful for volume controls etc.





The diagram on the right shows the approximate appearance of the variable resistor on its support.
Connect a voltmeter as shown and move s (that is, turn the rheostat).
Note that the voltmeter reading varies from zero to the full voltage of the battery.

Variable Potential Divider WITH LOAD

The word "load" in the title means any component which takes a current from the potential divider (in this experiment, the loads are resistors).
Using the circuit shown above, adjust the rheostat so that the voltage across S and B is 2 volts.
Connect a 10 kΩ resistor across S and B. Note the reading of the voltmeter when this resistor is connected. (Note that the *maximum* resistance of the rheostat is 500 kΩ ; a 10 kΩ resistor is *very small* compared with this.)

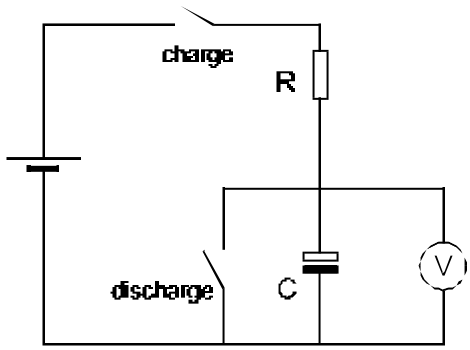
> This shows that the voltage given by a potential divider circuit in *not stable*, it varies depending on what is connected to it. As the current taken from a potential divider *increases*, the voltage *decreases*.

Capacitors (also called condensers)

A capacitor is a component which stores electric charge. The unit of capacitance is the Farad. However, 1 F is a very large capacitance. In most situations we use capacitors in the micro-Farad (µF) or nano-Farad (nF) range. Many capacitors can be connected either way but *electrolytic* capacitors (and some other types) are said to be *polarised* and must be connected the *right way round*. Nearly all “large” capacitors (greater than about 1 µF are electrolytic). Circuit symbols for capacitors are shown below.

Experiments to show what capacitors do

Set up the circuit shown below.



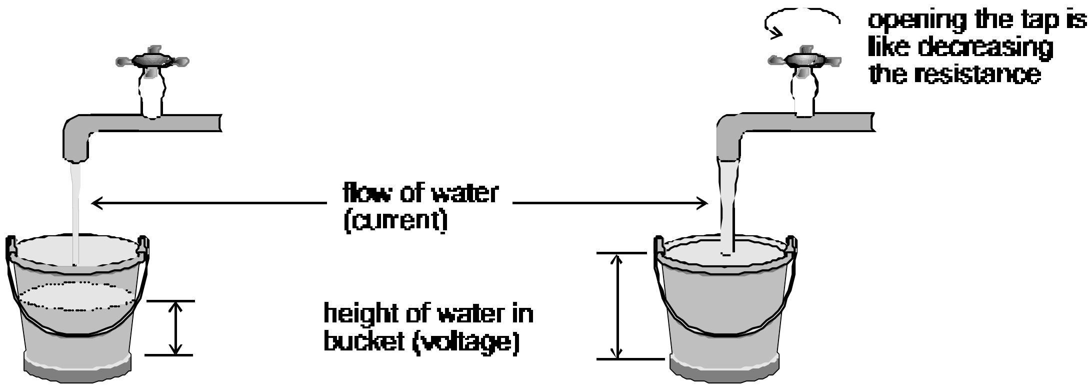
Start with
R = 22k
C = 470µF

When the “charge” switch is pressed, the voltmeter reading increases gradually as the capacitor “charges up”.

The voltage stops increasing when it is equal to the voltage of the supply.

Start with the values given above but then try the circuit with different resistors and capacitors (discharge the capacitor between tests).

The circuit is *in some ways* similar to the situation shown in the diagram below.

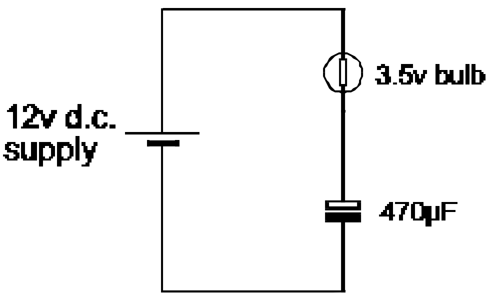


In this situation the tap can be compared to the resistor and the bucket to the capacitor.

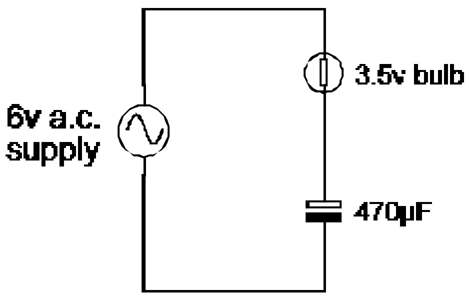
Capacitors in d.c. and a.c. circuits

Set up the following circuits.

D.C.



A.C.

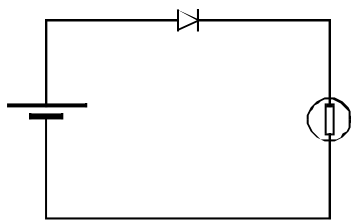


These circuits show that capacitors stop d.c. but allow a.c. to pass.

Capacitors are used in timing circuits, filter circuits (for separating signals of different frequencies) and in any situation in which charge must be stored e.g. some computer memories.

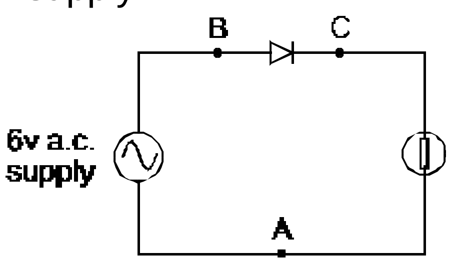
Diodes

a) Diode with d.c. supply.



Try reversing the battery connections. This show that a diode is a component which only conducts *one way.*

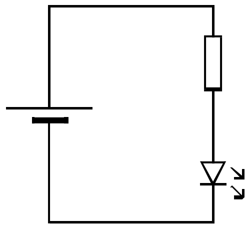
b) Diode with a.c. supply.

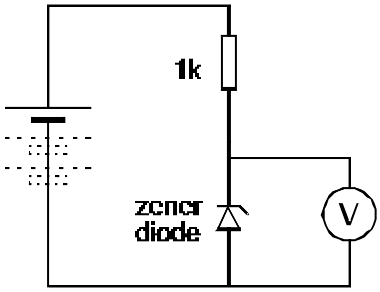


Note what happens when you put a short circuit round the diode (that is; when you connect B directly to C).

Connect the “earth” or “ground” connection of an oscilloscope to A. Connect the 'scope input first to B then to C. (This will allow you to compare the voltage produced by the supply with the voltage across the bulb.)

c) Some special diodes

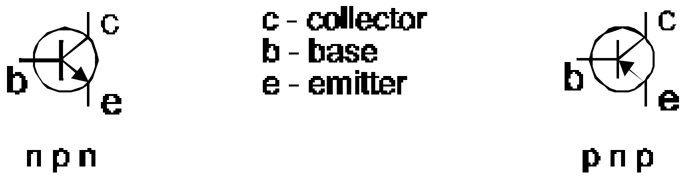




A light emitting diode must always have a resistor in series with it.

Try the zener diode circuit first with one battery, then with two batteries in series, then three …
This should show you why a zener diode is called a *voltage regulator* diode

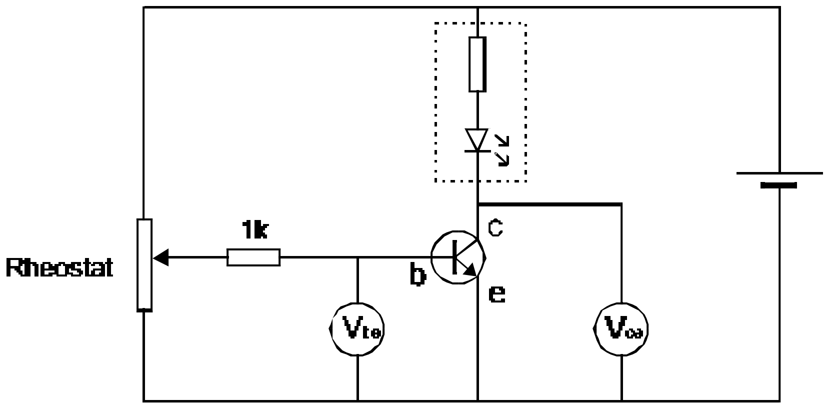
The Transistor



The two types of transistor shown above are called bi-polar transistors. The following circuits all use bi-polar transistors but there are many other types e.g. FET, MOS etc.

The Transistor as a Switch

In the circuit below we use a rheostat as a *variable potential divider* to apply a variable voltage across the base and emitter of the transistor to see how this affects the voltage across the collector and emitter.



Adjust the variable potential divider so that V_{be} = zero.

Slowly increase V_{be}. Notice that the LED lights when V_{be} = (about) 0·6v and that V_{be} does NOT increase much above this figure *no matter what we do with the rheostat*.

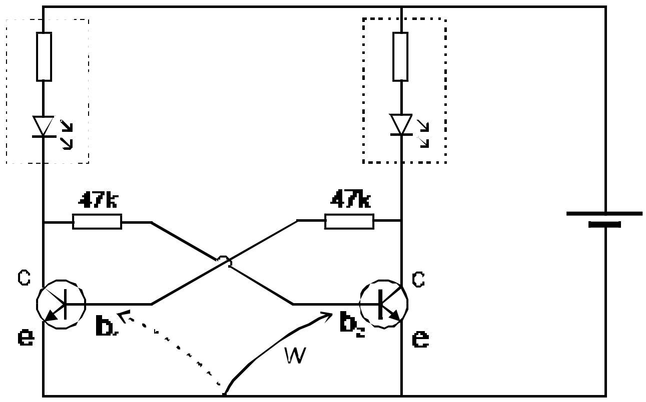
Conclusion

$V_{be} < 0{\cdot}6$v, transistor is OFF and V_{ce} = the voltage of the battery

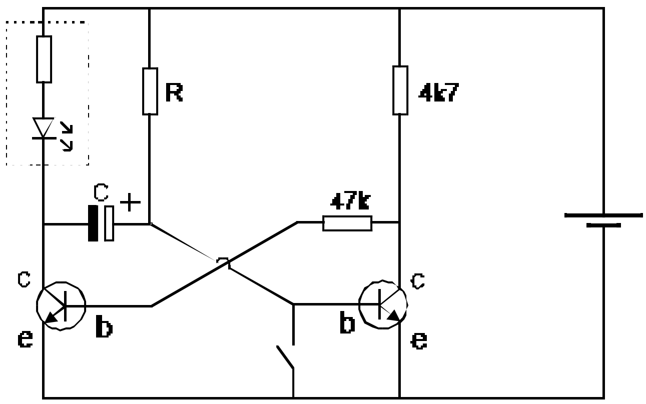
$V_{be} > 0{\cdot}6$v, transistor is ON and V_{ce} = about 0·2v

When we say that the transistor is ON, we mean that it allows current to flow easily into its collector and out of its emitter.
Transistors used as switches are found in nearly all modern electronic equipment, e.g. computers, calculators, T.V.'s.

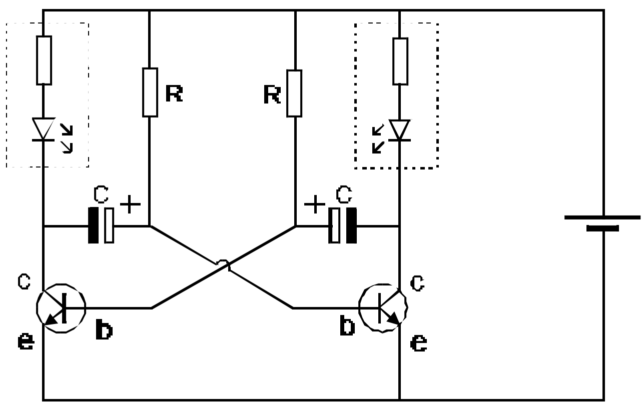
Three important transistor switching circuits



Touch the end of wire W for a fraction of a second to B_1 then to B_2. Do you see why this type of circuit is called a *bistable* ?

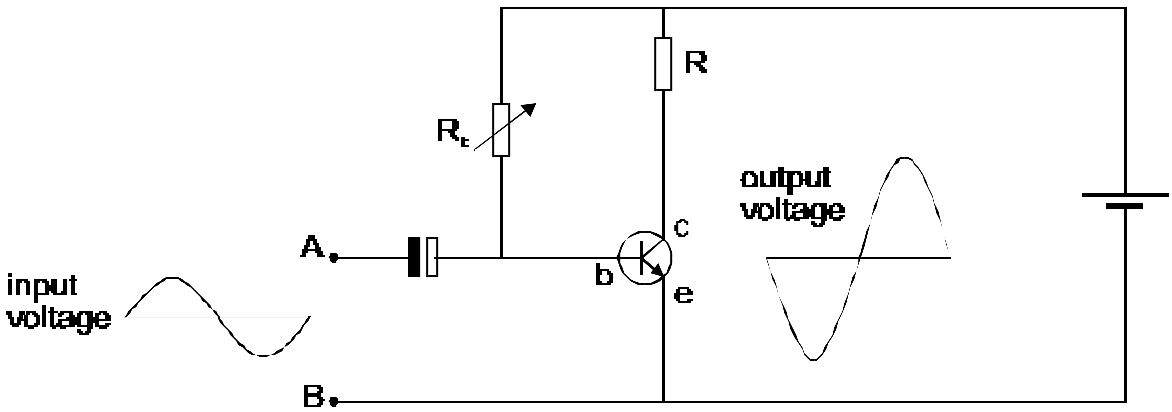


Start with C = 470µF and R = 47k. Push the switch, then wait. Do you see why this type of circuit is called a *monostable* ?
Try the circuit with different capacitor C and resistor R.



Start with C = 470µF and R = 47k. This circuit is called an *astable* because it continually *oscillates*. This is similar (in principle) to the circuits which produce the "clock" pulses in computers. Again, try with different capacitors and resistors, R.

The Transistor as an AMPLIFIER



As long as the transistor is in *just the right state* (R must be adjusted to give this “right state”) then the *output* voltage variations are much bigger than the *input* voltage variations. The input voltage is the voltage across points A and B and the output voltage is the voltage across the collector and emitter of the transistor.

The “wavy lines” on the diagram represent what would be seen on an oscilloscope screen when the circuit is operating correctly. This shows why we call the circuit an amplifier: to amplify means to make bigger.

The resistor, R_b, is called the *base bias resistor*, and the very small current which flows through it is called the (base) *bias current*.