GF's Godavari College of Engineering, Jalgaon

Department of Applied Science

Lab Manual

ELEMENTS OF ELECTRICAL & ELECTRONICS ENGINEERING (EEEE)

FIRST ENGINEERING (Semester-II)

Prepared by
Mr. Vijay D. Chaudhari
(Assistant Professor, E&TC Engg dept.)

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Evaluation Sheet

Sr. No.	Name of Experiment	Date of Perform	Date of Check	Grade/ Marks	Remark
1	**Group A:** Verification of Kirchhoff's Laws				
2	Verification of Thevenin's Theorem				
3	Verify Superposition Theorem				
4	Study of Lamps				
5	**Group B:** Study & testing of electronic components and their terminals				
6	Study of Half wave, Full wave and Bridge rectifier				
7	Implementation of Inverting and Non-Inverting amplifier using Op-Amp				
8	Implementation of simple Boolean expression using logic gates				
			Total Marks		
			Average Marks		

Experiment No. 1 **Date-**

Aim: Verification of Kirchhoff's Laws

Objective:

i. To measure voltage and current in a DC circuit for each element,
ii. to calculate analytically V & I
iii. compare analytical and practical values
iv. verify KVL & KCL.

Requirements:

Sr. No.	Equipment / Instrument	Device	Rating/Value	Quantity
1		Resistance	460 Ω, 720 Ω, 330 Ω, 680 Ω, 220 Ω	each 01
2	Current meter (DC) (Multimeter)		0-1 A	at least 02
3	Volt meter (Multimeter) (DC)		0-200 V	at least 02
4	DC regulated power supply		0-30 V	02
5	Connecting wires, bread board or experimental kit			As required

Circuit diagram:

Theory:

(I) Kirchhoff's Voltage Law (KVL)

It is also called as Mesh analysis.

Analytical solution:

(II) Kirchhoff's Current Law (KCL)

It is also called as Nodal analysis.

Analytical solution:

Procedure:

1. Make connections as shown in circuit diagram,
2. Switch ON both power supplies, adjust them to required values.
3. For KVL, Take the readings on Ammeter I_1, I_2,….I_5 flowing through R_1, R_2,….R_5 resistors.
4. Calculate IR drops, add those along with total voltages in network.
5. For KCL, Now measure the voltages Va and Vb w.r.t. Reference point. Get the current flowing through each resistor using V/R law.
6. Check whether incoming and outgoing current at node 'a' and node 'b'.
7. Verify KVL and KCL by comparing analytically calculated values with practical one.

Observations:

(I) KVL:

Sr. No.	**Supply Voltages (V)**		**Current through each resistor (mA)**				
	V_1	**V_2**	**I_1 (thru 460 Ω)**	**I_2 (thru 330 Ω)**	**I_3 (thru 220 Ω)**	**Current (thru 720 Ω)**	**Current (thru 680 Ω)**
1							

(II) KCL:

Sr. No.	**Supply Voltages (V)**		**Node voltages (V)**	
	V1	**V2**	**V_a (w.r.t. Ref)**	**V_b (w.r.t. Ref)**
1				

Calculation: (using measured values)

(I) Kirchhoff's Voltage Law (KVL)

Sr. No.	Supply Voltages (V)		Voltage drops, IR in (V)				
	V_1	V_2	I_1 x 460	I_2 x 330	I_3 x 220	(I_1-I_2) x 720	(I_3-I_2) x 680
1	10	15					

$\sum$ emf's + $\sum$ IR drops = 0

⇨

(II) Kirchhoff's Current Law (KCL)

Sr. No.	Supply Voltages (V)		Current through Nodes (mA)				
	V_1	V_2	$I_1 = (V_1 - Va)/460$	$I_4 = (V_a/720)$	$I_2 = (V_a - V_b)/330$	$I_5 = (V_b/680)$	$I_3 = (Vb-15)/220$
1							

Result:

(I) **KVL**:

	$\sum$ emf's + $\sum$ IR drops = 0	
Sr. No.	Theoretically	Practically
1		

(II) **KCL**:

	At node Va $I_1-I_2-I_3 = 0$		At node Vb $I_3-I_4+I_5 = 0$	
Sr. No.	Theoretically	Practically	Theoretically	Practically
1				

Current flowing through 460 Ω => I_1 ………………… mA

Current flowing through 720 Ω => I_1-I_2 ………………… mA

Current flowing through 330 Ω => I_2 ………………… mA

Current flowing through 220 Ω => I_3 ………………… mA

Current flowing through 680 Ω => I_3-I_2 ………………… mA

Conclusion:

Experiment No. 2 **Date-**

Aim: Verification of Thevenin's theorem

Objective:

i. Find analytical solution for load current for the given DC circuit using Thevenin's theorem.
ii. Measure the open circuit voltage, equivalent resistance and load current in network.
iii. Develop Thevenin's equivalent circuit from measured values.
iv. Compare the analytical and practical values.

Requirements:

Sr. No.	Equipment / Instrument	Device	Rating/Value	Quantity
1		Resistance	390 Ω, 330 Ω, 100 Ω, 470 Ω, 470 Ω	each 01
2	Current meter (DC) (Multimeter)		0-1 A	at least 02
3	Volt meter (Multimeter) (DC)		0-200 V	at least 02
4	DC regulated power supply		0-30 V	02
5	Connecting wires, bread board or experimental kit			As required

Circuit diagram:

Theory:

Using the Thevenin's theorem any complicated circuit can be replaced by a single voltage source in series with impedance this is called as Thevenin's equivalent circuit. The Thevenin's equivalent circuit is simplified circuit of any complicated circuit. The theorem has provided a powerful means of network analysis.

Statement:

Any two terminal network containing energy source and impedances can be replaced with an equivalent circuit consisting of a voltage source V_{TH} in series with impedance Z_{TH}. The value of V_{TH} is the open-circuit voltage between the terminals of the network and Z_{TH} is the impedance measured between the terminals with all energy sources eliminated (but not their impedances).

The Thevenin's equivalent will produce the same load current and voltage as the original circuit to any load. Consequently, if many different loads or sub-circuits are under consideration, using a Thevenin equivalent may prove to be a quicker analysis route.

Schematic of Thevenin's equivalent:

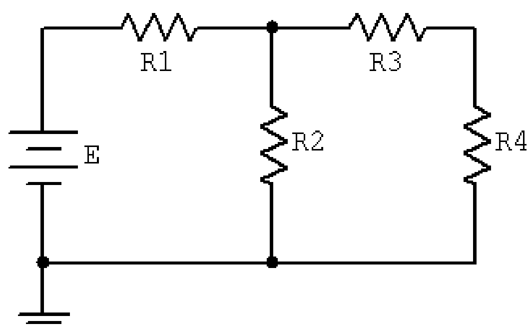


Fig. 1. DC network

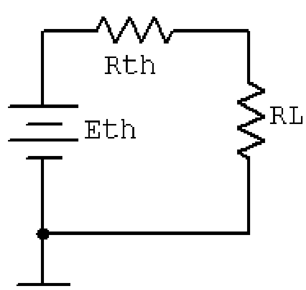


Fig.2. Thevenin's equivalent

Limitations of Thevenin Theorem:

1) Not applicable to the circuit of nonlinear elements

2) Not applicable to unilateral network.

3) There should not be magnetic coupling between the load & circuit to be replaced by Thevenin's theorem.

4) In the load side, there should not be controlled sources, controlled from some other parts of circuit.

Analytical solution:

(I) Calculate Thevenin's voltage (V_{OC} or V_{TH})

(II) Calculate Thevenin's resistance (Z_{TH})

(III) Calculate current flowing through load resistance R_L i.e. I_L

Thus, Thevenin’s equivalent circuit of the given circuit diagram is:

Procedure:

1. Make the connections as shown in circuit diagram.
2. Switch ON the power supply and adjust to required value.
3. Measure current flowing through and voltage reading using multimeter across two terminals where load resistance is connected.
4. Measure Thevinin’s resistance between terminals A&B using multimeter by shorting supply and also calculate it analytically.
5. Calculate current flowing through load resistance by Thevenin’s formula

   $I_L = V_{TH} / R_{TH} + R_L$

6. Verify value of I_L practically and through calculation.

Observations:

Sr. No.	**Supply Voltages (V)**		**Voltage measured by opening the load (V)**	**Thevenin’s Equiv. Resistance measured (Ω)**	**Current through Load resistance RL=470 Ω**
	V_1	V_2	V_{OC} or V_{TH}	Z_{TH}	I_L
1	10	05			

Result:

Sr. No.		Supply Voltages (V)		Thevenin's voltage (V)	Thevenin's Equiv. Resistance (Ω)	Load current (mA)
		V_1	V_2	V_{OC} or V_{TH}	Z_{TH}	I_L
1	Theoretically	10	05			
	Practically					

Conclusion:

Oral questions:

Experiment No. 3 **Date-**

Aim: Verification of Superposition theorem

Objective:

i. Apply Superposition theorem to find analytical values of the branch currents for the given DC network.
ii. Measure the branch current of the network with both sources acting simultaneously and with each source acting alone.
iii. Compare the analytical and measured values of currents.

Requirements:

Sr. No.	Equipment / Instrument	Device	Rating/Value	Quantity
1		Resistance	270 Ω	03
2		Resistance	100 Ω ,150 Ω, 27 Ω	each 01
3	Current meter (DC) (Multimeter)		0-1 A	at least 02
4	Volt meter (Multimeter) (DC)		0-200 V	01
5	DC regulated power supply		0-30 V	02
6	Connecting wires, bread board or experimental kit			As required

Circuit diagram:

Theory:

The superposition theorem states that in a linear bilateral multi-source DC circuit, the current through or voltage across any particular element may be determined by considering the contribution of each source independently, with the remaining sources replaced with their internal resistance. The contributions are then summed, paying attention to polarities, to find the total value. Superposition cannot in general be applied to non-linear circuits or to non-linear functions such as power.

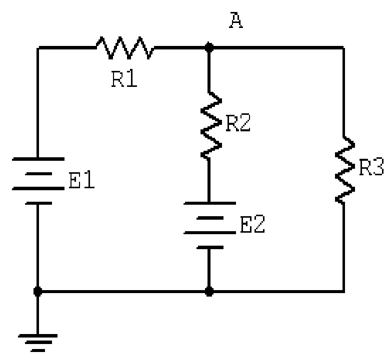


Fig.1. DC network

Circuit diagram:

Procedure:

1. Make the connections as shown in circuit diagram.
2. Switch ON both power supplies, adjust them to required values. Measure current flowing through the branch (here 270 Ω) as shown in circuit diagram using multimeter.

3. Now keep only one supply acting and other short. Measure the current flowing through the same branch using multimeter.
4. Repeat same procedure by acting second supply alone. Measure current through same branch.
5. Check whether Superposition theorem is verified analytically and practically.

Observations:

Sr. No.		**Supply Voltages (V)**		**Current through 270 Ω (mA)**	**Current through 270 Ω (mA)**	**Current through 270 Ω (mA)**
		$\mathbf{V_1}$	$\mathbf{V_2}$	$\mathbf{I_1}$	$\mathbf{I_1'}$	$\mathbf{I_1''}$
1	Both supply working				--	--
2					--	--
3	Only V_1 supply acting alone		--	--		--
4			--	--		--
5	Only V_2 supply acting alone	--		--	--	
6		--		--	--	

Calculation:

Result:

Current through branch (270 Ω resis)…

when V_1 =   V acting alone, I_1' = -------------- mA.

when V_2 =   V acting alone, I_1'' = -------------- mA.

when V_1 & V_2 acting, I_1 = I_1'+I_1'' = ------------- mA. (Measured)

when V_1 & V_2 acting, I_1 = I_1'+I_1'' = ------------- mA. (Theoretically)

Conclusion:

Oral questions:

Experiment No.: 05 **Date-**

Aim:

To Study testing of electronic components and identify their terminals

Requirements:

Various fixed & variable resistors, inductors & capacitors, diode and transistor. Digital multimeter etc.

Theory

Classification of Electronic components:

A Passive Device is one that contributes no power gain (amplification) to a circuit or system. It has not control action and does not require any input other than a signal to perform its function.

Active Devices are components that are capable of controlling voltages or currents and can create a switching action in the circuit. In other words, "Devices with smart properties!". Examples are Diodes, Transistors and Integrated circuits.

I. Passive components:

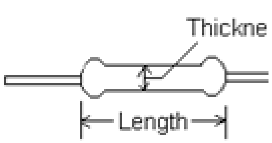
(A) RESISTOR:

It is an element which offers an opposition to the flow of electric current through circuit. It is measured in ohm. Power ratings & tolerance are important parameter of resistor.

Types of resistor:

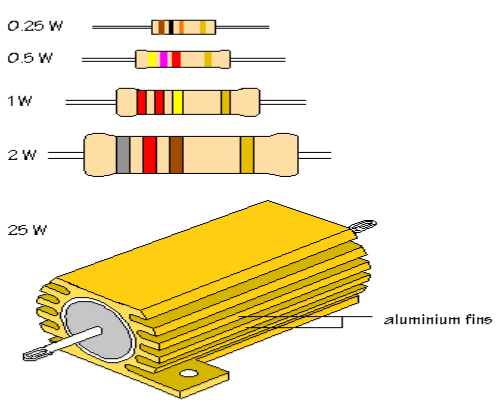
1) Fixed resistor
2) Variable resistor
3) Voltage dependent resistor (VDR)
4) Thermistor
5) Thick film resistor
6) Fusible resistor

1) Fixed resistor :-
   1) Carbon composition resistor



Approximate Size		
Rating Power (W)	Thickness (mm)	Length (mm)
1/8	2	3
1/4	2	6
1/2	3	9

The power rating indicates how much power the resistor can safely tolerate. **The maximum rated power of the resistor is specified in Watts**. Power is calculated using the square of the current (I^2) x the resistance value (R) of the resistor. If the maximum rating of the resistor is exceeded, it will become extremely hot and even bum.

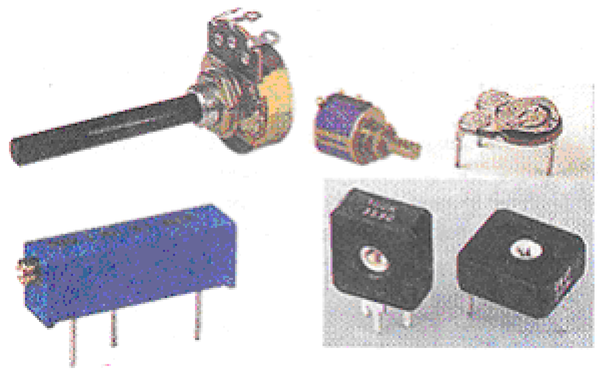


2) Film type resistor
    a) Carbon film resistor
    b) Metal film resistor
3) Wire wound resistor

2) <u>Variable resistor :-</u>

The variable resistor may be wire wound or carbon type three terminal with one fixed terminal of each end of the three movable arm or top potential meter is variable resistor .it may be:

a) Carbon potentiometer
    1) Linear potentiometer
    2) Non linear potentiometer

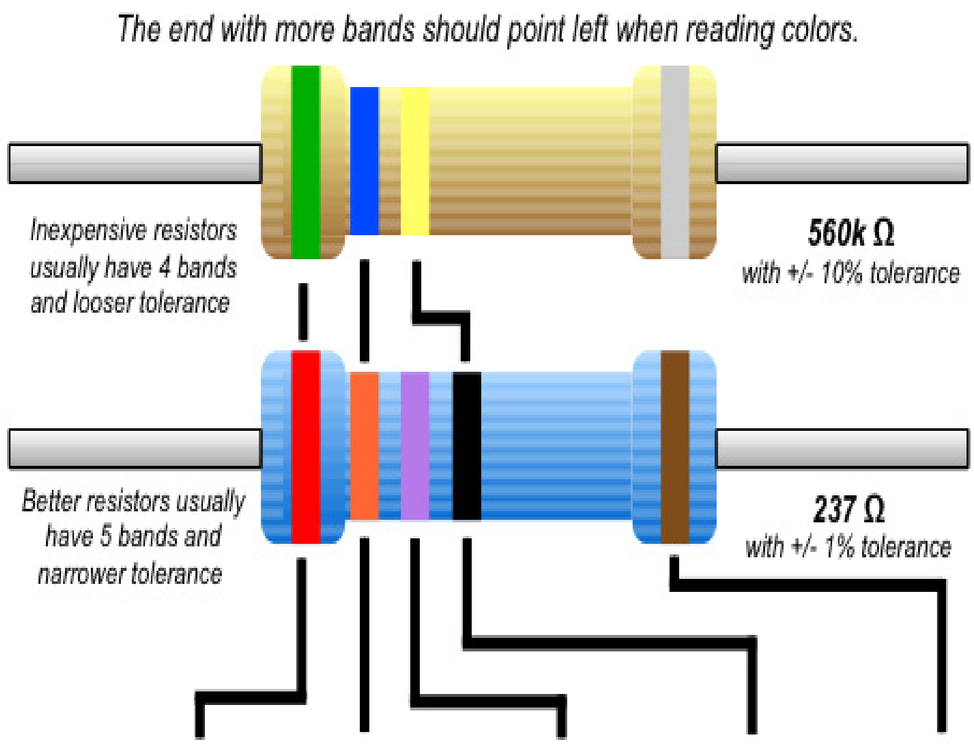


Variable Resistors

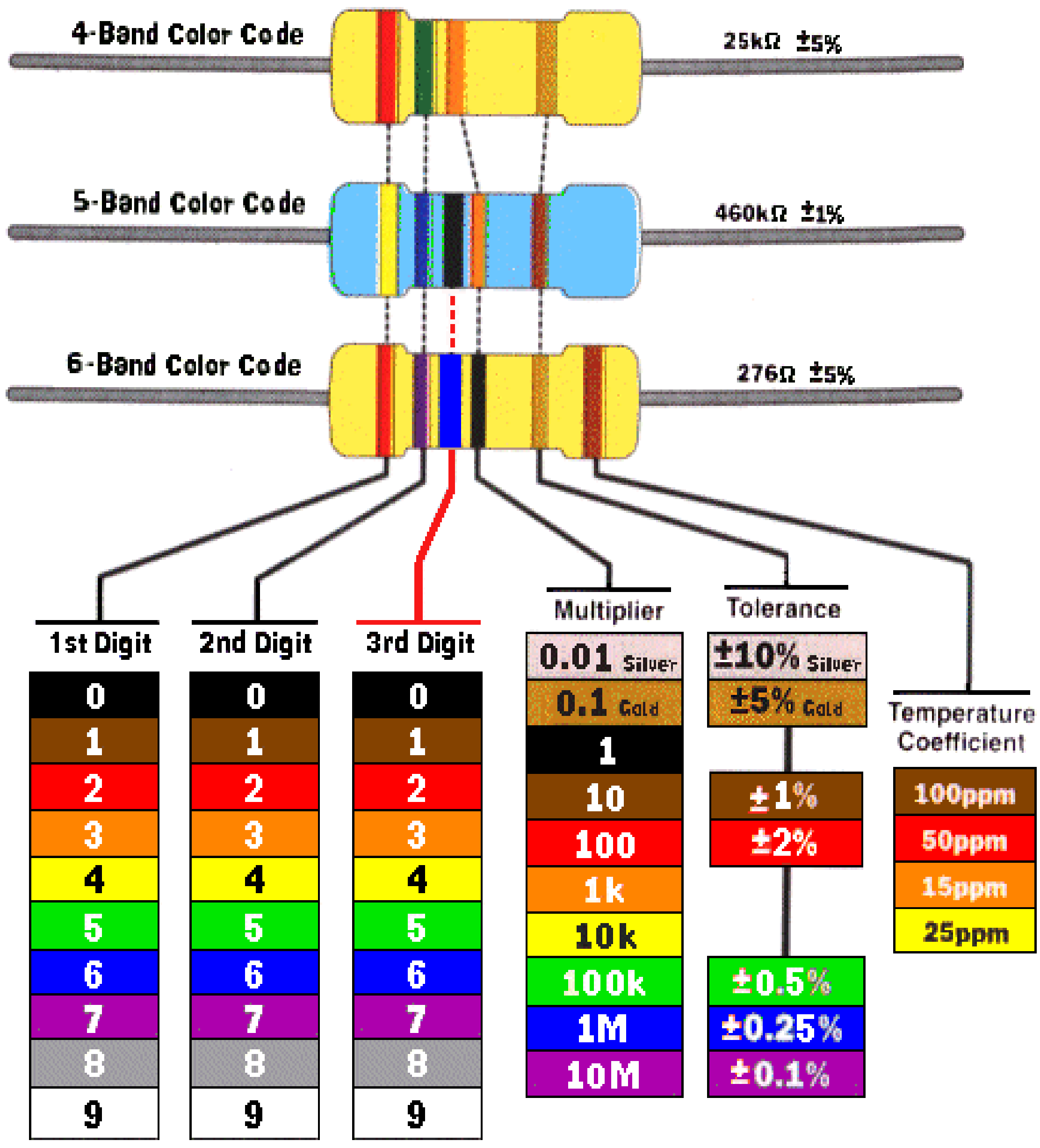
b) Wire wound potentiometer
    1) Present potentiometer
    2) Rheostat

Resister Color Code:

Four & Five band resistor:

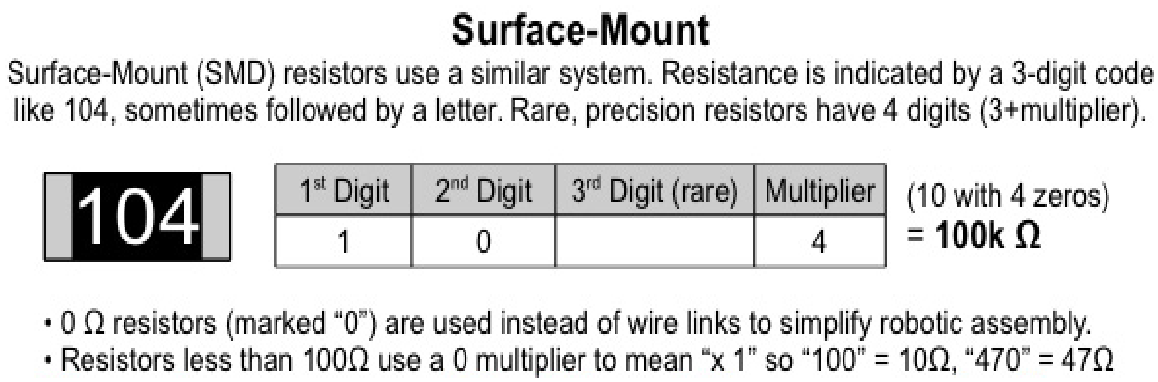


Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	x 1 Ω	
Brown	1	1	1	x 10 Ω	+/- 1%
Red	2	2	2	x 100 Ω	+/- 2%
Orange	3	3	3	x 1K Ω	
Yellow	4	4	4	x 10K Ω	
Green	5	5	5	x 100K Ω	+/- .5%
Blue	6	6	6	x 1M Ω	+/- .25%
Violet	7	7	7	x 10M Ω	+/- .1%
Grey	8	8	8		+/- .05%
White	9	9	9		
Gold				x .1 Ω	+/- 5%
Silver				x .01 Ω	+/- 10%



ppm – parts per million per degree centigrade

The tolerance of resistors is mostly 1 %, 2%, 5% and 10%. In the old days, 20% was also common, but these are now rare. Even 10% resistors are hard to get except in extremely high or low values (> 1M or < 1R), where they may be the only options available at a sensible price. A 100R resistor with 5% tolerance may be anywhere between 95 and 105 ohms – in most circuits this is insignificant, but there will be occasions where very close tolerance is needed (e.g. 0.1 % or better). This is fairly rare for audio, but there are a few instances where you may see such close tolerance components.


Surface-Mount

Surface-Mount (SMD) resistors use a similar system. Resistance is indicated by a 3-digit code like 104, sometimes followed by a letter. Rare, precision resistors have 4 digits (3+multiplier).

104

1st Digit	2nd Digit	3rd Digit (rare)	Multiplier
1	0		4

(10 with 4 zeros) = **100k Ω**

- 0 Ω resistors (marked "0") are used instead of wire links to simplify robotic assembly.
- Resistors less than 100Ω use a 0 multiplier to mean "x 1" so "100" = 10Ω, "470" = 47Ω

(B) Inductor :-

It is passive component used in electronics or electrical ac circuit. It is coil of inducting wire ground hollow for mg as core of same suitable material

Definition:

Inductance is the ability of conductor to produce induce voltage, when the current flowing through it is varies. Inductance is denoted by " Y"& measured in henry (H)

The inductance of coil is given by formula -

$$L = \mu o \mu a n^2/l$$

Where,

A = length of core of metal

A = area of cross sectional of core in m^2

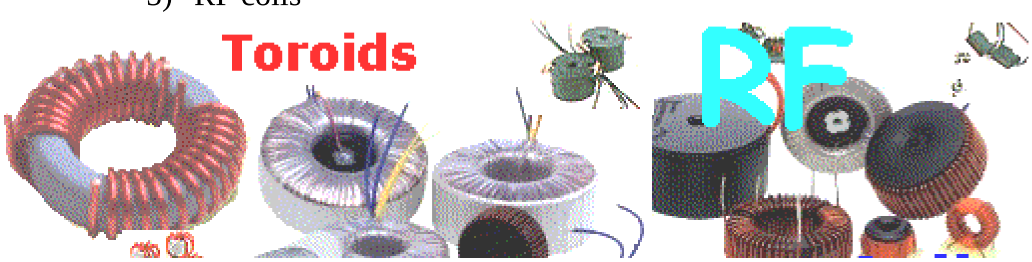
N = no. of turns of coil

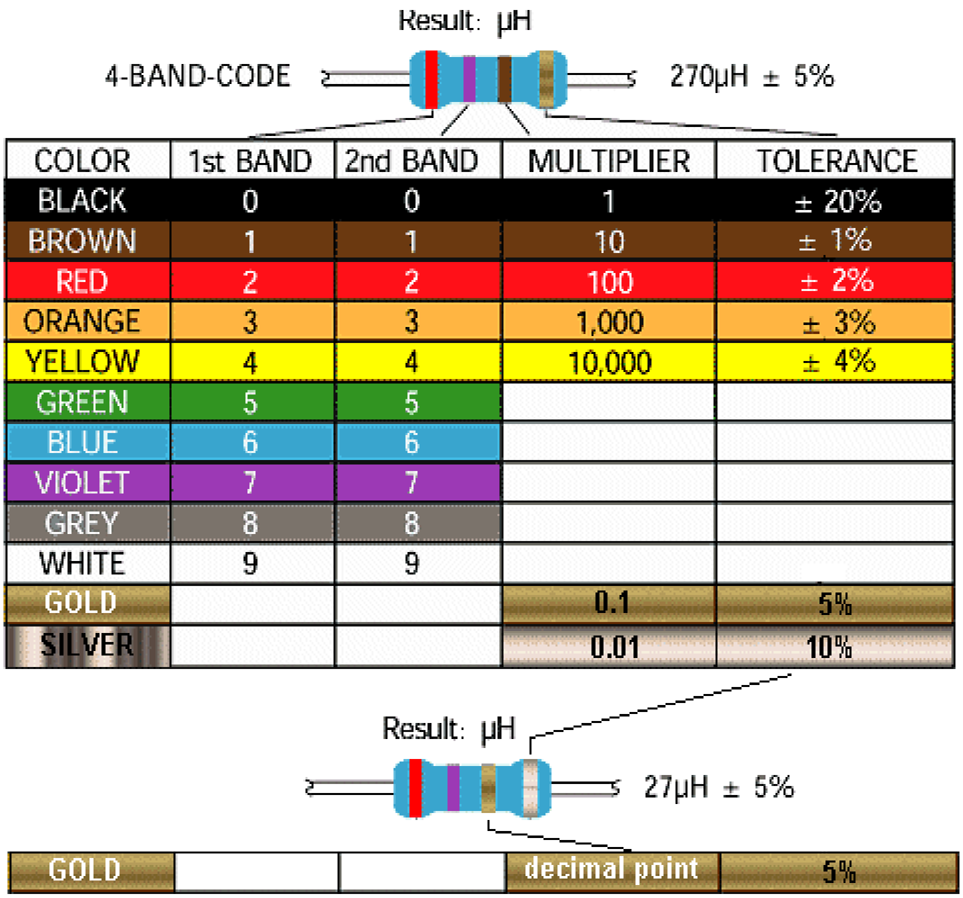
Mo = absolute permeability of core material 1.25*10^-6 for an core

Mr = relative permeability of core material & m:1

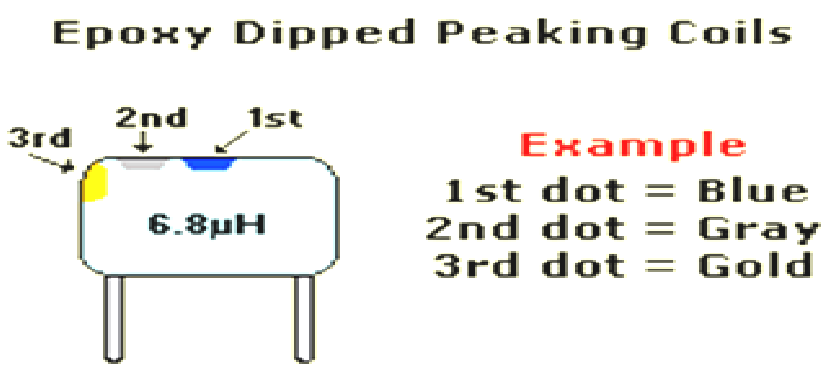
Types of inductor :-

1) Air core inductor
2) Iron core inductor
3) Ferrite inductor
4) Choke
5) RF coils





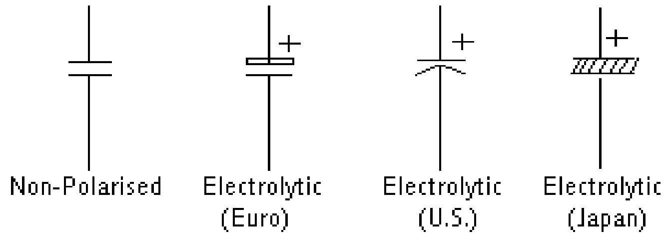
COLOR	1st BAND	2nd BAND	MULTIPLIER	TOLERANCE
BLACK	0	0	1	± 20%
BROWN	1	1	10	± 1%
RED	2	2	100	± 2%
ORANGE	3	3	1,000	± 3%
YELLOW	4	4	10,000	± 4%
GREEN	5	5		
BLUE	6	6		
VIOLET	7	7		
GREY	8	8		
WHITE	9	9		
GOLD			0.1	5%
SILVER			0.01	10%
GOLD			decimal point	5%



(C) CAPACITOR:

The capacitor's function is to store electricity, or electrical energy. The capacitor also functions as a filter, passing alternating current (AC), and blocking direct current (DC). The capacitor is constructed with two electrode plates facing each other, but separated by an insulator. When DC voltage is applied to the capacitor, *an electric charge* is stored on each electrode. While the capacitor is charging up, current flows. The current will stop flowing when the capacitor has fully charged.

Symbols:



A capacitor has an infinite (theoretically!) resistance at DC, and with AC, it has impedance. Impedance is defined as a non-resistive (or only partially resistive) load, and is frequency dependent. This is a very useful characteristic, and is used to advantage in many circuits. In the case of a capacitor, the impedance is called Capacitive Reactance generally shown as X_C. The formula for calculating X_C is shown below

$X_C = 1 / 2\pi fC$

Where, π is 3.14159

f is frequency in Hertz

and C is capacitance in Farads

With capacitors, there is no power rating. A capacitor in theory dissipates no power, regardless of the voltage across it or the current through it.

Three prefixes (multipliers) are used, µ (micro), n (nano) and p (pico):

Remember 1µF = 0.000001 F

µ means 10-6 (millionth), so 1000000µF = 1F

n means 10-9 (thousand-millionth), so 1000nF = 1µF

p means 10-12 (million-millionth), so 1000pF = 1nF

Recapping:

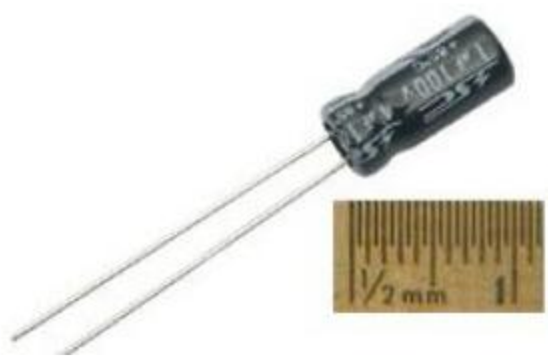
1p = 1 picofarad. 1,000p = 1n (1 nanofarad)
1,000n = 1u (1 microfarad)
1,000u = 1millifarad
1,000,000u = 1 FARAD.

Capacitor Types:

Sr.No.	Types	Dielectric Used
1	Paper capacitor	Waxed paper.
2	Plastic film capacitor	Plastic film.
3	Mica capacitor	Thin sheet of mica.
4	Ceramic capacitor	Ceramic material.
5	Glass capacitor	Flexible glass ribbon.
6	Electrical capacitor	Oxide layer acts as a dielectric.
7	Tantalum capacitor	Tantalum

Capacitor Coding:

Electrolytic capacitor:



Electrolytics are available in 1u, 2u2 3u3 4u7 10u, 22u, 47u, 100u, 220u, 330u, 470u, 1,000u, 2,200u, 3,300u, 4,700u, 10,000u and higher.
The "voltage" or "working voltage" can be: 3.3v, 10v, 16v, 25v, 63v, 100v, 200v and higher.
Electrolytics and Tantalums capacitors are the same for testing purposes but their performance is slightly different in some circuits. A tantalum is smaller for the same rating as an electrolytic and has a better ability at delivering a current. They are available up to about 1,000u, at about 50v but their cost is much higher than an electrolytic.

Ceramic capacitor:

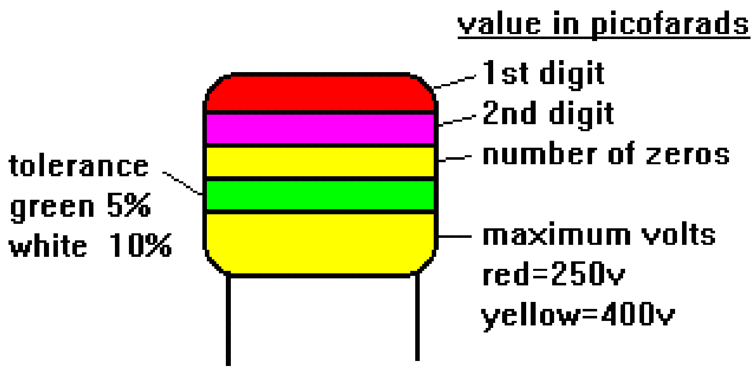
All ceramic capacitors are marked in "p" (puff")
A ceramic with 22 is 22p = 22 picofarad
A ceramic with 47 is 47p = 47 picofarad
A ceramic with 470 is 470p = 470 picofarad
A ceramic with 471 is 470p = 470 picofarad
A ceramic with 102 is 1,000p = 1n
A ceramic with 223 is 22,000p = 22n
A ceramic with 104 is 100,000p = 100n = 0.1u

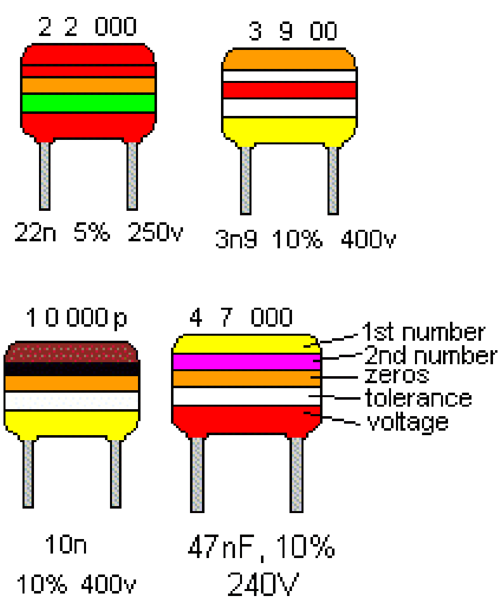
Mica Capacitor:

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	$-33x10^{-6}$
Red	2	2	x100	± 2%	± 0.25pF	$-75x10^{-6}$
Orange	3	3	x1,000	± 3%		$-150x10^{-6}$
Yellow	4	4	x10,000	± 4%		$-220x10^{-6}$
Green	5	5	x100,000	± 5%	± 0.5pF	$-330x10^{-6}$
Blue	6	6	x1,000,000			$-470x10^{-6}$
Violet	7	7				$-750x10^{-6}$
Grey	8	8	x0.01	+80%,-20%		
White	9	9	x0.1	± 10%	± 1.0pF	
Gold			x0.1	± 5%		
Silver			x0.01	± 10%		

CODE / Marking	µF microfarads	nF nanofarads	pF picofarads
1RO	0.000001	0.001	1
100	0.00001	0.01	10
101	0.0001	0.1	100
102	0.001	1	1,000
103	0.01	10	10,000
104	0.1	100	100,000
105	1	1,000	1,000,000
106	10	10,000	10,000,000
107	100	100000	100,000,000

CAPACITOR TOLERANCE TABLE	
C	+/- 0.25pF
D	+/- 0.5pF
F	1%
G	2%
J	5%
K	10%
M	20%
Z	+80 -20%





Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

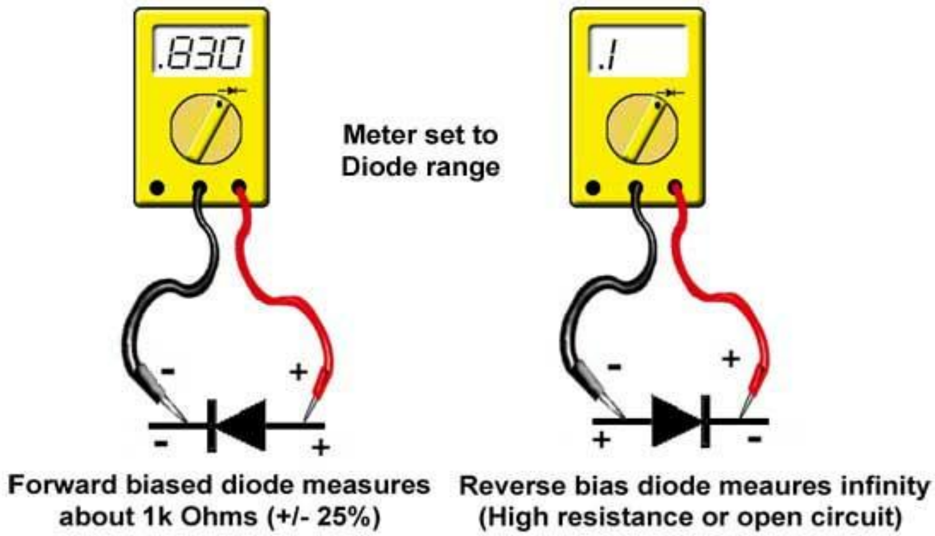
II. Active components:

P-N Junction Diode: It is used as a Rectifier.

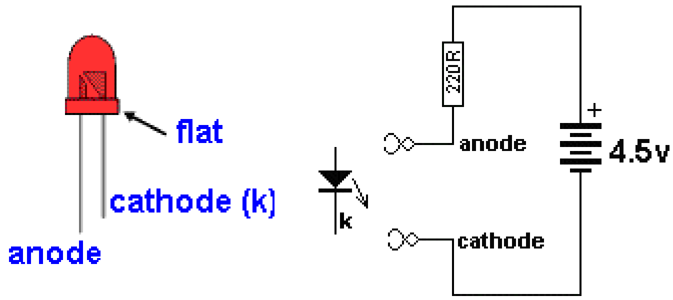
Diodes can have 4 different faults.

1. Open circuit in both directions.
2. Low resistance in both directions.
3. Leaky.
4. Breakdown under load.

TESTING DIODES: Silver ring indicates cathode.



For example: Light Emitting Diode tester:



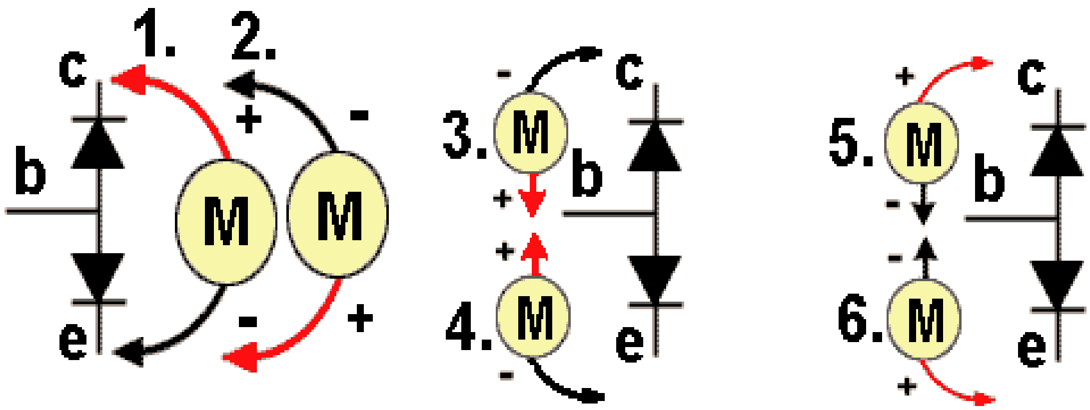
The illumination produced by a LED is determined by the quality of the crystal. It is the crystal that produces the colour and you need to replace a LED with the same quality to achieve the same illumination. Never connect a LED across a battery (such as 6v or 9v), as it will be instantly damaged. You must have a resistor in series with the LED to limit the current.

Transistors:

Transistors are solid-state devices and although they operate completely differently to a diode, they appear as two back-to-back diodes when tested. There are basically 2 types of transistor

NPN and PNP. A transistor is sometimes referred to as BJT (Bi-polar Junction Transistor) to distinguish it from other types of transistor such as Field Effect transistor, Programmable Unijunction Transistor and others.

Transistor testing: (If Base, Emitter and Collector terminals are known**)**



1. Test the resistance between collector and emitter.

2.Then reverse the positive and negative meter connections and test again.

If the meter reads zero or a few ohms in tests 1 and 2, there is a short circuit between collector and emitter and the transistor is faulty. If both readings are infinity, continue with test 3.

3. Now connect the positive meter lead to the base and test the resistance of both junctions by connecting the negative meter probe to one of the other two pins. It doesn't really matter whether this is the collector or the emitter, in our test we are simply testing a junction.

4. Now leave the positive lead on the base and move the negative lead to the other untested (collector or emitter) pin and measure the resistance of this junction.

For tests 3 and 4 you should get a typical forward resistance reading of less than 1k in both cases.

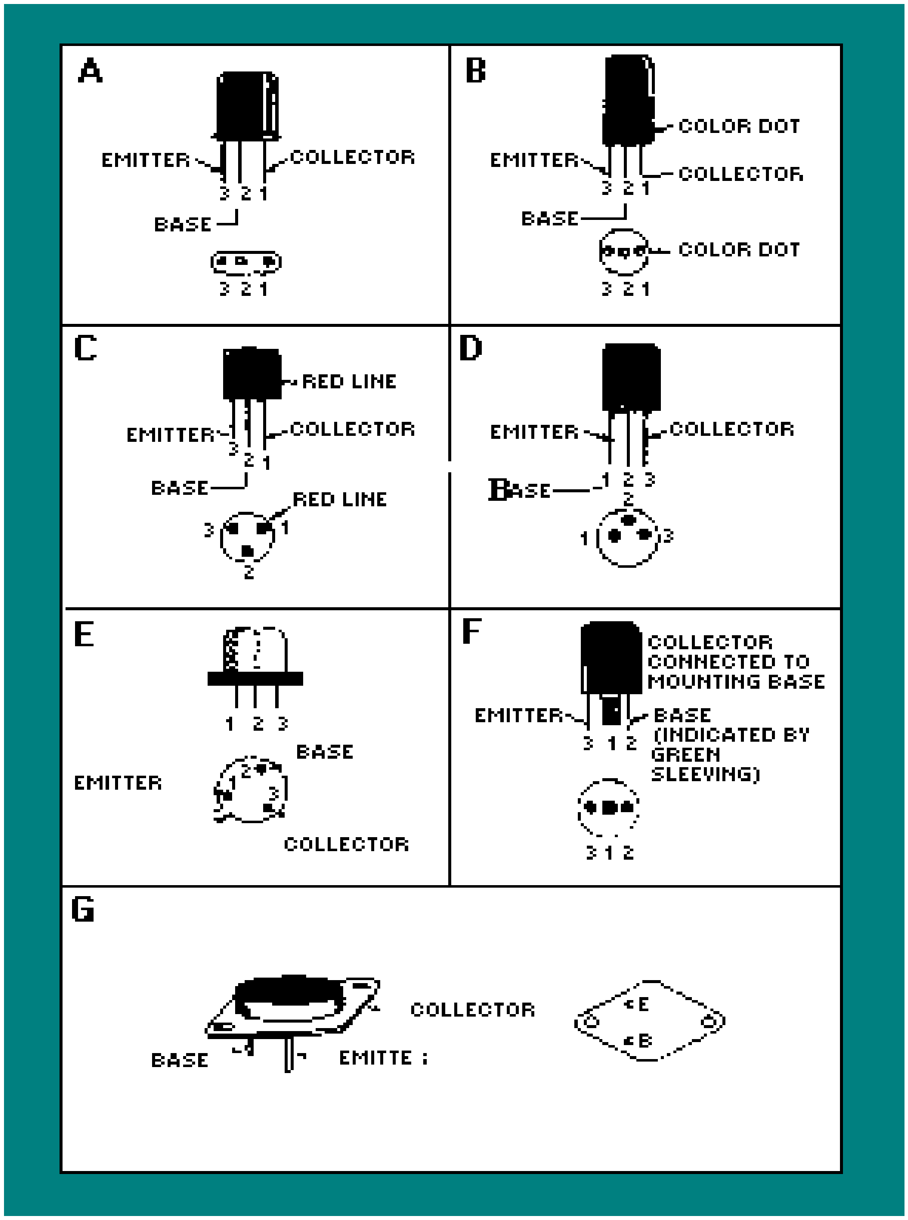
5. Now connect the negative lead of your meter to the base and the positive lead to another pin as shown at 5 in the diagram above.

6. Lastly connect the positive probe to the other untested pin as shown at 6 in the diagram above.

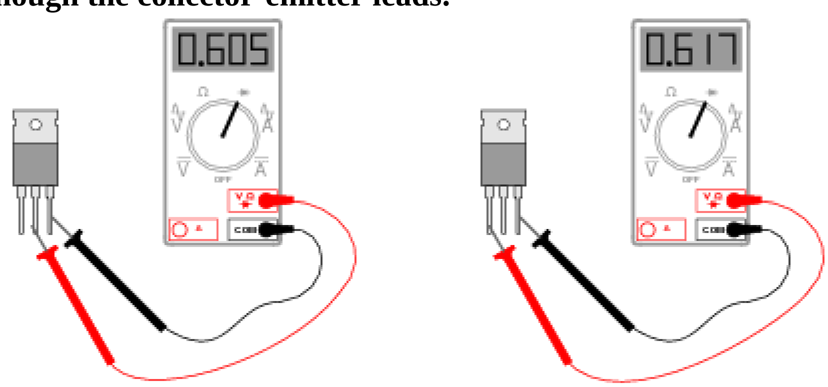
In tests 5 and 6 both junctions should read infinity. If all of these six tests are ok you have a good transistor. If one or more of the tests has failed, so has the transistor!

Transistor Lead identification:

If E, B and C terminals are unknown, you have to first find out those and then apply above test.



To test the transistor, one must know "**When the base voltage is higher than the emitter, current flows though the collector-emitter leads.**



Now identify terminals.
Testing a transistor with a **Digital Meter** must be done on the "DIODE" setting as a digital meter does not deliver a current through the probes on some of the resistance settings and will not produce an accurate reading. The "DIODE" setting must be used for diodes and transistors. It should also be called a "TRANSISTOR" setting.

Conclusion:

Thus, we have studied and practiced the colour coding of resistor, capasitor & inductors. Also we studied diode and transistor testing method and identifying its terminals.