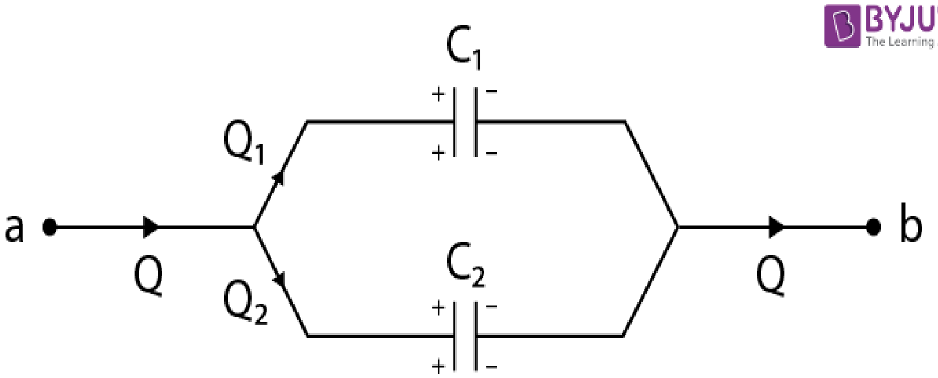
Parallel Combination of Capacitors

When capacitors are connected in parallel, the potential difference V across each is the same and the charge on C_1, C_2 is different i.e., Q_1 and Q_2.



The total charge is Q given as:

Q=Q1+Q2
Q=C1V+C2V
QV=C1+C2
Equivalent capacitance between a and b is:

$C = C_1 + C_2$

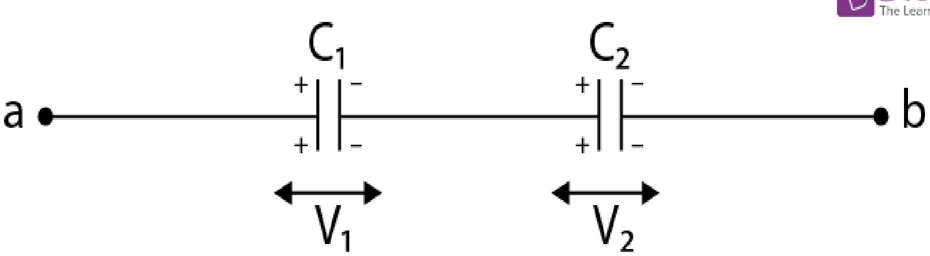
The charges on capacitors is given as:

- Q1=C1C1+C2Q
- Q2=C2C1+C2Q

In case of more than two capacitors, $C = C_1 + C_2 + C_3 + C_4 + C_5 + \ldots\ldots\ldots\ldots$

Series Combination of Capacitors

When capacitors are connected in series, the magnitude of charge Q on each capacitor is same. The potential difference across C_1 and C_2 is different i.e., V_1 and V_2.



$$\mathbf{Q = C_1 V_1 = C_2 V_2}$$

The total potential difference across combination is:

$V = V_1 + V_2$

$V=QC1+QC2$
$VQ=1C1+1C2$
The ratio Q/V is called as the equivalent capacitance C between point a and b.

The equivalent capacitance C is given by:

$1C=1C1+1C2$
The potential difference across C_1 and C_2 is V_1 and V_2 respectively, given as follows:

$V1=C2C1+C2;V2=C1C1+C2V$
In case of more than two capacitors, the relation is:

$1C=1C1+1C2+1C3+1C4+\ldots\ldots$
Important Points:

- If N identical capacitors of capacitance C are connected in series, then effective capacitance = C/N
- If N identical capacitors of capacitance C are connected in parallel, then effective capacitance = CN
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Capacitor Colour Codes

Capacitor colour codes are a simple and effective visual way of identifying the capacitance value of a capacitor

There are two common ways to know the capacitive value of a capacitor, by measuring it using a digital multimeter, or by reading the capacitor colour codes printed on it. These coloured bands represent the capacitance value as per the colour code including voltage rating and tolerance.

Sometimes the actual values of capacitance, voltage or tolerance are marked onto the body of a capacitor in the form of alphanumeric characters. However, when the value of the capacitance is of a decimal value problems arise with the marking of the “Decimal Point” as it could easily not be noticed resulting in a misreading of the actual capacitance value.

Instead letters such as p (pico) or n (nano) are used in place of the decimal point to identify its position and the weight of the number. For example, a capacitor can be labelled as, n47 = 0.47nF, 4n7 = 4.7nF or 47n = 47nF and so on.

Also, sometimes capacitors are marked with the capital letter K to signify a value of one thousand pico-Farads, so for example, a capacitor with the markings of 100K would be 100 x 1000pF or 100nF.

To reduce the confusion regarding letters, numbers and decimal points, an International colour coding scheme was developed many years ago as a simple way of identifying capacitor values and tolerances. It consists of coloured bands (in spectral order) known commonly as a **Capacitor Colour Codes** system and whose meanings are illustrated below:

Capacitor Colour Code Table

Band Colour	Digit A	Digit B	Multiplier D	Tolerance (T) > 10pf	Tolerance (T) < 10pf	Temperature Coefficient (TC)
Black	0	0	x1	± 20%	± 2.0pF	
Brown	1	1	x10	± 1%	± 0.1pF	-33×10^{-6}
Red	2	2	x100	± 2%	± 0.25pF	-75×10^{-6}
Orange	3	3	x1,000	± 3%		-150×10^{-6}
Yellow	4	4	x10,000	± 4%		-220×10^{-6}
Green	5	5	x100,000	± 5%	± 0.5pF	-330×10^{-6}
Blue	6	6	x1,000,000			-470×10^{-6}

Violet	7	7				-750×10^{-6}
Grey	8	8	x0.01	+80%,-20%		
White	9	9	x0.1	± 10%	± 1.0pF	
Gold			x0.1	± 5%		
Silver			x0.01	± 10%		

Capacitor Voltage Colour Code Table

Band Colour	Voltage Rating (V)				
	Type J	Type K	Type L	Type M	Type N
Black	4	100		10	10
Brown	6	200	100	1.6	
Red	10	300	250	4	35

Orange	15	400		40	
Yellow	20	500	400	6.3	6
Green	25	600		16	15
Blue	35	700	630		20
Violet	50	800			
Grey		900		25	25
White	3	1000		2.5	3
Gold		2000			
Silver					

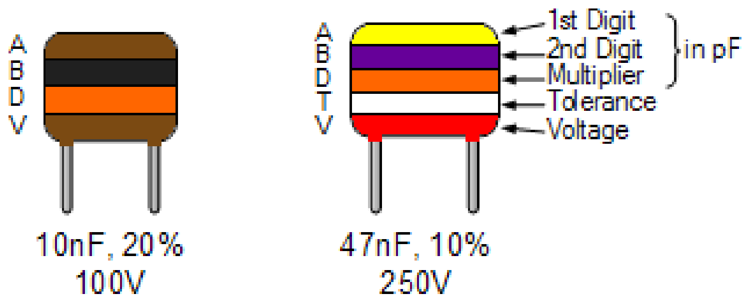
Capacitor Voltage Reference

- Type J – Dipped Tantalum Capacitors.
- Type K – Mica Capacitors.
- Type L – Polyester/Polystyrene Capacitors.
- Type M – Electrolytic 4 Band Capacitors.

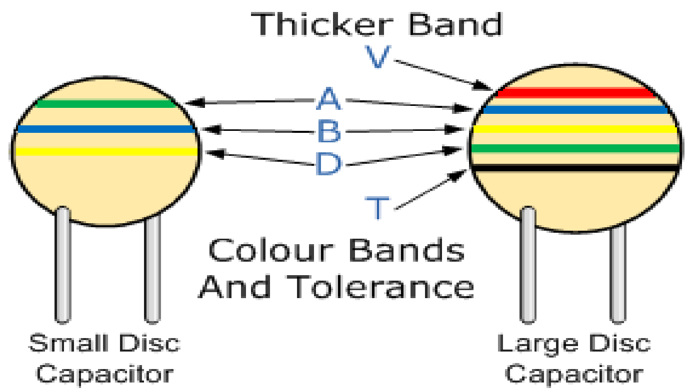
- Type N – Electrolytic 3 Band Capacitors.

An example of the use of capacitor colour codes is given as:

Metalised Polyester Capacitor



Disc & Ceramic Capacitor



The **Capacitor Colour Codes** system was used for many years on unpolarised polyester and mica moulded capacitors. This system of colour coding is now obsolete but there are still many "old" capacitors around. Nowadays, small capacitors such as film or disk types conform to the BS1852 Standard and its new replacement, BS EN 60062, were the colours have been replaced by a letter or number coded system.

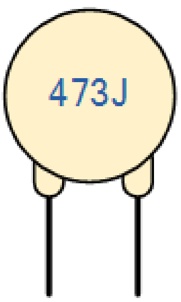
Generally the code consists of 2 or 3 numbers and an optional tolerance letter code to identify the tolerance. Where a two number code is used the value of the capacitor only is given in picofarads, for example, 47 = 47 pF and 100 = 100pF etc. A three letter code consists of the two value digits and a multiplier much like the resistor colour codes in the resistors section.

For example, the digits 471 = 47*10 = 470pF. Three digit codes are often accompanied by an additional tolerance letter code as given below.

Capacitor Tolerance Letter Codes Table

	Letter	B	C	D	F	G	J	K	M	Z
Tolerance	C <10pF ±pF	0.1	0.25	0.5	1	2				
	C >10pF ±%			0.5	1	2	5	10	20	+80 -20

Consider the capacitor below:



The capacitor on the left is of a ceramic disc type capacitor that has the code 473J printed onto its body. Then the 4 = 1st digit, the 7 = 2nd digit, the 3 is the multiplier in pico-Farads, pF and the letter J is the tolerance and this translates to: 47pF * 1,000 (3 zero's) = 47,000 pF, 47nF or 0.047uF
the J indicates a tolerance of +/- 5%

Then by just using numbers and letters as codes on the body of the capacitor we can easily determine the value of its capacitance either in Pico-farad's, Nano-farads or Micro-farads and a list of these "international" codes is given in the following table along with their equivalent capacitances.

Common faults with capacitors

The common faults of capacitors include wire break, short circuit, leakage and failure.

(1) capacity determination: set the electrical block R×1K or R×10K of the multimeter, and contact the poles of the capacitor respectively. If the pointer of the meter head rapidly swings forward by an Angle, then gradually recover and return to the starting position.Then exchange the two watch pens, and then contact the capacitor's poles, the meter head pointer is positive deflection, and the Angle is larger than the previous, and then gradually restore and return to the

starting position, indicating that the capacitor is intact.The higher the deflection Angle of the pointer, the slower the recovery speed, indicating the larger the capacitor.

(2) leakage: multimeter (R×1K).When stable, the indicator value of the pointer is the insulation resistance of the capacitor, and a certain value is generally several hundred to several thousand megabytes. The higher the resistance value is, the better the insulation performance of the capacitor is.

(3) short circuit: if the pointer of the multimeter is at full scale, that is, R=0, and does not return, it indicates that the capacitor has been short-circuited.

(4) disconnection: when the two stylus of the multimeter touch the electrode of the capacitor, the pointer will not be deflected at all. If the stylus is not deflected when replaced, it indicates that the capacitor has been disconnected.

(5) electrolytic capacitor polarity determination: use a multimeter R×1K electrical barrier to measure the insulation resistance between the two poles, and then switch the two meter pen, and then measure the insulation resistance, the resistance value of the two measurements is larger a black (positive) meter pen to connect the positive pole or a red (negative) meter pen to connect the positive pole.For low-voltage electrolytic capacitors, do not arbitrarily use R×10K electrical barrier to avoid breakdown of electrolytic capacitors.