Components

by

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Introduction

We will discuss basic electronic components

Resistors
Capacitors
Inductors
Diodes
Transistors

Properties
Various physical forms
Uses

Resistors

Resistors oppose the flow of electric current (DC and AC), in a defined way.
The opposition is defined by Ohms Law, which can be summarized by the expression

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

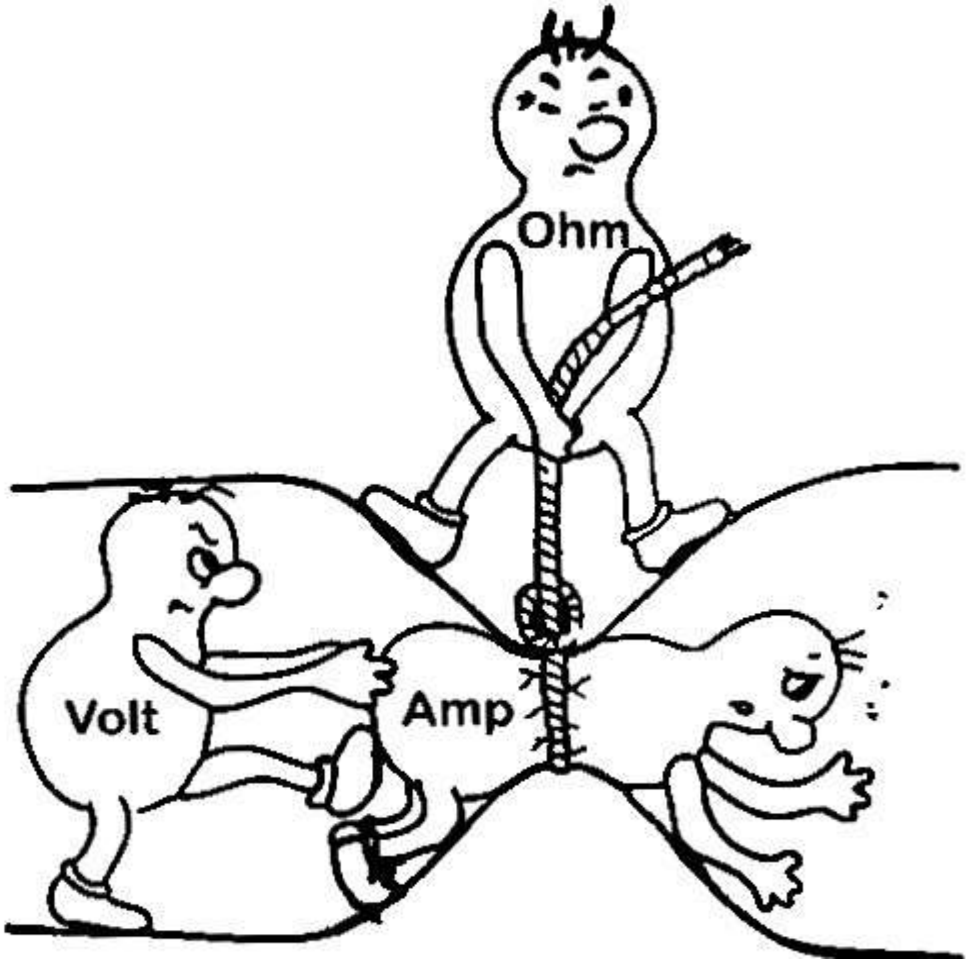
Where I is the current in Amperes
V is the voltage in Volts
R is the resistance in Ohms

The current through a circuit is equal to the voltage applied to the circuit divided by the resistance of the circuit.

When measuring resistance, the unit of measurement is the Ohm.

The effect of resistance can be depicted pictorially…

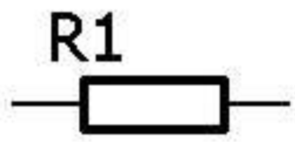
Ohms Law in pictures…



Resistor Symbols

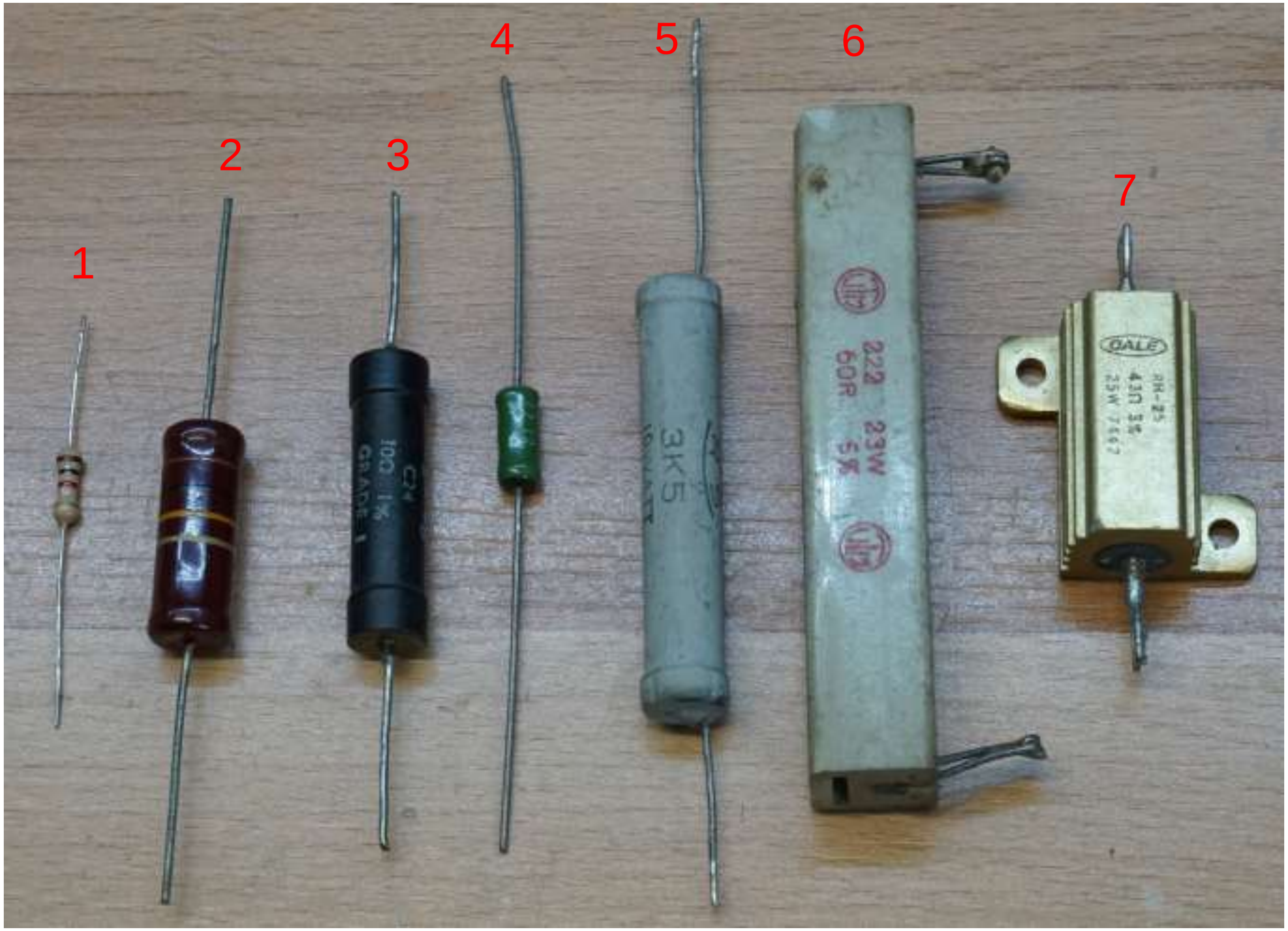
Resistor symbols used on circuit diagrams

European



USA

Resistor types



1 0.33W Carbon film

2 2W Carbon film

3 1% Precision resistor

4 1W Wire wound

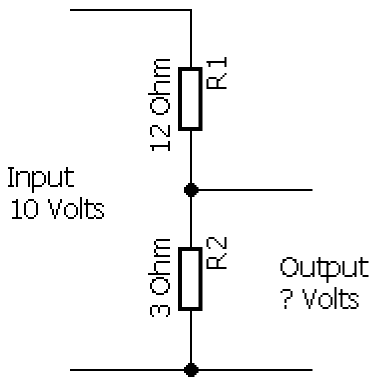
5 10W Wire wound

6 23W Ceramic, wire wound

7 25W Metal clad, wire wound

The voltage divider

The voltage divider uses two or more resistors connected in series to provide a lower voltage from a higher voltage supply.



What is the output voltage?

1 Calculate the total resistance $Rt = R1 + R2 = 12 + 3 = 15\ Ohm$

2 Calculate the current through Rt (Use Ohms Law)

$$I = \frac{V}{Rt} = \frac{10}{15} = 0.666\ Amp$$

3 Calculate the voltage across R2 (Use Ohms Law)

$$V = I \times R = 0.666 \times 3 = 1.998\ Volts$$

Or, we could use

$$Vout = Vin \times \frac{R2}{(R1 + R2)}$$

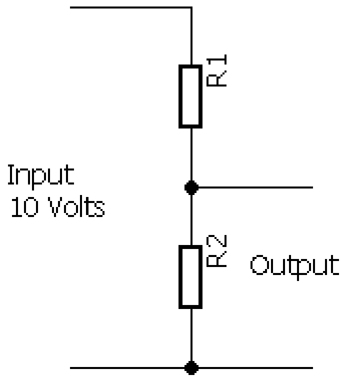
$$Vout = 10 \times \frac{3}{(12 + 3)} = 2.000\ Volts$$

Voltage divider practical - 1

Build three versions of the voltage divider using the resistor values shown in the table.

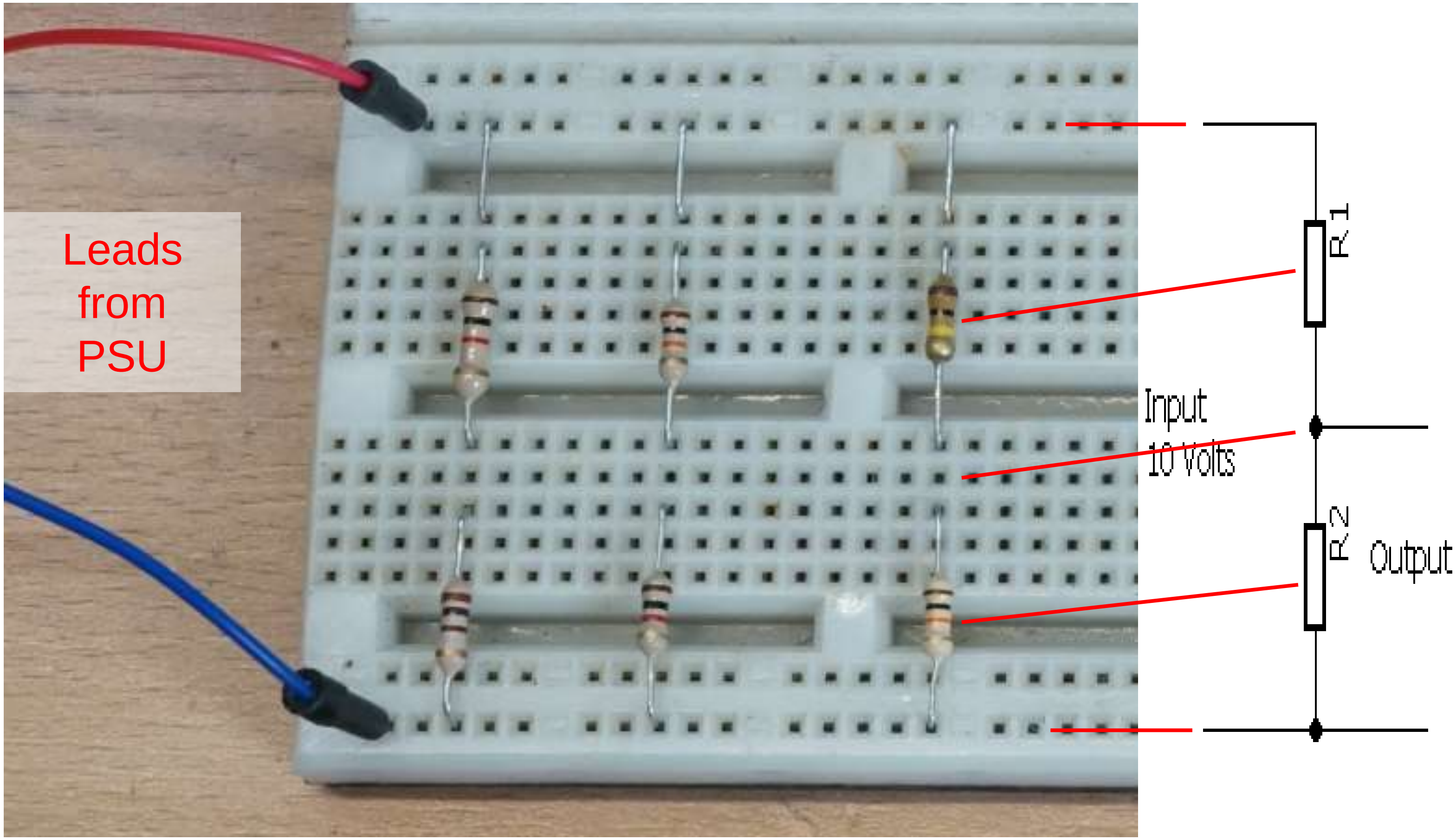
Connect the dividers to a 10volt supply.

Measure the supply voltage and the outputs from the dividers using three different voltmeters.



		Output		
		Fluke 8840A	Cheap DMM	AVO 7
Supply Voltage				
R1	R2			
1k	100R			
10k	1k			
100k	10k			

Voltage divider practical - 2



Capacitors

Capacitors will pass AC currents, but will not pass DC.

Capacitors do offer some opposition to AC currents, this opposition is known as the reactance of the capacitor.

The reactance varies inversely* with frequency and is measured in Ohms.
We can calculate the reactance using the formula

$$Xc = \frac{1}{2.\pi.F.C}$$

Where Xc is the capacitive reactance in Ohms
F is the frequency in Hertz
C is the capacitance in Farads

When measuring capacitance, the unit of measurement is the Farad.

* i.e. The higher the frequency, the lower the reactance.
Hence less opposition to the flow of AC current.

We use capacitors to:

Couple AC signals from one stage of a circuit to the next stage (coupling capacitor).

Remove AC signals from parts of a circuit where we do not want any signal (de-coupling capacitor).
In a PSU, we usually refer to this as a reservoir capacitor or a smoothing capacitor.

Used together, a capacitor and a resistor can be used as part of a timing circuit or as part of an oscillator circuit.

When a capacitor is used with an inductor, the resulting circuit can be used as a filter to remove certain frequencies, or to allow a restricted range of frequencies to pass to the next stage of a circuit.

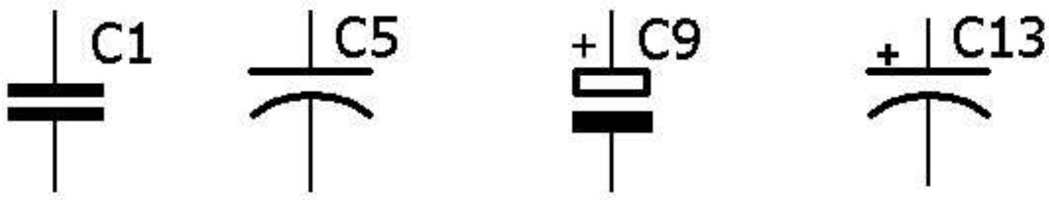
Often a capacitor and an inductor are used as a tuned circuit in an oscillator or an RF amplifier.

Capacitor Symbols

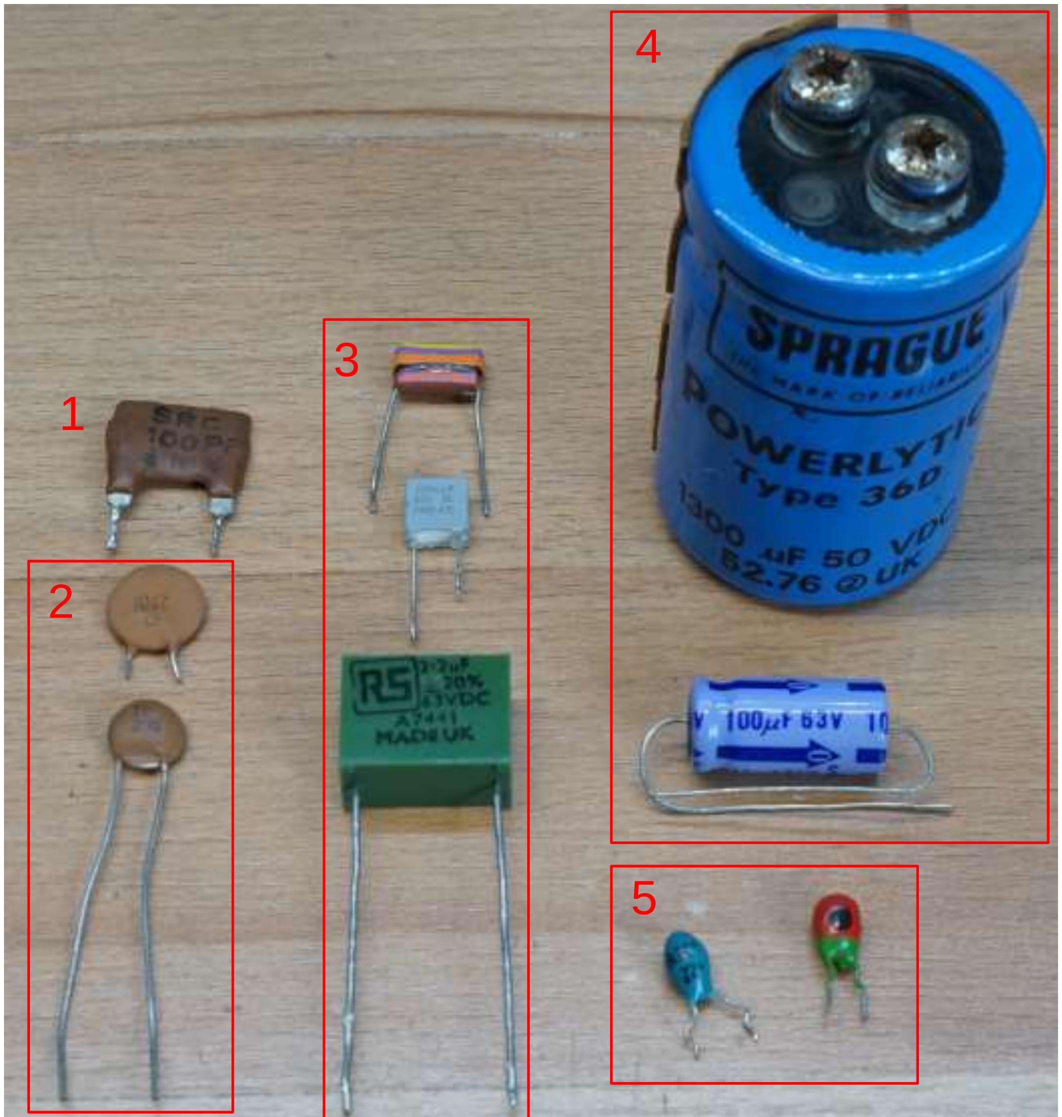
Capacitor symbols used on circuit diagrams

Non-polarized | Polarised

European | USA | European | USA



Capacitor Types



1 Mica capacitor. Used in RF tuned circuits.

2 Ceramic capacitors. Used for coupling and de-coupling in RF stages, and in RF tuned circuits where capacitance stability is not critical.

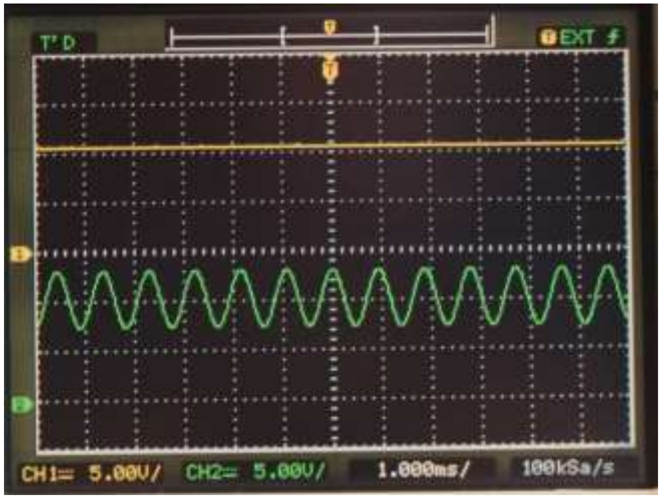
3 Film dielectric capacitors. Used in low frequency timing and tuned circuits. Good capacitance stability.

4 Electrolytic capacitors. Capacitance stability can be poor. Good for PSU reservoir capacitors and low frequency de-coupling.

5 Tantalum capacitors. Often used for supply decoupling.

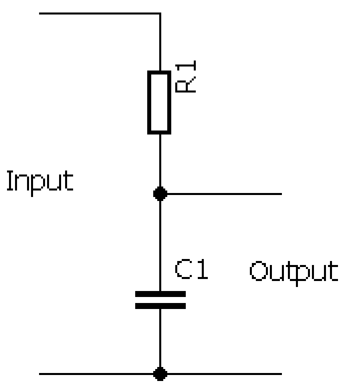
Electrolytic and Tantalum capacitors are polarized. i.e. must be connected the correct way around in a circuit.

Capacitor Practical

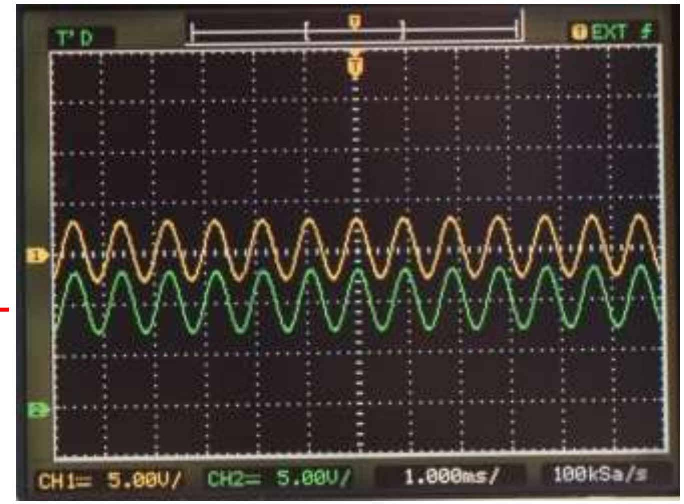


Input from a noisy supply, 10v DC with 6v p-p AC superimposed.

Output, the AC is removed leaving a clean 10v DC.

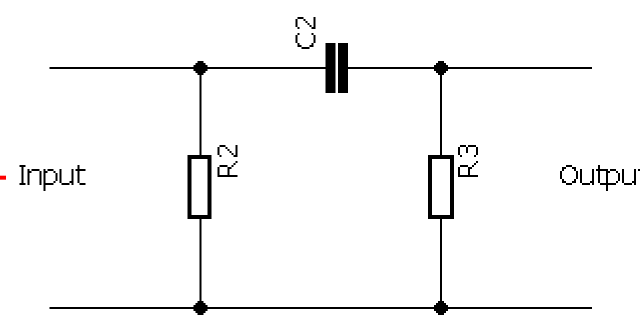


De-coupling



Input is a 6v p-p signal superimposed on 10v DC

Output, the DC is removed leaving a clean a 6v p-p signal centred on 0v.



Coupling

Inductors

Inductors will pass DC currents, but will oppose AC currents.

Inductors offer opposition to AC currents, this opposition is known as the reactance of the inductor.

The reactance varies directly* with frequency and is measured in Ohms.
We can calculate the reactance using the formula

$$Xl = 2.\pi.F.L$$

Where X_L is the inductive reactance in Ohms
F is the frequency in Hertz
L is the inductance in Henries

When measuring inductance, the unit of measurement is the Henry.

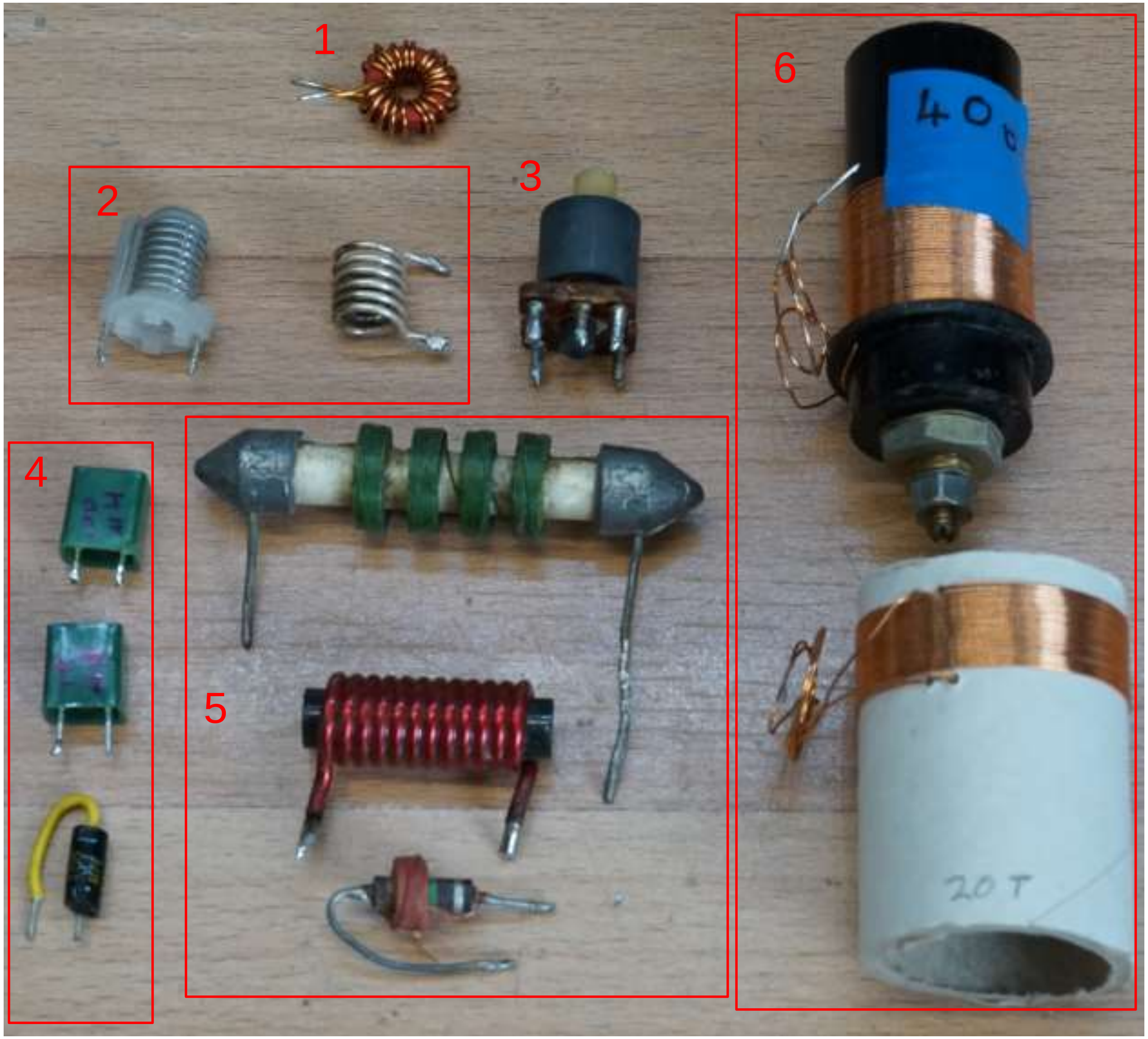
* i.e. The higher the frequency, the higher the reactance.
Hence greater opposition to the flow of AC current.

We use inductors to:

Prevent AC signals from entering parts of a circuit where we do not want that signal (In this instance we may refer to the inductor as a choke).

Used together, an inductor and a capacitor can be used as part of a tuned circuit for use in an amplifier, oscillator, or filter.

Inductor types



1 Small Toroid.

2 Two VHF inductors the one on the left has a tuning slug, the one on the right is air cored.

3 A Pot-Core inductor. The windings are surrounded by an iron dust core.

4 Small 10 and 100uH inductors.

5 RF Chokes.

6 Two home made experimental inductors. The one at the top has an adjustable iron dust core. The one at the bottom has a simple cardboard former.

Diodes

Generally a diode will pass current in one direction only.
This property of the diode is used to rectify AC to DC in power supplies, and to detect (de-modulate) some types of RF signal.

Some types of diode have had some secondary properties enhanced to provide special functions.

Zener diodes provide defined voltages for use as voltage references in PSU voltage regulators and measurement circuits.

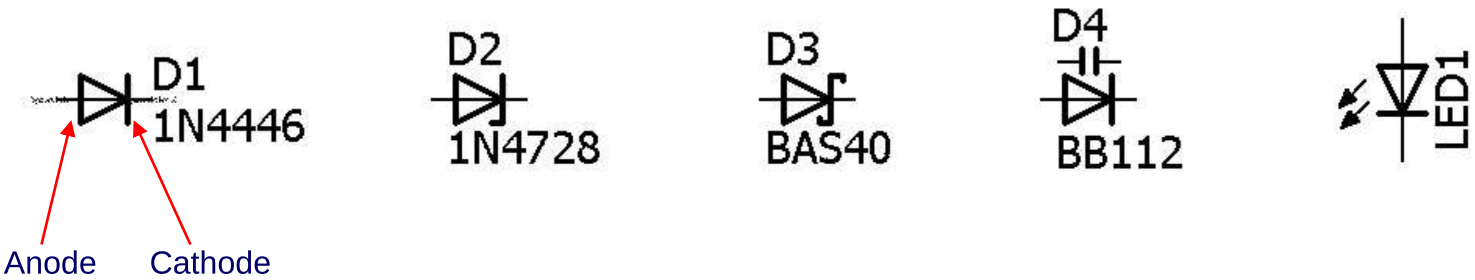
Variable Capacitance diodes (Varicap) provide a capacitance which varies as the voltage across the diode is varied. This is varying capacitance is used to tune variable frequency oscillators and filters.

Light Emitting Diodes can be used as status indicators or as general illumination.

Diode Symbols

Diode symbols used on circuit diagrams

Diode | Zener Diode | Schottky Diode | Variable Capacitance Diode | Light Emitting Diode



The normal operation of most diodes is with the Anode at positive potential with respect to the Cathode. i.e. Forward biased.

A Zener Diode is reverse biased (anode negative, cathode positive) such that there is no current flow through the diode until Zener breakdown occurs at some voltage. The exact breakdown voltage depends on the internal construction of the diode.

A Variable Capacitance Diode is reverse biased and non-conducting. The capacitance presented by the reverse biased diode junction depends on the reverse bias voltage.
The greater the reverse bias, the lower the capacitance.

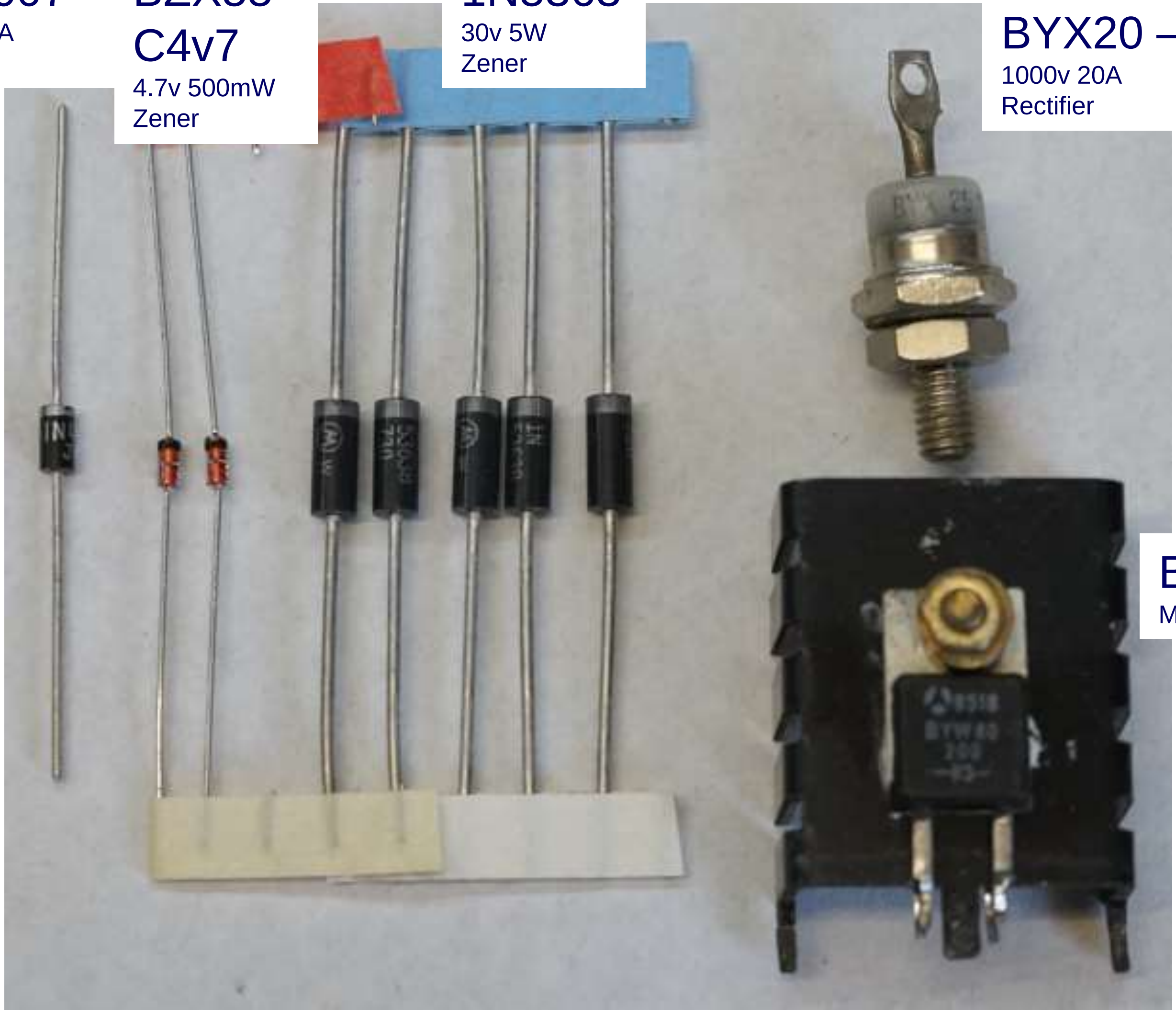
Diode types

1N4007
1000v 1A
Rectifier

BZX55
C4v7
4.7v 500mW
Zener

1N5363
30v 5W
Zener

BYX20 – 1000R
1000v 20A
Rectifier



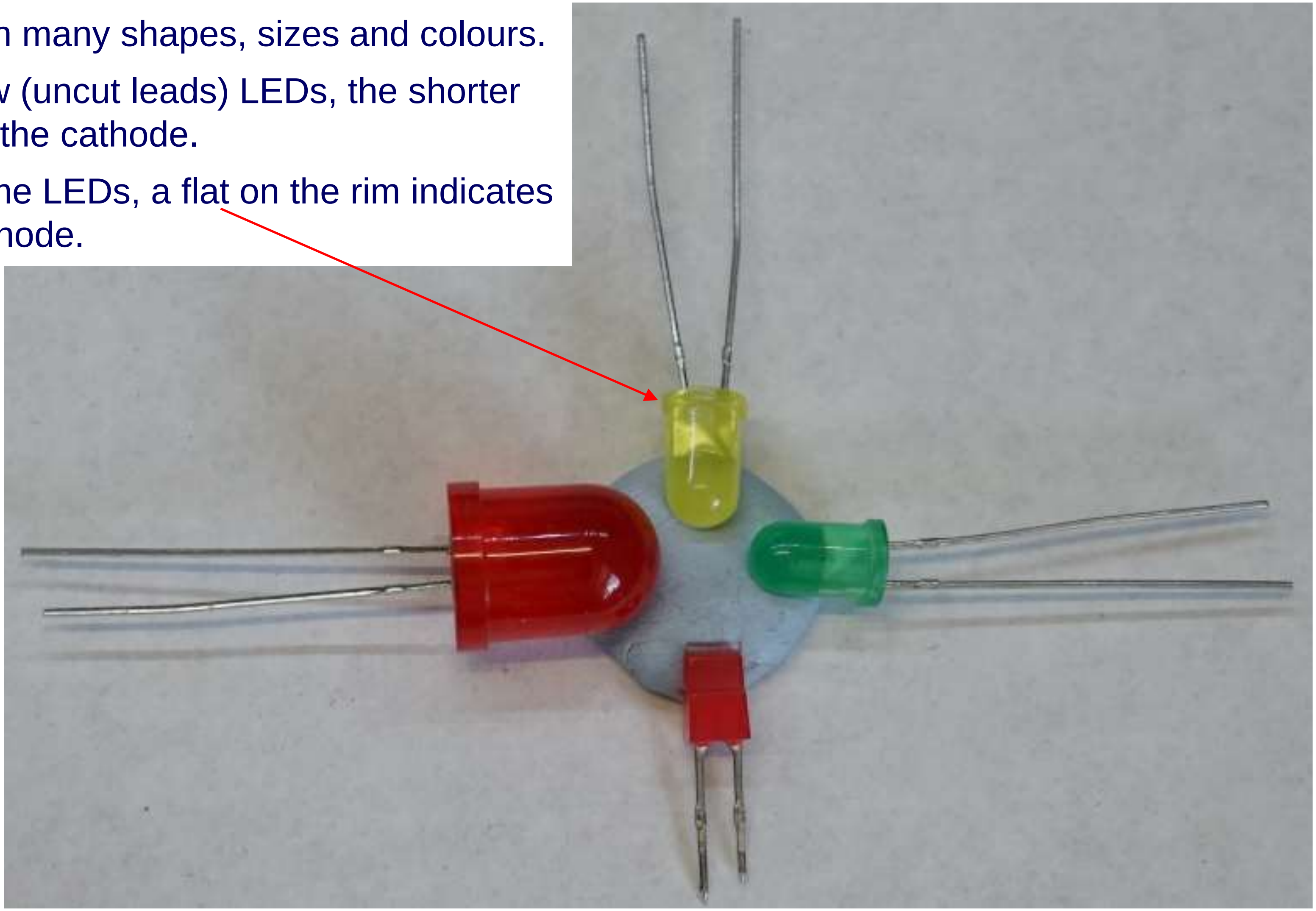
BYW80 – 200
Mounted on heatsink

LED polarity

LEDs in many shapes, sizes and colours.

On new (uncut leads) LEDs, the shorter lead is the cathode.

On some LEDs, a flat on the rim indicates the cathode.



Zener Practical

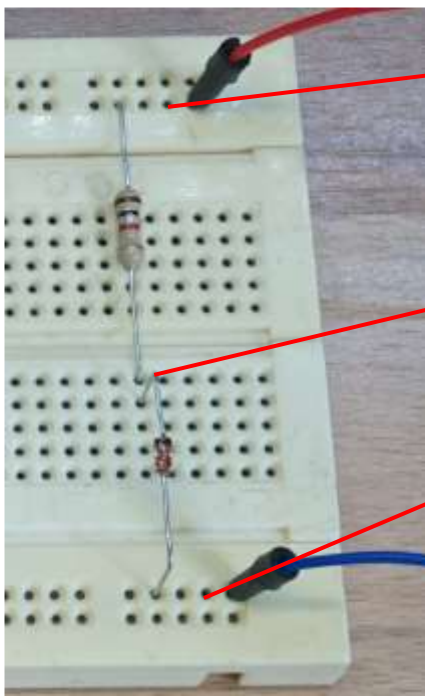
Zener Diode

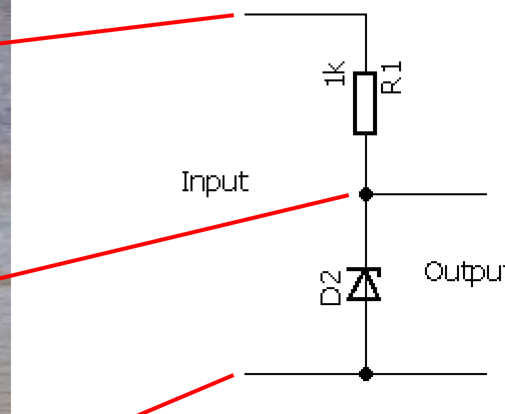
Connect in series with a resistor as shown.

Connect a variable voltage DC PSU to the Input (+ve to resistor, -ve to diode anode).

Connect a voltmeter to the Output.

Vary the PSU from 0 to 10v, note that the Zener voltage remains constant when the input is above the rated voltage of the diode.





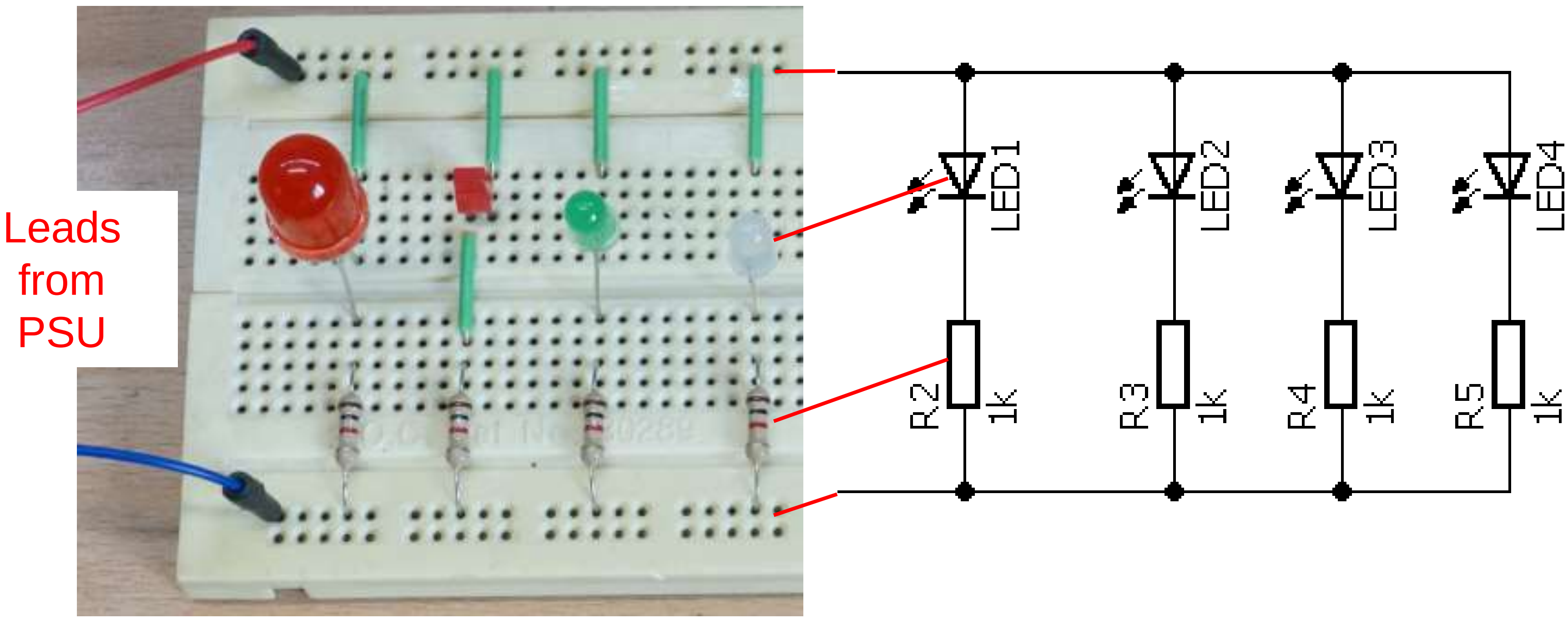
Note that in normal operation the Zener Diode is “reverse biased” i.e. the cathode is positive w.r.t. the anode.

LED Practical

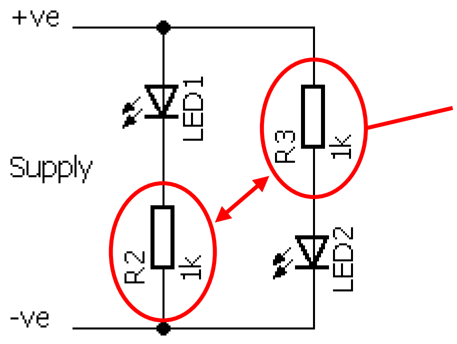
Connect a variable voltage DC PSU to the breadboard as shown

Adjust the PSU from 0 to 10v, note that the LEDs do not all illuminate at the same voltage.

Use a voltmeter to measure the voltage across each LED. Note that they are not all the same.



LED Tips and Tricks



It makes no difference if the resistor connects to the anode or to the cathode of the LED.

LEDs are CURRENT operated devices.
Connecting the LED to a supply without the current limiting resistor will usually result in the destruction of the LED.

What value to use for the current limiting resistor?

For a quick and dirty best guess, use:

Supply voltage	Resistor value
5v	470 Ohm
12v	1200 Ohm
24v	2200 Ohm

Transistors

Transistors may be used as amplifiers, i.e. a small signal on the input becomes a larger signal on the output.
How much gain a transistor amplifier produces depends on the individual transistor and the circuit configuration.

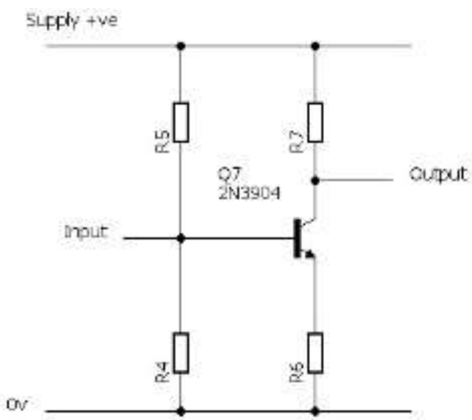
When used in an oscillator circuit the transistor is still effectively an amplifier which compensates for losses in the frequency determining circuits.

A transistor may also be used as a switch, i.e. a small current or voltage may be used to vary (turn on/off) a larger current or voltage.

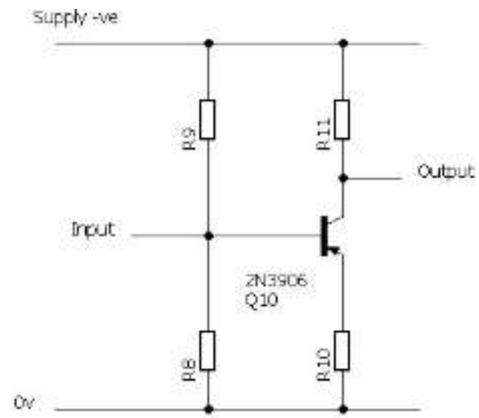
Typical Amplifier Circuits

Three circuit fragments of low frequency amplifiers using different types of transistor.

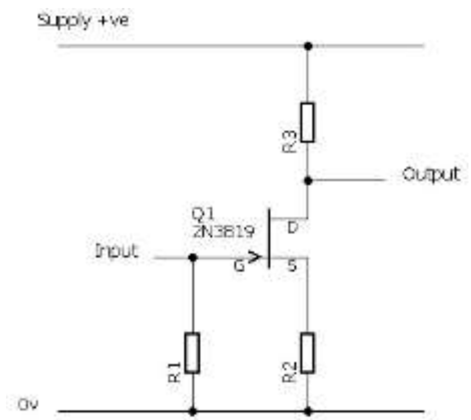
NPN Junction Transistor



PNP Junction Transistor



N Channel Junction FET



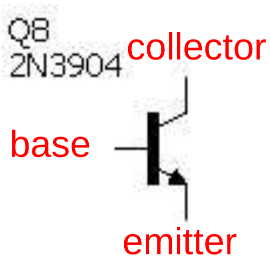
Note:

These circuit fragments require further components to build a working amplifier.

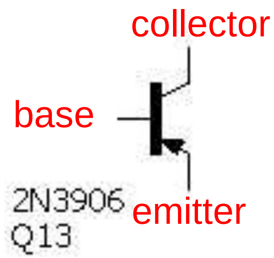
The supply line for the PNP circuit is negative w.r.t. the 0v line.

Transistor Nomenclature

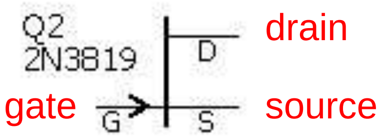
NPN



PNP

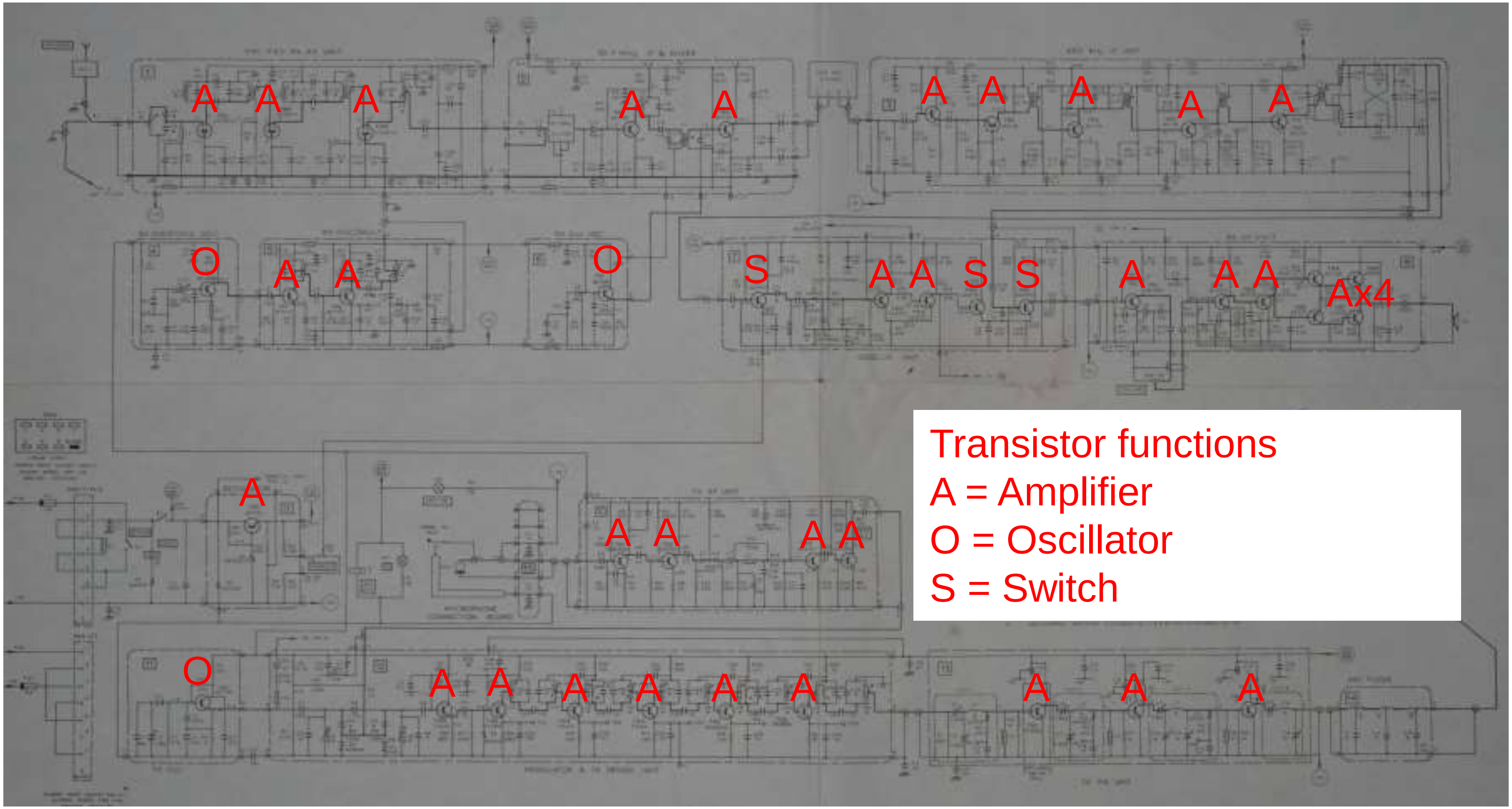


J-FET



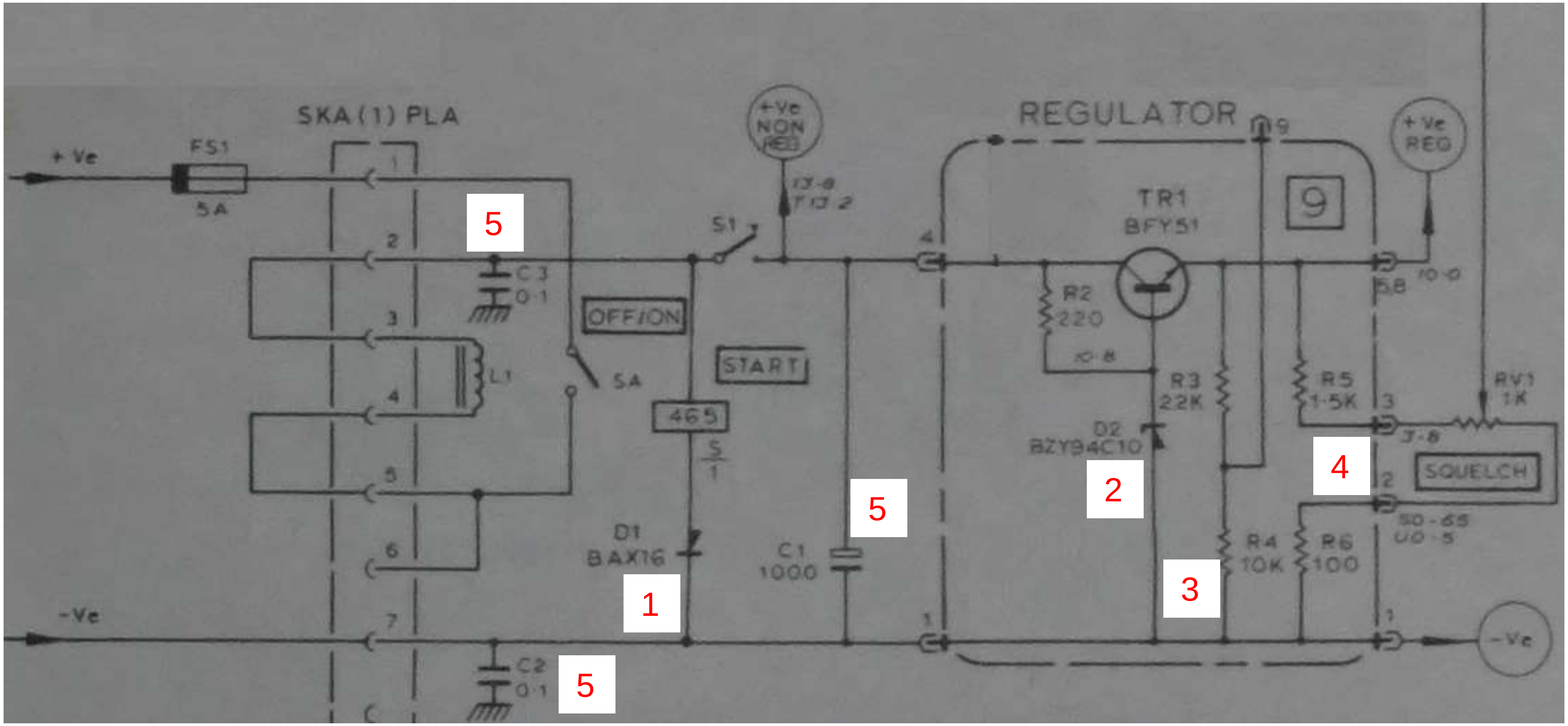
Transistors in an old Pye Westminster

Transistors in an old Pye Westminster



Transistor functions
A = Amplifier
O = Oscillator
S = Switch

Real World Examples – Pye Westminster PSU



1 – Diode, part of reverse polarity supply protection. Prevents relay S1 from closing when supply is reversed.

2 – Zener Diode. In conjunction with TR1, creates a regulated 10v supply.

3 – Voltage divider. Provides a bias supply for the receiver RF Amplifier.

4 – Voltage divider. Uses two fixed resistors and a potentiometer to provide bias voltage to set the squelch level.

5 – De-Coupling Capacitors. In conjunction with L1, filter noise from the incoming DC Supply.

Tolerance

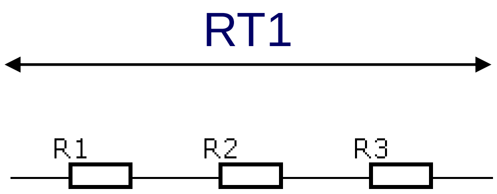
Very few electronic components have the actual value shown on their markings. The actual value will be within a range of values specified by the tolerance of the component.

Consider a 1k Ohm (1000 Ohms) resistor:

A resistor with a 5% tolerance will have an actual value within the range 1000 +/- 5%
i.e. between 0.950 and 1.050 kOhm. (950 to 1050 Ohm)

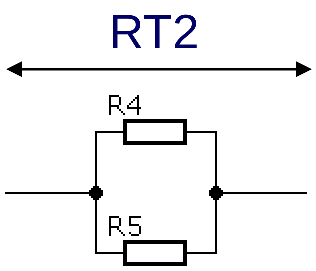
A resistor with a 1% tolerance will have an actual value within the range 1000 +/- 1%
i.e. between 0.990 and 1.010 kOhm. (990 to 1010 Ohm)

Resistors - Series and Parallel



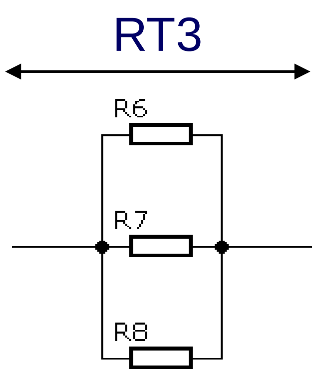
Series - Just add the values together.

$$RT1 = R1 + R2 + R3$$



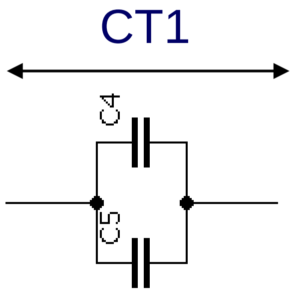
Parallel - Needs a bit of maths.

$$RT2 = \frac{R4 \times R5}{R4 + R5} \qquad \left[\frac{1}{RT2} = \frac{1}{R4} + \frac{1}{R5} \right]$$



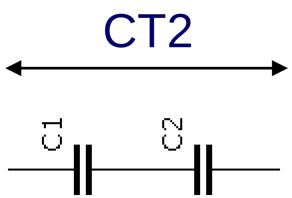
$$\frac{1}{RT3} = \frac{1}{R6} + \frac{1}{R7} + \frac{1}{R8}$$

Capacitors – Parallel and Series



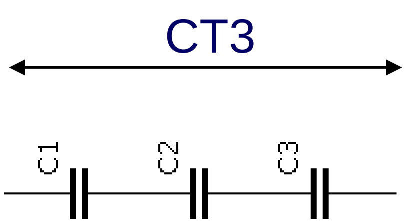
Parallel - Just add the values together.

$$CT1 = C4 + C5$$



Series - Needs a bit of maths.

$$CT2 = \frac{C1 \times C2}{C1 + C2} \qquad \left[\frac{1}{CT2} = \frac{1}{C1} + \frac{1}{C2} \right]$$



$$\frac{1}{CT3} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}$$

The End