Basic Electronic Circuits (IEC-103)

Lecture-11

Semiconductor Diode

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S.No.	Substance	Nature	Resistivity
1	Copper	good conductor	$1.7 \times 10^{-8}\ \Omega$ m
2	Germanium	semiconductor	$0.6\ \Omega$ m
3	Glass	insulator	$9 \times 10^{11}\ \Omega$ m
4	Nichrome	resistance material	$10^{-4}\ \Omega$ m

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- When suitable metallic impurity (e.g. arsenic, gallium) is added to a semiconductor, its current conduction properties change appreciably. (important property).

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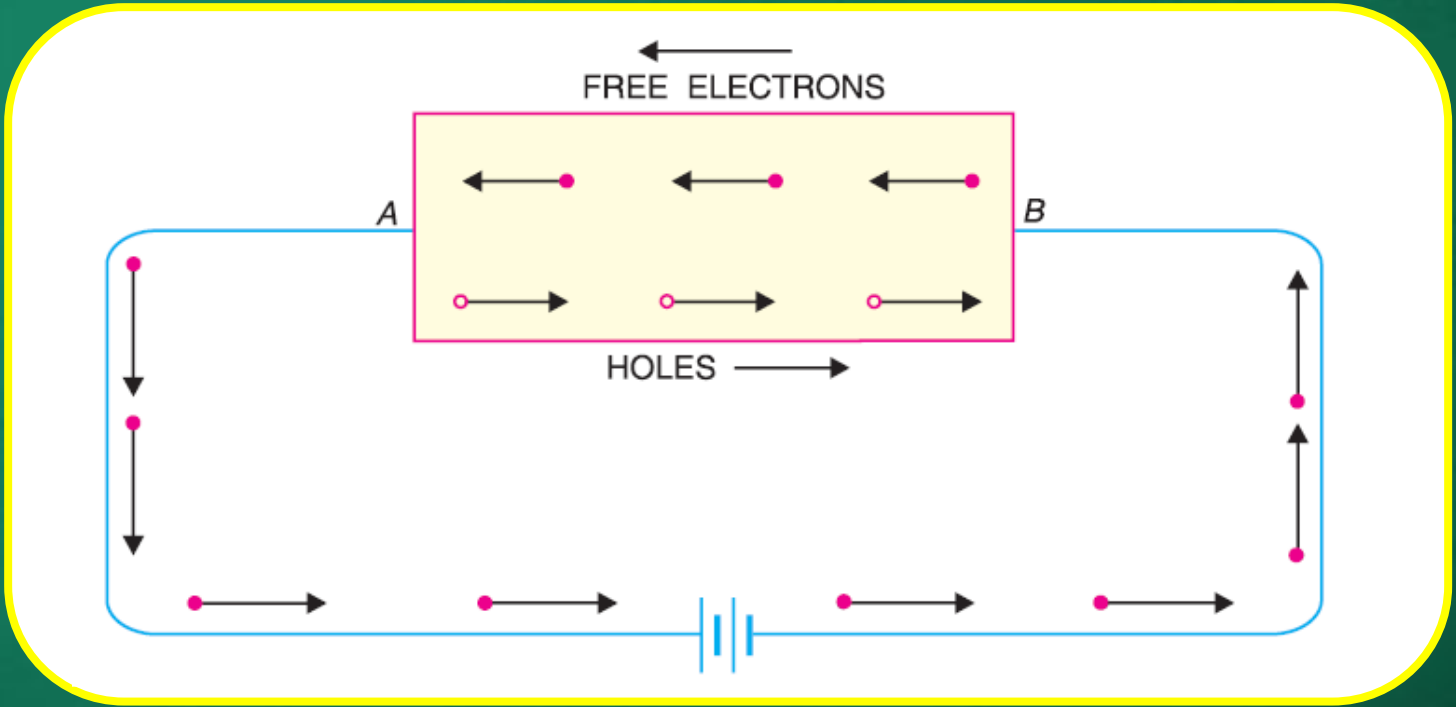

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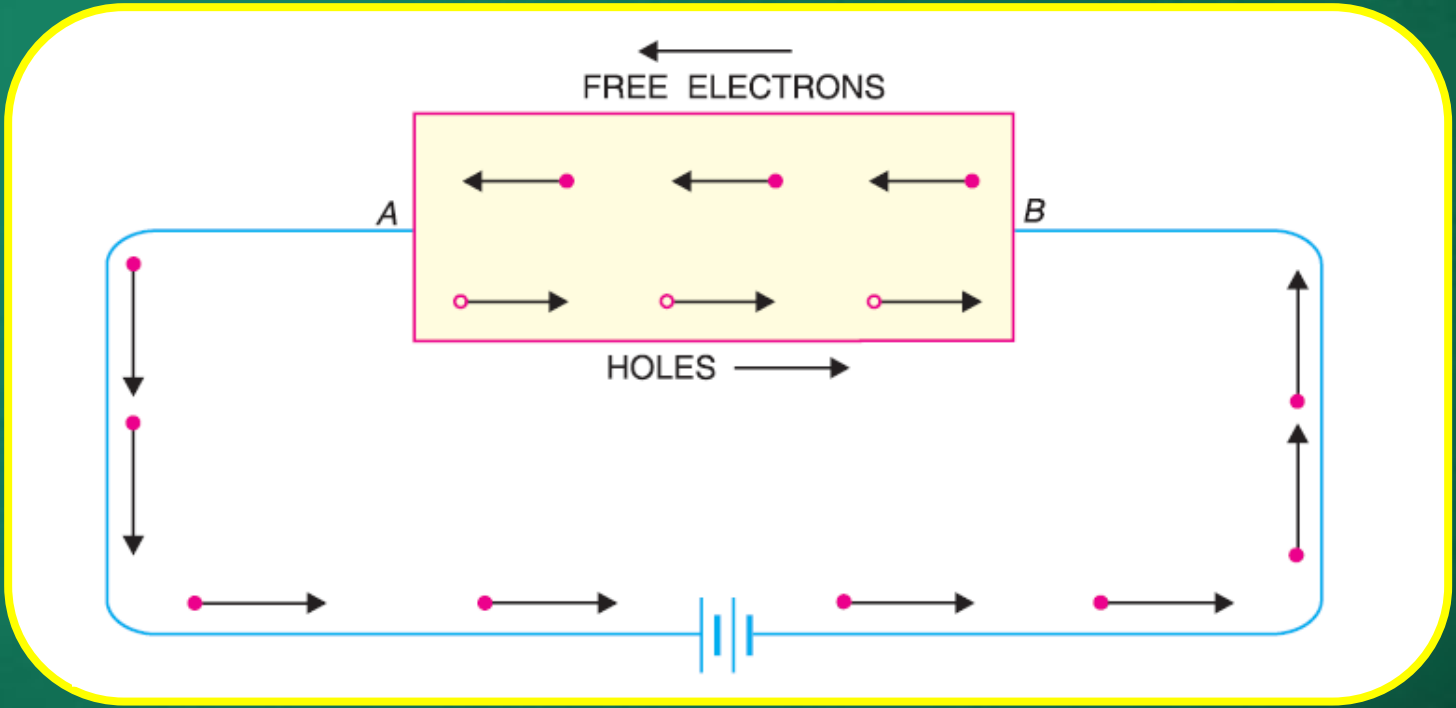

- An intrinsic semiconductor has little conduction capability at room temperature.

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- The purpose of adding impurity is to increase the number of free electrons or holes.

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  - n-type **semiconductor**
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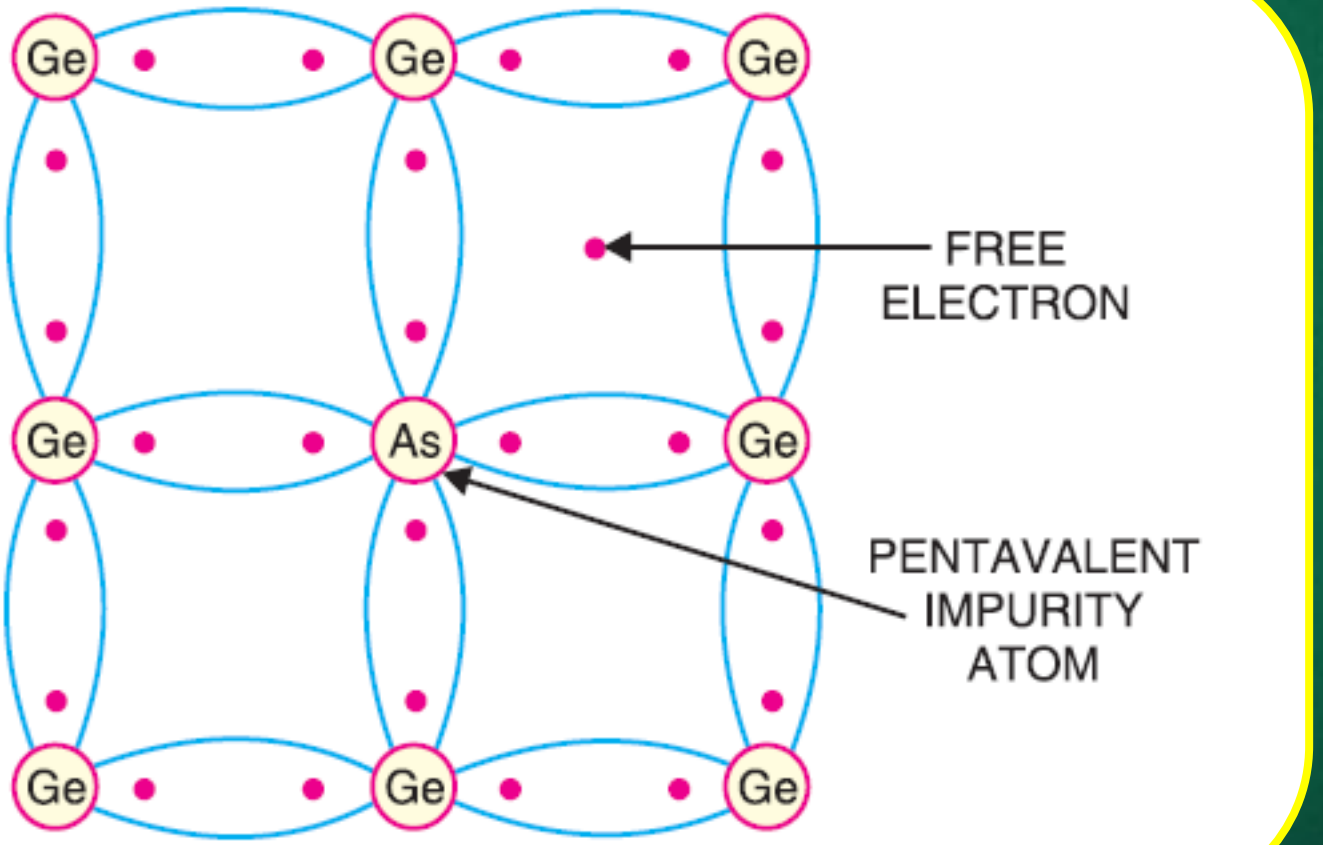

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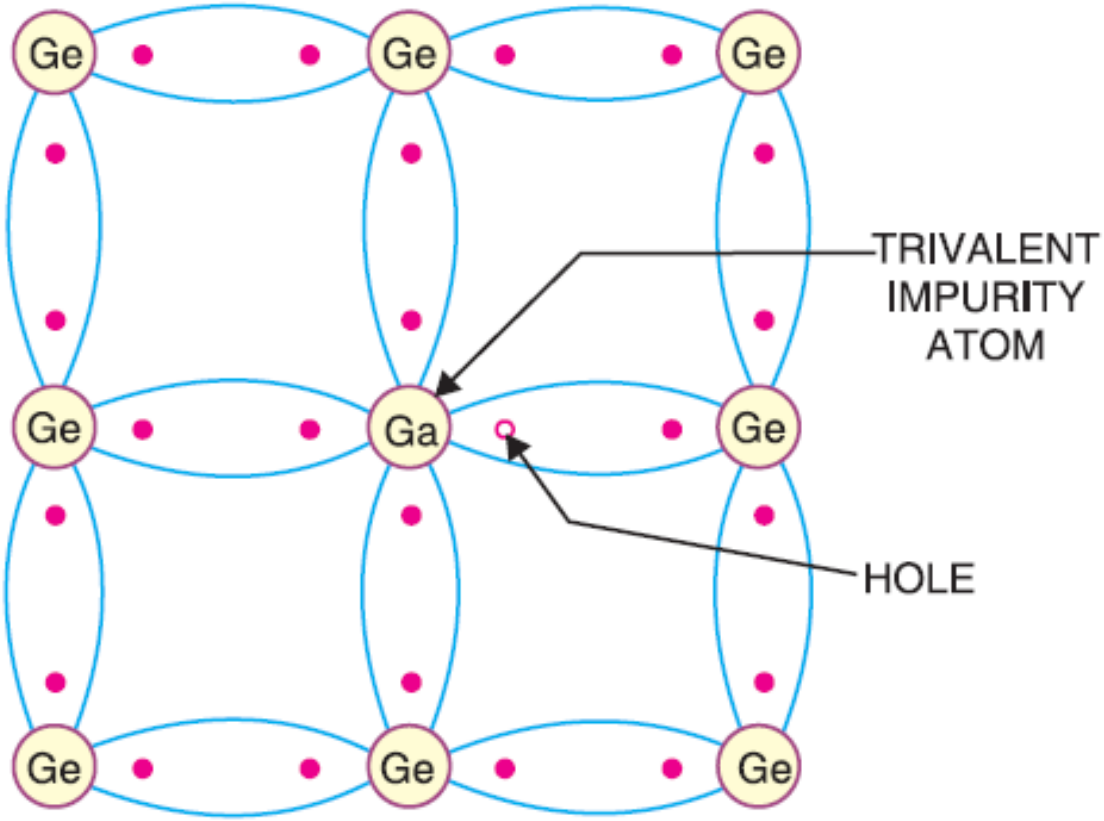
- Missing electron is called a hole.

p-type Semiconductor



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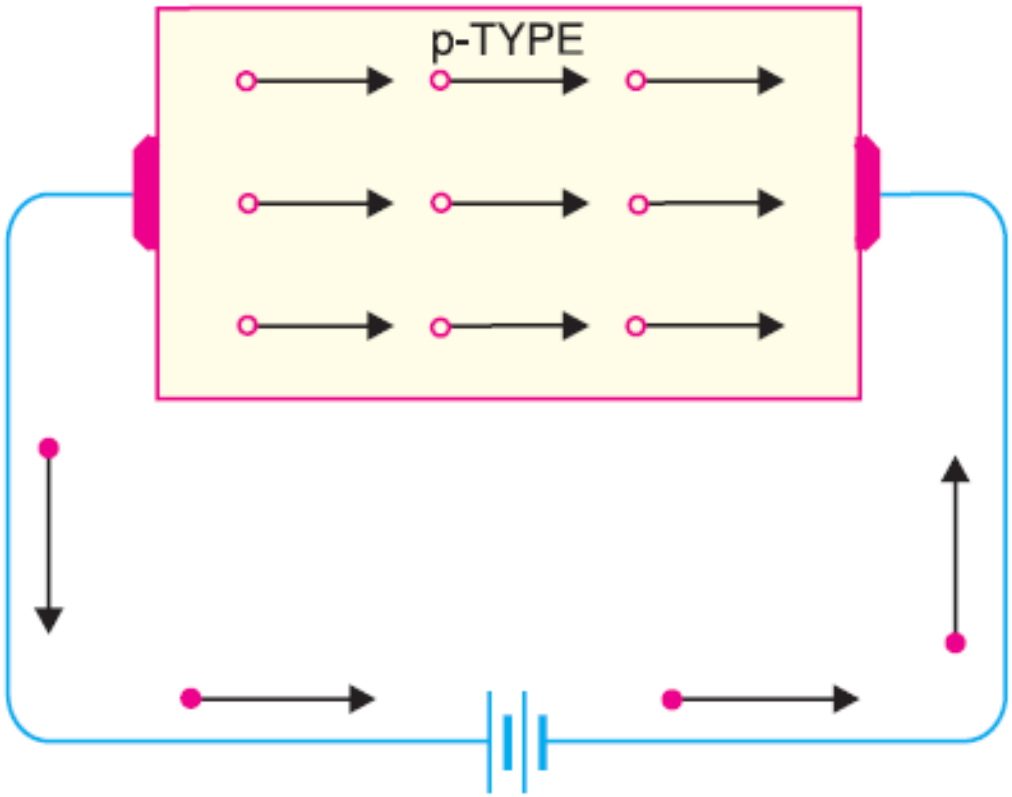
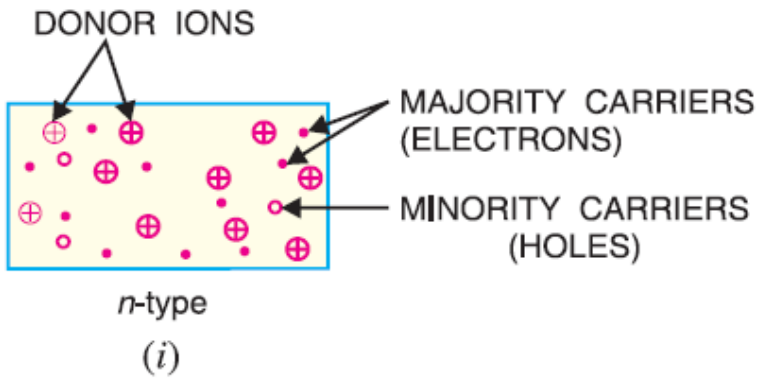
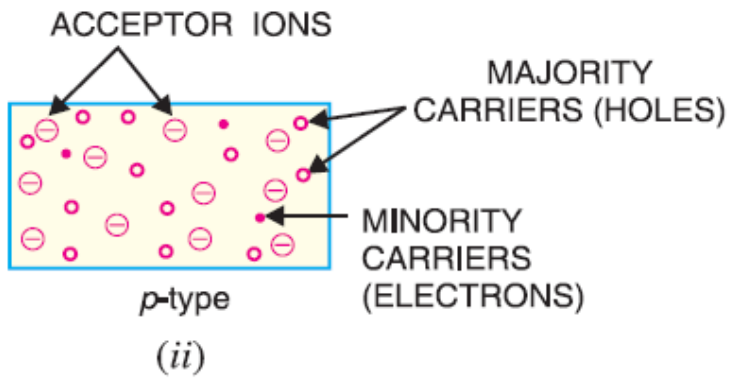
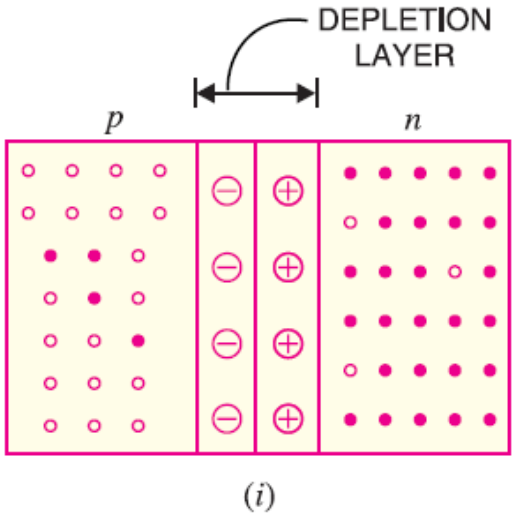


Majority & Minority Carriers

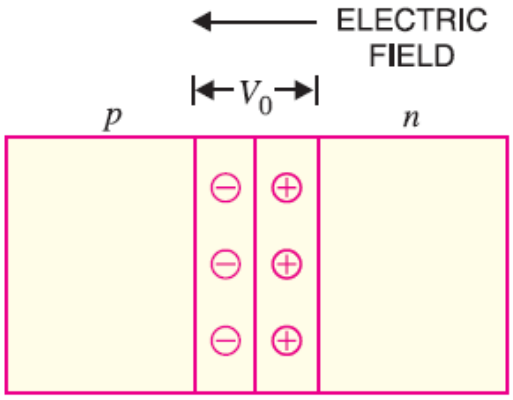




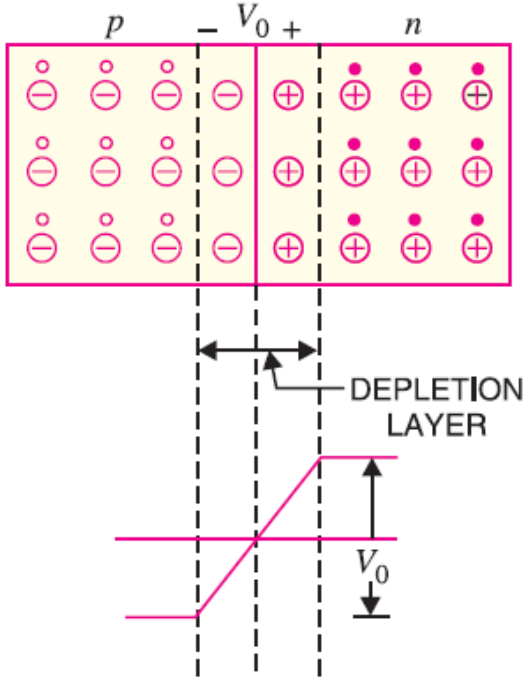
pn junction



(i)



(ii)



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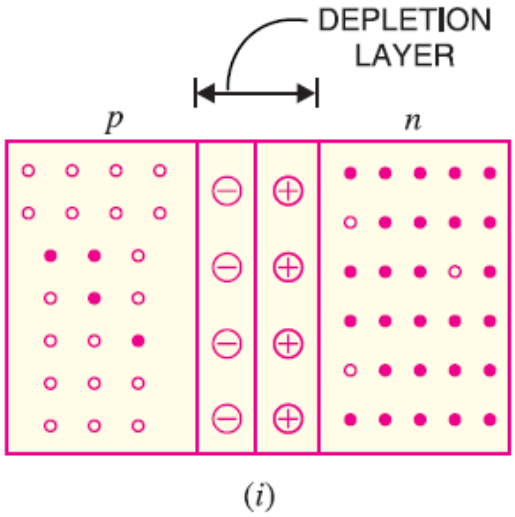
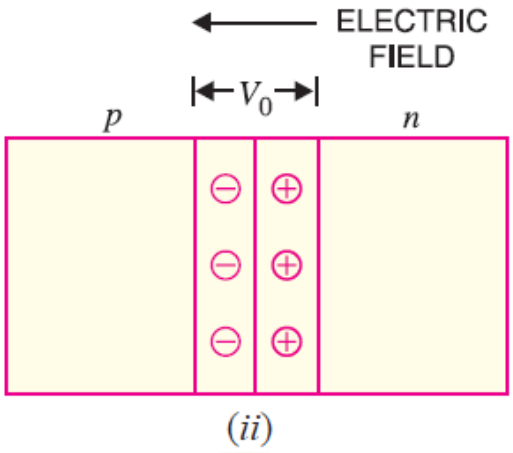
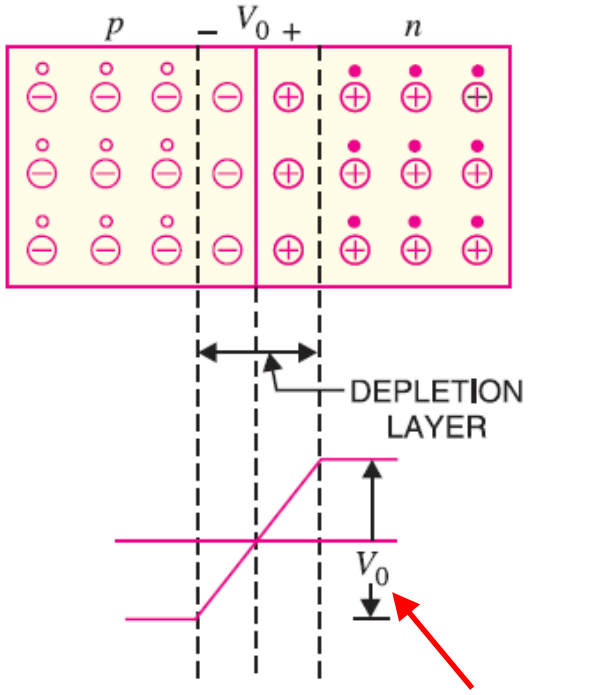

DEPLETION
LAYER
p
n
(i)


ELECTRIC
FIELD
V_0
p
n
(ii)


p
V_0
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DEPLETION
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Barrier potential

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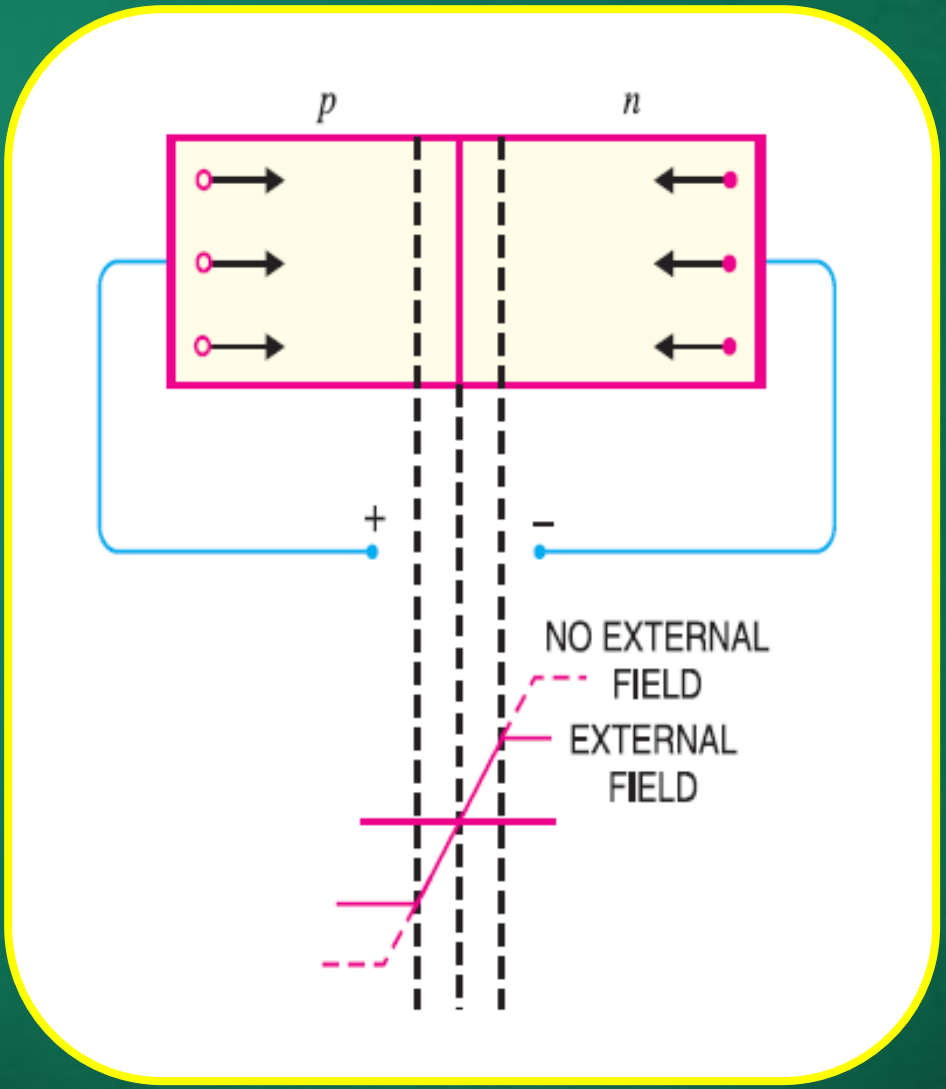
- **Forward biasing**: When an external dc voltage is applied to the junction is in such a direction that it cancels the potential barrier, thus permitting current flow is called forward biasing.

Forward Biased pn junction



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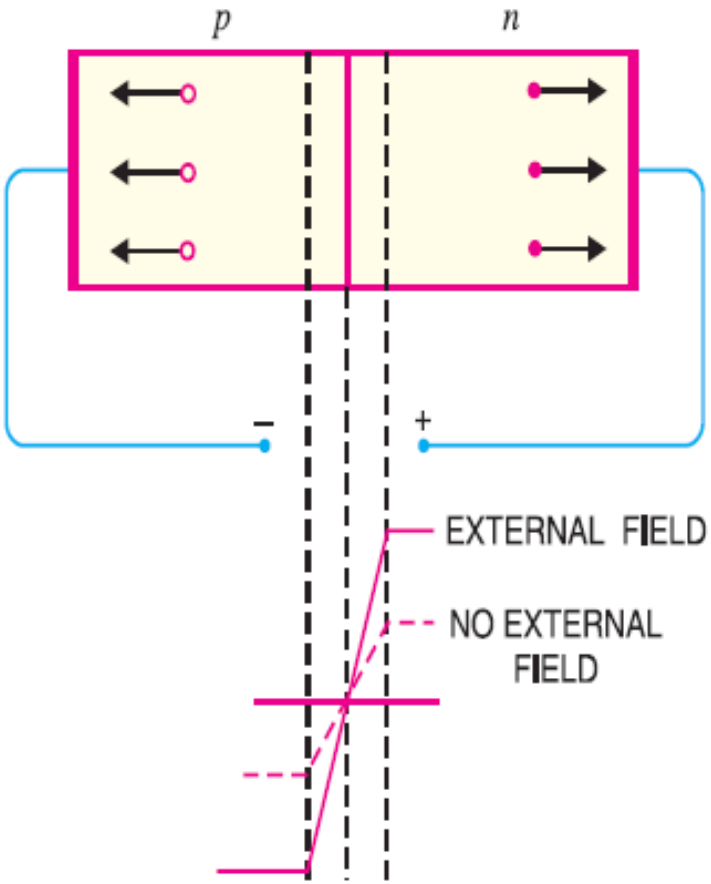
- The current flows in the circuit due to low resistance path and its magnitude will depend on the applied forward voltage.

Reverse Biasing a pn junction

Reverse biasing: When an external dc voltage is applied to the junction is in such a direction that the potential barrier increases, it is called reverse biasing.

Reverse Biasing a pn junction



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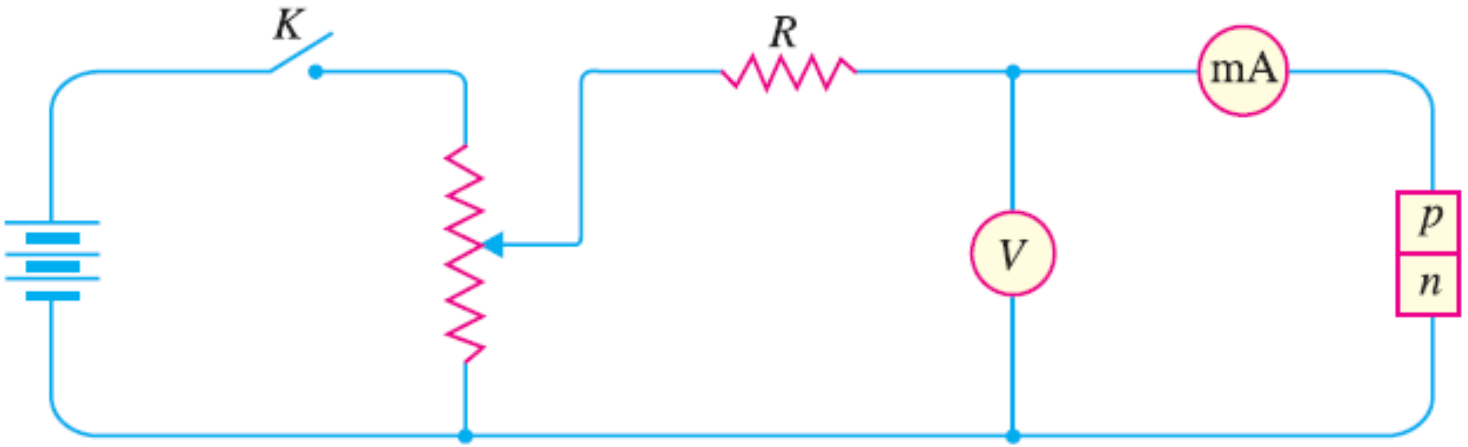
- The junction offers a very high resistance (called reverse resistance R_r) to current flow.
- No current flows in the circuit due to high resistance path (in practice a negligible current called reverse saturation current (of the order of μA flows in the circuit).

VI Characteristics of a pn junction



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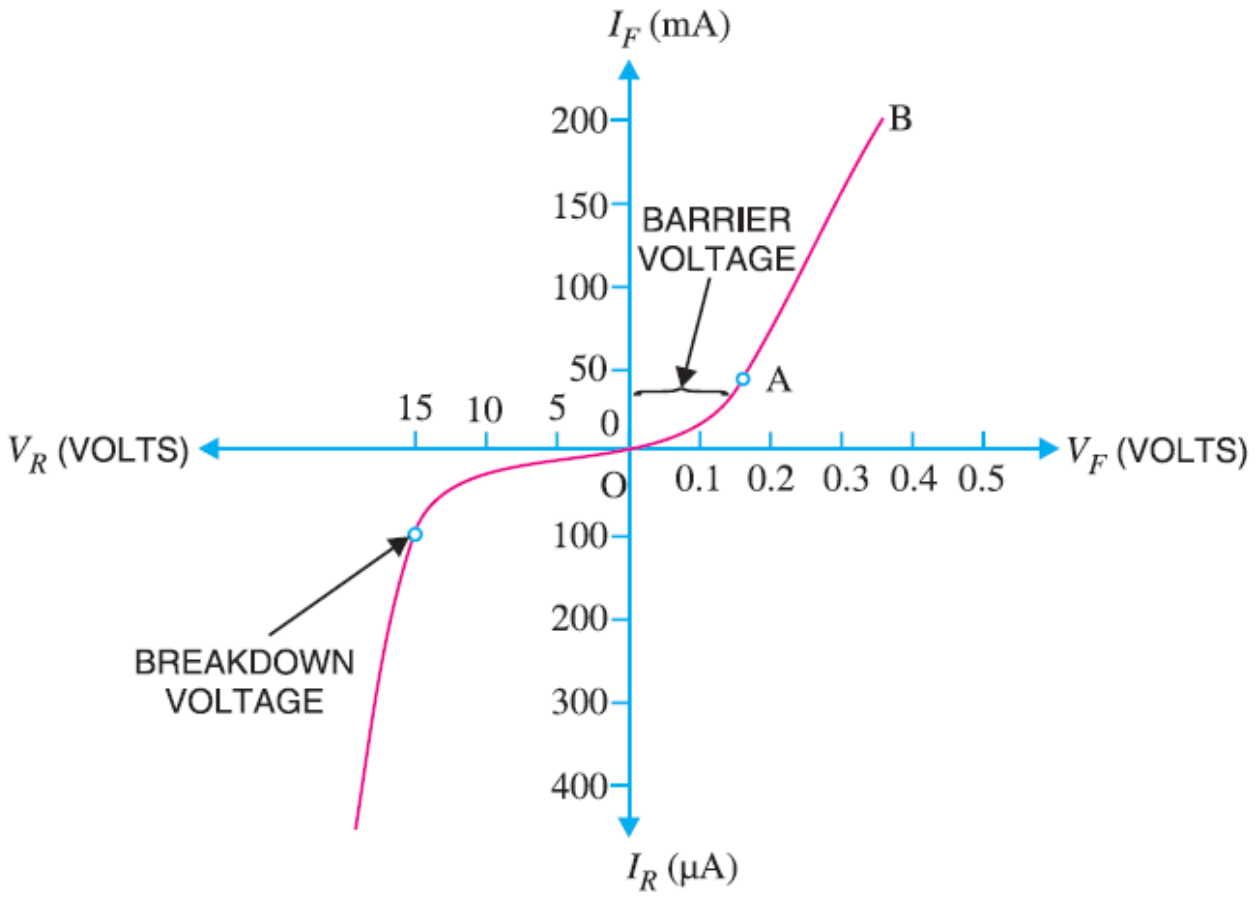

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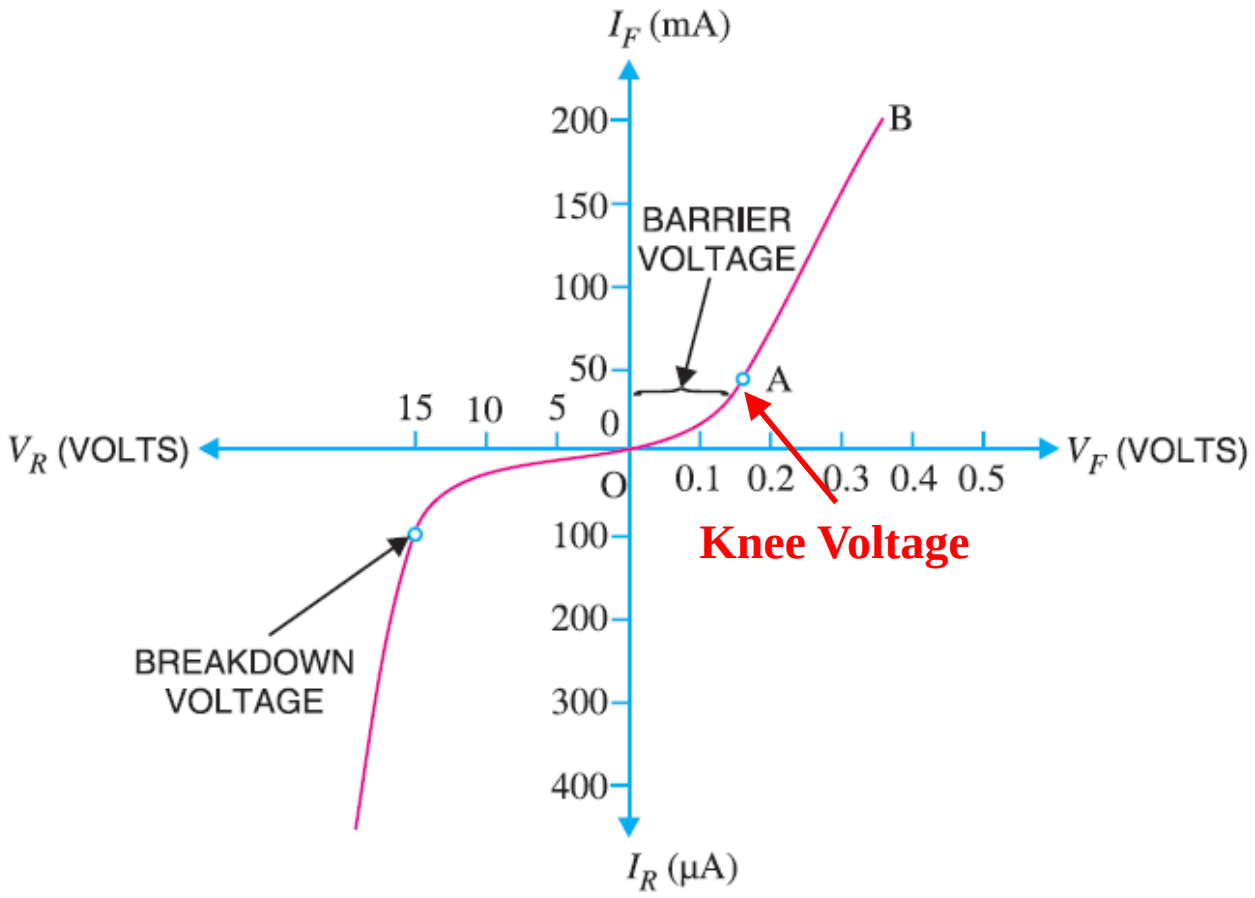

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- **Maximum Power Rating**: The maximum power that can be dissipated in the pn junction without damaging it.

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- PN junction is called a semiconductor diode or crystal diode.

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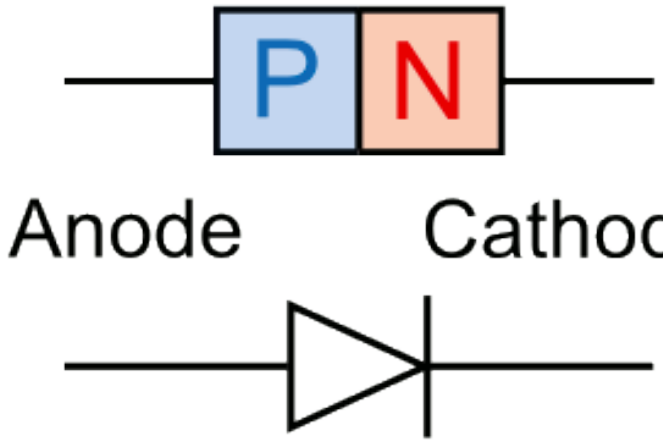

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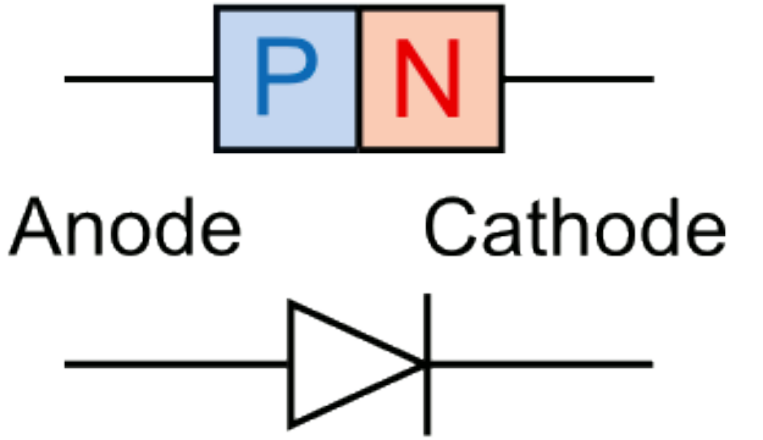

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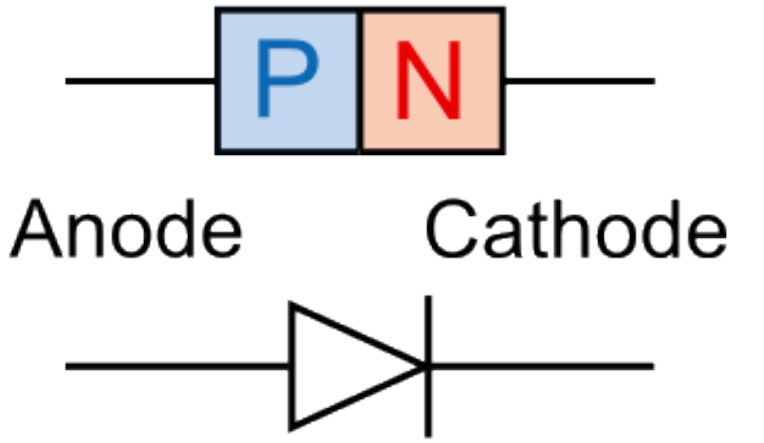

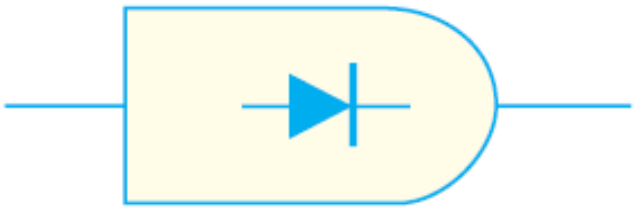

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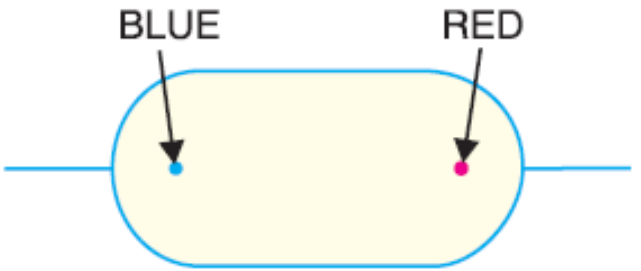
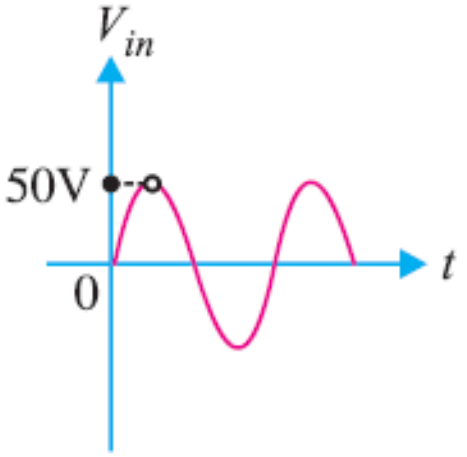
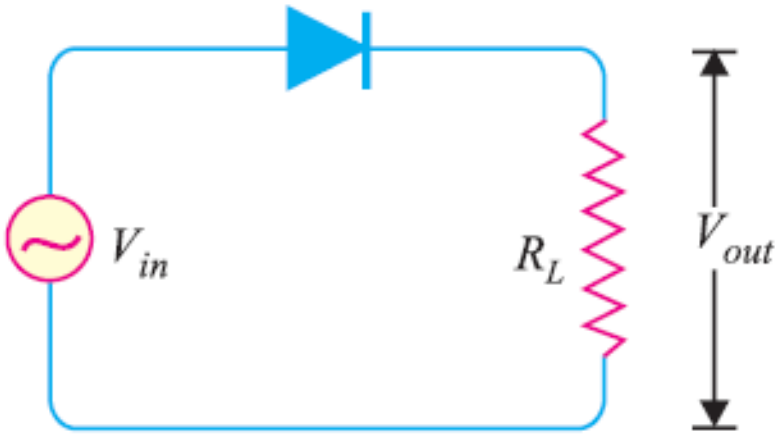
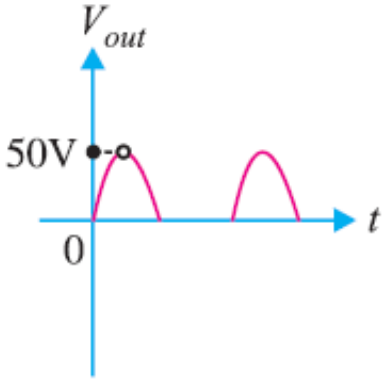


OA 80

Diode as a Switch







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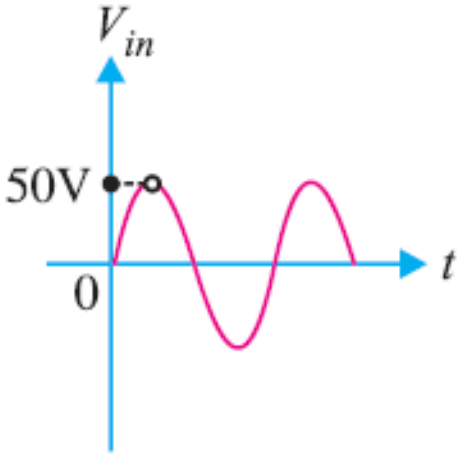

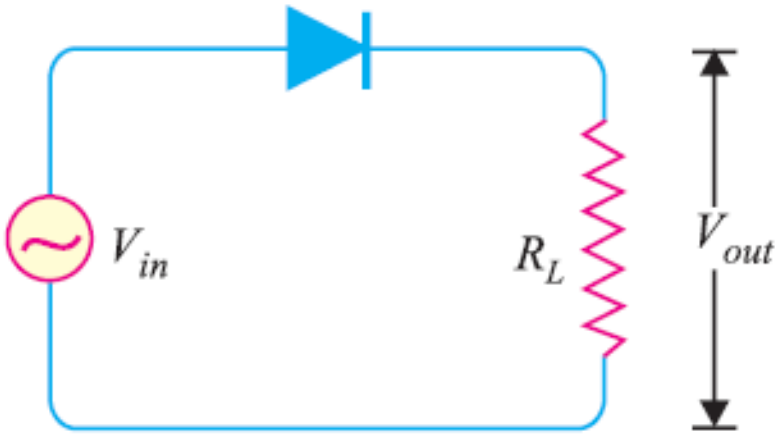

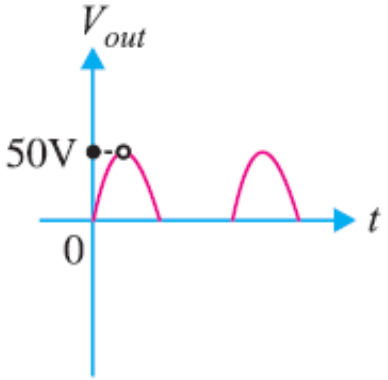

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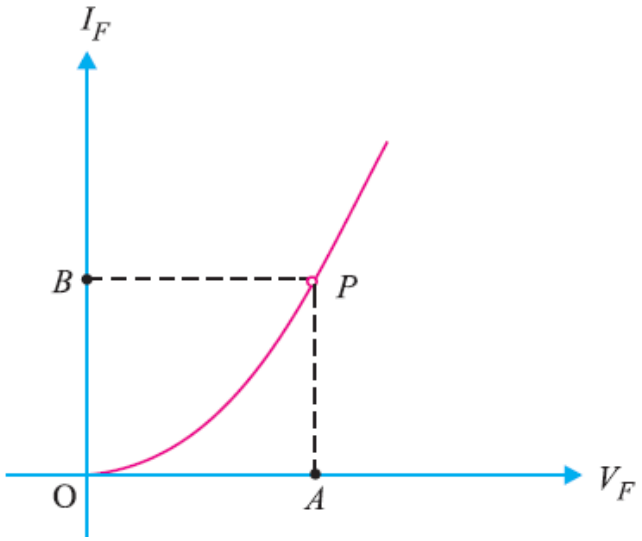

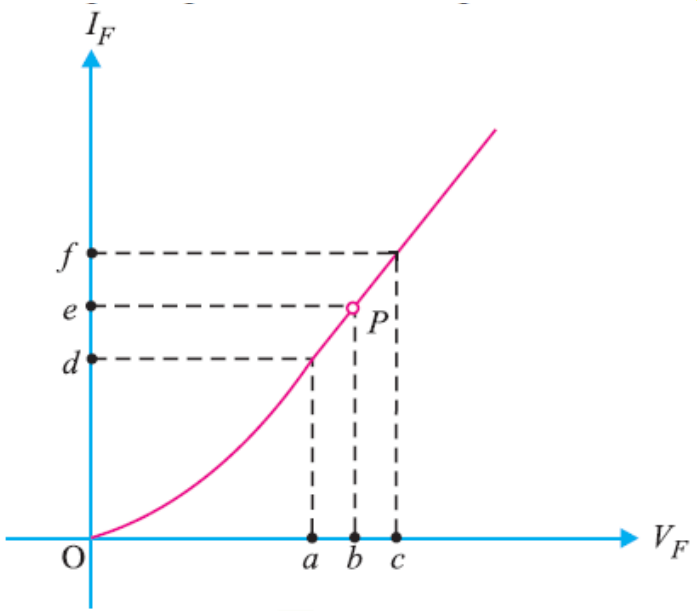

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- Practically, small current called reverse saturation or leakage current flows through the diode even if is reverse biased.
- The resistance offered by diode when reverse biased will be very high.

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i_D = the net current flowing through the diode;
I_0 = "dark saturation current", the diode leakage current in the absence of light;
v_D = applied voltage across the terminals of the diode;
q = absolute value of electron charge (1.6×10^{-19} C);
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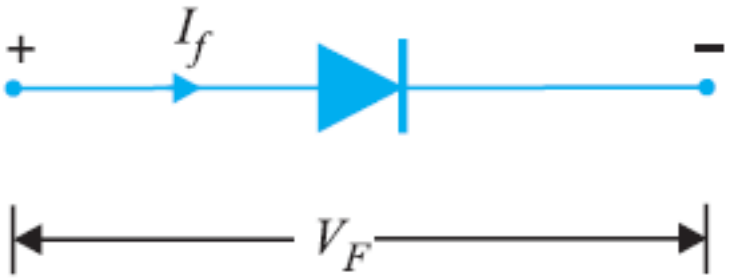
At 300 K, kT/q = 23 mV, the thermal voltage.

Approximate Equivalent Circuit



DIODE

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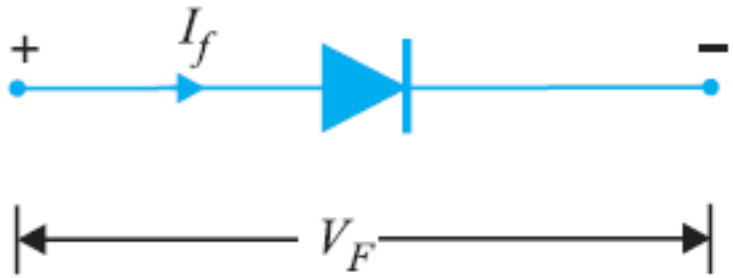
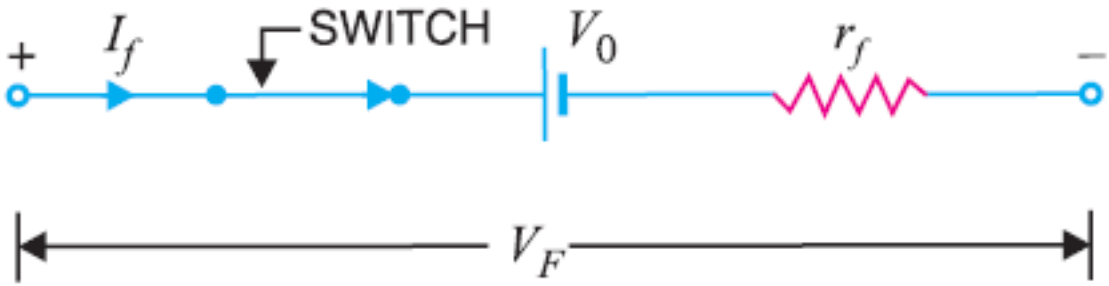


DIODE



EQUIVALENT CIRCUIT

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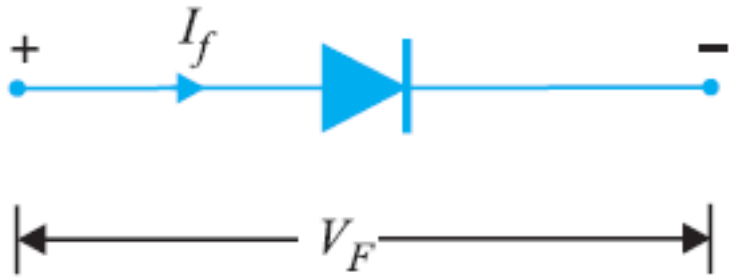
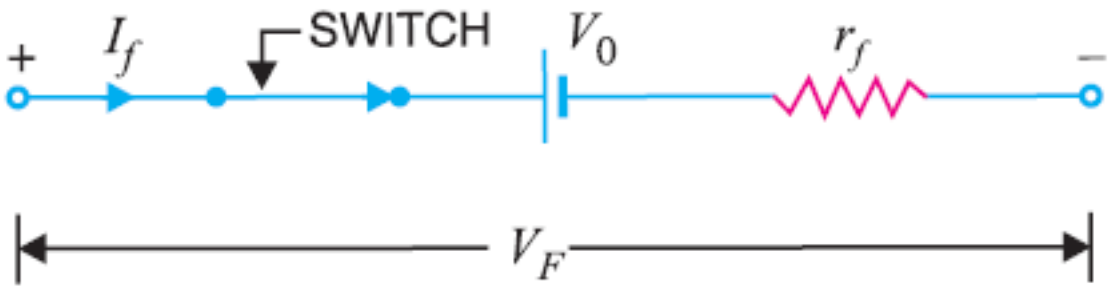


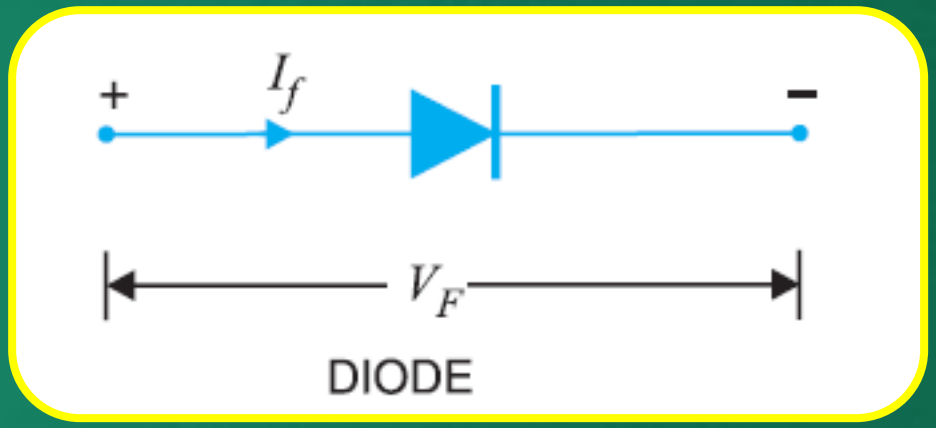
DIODE



EQUIVALENT CIRCUIT

$$V_F = V_0 + I_f r_f$$

Simplified Equivalent Circuit



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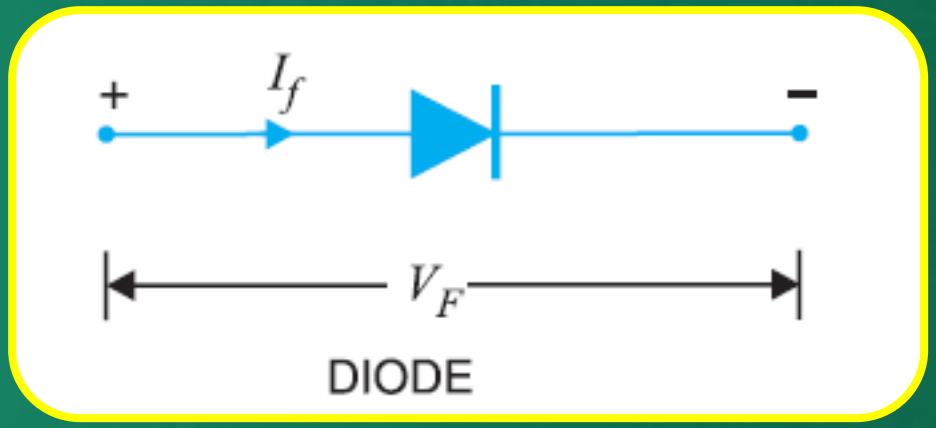
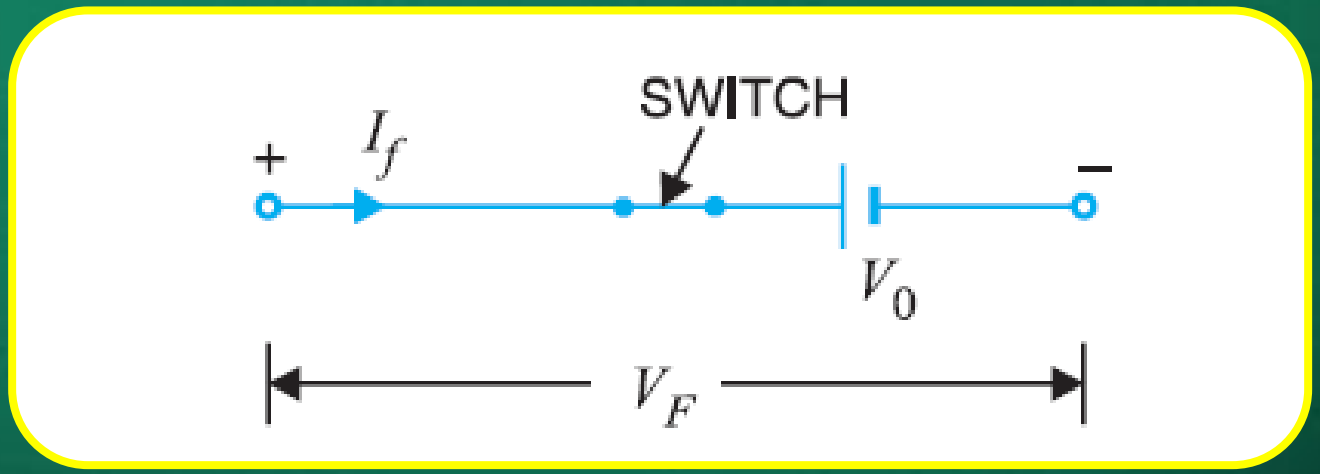
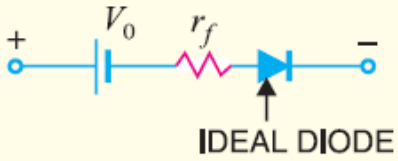
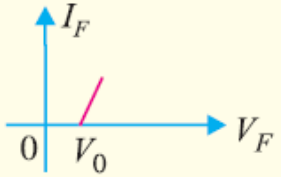
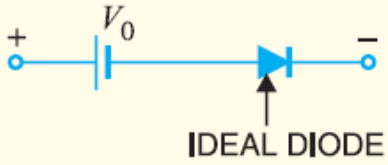
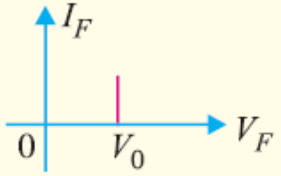
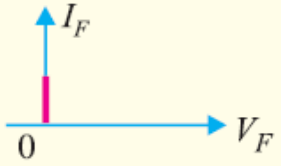




Diode Equivalent Circuit

S.No.	Type	Model	Characteristic
1.	Approximate model		
2.	Simplified model		
3.	Ideal Model		

Example

Ex. An ac voltage of peak value 20 V is connected in series with a silicon diode and the load resistance is $500\ \Omega$. If the forward resistance of diode is $10\ \Omega$, find

a) peak current through the diode

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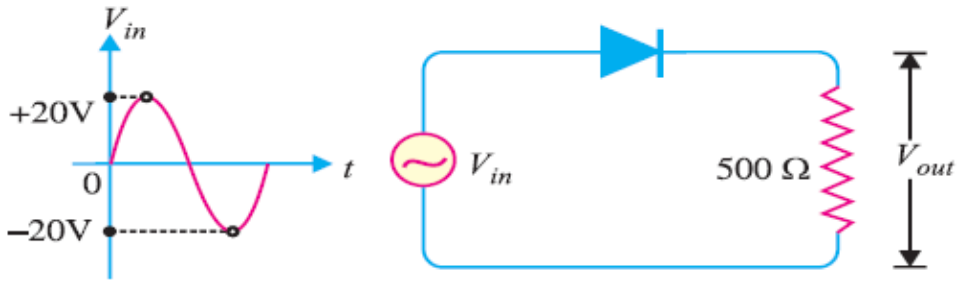

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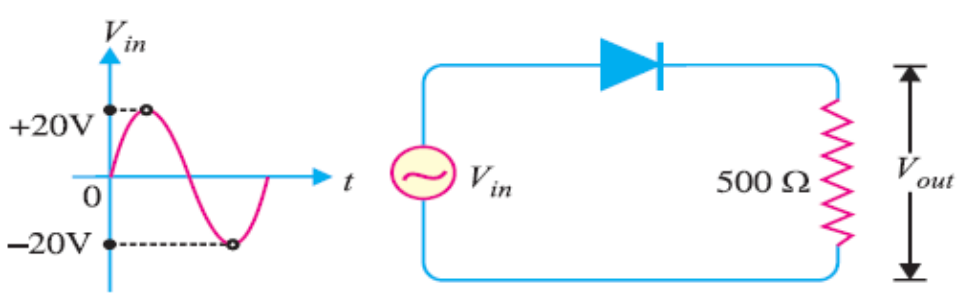

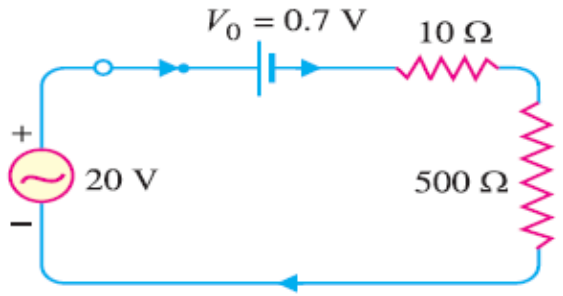

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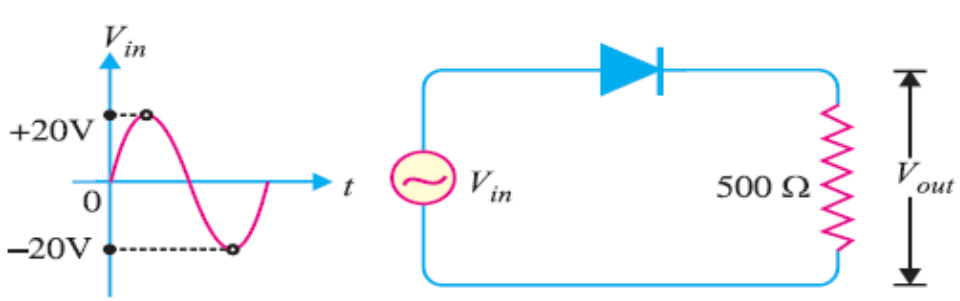
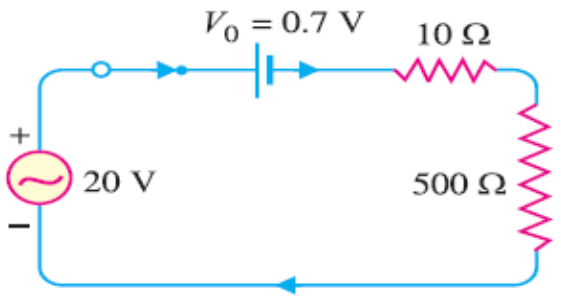
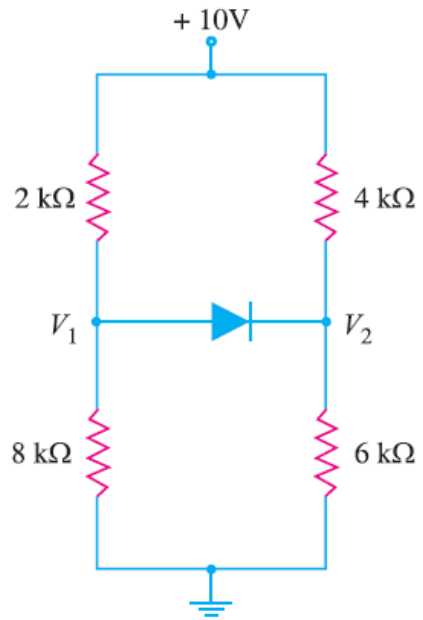




Ans: 37.843 mA, 18.922 V (comment)

Example

Ex. Determine if the diode (ideal) is forward or reverse biased.



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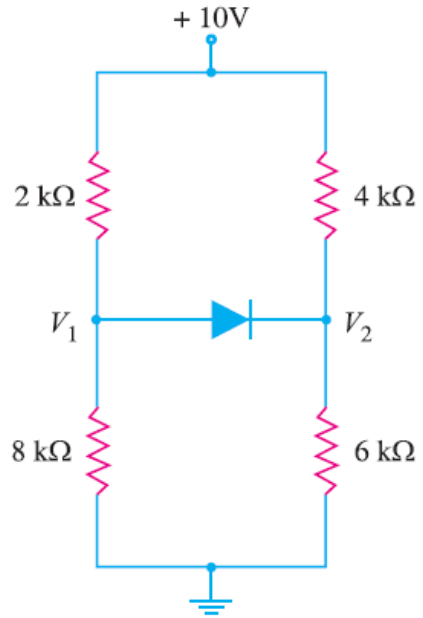

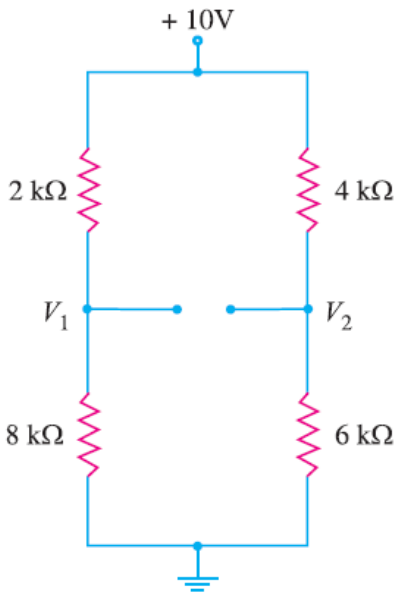

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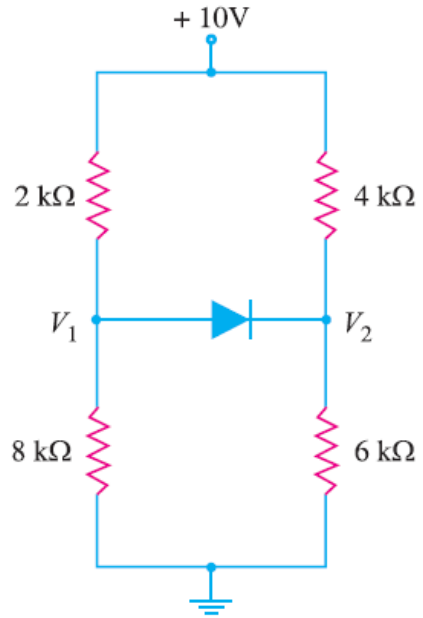
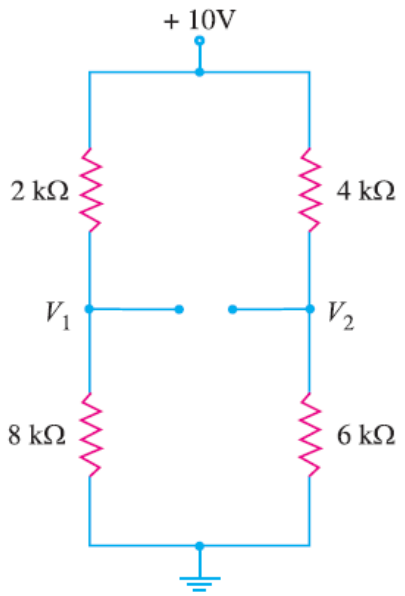
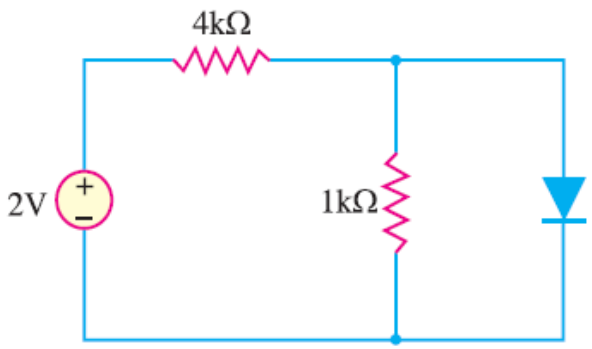




Ans: $V_1 - V_2 = 2$ V, Since the anode voltage is more than cathode voltage, the diode is forward biased.

Example

Ex. Determine the state of silicon diode (assume simplified model of diode).



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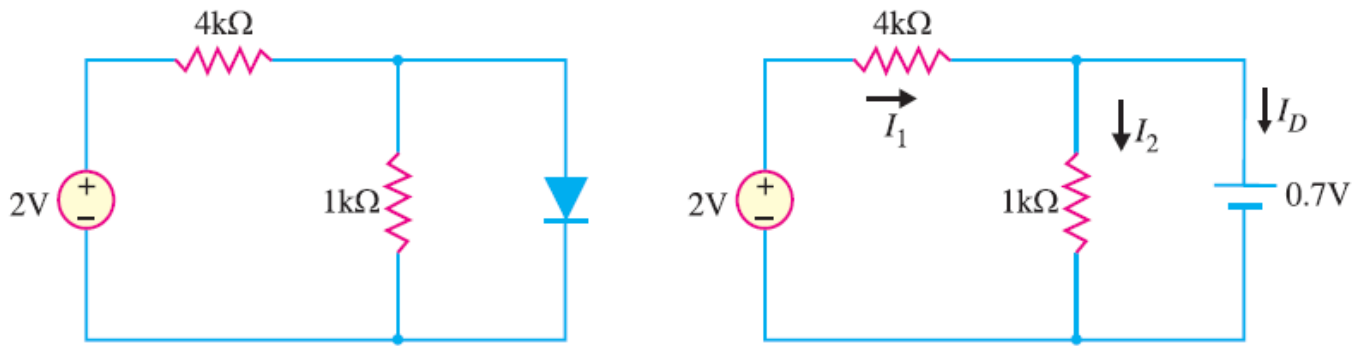

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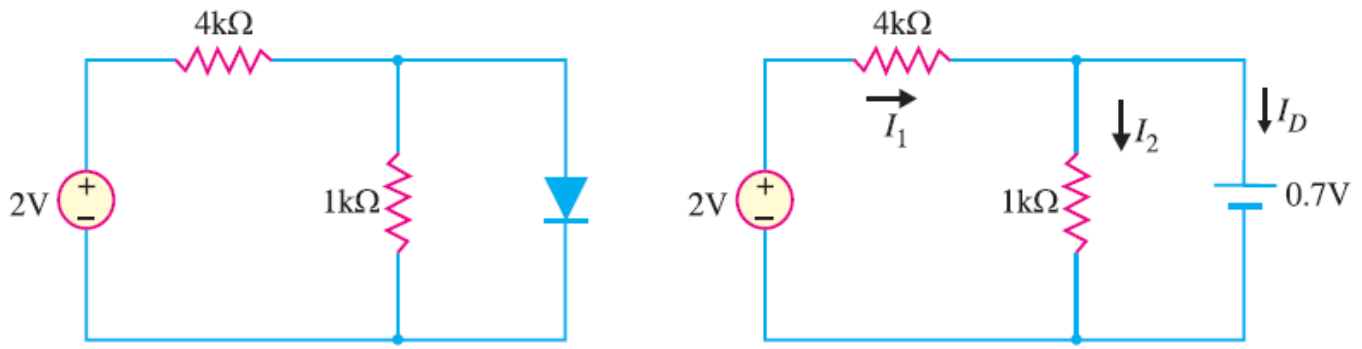

Ans: Assume diode is forward biased I_D = -0.375 mA

So, our assumption is wrong, it is in fact reverse biased.

Specifications of a Diode

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- **Peak Inverse Voltage** (PIV): The maximum reverse voltage that can be applied to a diode junction without damage to the junction.
- **Reverse Current or Leakage Current**: The current that flows through the diode when reverse biased. For silicon diode it is less than 1 micro A and for germanium is approximately 100 micro A.

DC Power Supplies

Power Supply

- All electronic circuits need a power source to work.
- For electronic circuits made up of transistors and /or ICs, this power source must be a DC voltage of a specific value.
- A battery is a common DC voltage source for some types of electronic equipment especially portables like cell phones and iPods.
- Most non-portable equipment uses power supplies that operate from the AC power line but produce one or more DC outputs.

Power Supplies

Bench Power Supply

Power Supplies

Bench Power Supply

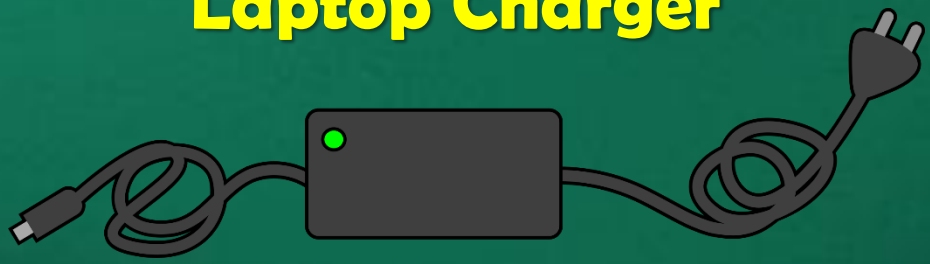
Switch Mode Power Supply

Power Supplies

Bench Power Supply

Switch Mode Power Supply

Laptop Charger



Power Supply System

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- The power supply system has output which is used to power an electronic circuit.

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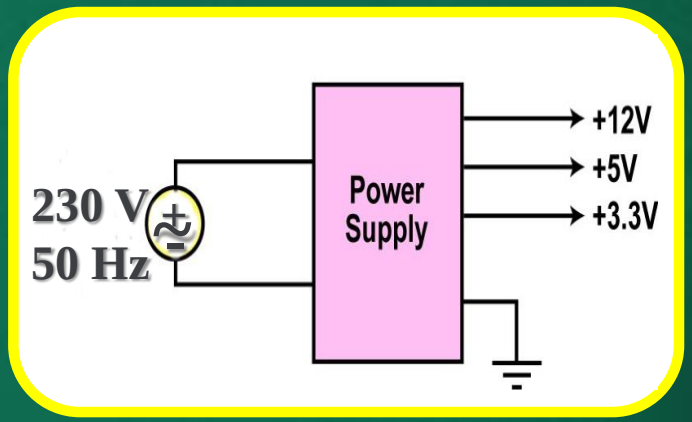
- The power supply system has output which is used to power an electronic circuit.
- The input is 230 V 50 Hz mains supply.

Power Supply Characteristics

- **The input is the** 230 V 50 Hz AC **power line.**
- **The power supply converts the** AC **into** DC **and provides one or more** DC **output voltages.**
- **Common voltages are** 48, 24, 15, 12, 9, 5, 3.3, 2.5, 1.8, 1.5, 1.2 **and** 1 V**.**
- **A good example of a modern power supply is the one inside a** PC **that furnishes** 12, 5, 3.3 **and** 1.2 V**.**



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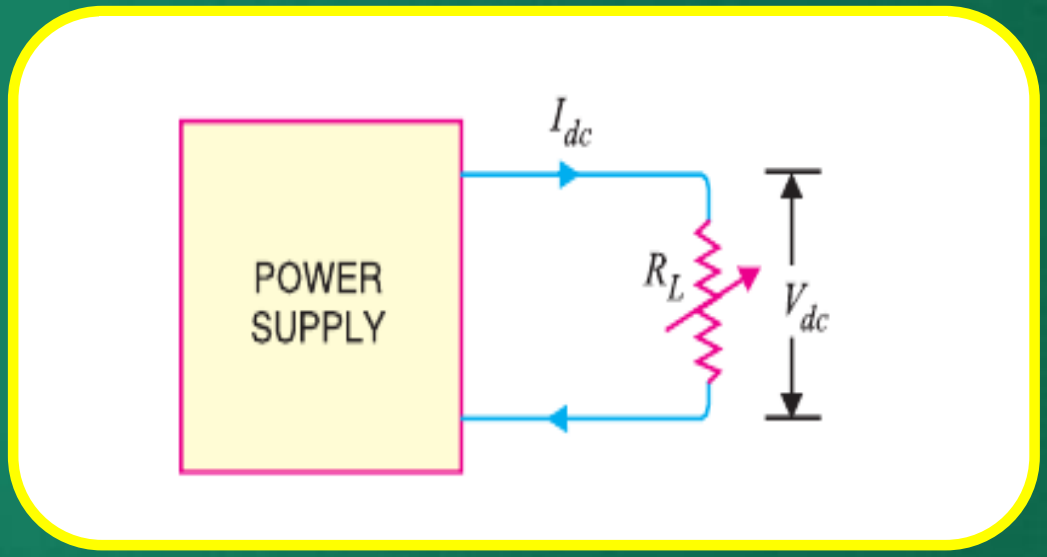
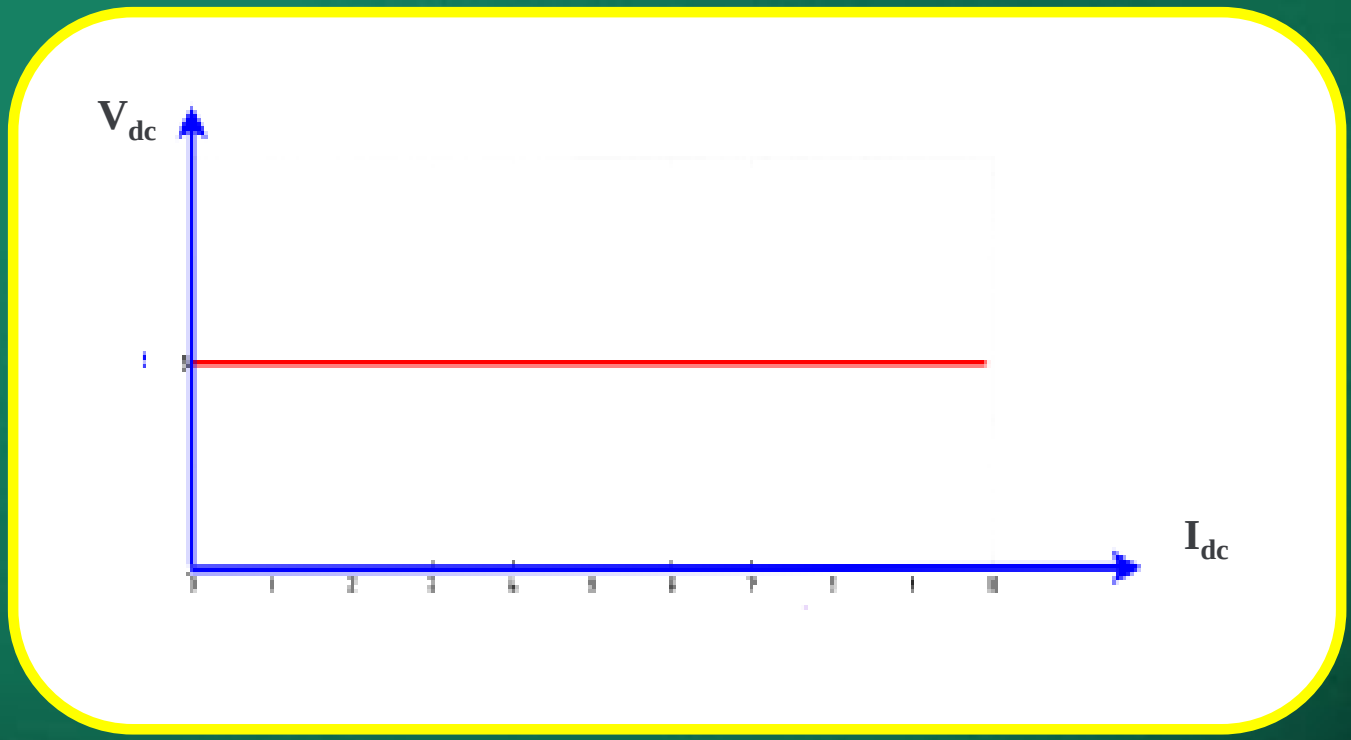


Note: In spite of variations in the load or variations in the input voltage, the output voltage should be maintained constant.

Power Supply Characteristics

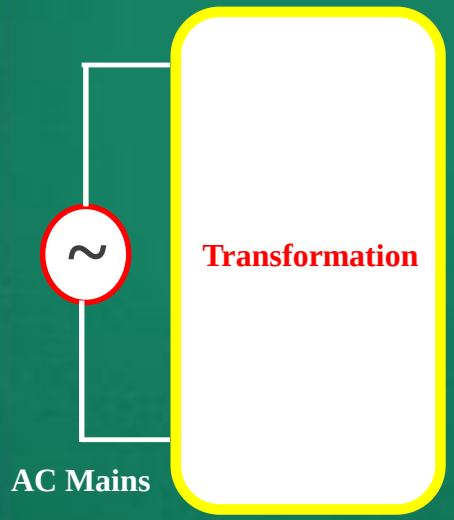
VI **characteristics of an ideal regulated power supply**



Different Stages of a Power Supply

AC Mains

Different Stages of a Power Supply



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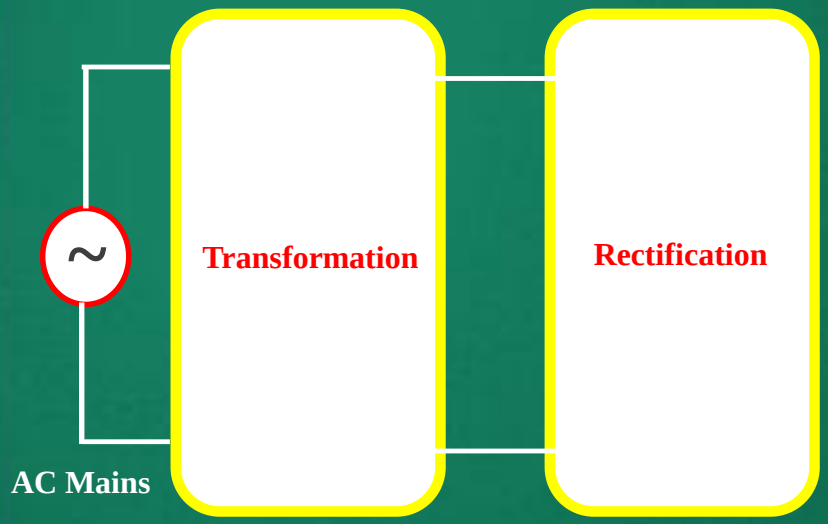

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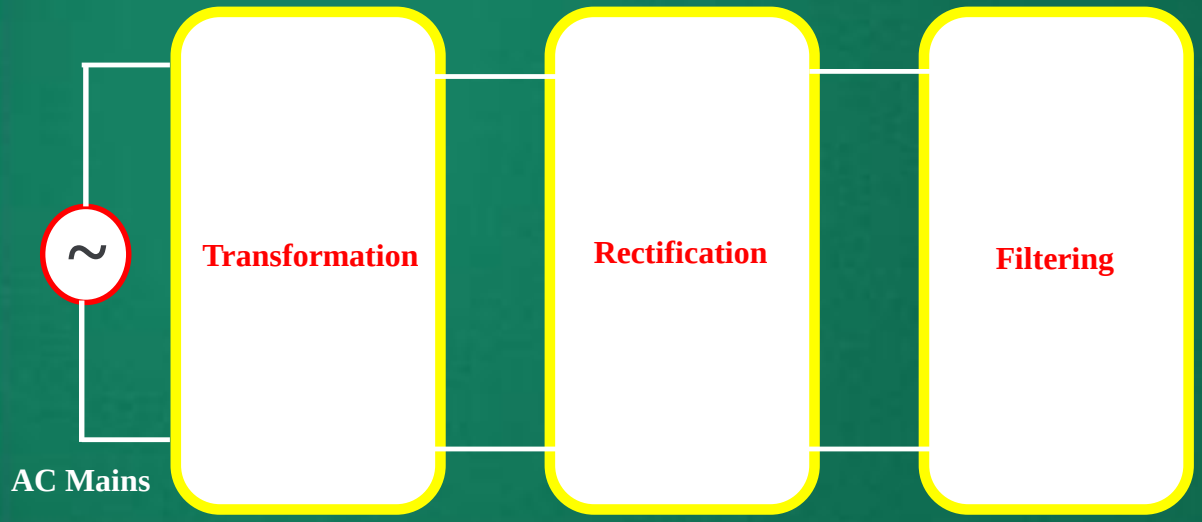

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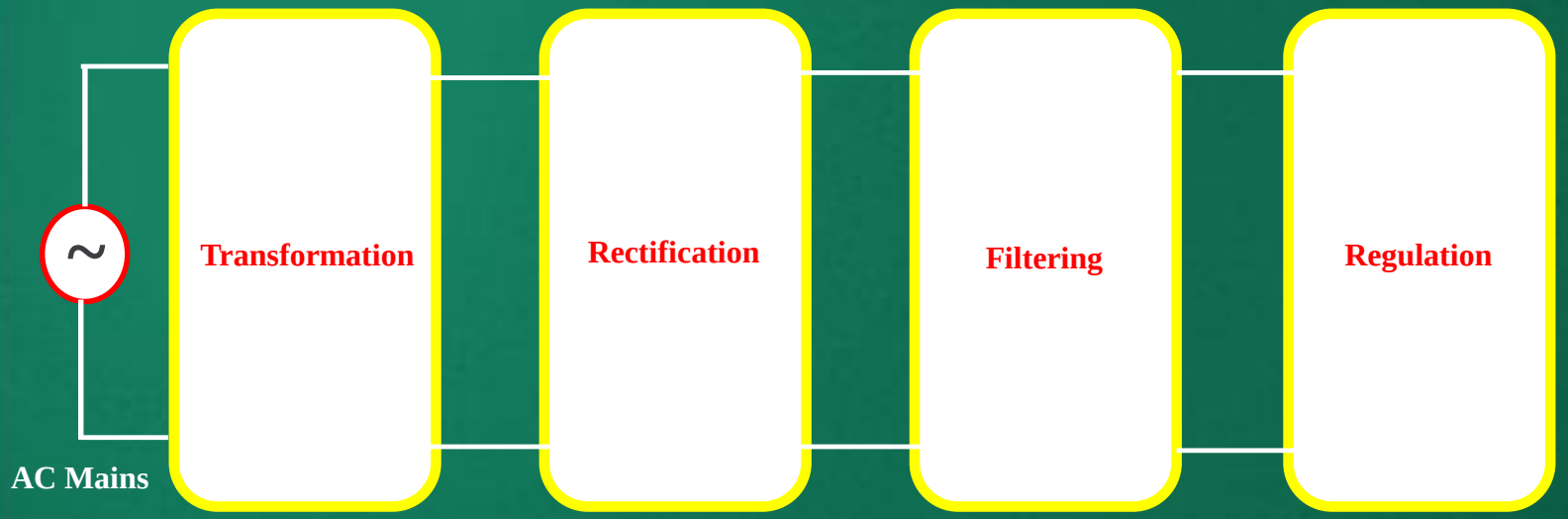

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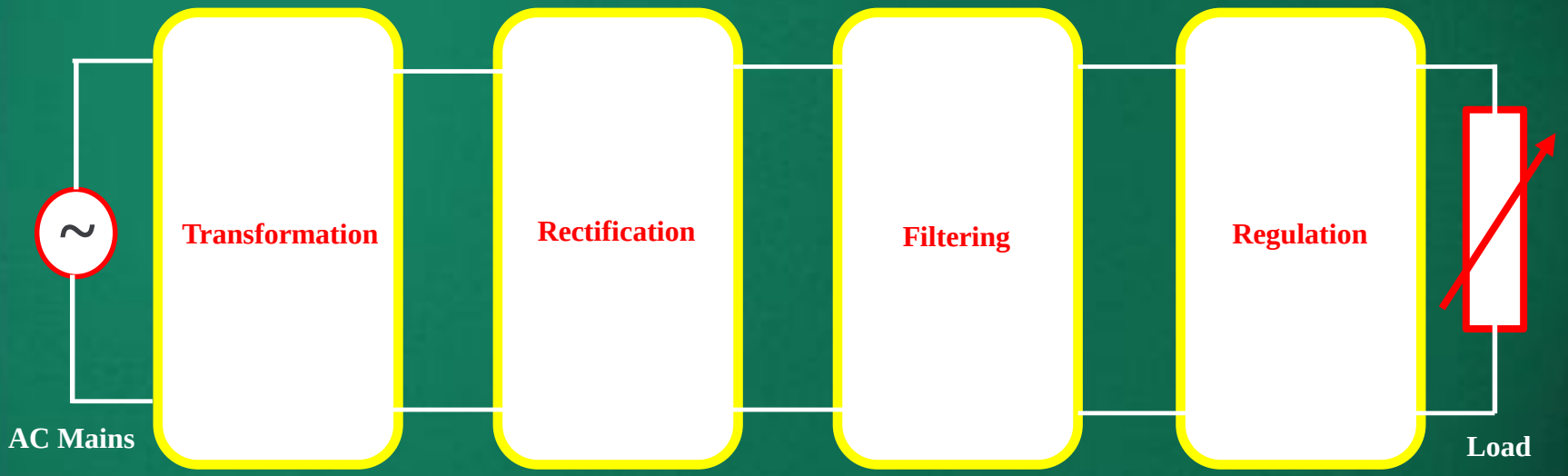

Realization of each Stage

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- Voltage Transformation

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  - Step down Transformer

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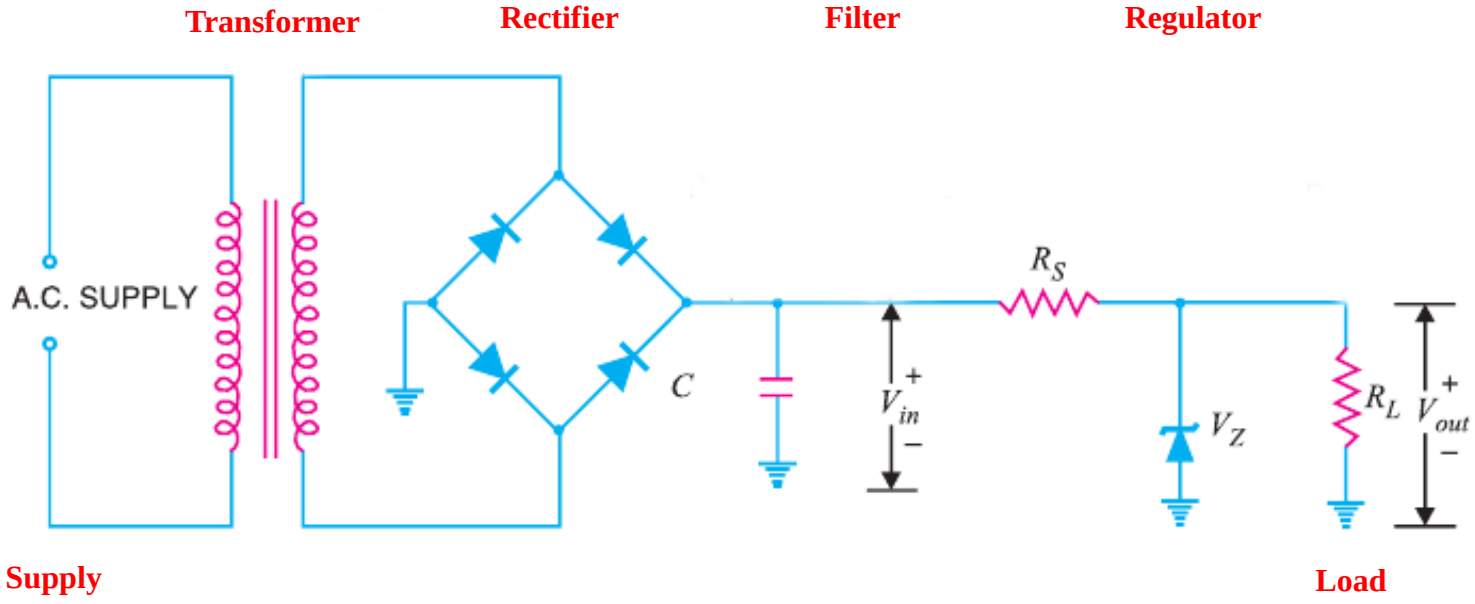
  - Zener Regulator

Circuit Diagram of a Simple Regulated Power Supply



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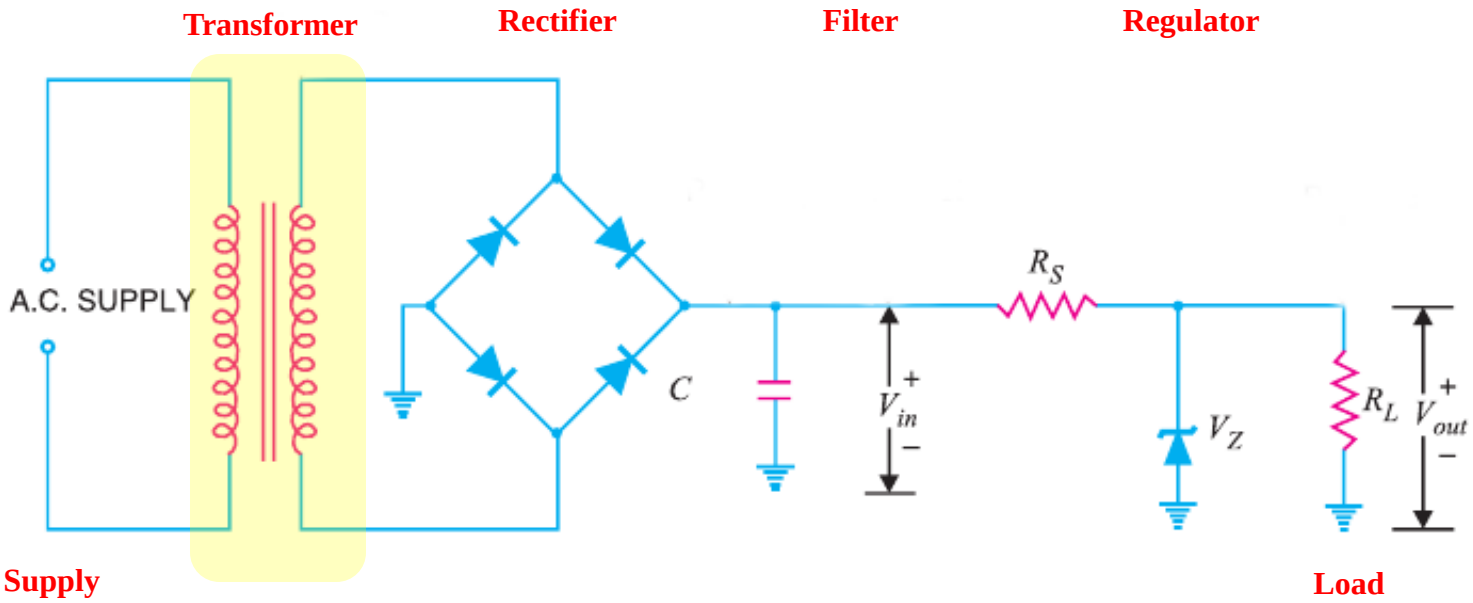

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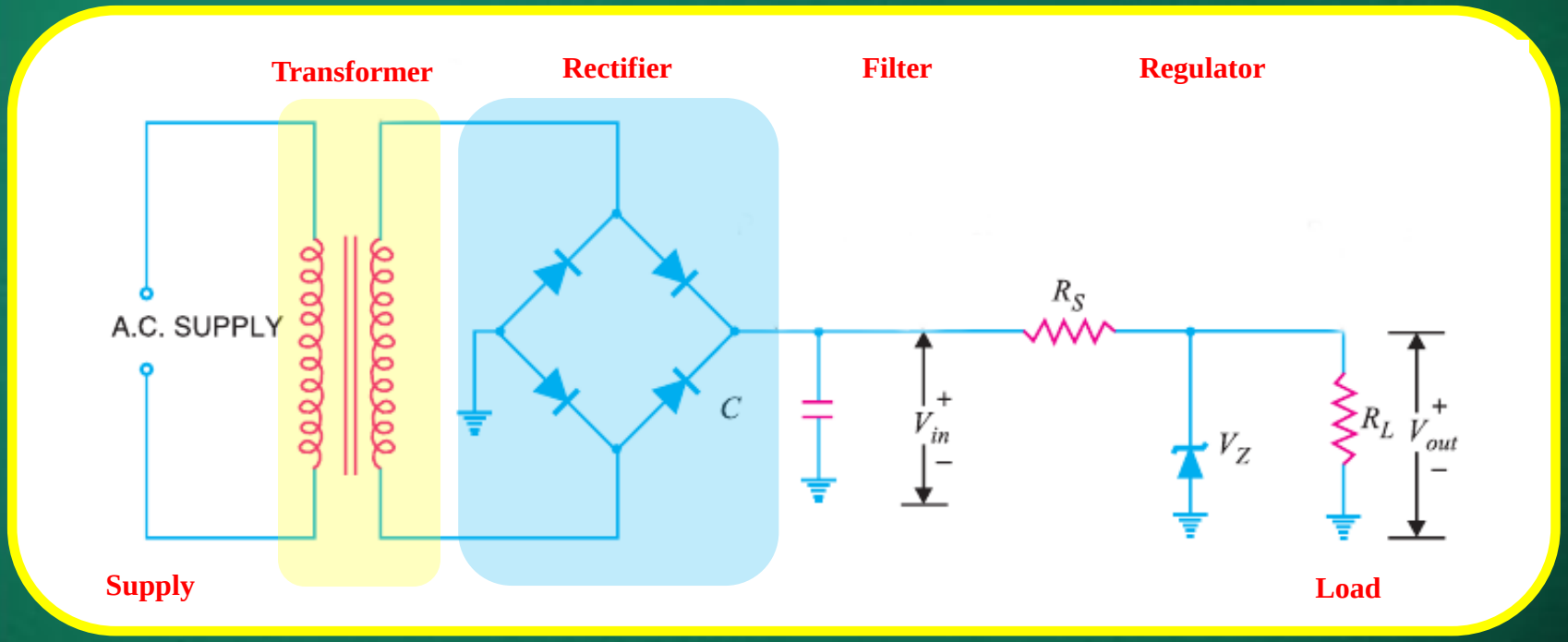

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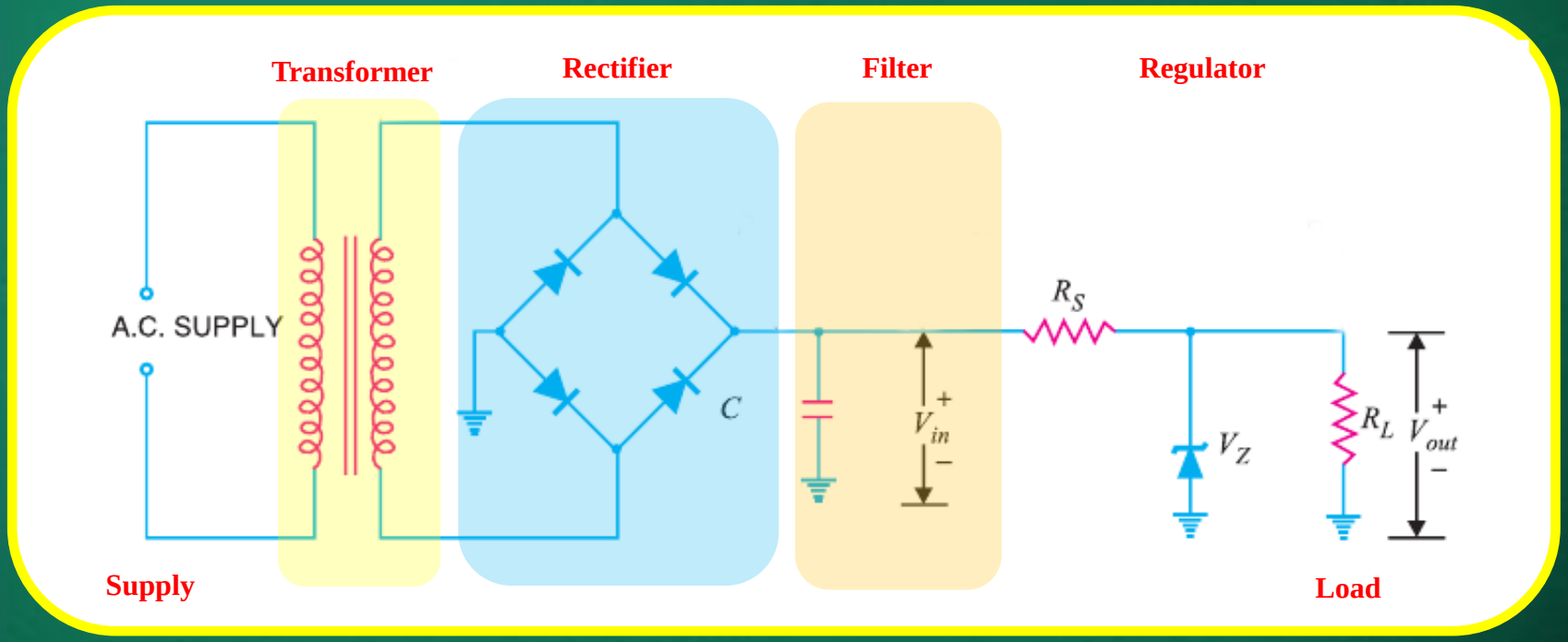

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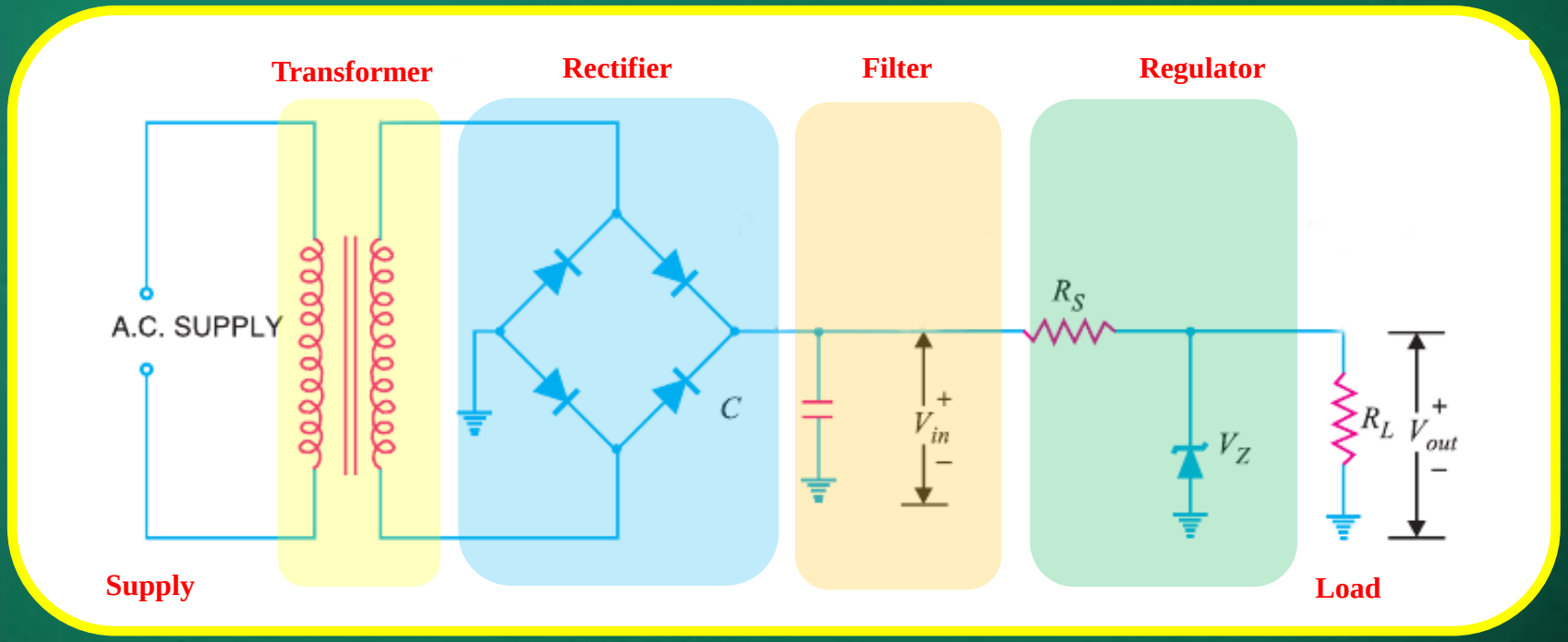
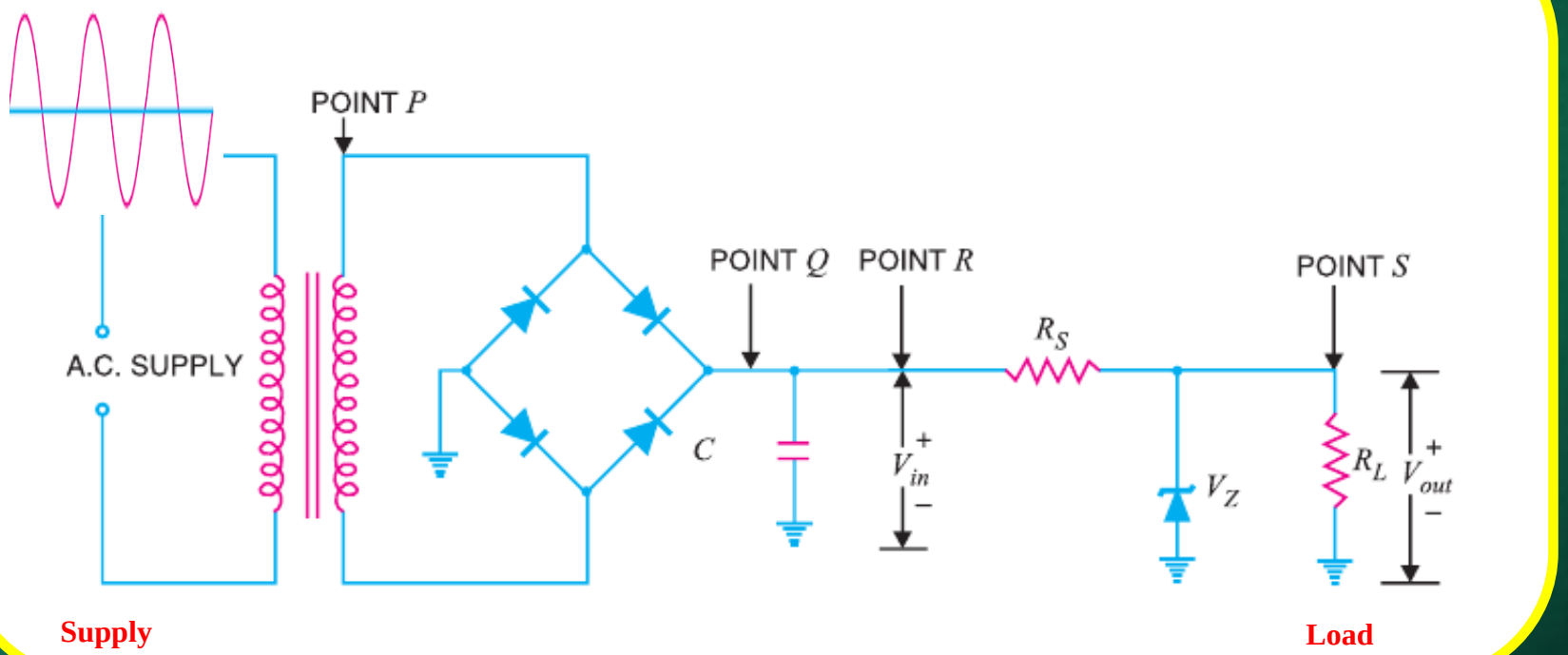


Output Waveform after each Stage



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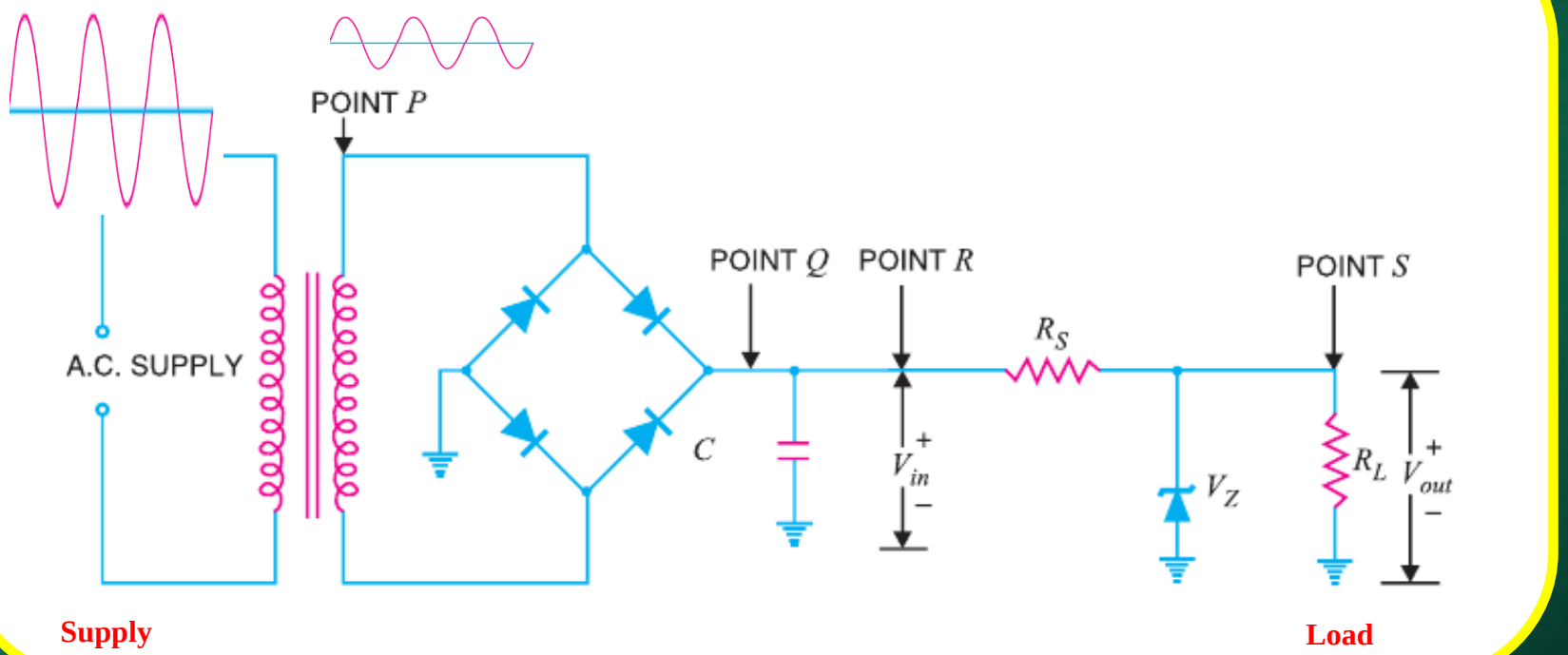

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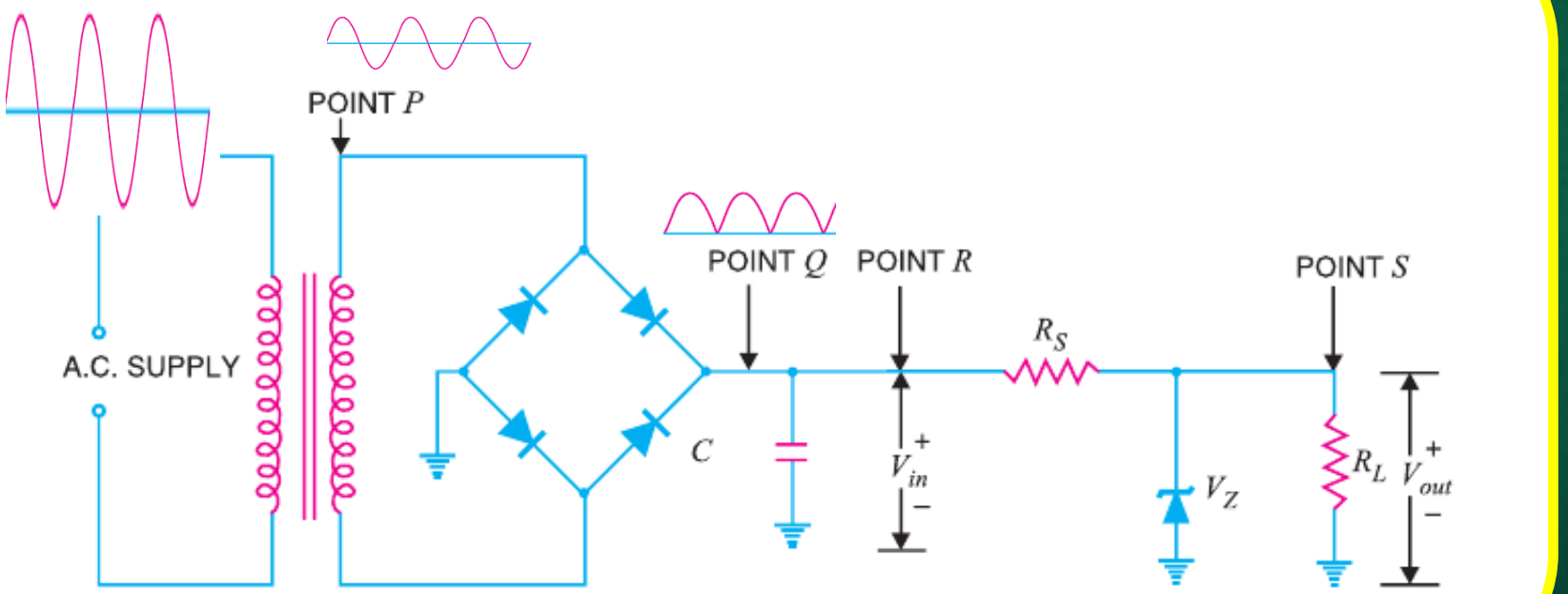

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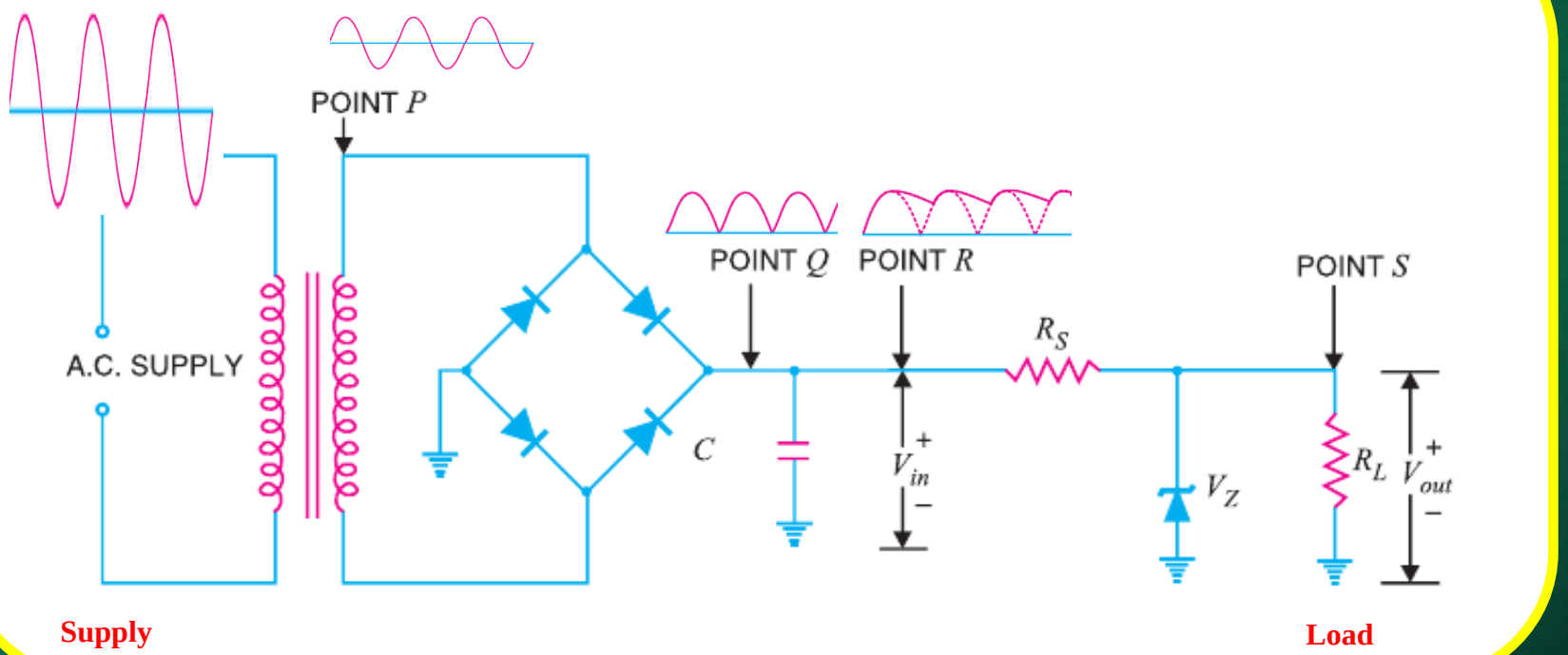

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