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Engineering Design Project-II
(UTA 024)

THAPAR INSTITUTE
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Engineering Design-III
(UTA 014)
Buggy Lab

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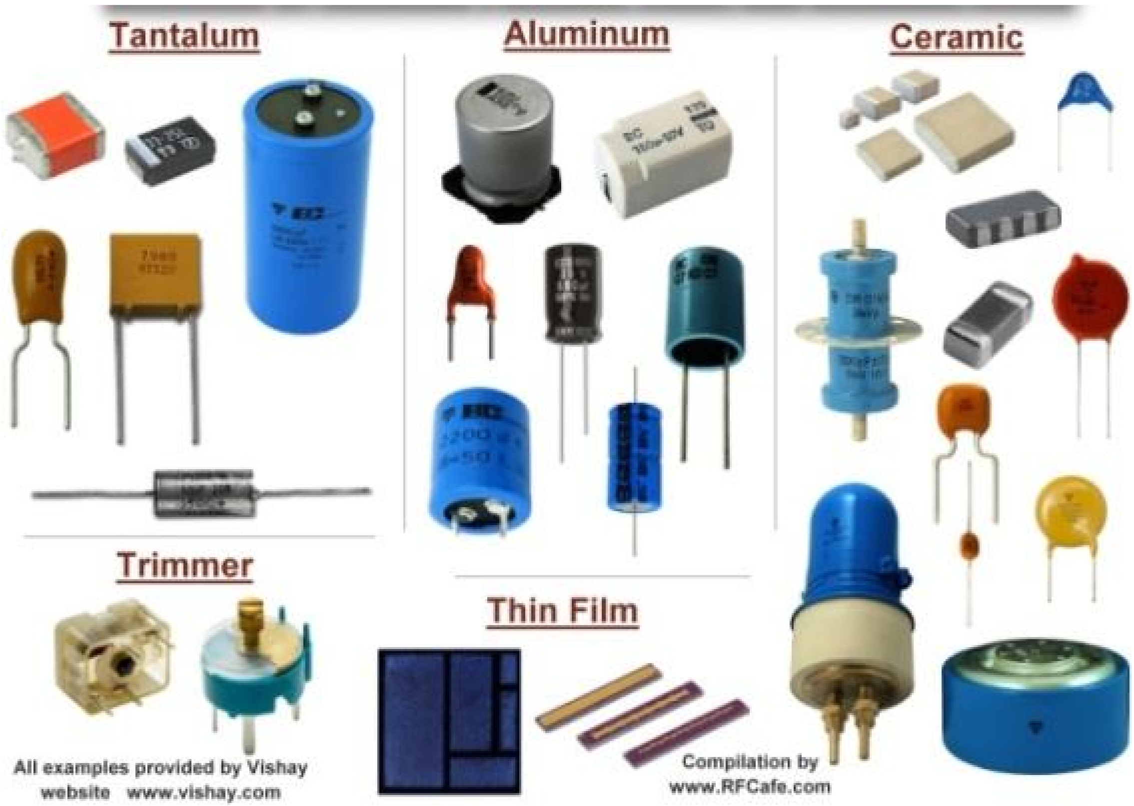
Classification of Capacitor

There are different types of capacitors available in the market with diverse rating and sizes. Some of these are described below.

- ❖Ceramic capacitor
- ❖Silver mica capacitor
- ❖Polyester Film capacitor
- ❖Electrolytic capacitor
- ❖Tantalum capacitor
- ❖Variable capacitor
- ❖Super capacitor



Ceramic capacitor

The ceramic capacitor is a type of capacitor that is used in many applications from **audio to RF**. Values range from a few picofarads to around 0.1 microfarads. Ceramic capacitor types are by far the most commonly used type of capacitor being **cheap and reliable** and their loss factor is particularly low although this is dependent on the exact dielectric in use. In view of their constructional properties, these capacitors are widely used both in leaded and surface mount formats

Fig. 12

Silver Mica Capacitor

Silver mica capacitors are not as widely used these days, but they still offer **very high levels of stability**, low loss and accuracy where space is not an issue. They are primarily **used for RF applications** and they are limited to maximum values of 1000 pF or so.

Fig. 13

Polyester Film Capacitor

Polyester film capacitors are **used where cost is a consideration** as they **do not offer a high tolerance**. Many polyester film capacitors have a tolerance of 5% or 10%, which is adequate for many applications. They are generally only available as leaded electronics components.

Fig. 14

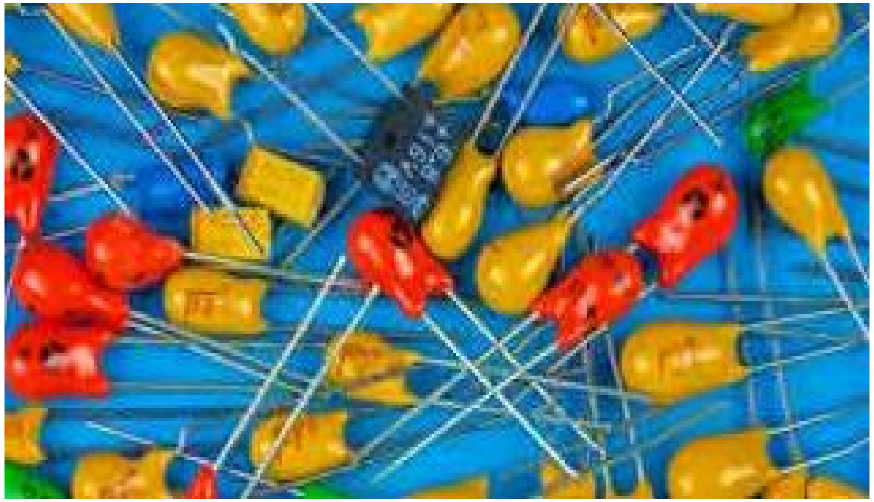
Electrolytic capacitor

Electrolytic capacitors are a type of capacitor that is **polarised.** They are able to offer **high capacitance values** - typically **above 1μF**, and are most widely used for **low frequency applications - power supplies**, **decoupling** and **audio coupling** applications as they have a **frequency limit around 100 kHz.**

Fig. 15

Tantalum capacitor

Like electrolytic capacitors, tantalum capacitors are **also polarised** and offer **a very high capacitance** level for their volume. However this type of capacitor is very intolerant of being reverse biased, often exploding when placed under stress. This type of capacitor must also not be subject to high ripple currents or voltages above their working voltage. They are available in both leaded and surface mount formats.



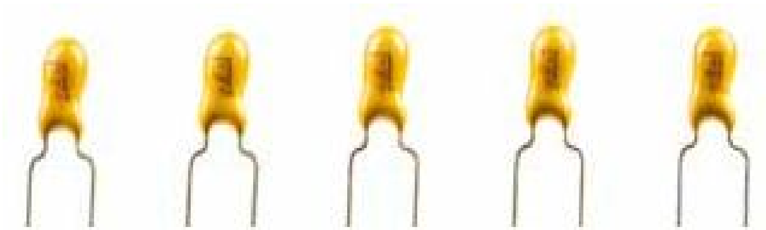


Fig. 16

Variable Capacitor

As well as the continuously variable types, preset type variable capacitors are also available called **Trimmers**. These are generally small devices that can be adjusted or "pre-set" to a particular capacitance value with the aid of a small screwdriver and are available in very small capacitance's of 500pF or less and are non-polarized.

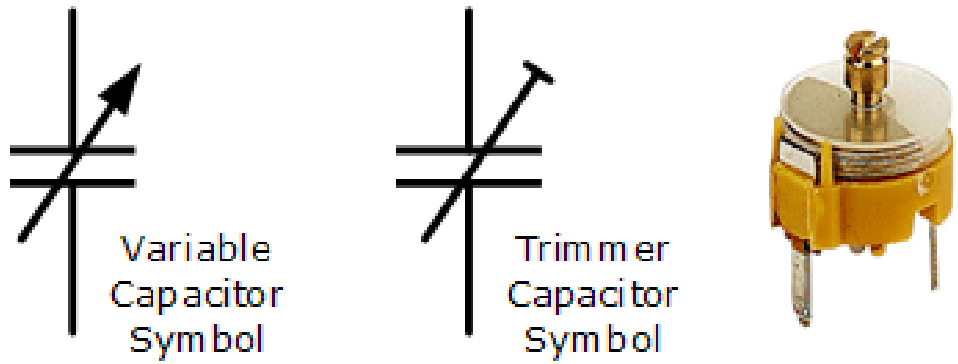


Fig. 17

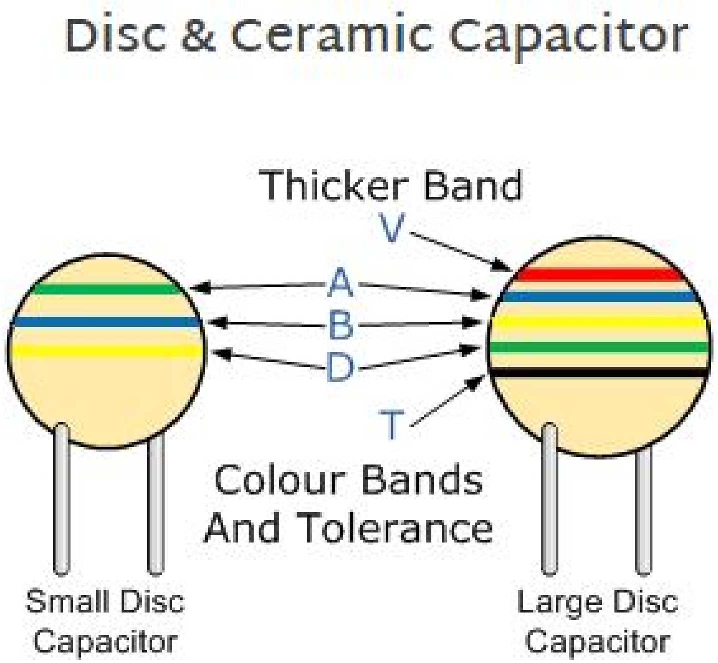
Super capacitor

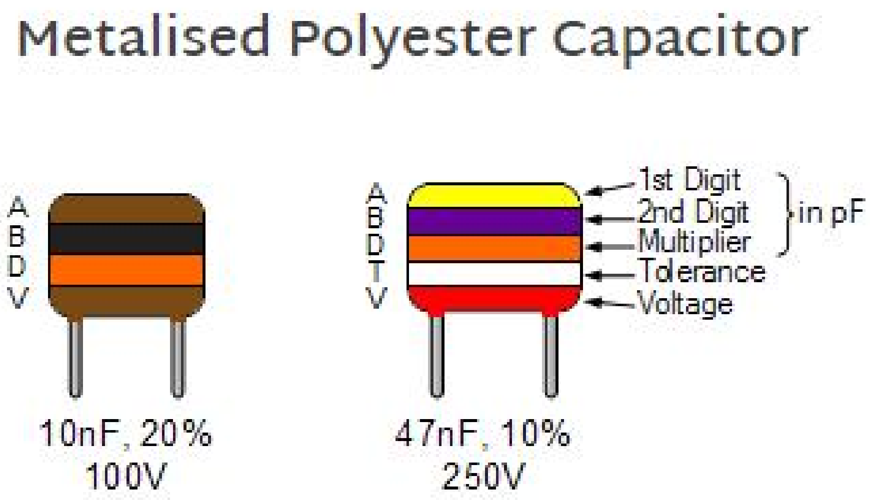
Also known as a supercap or ultracapacitor, as the name implies these capacitors have very large values of capacitance, of up to **several thousand Farads**. They find uses for providing a **memory hold-up supply** and also within **automotive applications**. These devices which are also known as supercaps or ultracapacitors may have capacitance levels up to several thousand farads and as a result they are half way between a capacitor and a battery. These capacitors may also be known as double-layer capacitors as a result of the way in which they are constructed.

Fig. 18

Color coding scheme for capacitor

An International colour coding scheme was developed as a simple way of identifying capacitor values and tolerances. It consists of coloured bands (in spectral order) known commonly as the **Capacitor Colour Code** system





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.

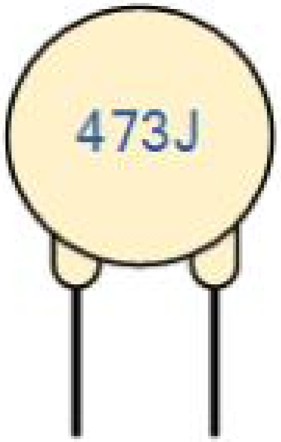
Type K – Mica Capacitors.

Type L – Polyester/Polystyrene Capacitors.

Type M – Electrolytic 4 Band Capacitors.

Type N – Electrolytic 3 Band Capacitors.

Example:



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

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 digi**t, 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%

Capacitor Letter Codes Table

Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5.0	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473

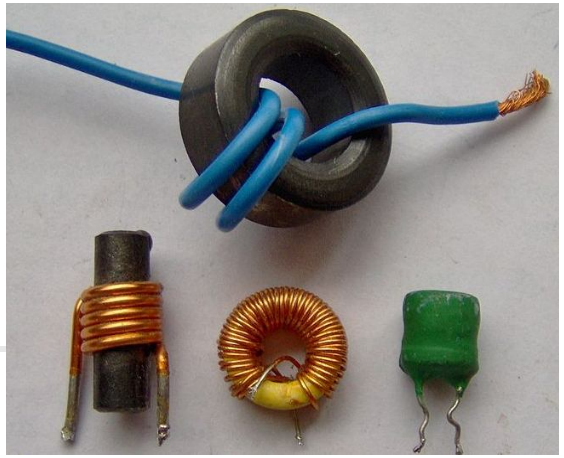
Capacitor Letter Codes Table

Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	254
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	751	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1.0	0.001	102	1000000	1000	1.0	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2.0	0.002	202	2000000	2000	2.0	205

Applications:

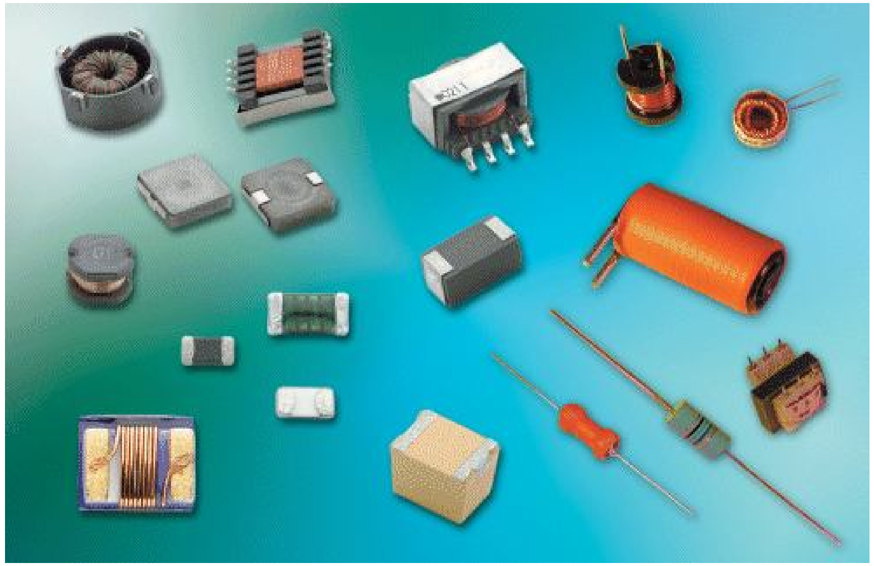
- ❖Energy storage
- ❖RC Filter: High pass, low pass
- ❖Noise filters or snubbers
- ❖RC Oscillators (Phase shift and Wein bridge)
- ❖Tuner: AF & RF
- ❖DC Power supply
- ❖Motor starters (i.e. single phase squirrel cage motor, Electric Fan)

Classification of Inductor



There are different types of inductors available in the market with diverse rating and sizes. Some of these are described below.

- ❖Air core inductor
- ❖Iron core inductor
- ❖Ferrite core inductor
- ❖Laminated core inductor
- ❖Toroidal inductor
- ❖Iron powder inductor
- ❖Variable inductor
- ❖ Cylindrical shaped lead type inductors



Air Core Inductor

Ceramic core inductors are referred as "**Air core inductors**". Ceramic is the most commonly used material for inductor cores. Ceramic has very low thermal co-efficient of expansion, so even for a range of operating temperatures the stability of the inductor's inductance is high. Since ceramic has no magnetic properties, there is no increase in the permeability value due to the core material.

Fig. 19

Iron Core Inductor

In the areas where low space inductors are in need then these iron core inductors are best option. These inductors have high power and high inductance value but limited in high frequency capacity. These are applicable in audio equipments. When compared with other core indictors these have very limited applications.

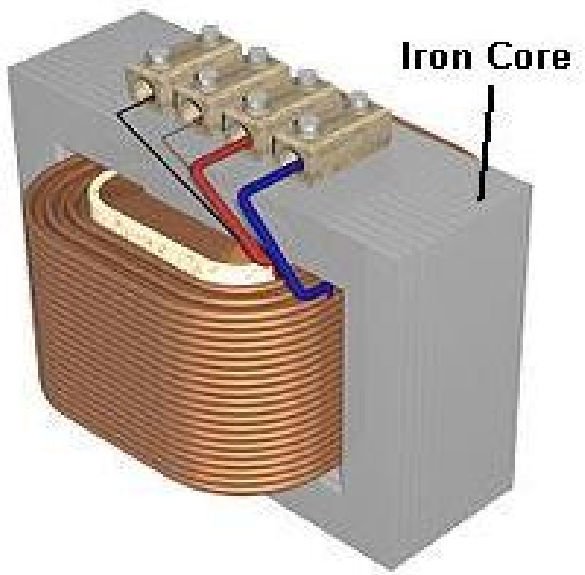


Fig. 20

Ferrite Core Inductor

Ferrite is also referred as ferromagnetic material. They exhibit magnetic properties. They consist of mixed metal oxide of iron and other elements to form crystalline structures. The general composition of ferrites is XFe_2O_4. Where X represents transition materials. Mostly easily magnetized material combinations are used such as manganese and zinc (MnZn), nickel and zinc (niZn).

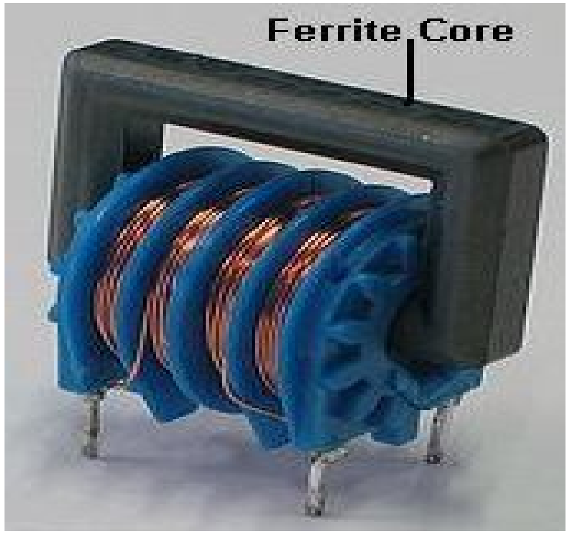


Fig. 21

Laminated Core Inductor

These core materials are formed by arranging many number of laminations on top of each other. These laminations may be made up of different materials and with different thicknesses. So this construction has more flexibility. These laminations are made up of steel with insulating material between them.

These are arranged parallel to the field to avoid eddy current losses between the laminations. These are used in low frequency detectors. They have high power levels so , they are mostly used at power filtering devices for excitation frequencies above several KHz.

Fig. 22

Toroidal Inductor

Wire wounded on core which has ring or donut shaped surface. These are generally made up of different materials like ferrite, powdered iron and tape wound etc. This inductor has high coupling results between winding and early saturation.

Its arrangement **gives** minimum loss in magnetic flux which helps to avoid coupling magnetic flux with other devices. It has high energy transferring efficiency and high inductance values at low frequency applications. These inductors mainly used in medical devices, switching regulators, air conditioners, refrigerators, telecommunications and musical instruments etc.

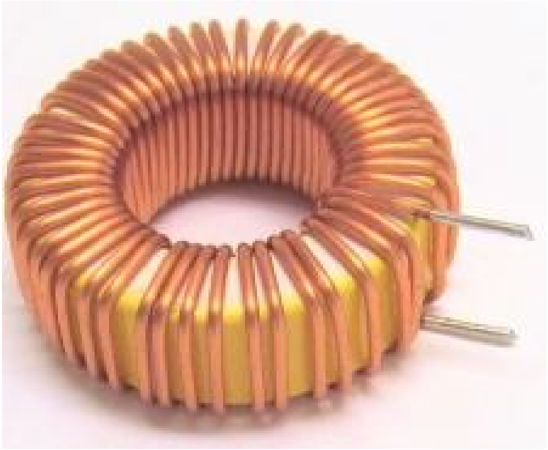


Fig. 23

Iron Powder Inductor

These are formed from very **fine particles with insulated particles of highly pure iron powder**. This type of inductor contains nearly 100% iron only. It gives us a solid looking core when this iron power is compressed under very high pressure and mixed with a binder such as epoxy or phenolic. By this action iron powder forms like a magnetic solid structure which consists of distributed air gap.

Due to this air gap it is capable to store high magnetic flux when compared with the ferrite core. This characteristic allows a higher DC current level to flow through the inductor before inductor saturates. This leads to reduce the permeability of the core.

Mostly the initial permeability's are below 100 only. Thus these inductors posses with **high temperature co-efficient** stability. These are mainly **applicable** in **switching power suppli**es.

Fig. 24

Variable Inductors

By moving the magnetic core of an inductor in and out of the inductor windings, an inductor can be made variable. A ferrite cored inductor can be made variable by moving its core in or out of the former onto which the coil is wound. Many small inductors have threaded ferrite cores to make this possible. Such inductors are often used in radio and high-frequency applications where precise tuning is required. Typical values for variable inductors tend to range from about **10µH to 100µH**.

Fig. 25

Cylindrical shaped lead type inductors

In this, the value of the inductor is printed on inductor body which consists of numerical digits and alphabets. For this marking, micro Henry is the fundamental unit of measurement (even if no units are given). The following are the steps of identifying the value of inductor by using text marking method.

Fig. 26

Inductor

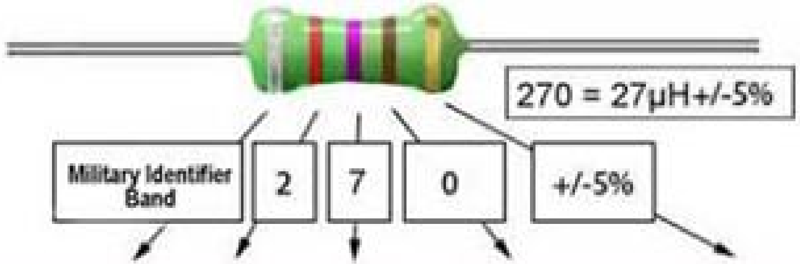
Four Band Standard EIA Colour Code For Inductors

Therefore value = 27 x10 = 270μH +/-20%

Band	1	2	3	4
Meaning	1^{st} Digit	2^{nd} Digit	Multiplier (No. of zeros)	Tolerance %
Gold			x 0.1 (divide by 10)	+/-5%
Silver			x 0.01 (divide by 100)	+/-10%
Black	0	0	x1 (No Zeros)	+/-20%
Brown	1	1	x10 (0)	
Red	2	2	x100 (00)	
Orange	3	3	x1000 (000)	
Yellow	4	4	x10000 (0,000)	
Green	5	5		
Blue	6	6		
Violet	7	7		
Grey	8	8		
White	9	9		

Note: If there is no Band 4, tolerance is also +/-20%

Five Band Military Standard Inductor Colour Code



Band	1	2	3	4	5
Meaning (See Notes)	**Mil. Spec.**	**Digit or Dec. point**	**Digit or Dec. point**	**Digit (or Multiplier)**	**Tolerance %**
Gold		Decimal point	Decimal point		+/-5%
Silver	Always Silver double width				+/-10%
Black		0	0	0 (or x 1)	+/-20%
Brown		1	1	1 (or x 10)	+/-1%
Red		2	2	2 (or x 100)	+/-2%
Orange		3	3	3 (or x 1,000)	+/-3%
Yellow		4	4	4 (or x 10,000)	+/-4%
Green		5	5	5	
Blue		6	6	6	
Violet		7	7	7	
Grey		8	8	8	
White		9	9	9	

Notes:

The military standard for cylindrical inductors specifies 5 colored bands The same colors are used as in the EIA 4 band code, but:

For band 1, a **double width** sliver band is used to signify Military Standard.

For values less than 10μH:

Bands 2, 3 and 4 indicate the value of inductance in μH

A gold band might be used in either band 2 or band 3. In either of these two bands, gold indicates a decimal point and band 4 is used as a digit instead of a multiplier band.

When no gold band is present in bands 2 or 3, band 4 is a multiplier band.

For example:

•If bands 2,3 and 4 are red, gold, red the value would be 2.2 μH

•If bands 2,3 and 4 are gold, yellow, violet the value would be 0.47 μH (470nH)

Band 5 indicates the tolerance between 1% and 20%.

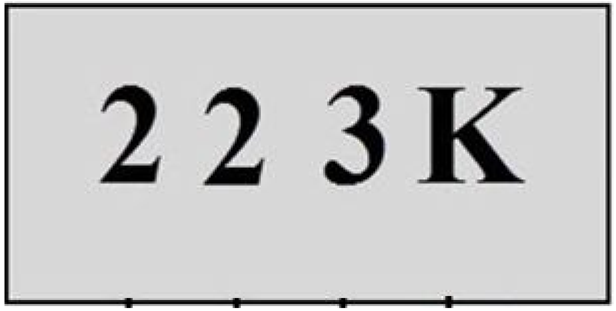
For values of 10μH or more:

Bands 2 and 3 represent basic value, and band 4 gives the number of zeros.

For example:

If bands 2, 3 and 4 are red, violet, orange the value would be 27000 μH

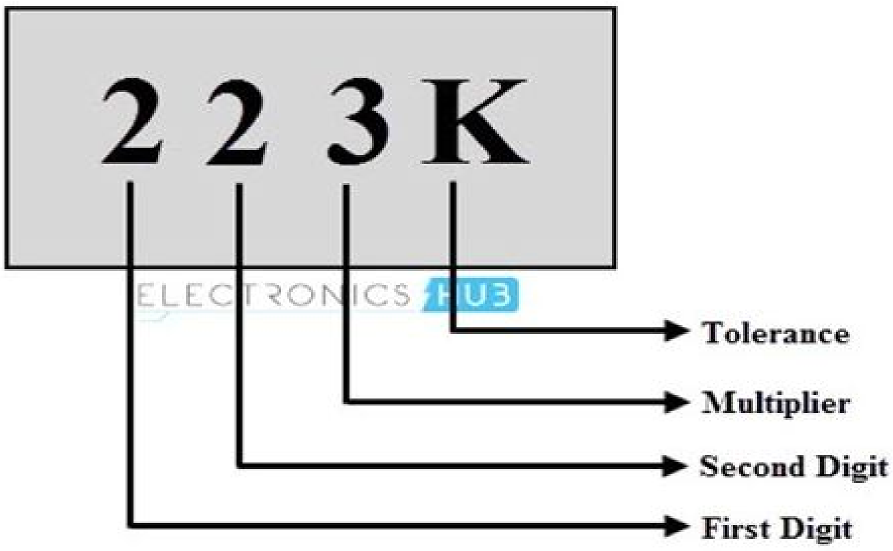
Inductor Value Identification using Text Marking



It consists of three or **four letters** (including alphabets and numerical digits).
First two digits indicate the value.
Third digit is the power to be applied for the first two , this means it is the multiplier and power of 10. For example, 101 is expressed as 10* 10^1 micro Henry (μH).
Suffix or **fourth letter** or alphabet represents the **tolerance value** of the inductor. Suppose if this letter is **K**, then tolerance value is ± 10%, for **J** it is ± 5%, for **M** it is ± 20% and so on. Follow the tolerance value table given below to know each letter value.

Example for Text Marking Method

Suppose if an inductor is labeled as 223K, find the exact value of inductor.



Symbol	Tolerance
B	±0.15nH
C	±0.2nH
S	±0.3nH
D	±0.5nH
F	±1%
G	±2%
H	±3%
J	±5%
K	±10%
L	±15%
M	±20%
V	±25%
N	±30%

First two digits, i.e., **2** and **2** represent the first two digits of the inductor value. Third digit, **3** is the multiplier and hence it is 10^3 = **1000**. Now, multiplying with first two digits we get **22000**.

Now, it is to be noted that **no units** are given, hence this value is in **micro Henry** (µH). Thus the value becomes **22000 µH** or **22mH**.

Last letter **K** represents the tolerance and is equal to **± 10%.**

Therefore, this is a **22000 µH** or **22mH** inductor with **± 10%** tolerance.

Applications:

- ❖Transformers
- ❖Inductive Filters
- ❖Chokes
- ❖Relays
- ❖Energy Storage Devices
- ❖Induction Motors

Thanks !