6.1 Function of capacitor

A **capacitor** is an electrical/electronic device that can store energy in the electric field (produced by the voltage between a pair of conductor called "plates").

Capacitor and DC voltage

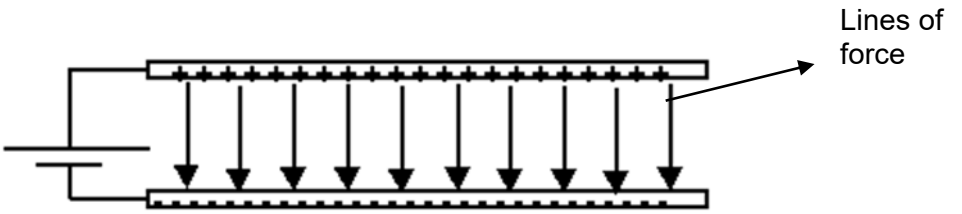


Fig 6.1 The Electric Field stores energy in a capacitor

When there is a current through a capacitor, electrons accumulate on one plate and electrons are removed from the other plate.

This process is commonly called 'charging' the capacitor -- even though the capacitor is at all times electrically neutral.

Net positive charge tends to accumulate on one plate and net negative charge on the other.

An electric field develop between the plates of the capacitor giving rise to voltage across the plates.

For circuits with a constant (DC) voltage source, the voltage across the capacitor cannot exceed the voltage of the source.

For this reason, it is commonly said that **capacitors block DC current**.

The Coulomb

A capacitor is used to store electric charge. The more voltage (electrical pressure) you apply to the capacitor, the more charge is stored onto the capacitor.

The larger the capacitance, the larger will be the charge that is stored from a given voltage.

This relation is described by the formula Q = CV, where Q is the charge stored, C is the capacitance, and V is the voltage applied.

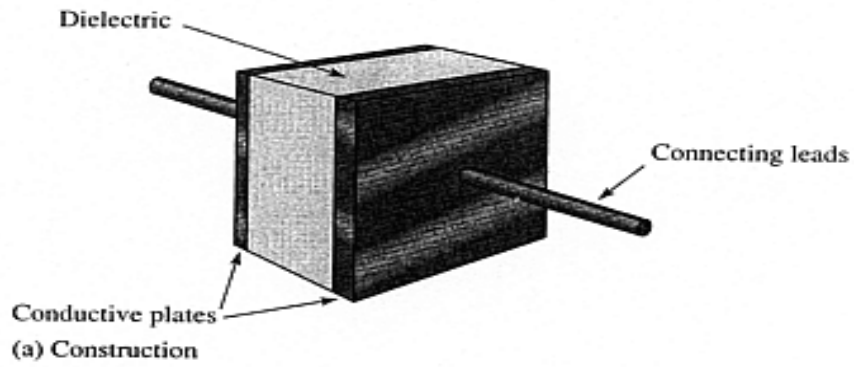
Charge (Q) = C V

The amount of charge in a capacitor is measured in coulombs (C).

6.2 Construction of capacitors

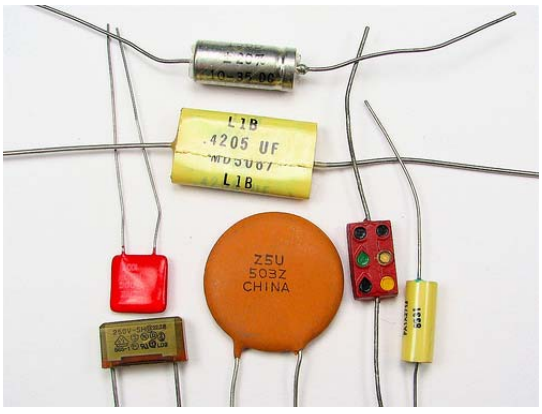
A capacitor consists of basically two metal plates separated by an insulating material called 'dielectric'. Some of the dielectric materials commonly used in capacitors are:

(a) air
(b) ceramic
(c) mica
(d) Oxide layer on metal (Aluminum, Tantalum, Niobium-electrolytic film)
(e) Plastic film



The basic capacitor.

Structure of a Capacitor



Different Types of Capacitors

6.3 Capacitance

Capacitance (symbol C) is a measure of a capacitor's ability to **store charge**.

A large capacitance means that more charge can be stored.

Capacitance is measured in **farads**, symbol F.

However 1F is very large, so prefixes (multipliers) are used to show the smaller values:

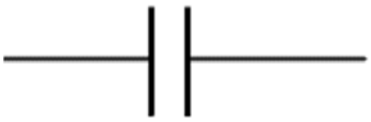
- μ (micro) means 10^{-6} (millionth), so 1000000μF = 1F
- n (nano) means 10^{-9} (thousand-millionth), so 1000nF = 1μF
- p (pico) means 10^{-12} (million-millionth), so 1000pF = 1nF

6.4 Common types of capacitor

6.4.1 Fixed Capacitors

A fixed capacitor is constructed in such manner that it possesses a fixed value of capacitance which cannot be adjusted.

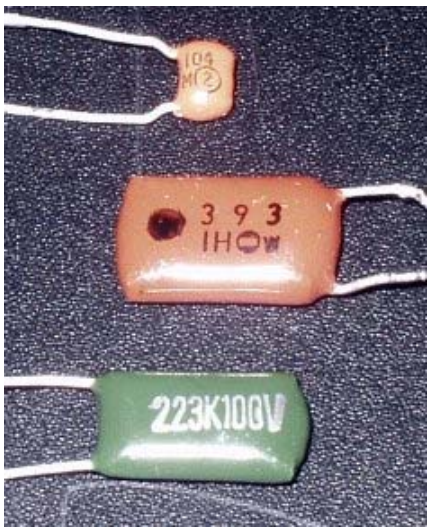
Symbols of Fixed Capacitor



Non-polarity Capacitor

Electrolytic Capacitor

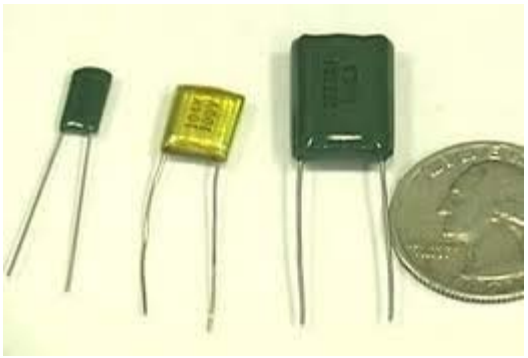
(a) Ceramic



(b) mica

(c) oxide film (electrolytic film) rated at 1000uF/10V

(d) Tantalum electrolytic rated at 2.2uF/25V



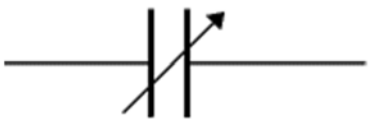
(e) plastic film

6.4.2 Variable Capacitors

It consists of one set of fixed plates and another set of movable plates whereby its capacitance is required to be varied. In this type, air acts as the di-electric.

Variable air capacitors are used in the radio tuning circuits.

Air dielectric variable capacitor



Symbol of variable Capacitor

6.5 Capacitor Number Code

A number code is often used on small capacitors where printing is difficult:

- the 1st number is the 1st digit,
- the 2nd number is the 2nd digit,
- the 3rd number is the number of zeros to give the capacitance in pF.
- Ignore any letters - they just indicate tolerance and voltage rating.

For example: **102** means 1000pF = 1nF *(not 102pF!)*

For example: **472J** means 4700pF = 4.7nF (J means 5% tolerance).

Capacitor Value Codes Fig. 2

3rd Digit	Multiplier	Letter	Tolerance
0	1	D	0.5 pF
1	10	F	1 %
2	100	G	2 %
3	1,000	H	3 %
4	10,000	J	5 %
5	100,000	K	10 %
6,7	Not Used	M	20 %
8	.01	P	+100, -0 %
9	.1	Z	+80, -20 %

Exercise

What is the value of the capacitor with 333 printed on it?

6.6 Characteristic of a capacitor

6.6.1 - Nominal Capacitance, C

The nominal value of the **Capacitance**, C of a capacitor is measured in pico-Farads (pF), nano-Farads (nF) or micro-Farads (μF).

6.6.2 - Working Voltage, V

The **Working Voltage** is the maximum continuous voltage either DC or AC that can be applied to the capacitor without failure during its working life

6.6.3 - Tolerance, ±%

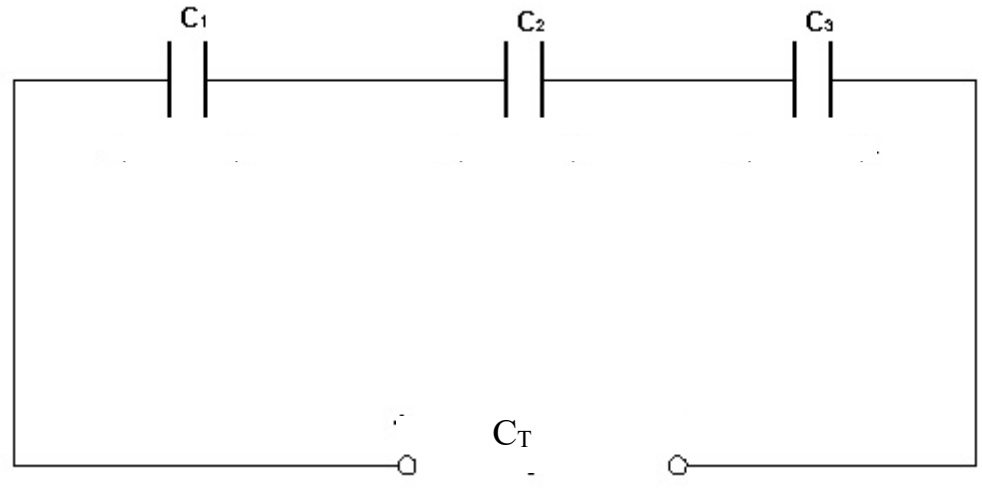
Capacitors have a **Tolerance** rating expressed as a plus-or-minus value either in picofarad's (±pF) for low value capacitors generally less than 100pF or as a percentage (±%) for higher value capacitors generally higher than 100pF

6.6.4 - Block DC

A capacitor has the virtue of being able **to block DC** current and pass **AC.**

6.7 Capacitors in Series

Capacitors in series are capacitors those are connected end-to-end as shown in figure below.



Capacitors in series

6.7 Capacitance in Series

For a series circuit:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

where C_T is the total capacitance or equivalent capacitance of the circuit.

The total capacitance C_T is smaller than the lowest individual capacitance.

Capacitors of equal capacitance connected in series

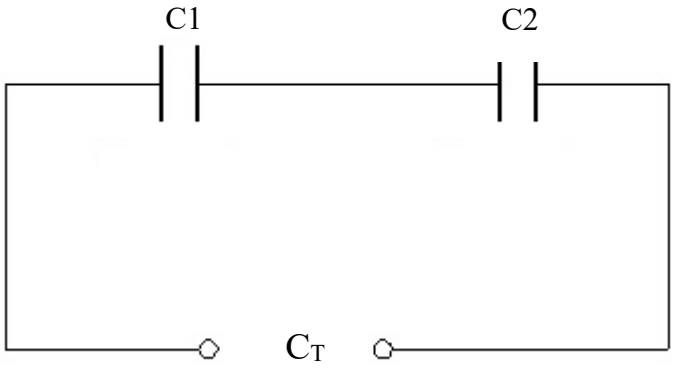
Therefore, if there are ' n' number of capacitors of equal capacitance C each connected in series,

$$C_T = \frac{C}{n}$$

Exercise

The combined capacitance of five equal capacitors is 10 μF. Calculate the value of each capacitor.

6.7.1 Two unequal capacitors in series



Two un-equal capacitors in series

If two capacitors of capacitance C_1 and C_2 are connected in series as shown in the figure above and let C_T is the total capacitance of the circuit, then

$$C_T = \frac{C_1 C_2}{(C_1 + C_2)}$$

$$C_T = \frac{\text{Product of capacitance}}{\text{Sum of capacitance}}$$

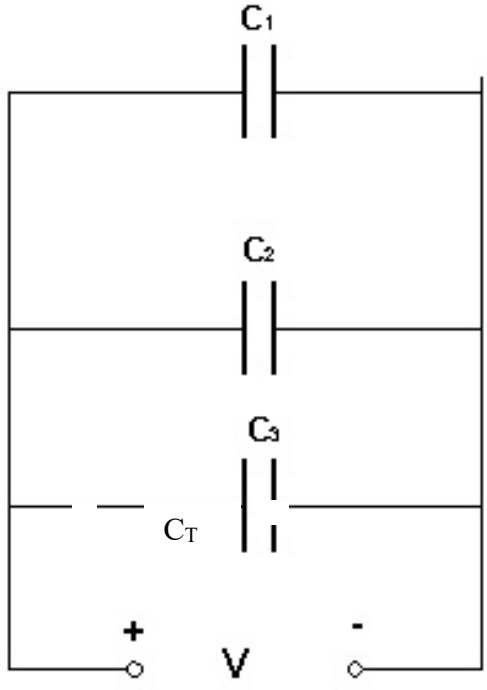
Exercise

Two capacitors of capacitance 10 μF and 20 μF respectively, are connected in series. Find the total capacitance?

Three capacitors of capacitance 5 μF , 10 μF and 15 μF respectively are joined in series. Calculate the circuit capacitance.

6.8 Capacitors in Parallel

Capacitance in parallel are capacitors with their corresponding ends connected together as shown in figure below.



Parallel connection of capacitors

For the circuit shown above, the total capacitance is given by

$$C_T = C_1 + C_2 + C_3$$

Total capacitance or equivalent capacitance is **greater** than the largest individual capacitance.

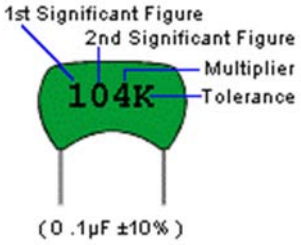
Exercise

Four capacitors, each of capacitance 3.2 μF are connected in parallel. Find the equivalent (total) capacitance?

Capacitor data Book and resources

Capacitor Chart

Mica Capacitor Values

Charts	Value	Multiplier	Letter	Tolerance
	0	1	B	± 0.1pF
	1	10	C	± 0.25pF
	2	100	D	± 0.5pF
	3	1,000	F	± 1%
	4	10,000	G	± 2%
	5	100,000	H	± 3%
Parallel Capacitance Math: $C_T = C_1 + C_2 + C_3$			J	± 5%
Series Capacitance Math: $1/C_T = 1/C_1 + 1/C_2 + 1/C_3$	8	0.01	K	± 10%
	9	0.1	M	± 20%

Capacitor Code Guide

VALUE	TYPE	CODE	VALUE	TYPE	CODE
1.5pF	Ceramic		1,000pF / .001uF		
	Ceramic / Mylar				102
3.3pF	Ceramic		1,500pF / .0015uF		
	Ceramic / Mylar				152
10pF	Ceramic		2,000pF / .002uF		
	Ceramic / Mylar				202
15pF	Ceramic		2,200pF / .0022uF		
	Ceramic / Mylar				222
20pF	Ceramic		4,700pF / .0047uF		
	Ceramic / Mylar				472
30pF	Ceramic		5,000pF / .005uF		
	Ceramic / Mylar				502
33pF	Ceramic		5,600pF / .0056uF		
	Ceramic / Mylar				562
47pF	Ceramic		6,800pF / .0068uF		
	Ceramic / Mylar				682
56pF	Ceramic		.01		
	Ceramic / Mylar				103
68pF	Ceramic		.015		Mylar
75pF	Ceramic		.02		Mylar
		203			
82pF	Ceramic		.022		Mylar
		223			

91pF	Ceramic		.033	Mylar
		333		
100pF	Ceramic	101	.047	Mylar
		473		
120pF	Ceramic	121	.05	Mylar
		503		
130pF	Ceramic	131	.056	Mylar
		563		
150pF	Ceramic	151	.068	Mylar
		683		
180pF	Ceramic	181	.1	Mylar
		104		
220pF	Ceramic	221	.2	Mylar
		204		
330pF	Ceramic	331	.22	Mylar
		224		
470pF	Ceramic	471	.33	Mylar
		334		
560pF	Ceramic	561	.47	Mylar
		474		
680pF	Ceramic	681	.56	Mylar
		564		
750pF	Ceramic	751	1	Mylar
		105		
820pF	Ceramic	821	2	Mylar
		205		

Usually the first two digits of the code represent part of the value; the third digit corresponds to the number of zeros to be added to the first two digits. This is the value in pf.

General Capacitance Codebreaker Charts

pico-farad (pF)	nano-farad (nF)	micro-farad (mF,uF or mfd)	capacitance code
1000	1 or 1n	0.001	102
1500	1.5 or 1n5	0.0015	152
2200	2.2 or 2n2	0.0022	222
3300	3.3 or 3n3	0.0033	332
4700	4.7 or 4n7	0.0047	472
6800	6.8 or 6n8	0.0068	682
10000	10 or 10n	0.01	103
15000	15 or 15n	0.015	153
22000	22 or 22n	0.022	223
33000	33 or 33n	0.033	333
47000	47 or 47n	0.047	473
68000	68 or 68n	0.068	683
100000	100 or 100n	0.1	104
150000	150 or 150n	0.15	154
220000	220 or 220n	0.22	224

330000	330 or 330n	0.33	334
470000	470 or 470n	0.47	474

1 http://en.wikipedia.org/wiki/Types_of_capacitor

2 https://eepower.com/capacitor-guide/types/tantalum-capacitor/

3 https://www.desertcart.sg/products/9136810-capacitor-variable-single-365-pf-cw-rotation