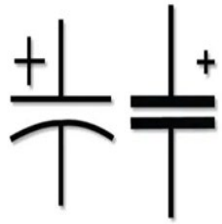
Capacitors

What are they & how do they work

Nigel Moorby

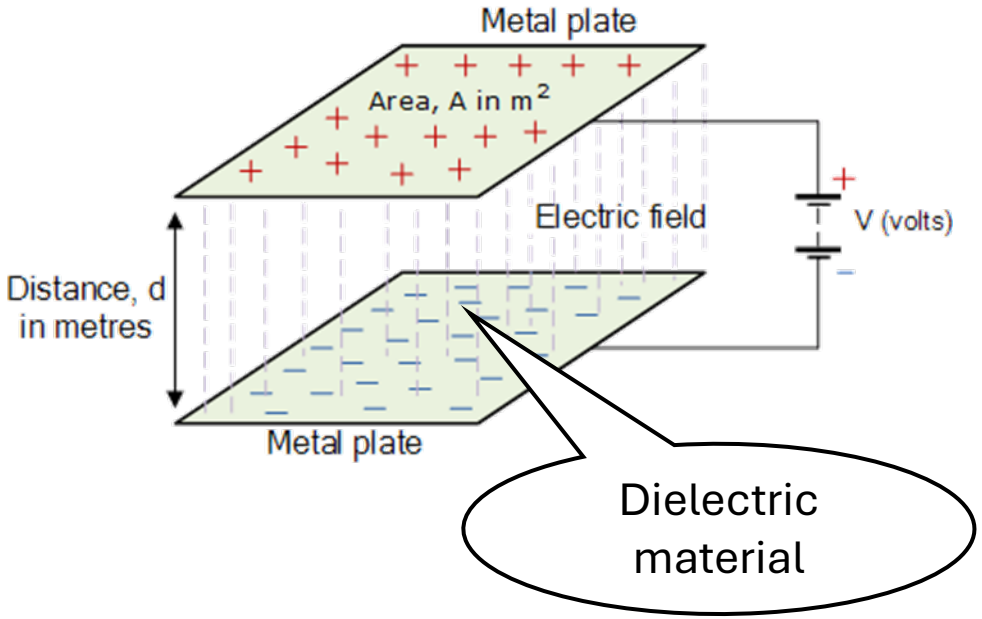
What is a capacitor ?



- A **capacitor** is a two-terminal passive electrical component that can store electrical energy in an electric field.
- This effect of a capacitor is known as capacitance.
- Whilst some capacitance may exist between any two electrical conductors in a circuit, capacitors are components designed to add specific capacitance to a circuit.
- The capacitor was originally known as a
  - **Condenser,**
  - **Condensator,**
  - **Reservoir**
  - but these terms are not widely used nowadays.

Electric field

- When a voltage is applied across the two plates of a capacitor, a concentrated field flux is created between them, allowing a significant difference of free electrons (a charge) to develop between the two plates:
- One plate becomes positive, the other plate become negative.
- The space between the plates is occupied by the Dielectric material



Capacitance

- Capacitance is measured in Farad (SI unit).
- A Farad is a very large unit of measurement.
- In general circuits, capacitance added is a small fraction of a Farad.

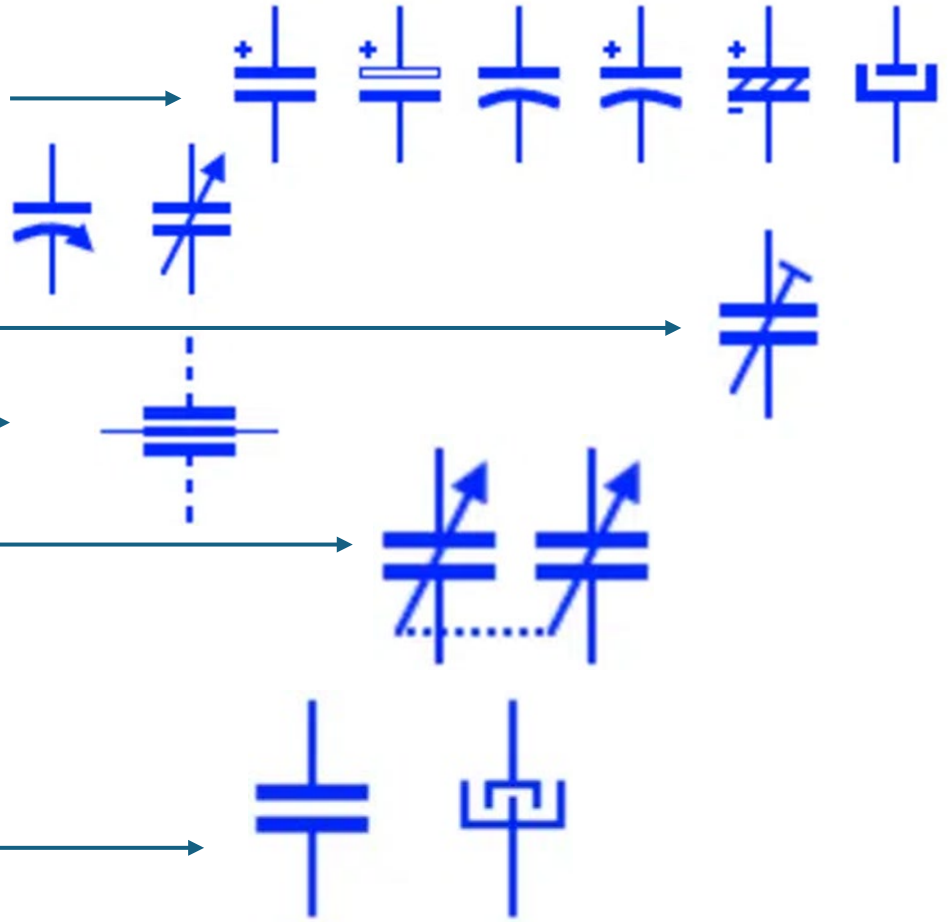
		Farad
1F	=	1
1mF	=	10^{-3} [milli farad]
1uF	=	10^{-6} [micro farad]
1nF	=	10^{-9} [nano farad]
1pF	=	10^{-12} [pico farad]

- In the recent past Super capacitors have become available, example 1Fard @2.5vDC, ~£2.50

Capacitor symbols

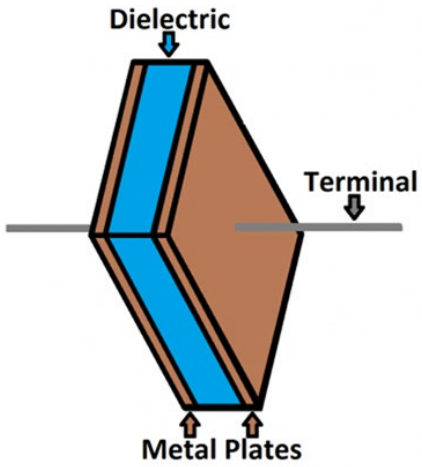
- Polarized Electrolytic Capacitor
- Variable Capacitor
- Trimmer Capacitor
- Feed through Capacitor
- Dual Ganged Capacitor
  - *And many more!*

- Generic symbol



Types of capacitor

- The types of capacitors are defined by their Dielectric material.
- Typical types of Dielectric materials are,
  - Ceramic (most common)
  - Metal oxides (electrolytic capacitors)
  - Plastic films (different types of plastic)
  - Mica
  - Paper (wet or dry)
  - Air

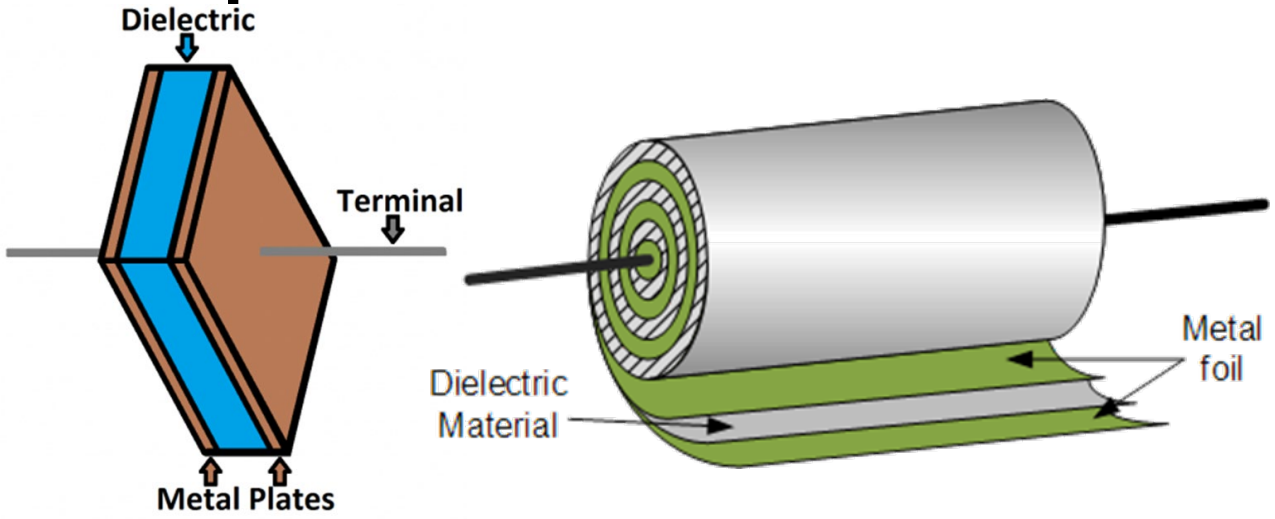


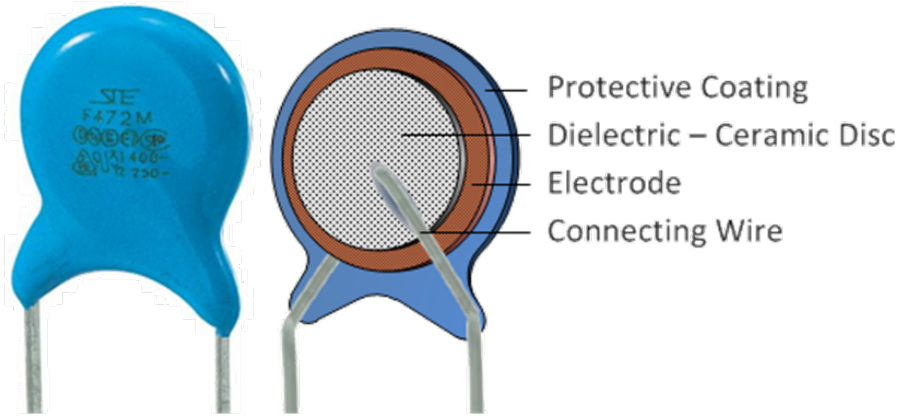
- One property of materials is their Dielectric Constant, [K].
  - The larger K is the large the capacitance for a given physical size.

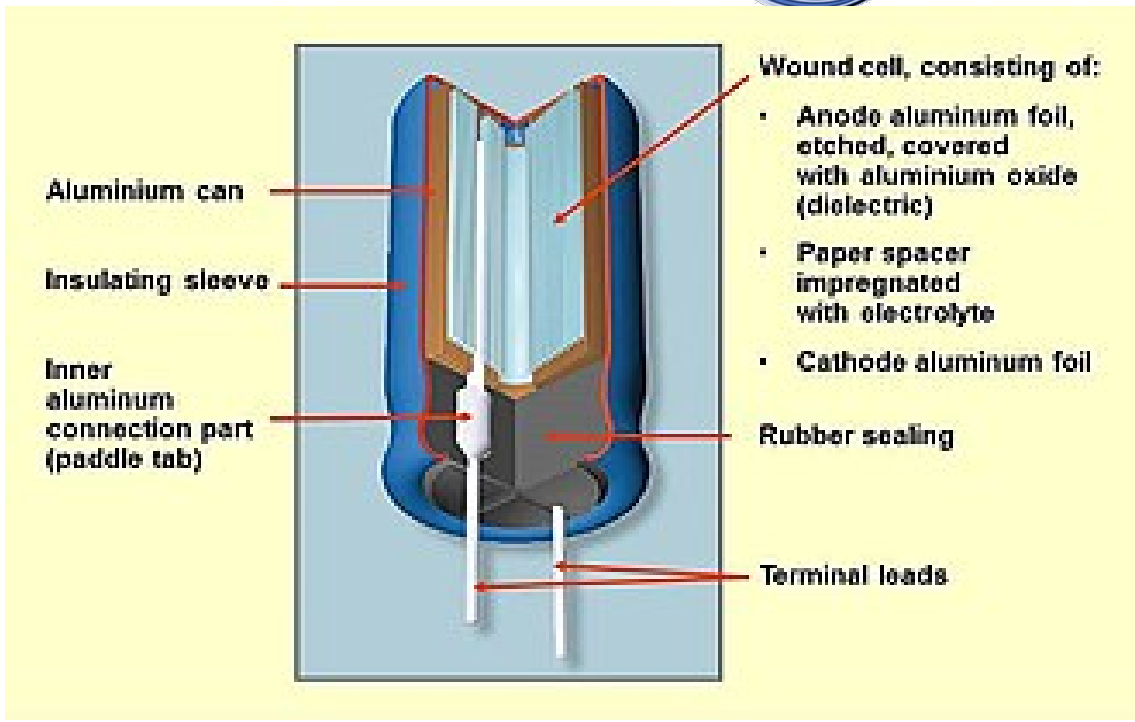
Variable capacitors

- Variable capacitors are generally used for either tuning or trimming of a circuit
- They can be either
  - Tuning Capacitors
  - Trimmer Capacitors
  - Mechanical Capacitors
  - Electronic Capacitors

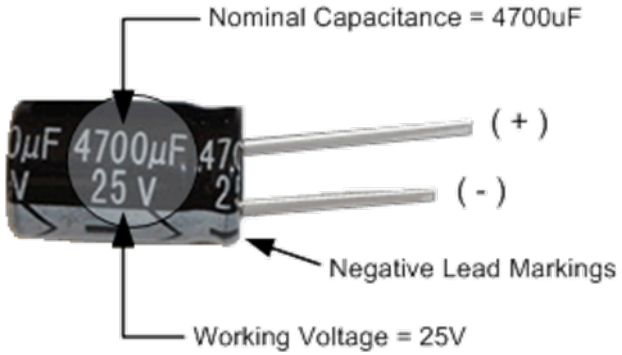
Capacitor construction

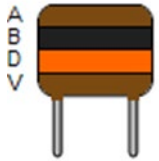




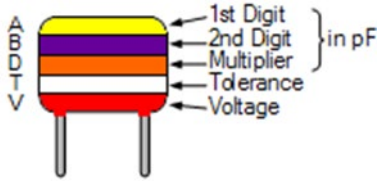


Capacitor marking

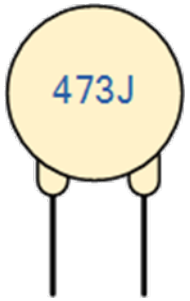




10nF, 20%
100V



47nF, 10%
250V



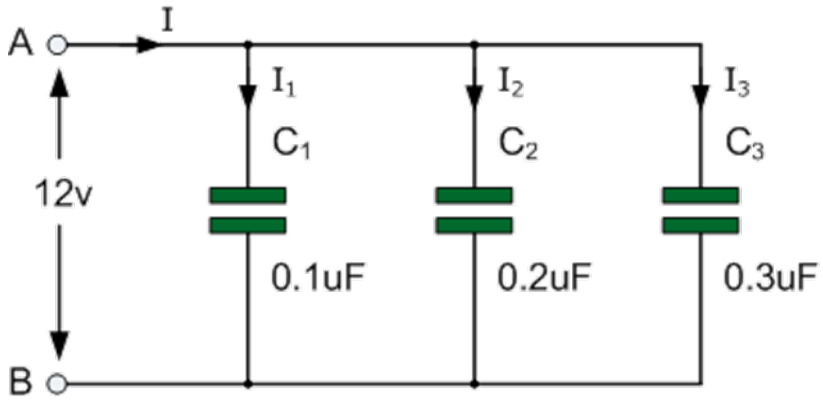
Capacitors, standard values

- The International Electrotechnical Commission (IEC) defined the preferred number series in 1952.
- Tables shows part of the values for
  - E6
  - E12
  - **E24 (**common range)
  - E48
  - E96
  - E192
- E24: 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91

E 6	E12	E24	E48	E96	E192	E 6	E12	E24	E48	E96	E192	E 6	E12	E24	E48	E96	E192
100	100	100	100	100	100	220	220	220	215	215	215	470	470	470	464	464	464
					101						218						470
				102	102					221	221					475	475
					104						223						481
			105	105	105				226	226	226				487	487	487
					106						229						493
				107	107					232	232					499	499
					109						234						505
		110	110	110	110			240	237	237	237			510	511	511	511
					111						240						517
				113	113					243	243					523	523
					114						246						530
			115	115	115				249	249	249				536	536	536
					117						252						542
				118	118					255	255					549	549
					120						258						556
	120	120	121	121	121		270	270	261	261	261		560	560	562	562	562
					123						264						569
				124	124					267	267					576	576
					126						271						583
			127	127	127				274	274	274				590	590	590
					129						277						597
				130	130					280	280					604	604
					132						284						612
		130	133	133	133			300	287	287	287			620	619	619	619
					135						291						626
				137	137					294	294					634	634
					138						298						642

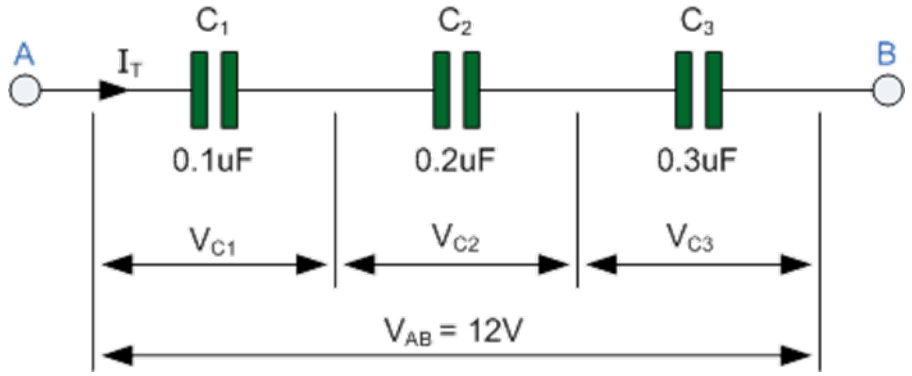
Capacitors in parallel

- $C_{total} = C_1 + C_2 + C_3$
- $C_{total} = 0.1 + 0.2 + 0.3$
- $C = 0.6uF$



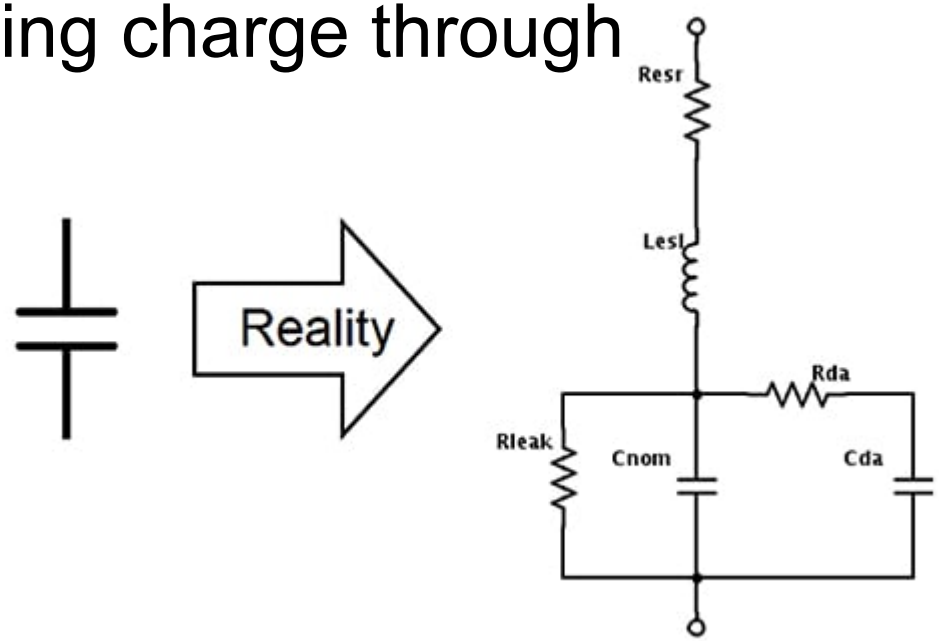
Capacitors in series

- $1/C_{Total} = 1/C_1 + 1/C_2 + 1/C_3$
- $1/C_{total} = 1/0.1uF = 1/0.2uF = 1/0.3uF$
- $C = 0.0545uF$



Capacitor ESR

- All capacitors have an **E**quivalent **S**eries **R**esistance (ESR)
- It describes losses associated with moving charge through a capacitor.
- A real-life capacitor is show in diagram



An increase in ESR is an indicator

that the component is starting to fail

Summary

- Capacitors store an electric charge.
- They come in many and varied forms of construction and capacity
- They are used in most electronic circuits for a variety of tasks.
  - Smoothing
  - Isolation
  - Bypass
  - etc.
- As time goes on, capacitors can age and change their capacitance, a common failure in electronic circuits.
- **The next talk will cover inductors**