**Resistors**

1. Linear resistor
2. Non linear resistor
A-photo resistors
B-thermostats
C-voltage-dependent resistors

1. Linear resistor (obeys ohms law)
   \[ R = \frac{I}{V}, \ \Omega, \ K\Omega, \ M\Omega \]
   Power rating (wattage) \( W = V \times I = I^2 \times R \). (1/8W, 1/4W, ....... 1)

**-COLOUR CODING**

<table>
<thead>
<tr>
<th>Color</th>
<th>figure</th>
<th>Tolerance(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BROWN</td>
<td>1</td>
<td></td>
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<tr>
<td>RAD</td>
<td>2</td>
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<tr>
<td>ORANGE</td>
<td>3</td>
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<tr>
<td>YELLOW</td>
<td>4</td>
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<tr>
<td>GREEN</td>
<td>5</td>
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<tr>
<td>BLUE</td>
<td>6</td>
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<tr>
<td>VIOLET</td>
<td>7</td>
<td></td>
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<tr>
<td>GREY</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>WHITE</td>
<td>9</td>
<td>±5%</td>
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<tr>
<td>SILVER</td>
<td></td>
<td>±0.1%</td>
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<tr>
<td>NONE</td>
<td></td>
<td>±0.2%</td>
</tr>
<tr>
<td>GOLD</td>
<td></td>
<td>±1.0%</td>
</tr>
</tbody>
</table>

Resistor \( \Omega = \text{first colour} + \text{second colour} \times 10 + \text{third colour} \pm \text{fourth colour} \)

\[ R = 18 \times 10^2 \pm 5\% \]

**2-CAPACITORS**

The ability of capacitor to store energy is called (capacitance)

* capacitance, \( C = \frac{\text{charge}}{\text{charge}} V, C = \varepsilon \times A/d \)
\[ C, \mu F = 1 \times 10^{-9} \text{ FARAD}, \quad nF = 1 \times 10^{-12} \text{ FARAD} \]

\[ \varepsilon = \text{dielectric constant of insulator} \]
\[ A = \text{area of plat} \]
\[ d = \text{distance between two plates} \]

*VOLTAGE RATING*

The maximum voltage that can applied between the plates of a capacitor without

*STOED ENERGY IN CAPACITORS*

Energy (Joules) = \( \frac{1}{2} CV^2 \)

*TYPES OF CAPACITORS*

A- NON-ELECTROLYTIC (not polarized)
B- ELECTROLYTIC (polarized)

*SERIES CONNECTIONS*

\[ C_t = \frac{1}{C_1 + \frac{1}{C_2}} \]

*PARALLELED CONNECTION*

\[ C_t = C_1 + C_2 \]

\[
\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{capacitor_connections}
\caption{Series and paralleled capacitor connections}
\end{figure}
**CHARGING AND DISCHARGING CAPACITOR**

**A) - CHARGING CAPACITORS**

The capacitor may be charged from a D.C. supply ($V_s$) to a ($V_c$)

$$V_c = V_s (1 - \exp(-t / RC))$$

$RC = \text{time constant} = (\tau)$

$$RC = V / I \times Q / V = Q / (Q / t) = \text{sec}$$

After $t = \tau = RC$

$$V_c = 0.63 V_s$$

After $t = 0.63 RC = V_c \approx V_s$

**B) - CHARGING CURRENT**
\[ I = \frac{V_s}{R} \exp\left(\frac{-t}{RC}\right) \]

After \( t = \tau = RC \)
\[ i = \frac{0.37V_s}{R} \approx i \text{ after } t \approx 5RC \]

**B) DISCHARGING CAPACITOR**

After the process to \( V_s \), the discharge will take the form:

\[ V_c = V_s \exp\left(-\frac{t}{RC}\right) \]

(Voltage across the capacitor)

\[ i = \frac{V_s}{R} - \exp\left(-\frac{t}{RC}\right) \]

(Discharge current in the discharge circuit)

*The discharge & the charge frequency of the circuit is related to the (\( \tau \))
\[ F_{Hz} = \frac{1}{\tau} \]

**INDUCTORS & TRANSFORMERS:**

1-SELF-INDUCTANCE. Is the property in which e.m.f is produced when a charging current flows in the circuit or component.

\[ e.m.f., C = n \left( \frac{d \Phi}{dt} \right) = -L \left( \frac{d I}{dt} \right) \ldots \text{Faraday's law} \]

THES, the self-inductance \( L = N \left( \frac{d \Phi}{dt} \right) \)
\[ L = \mu_0 \mu r AN^2/l \quad \text{(coil)} \]
Where \( \mu \circ \mu_r = \mu \) (permeability of the core).
\( \mu \) is the ability of a material to conduct magnetic flux (permeability)
\( N \) is the number of turns of coil
\( A \) is the cross sectional area of coil
\( L \) is the length of coil

2-MUTUAL INDUCTANCE

Two circuits are said to possess mutual inductance if a charging current in one circuit gives rise to charging magnetic flux, which links with the second circuit, causing an e.m.f. to be induced in the second coil

3-TRANSFORMERS

The transformers are used either step-up transformer or step down transformer.
*step-up \( V_s \uparrow, I_s \downarrow \)
*step-down \( V_s \downarrow, I_s \uparrow \)

*transformation ratio, \( N= \frac{V_p}{V_s} = \frac{N_p}{N_s} \)
= \( \frac{I_s}{I_p} \)
4. **IDEAL DIODE:**

The ideal diode, is an open circuit in reverse biasing and is a short circuit in forward biasing.

- **Short Circuit:**
  + ← | -

- **Open Circuit:**
  + ← | ← -

a) Forward biasing: + ← |

b) Reverse biasing: - ← |

5. **REAL DIODE:**

1) **CURRENT-VOLTAGE CHARACTERISTICS OF DIODES**

The diode current can be related to the applied Voltage on the temperature with the following equation:

\[ I_d = I_s \left( \exp \left( \frac{KV}{T} \right) - 1 \right) \]

Where \( I_s \) is reverse current saturation

\[ K = \frac{11600}{\eta} \]

\( \eta = 1 \) for Ge diode & 2 for Si diode

\( V \) = the applied voltage (+) for forward biasing & (-) for reverse biasing

2) **DC OR STATIC RESISTANCE OF DIODE** (\( R_{dc} \))

\[ R_{dc} = \frac{V_D}{I_D} \Omega \]

3) **AC OR DYNAMIC RESISTANCE OF DIODE** (\( R_{ac} \))

\[ R_{ac} = \frac{\Delta V_d}{\Delta I_d} \Omega \]

**C) DIODE SPECIFICATION:**

The specifications of semiconductor diode are:

1. The maximum forward voltage \( V_{f_{\text{max}}} \)
2. The maximum forward current \( I_{f_{\text{max}}} \)
3- The maximum reverse current IR max

**D-Diode applications:**

- A- half-wave Rectification
- B- full-wave Rectification

1- Rectification.

A- half-wave Rectification.

\[ V_{d.c} = 0.318 \, V_m - V_t \]

\[ PIV \, Rating = V_m \]
**b- full-wave Rectification.**

![Diagram of full-wave rectification](image)

1 – Bridge Rectification

*During the period*

\[ T = 0 \text{ to } t / 2 \quad D_2, D_3 \text{ (short)} \]

*During the period*

\[ T = t / 2 \text{ to } t \quad D_1, D_4 \text{ (short)} \]

\[ D_2, D_3 \text{ (open)} \]

\[ V_{dc} = 0.636 \ (V_m - 2V_t) \]

\[ PIV = V_m \]

2- full-wave Rectification with center-tapped transformer

![Diagram of full-wave rectification with center-tapped transformer](image)
* The potential at point (a) = zero (center the secondary coil).

* during the negative port (0→T/2)  
  D2 (short)  
  D1 (open)

* during the positive port (T/2→T)  
  D1 (short)  
  D2 (open)

V d.c = 0.636 (V m -Vt)  
PIV=2Vm

2-Clippers
The diode networks that have the ability" clip" of apportion of the input signal without distorting the remaining part of the alternating wafer.

A-Series

b- Parallel

3- Clampers.
The diode network that will "Clamp" a signal to a different DC level
Examples

1- Sketch (V out) for each networks (ideal diode)

A-

B-

2- Determine the output wave from for the network

3- A full-wave bridge rectifier with a 20 V r. M. s sinusoidal input has a load resistor of 1kΩ

a- if silicon diode employed, what is the (D C) voltage an available at the load.
b- determine the required PIV rating of each diode.

c- Find the maximum current through each diode during conduction

4- Determine \((V_{out})\) and the required PIV rating of each diode for the network

5- Assuming an ideal diode, sketch \(V_I, V_D\) and \(I_d\) for the half-wave rectifier of the figure. The input is a sinusoidal waveform with a frequency of 60 Hz

*repeat (Q5) with a silicon diode \((V_t = 0.7)\).

6- sketch \((V_{out})\) for the network of fig and determine the DC voltage viable
4-Filtering

The o/p voltage from bridge rectifier or half-wave rectifier is not pure DC voltage to increase the DC component in the o/p wave for a capacitor must be used.

* The pulse period \( T = \frac{1}{F_{\text{out}}} \)  \( F_{\text{out}} = 2F_{\text{in}} \)

*for good DC (nearly pure DC) \( RLC \geq 10^* \) \( T \)

*\( V_{\text{DC}} = [1- \frac{0.00417}{RLC}] \times V_p \)

Where \( V_{\text{DC}} \) is the o/p DC voltage, \( V_p \) is the peak a flow the bridge rectifier

*the ripple voltage

\[ V_r = 0.0024 \frac{V_p}{RLC} \]  \( r.m.s \)

* The important parameter in Dc power supply. Is the ripple factor \( (r) \)

\[ r = \frac{V_r}{V_{\text{DC}}} \times 100 \% \]

e \( x \): for the circuit in fig (a) if the \( V_p = 30v \), find the \( V_{\text{DC}} \) and the ripple voltage

e \( x \): Design voltage mode power supply with the following characteristics
A- Output voltage 10V?
b- Output current 1 A?
c- Ripple factor 5%?