CSE 350
Digital Electronics and Pulse Techniques

Prerequisite:
CSE 251 : Electronic Devices and Circuits,
CSE 260 : Digital Logic Design

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Mail: shomen.kundu@bracu.ac.bd
Desk: #4N166

Course Instructor: Shomen Kundu (SDU)

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Name: Shomen Kundu (SDU)

Mail: shomen.kundu@bracu.ac.bd

Desk: #4N166

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Marks Distribution

Attendance	:	0 (Required greater than 70 %)
Assignment	:	10
Quiz	:	20
Lab	:	20
Midterm	:	20
Final	:	30
Total	:	100

CSE 350: Digital Electronics and Pulse Techniques (3 Credits)

Diode logic gates, transistor switches, transistor gates, MOS gates, Logic families: TTL, ECL, IIL and CMOS logic with operation details. Propagation delay, product and noise immunity. Open collector and High impedance gates. Electronic circuits for flip flops, counters and register, memory systems. PLA's (A/D, D/A converters with applications, S/H circuits) LED, LCD and optically coupled oscillators. Non-linear applications of OPAMPs. Analog switches. Linear wave shaping: diode wave shaping techniques, clipping and clamping circuits, comparator circuits, switching circuits. Pulse transformers, pulse transmission. Pulse generation:monostable, bistable and stable multivibrations, Timing circuits. Simple voltage sweeps, linear circuit sweeps. Schmitrigger, blocking oscillators and time base circuit. The course includes a compulsory 3 hour laboratory work each week.
(Pre req. CSE 251, CSE 260)

Suggested Books:
1. Jacob Millman," Microelectronics: Digital and Analog Circuits and Systems", McGraw-Hill, 1979.

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Course Content

1. Digital Electronics (70 %)
   i. Logic families
   ii. DC analysis of these circuits

2. Pulse Techniques (30 %)
   i. Signal generator
   ii. ADC
   iii. DAC

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Review (Circuits and Electronics)

- Charge
- Voltage
- Current
- Ohm’s law
- KCL
- KVL
- Node Analysis

Review (Circuits and Electronics)

Charge : Fundamental property of elementary particle.

Particle: electron (-e) , proton (+e) , neutron (0)

SI Unit : Coloumb (C)

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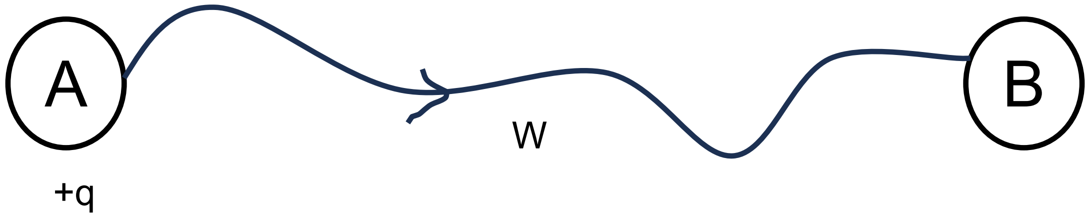
Review (Circuits and Electronics)

Voltage : The amount of work needed to displace a unit charge from one place to another.

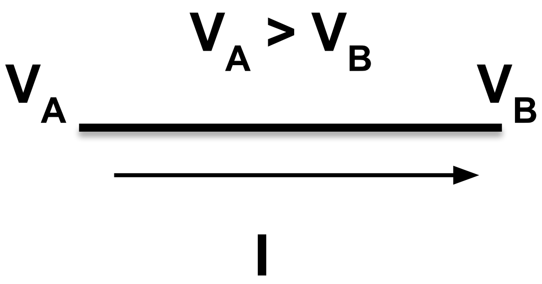
$$V = \frac{W}{q}$$



Review (Circuits and Electronics)

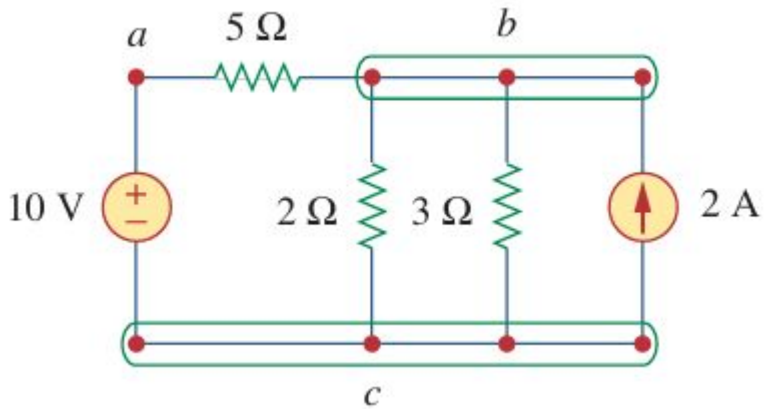
Current: The amount of charge flow through a conductor per unit time.
Ohm's Law: In a fixed temperature the current flows through a conductor is proportional to the voltage difference across the conductor.

$$I \propto (V_A - V_B)$$
$$I = G\,(V_A - V_B)$$



Review (Circuits and Electronics)

Node : Interconnected points between two and more electrical component.



Review (Circuits and Electronics)

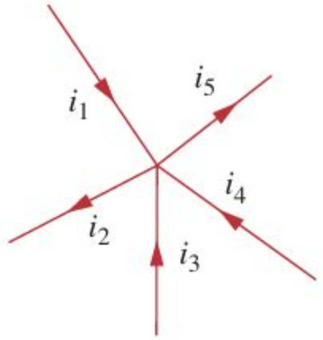
Kirchhoff's current law (KCL): states that the algebraic sum of currents entering a node (or a closed boundary) is zero.

Convention: a. Current Entering a node is positive

b. Current Exiting a node positive

Mathematically, KCL implies that

$$\boxed{\sum_{n=1}^{N} i_n = 0}$$



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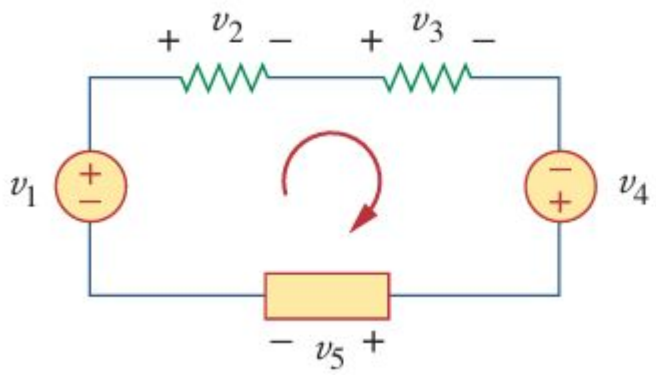
Review (Circuits and Electronics)

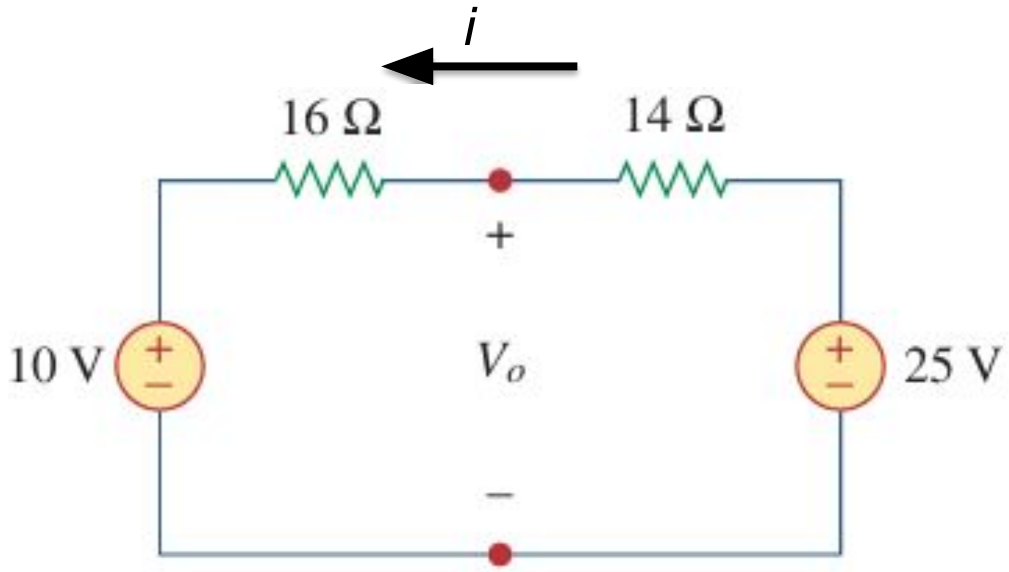
Kirchhoff's voltage law (KVL) states that the algebraic sum of all volt ages around a closed path (or loop) is zero.

$$\boxed{\sum_{m=1}^{M} v_m = 0}$$



Review (Circuits and Electronics)

Example: Find the value of I for the below circuit.



Review (Circuits and Electronics)

Node Analysis: Goal -> Finding "**node voltage**"

Techniques -> **KCL and Ohm's Law**

Step:

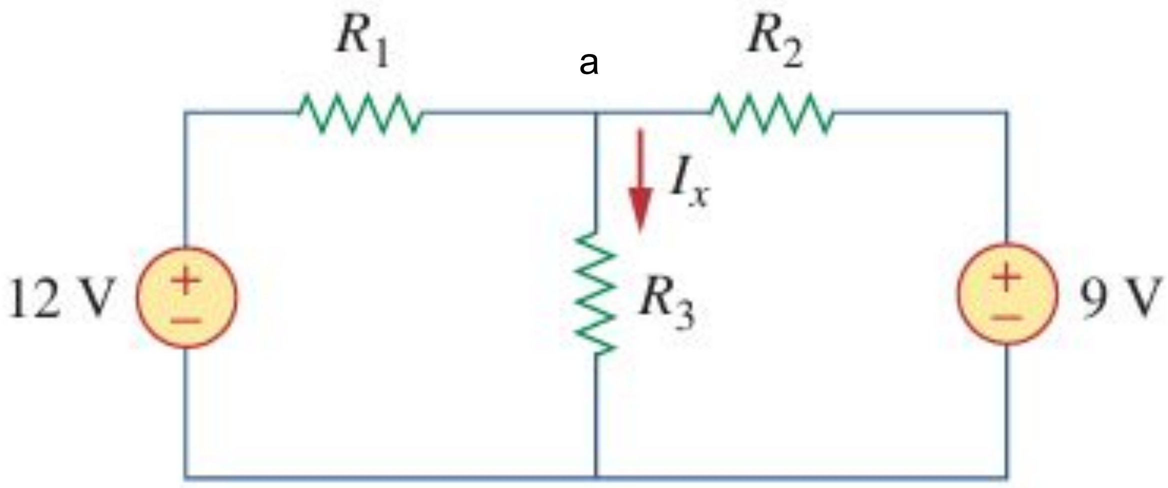
1. Identify reference voltage
2. Identify unknown node voltage
3. Write the node equation
4. Solve the node equation

$$i = \frac{v_{\text{higher}} - v_{\text{lower}}}{R}$$

$$\sum_{n=1}^{N} i_n = 0$$

Review (Circuits and Electronics)

Example: Find the voltage of the node a. Given $R_1 = 10\Omega$, $R_2 = 5\Omega$ and $R_3 = 20\Omega$.

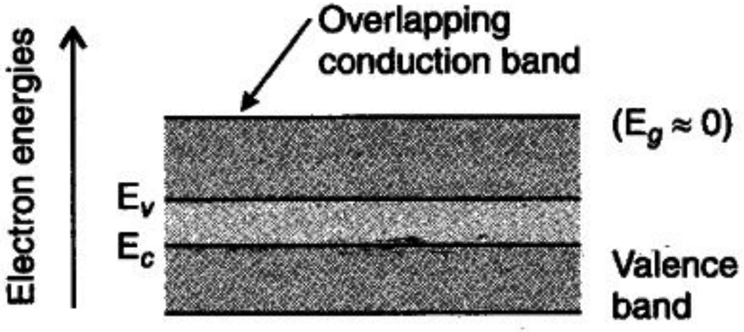


Review (Electronic Circuits and Devices)

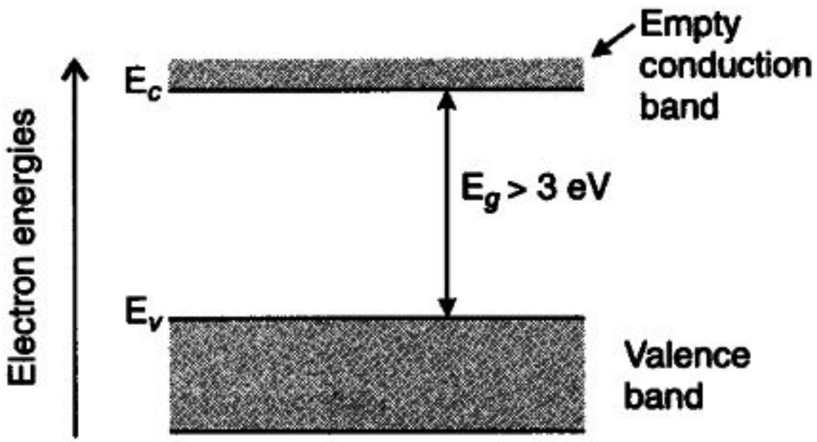
Electronics: The method or process that can be used to control flow of electron using external electric field / voltage.

Review (Electronic Circuits and Devices)

Electron energy level in solid form band.



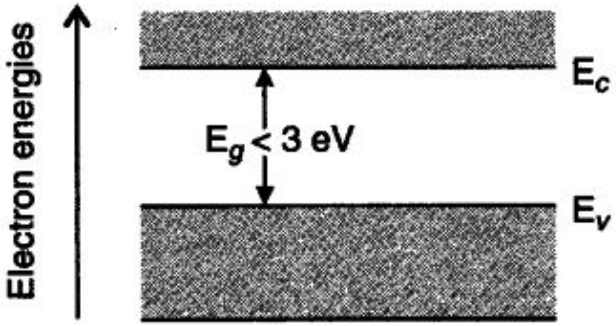
(a)



(b)

Metal: Al, Cu, Zn, Au

Insulator: SiO2, SiC, SiN, ZnO



(c)

Semiconductor: Si, Ge, GaAs, GaN

Review (Electronic Circuits and Devices)

Semiconductor (Si)

- **Intrinsic Semiconductor:** pure semiconductor crystal
- **Extrinsic Semiconductor:** impurity is being added.

Extrinsic Semiconductor is of two types:

- **n-type:** Majority electron, Minority hole
- **p-type:** Majority hole , Minority electron

Review (Electronic Circuits and Devices)

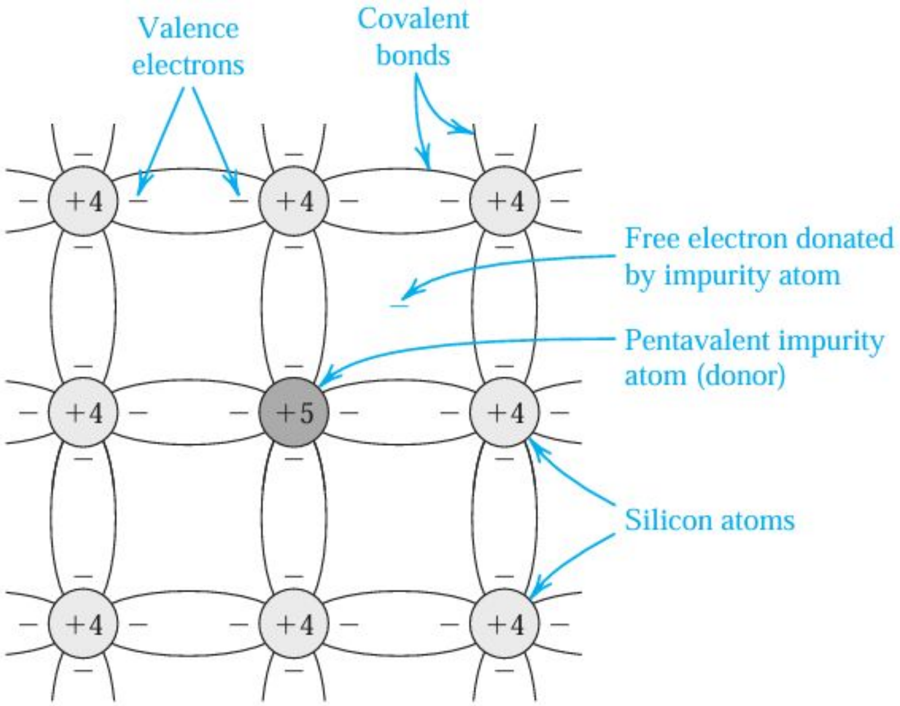


Fig: n-type [Si + group V (P, As, Sb)]

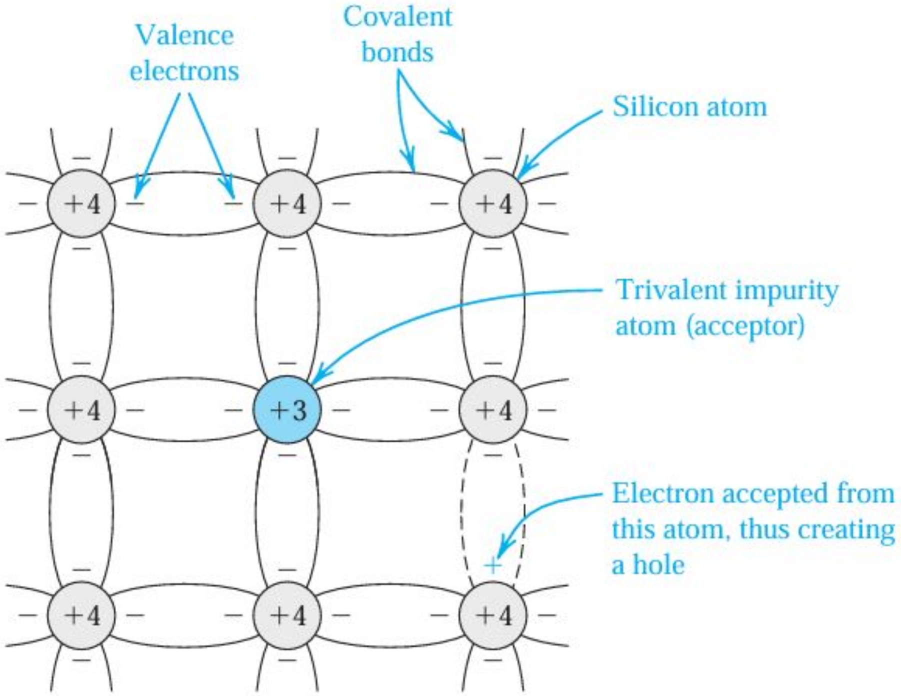


Fig: p-type [Si + group III (B,Ga)]

Review (Electronic Circuits and Devices)

Diode:

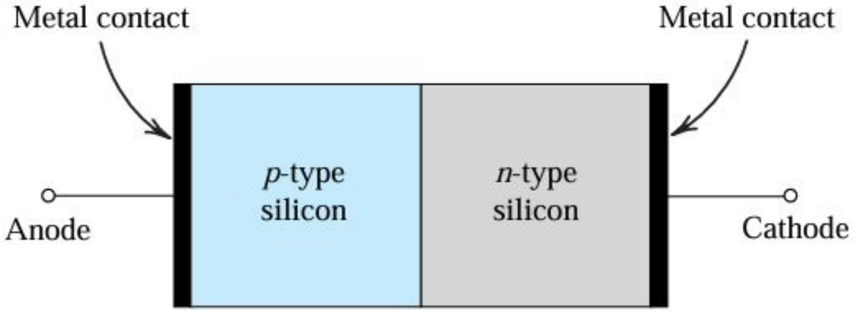


Fig: Simplified physical structure of the pn junction.

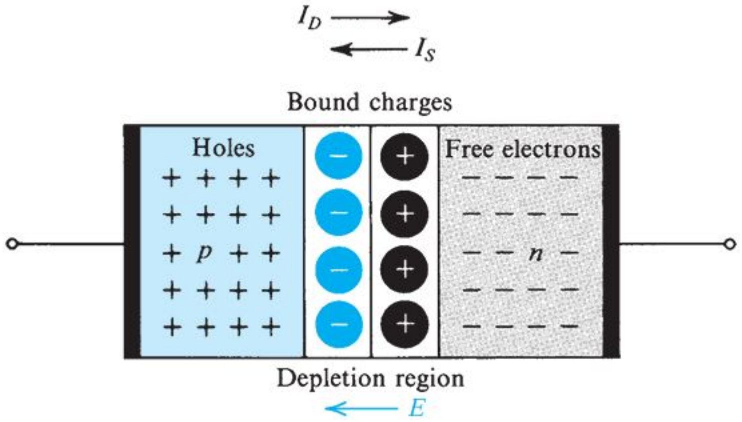


Fig: pn junction with no applied voltage

Review (Electronic Circuits and Devices)

IV curve:

In this course we will assume these two voltage of the diode. But they can vary depending on diode model.

Conduction Voltage, $\boldsymbol{V_D = 0.7V}$

Threshold Voltage/Knee Voltage, $\boldsymbol{V_\gamma = 0.6\,V}$

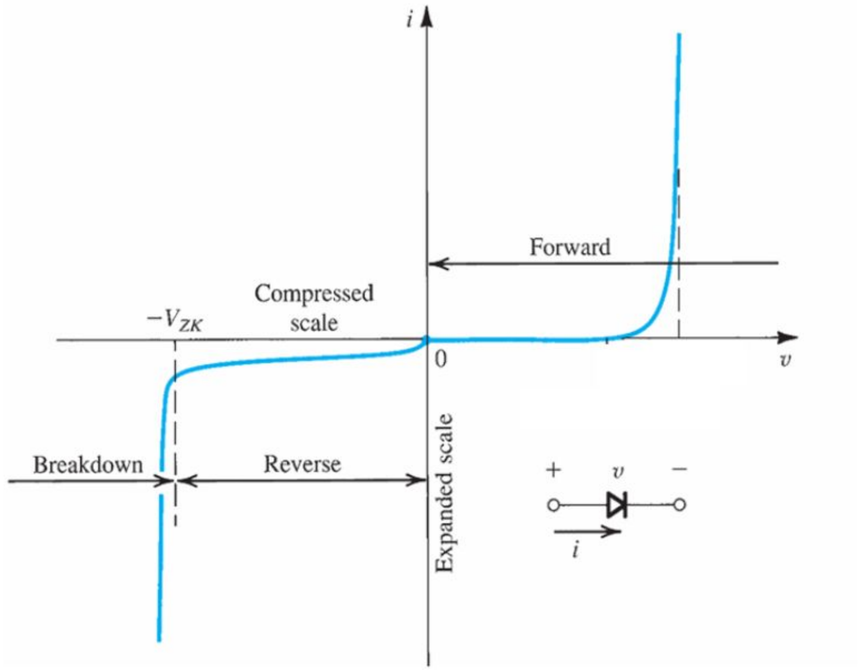
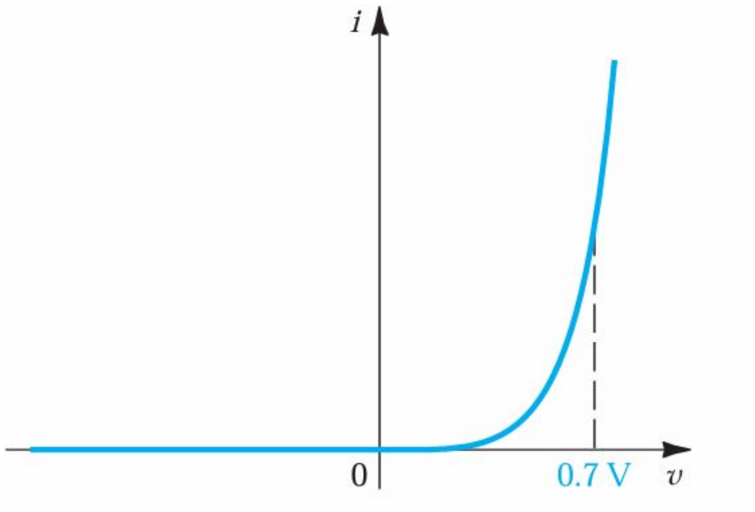


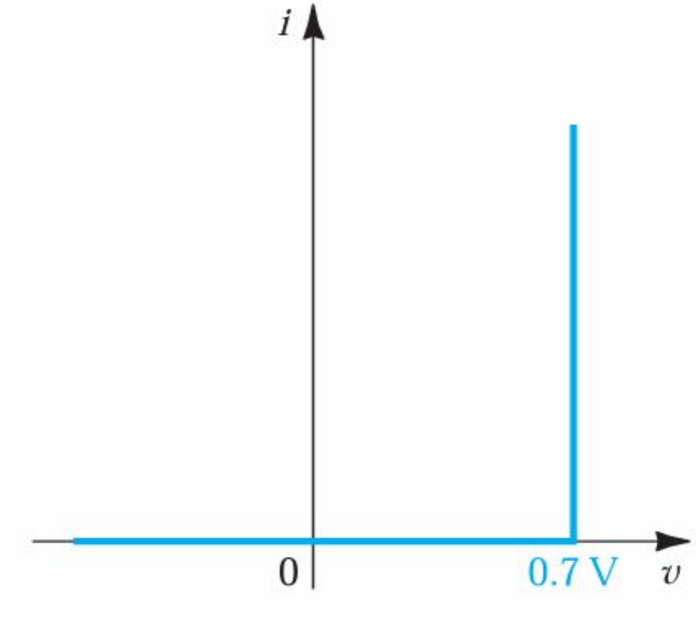
Fig: The I-V characteristic of the pn junction showing the rapid increase in reverse current in the breakdown region.

Review (Electronic Circuits and Devices)

The Constant-Voltage-Drop Model:

The simplest and most widely used diode model is the constant-voltage-drop model. This model is based on the observation that a forward-conducting diode has a voltage drop that varies in a relatively narrow range, say 0.6 to 0.8 V. The model assumes this voltage to be constant at a value, say, $V_D = 0.7\,V$.





Review (Electronic Circuits and Devices)

Conductance voltage (V_D) of different diode for constant voltage drop model:

- Ideal diode: $V_D = 0$ V
- Ge diode: $V_D = 0.3$ V
- Si diode: $V_D = 0.7$ V (will be used most of the time)

We will use Si diode with constant voltage model for simplicity. If nothing is mentioned in the question, we will assume Si diode.

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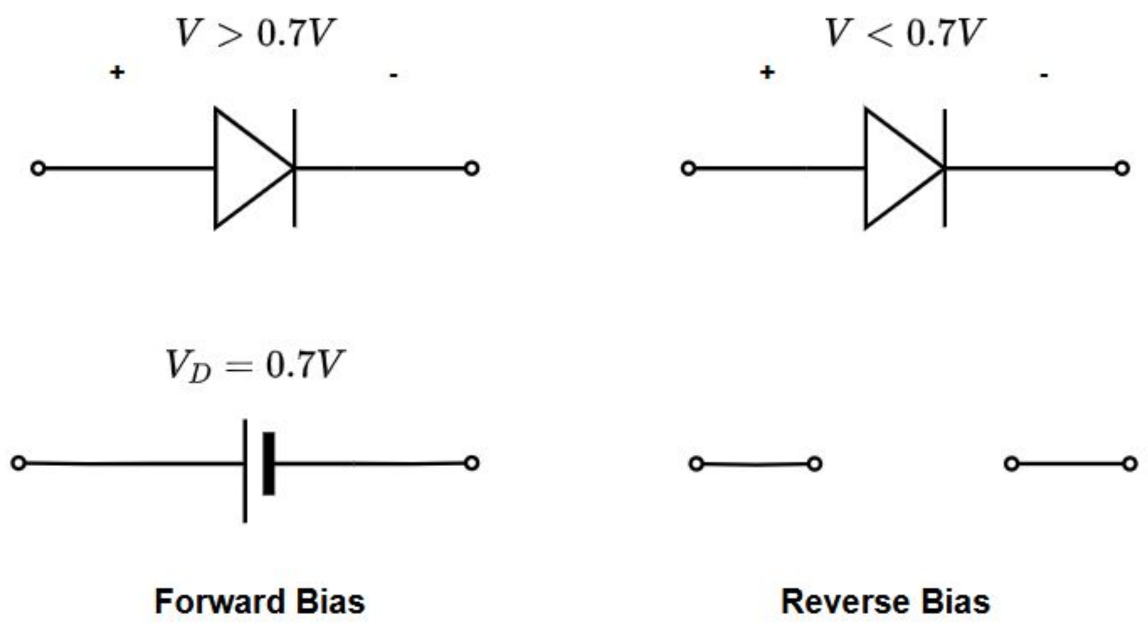
Review (Electronic Circuits and Devices)

Equivalent circuit of Si diode for constant voltage drop model:



Review (Electronic Circuits and Devices)

Transistors are three terminal devices

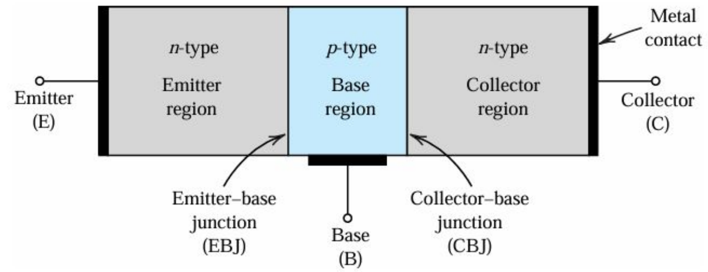
- **BJT**: Used in switching and amplification for audio and analog circuits.
- **FET**: Ideal for analog switches and high-impedance amplifiers.
- **MOSFET**: Key in digital circuits, power electronics, and RF amplification.

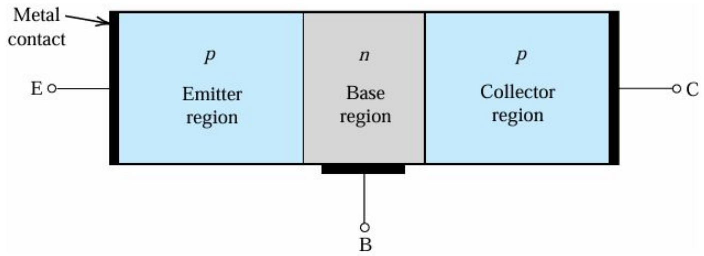
✔ **Bipolar devices** both electron and hole take part in current conduction for example BJT.

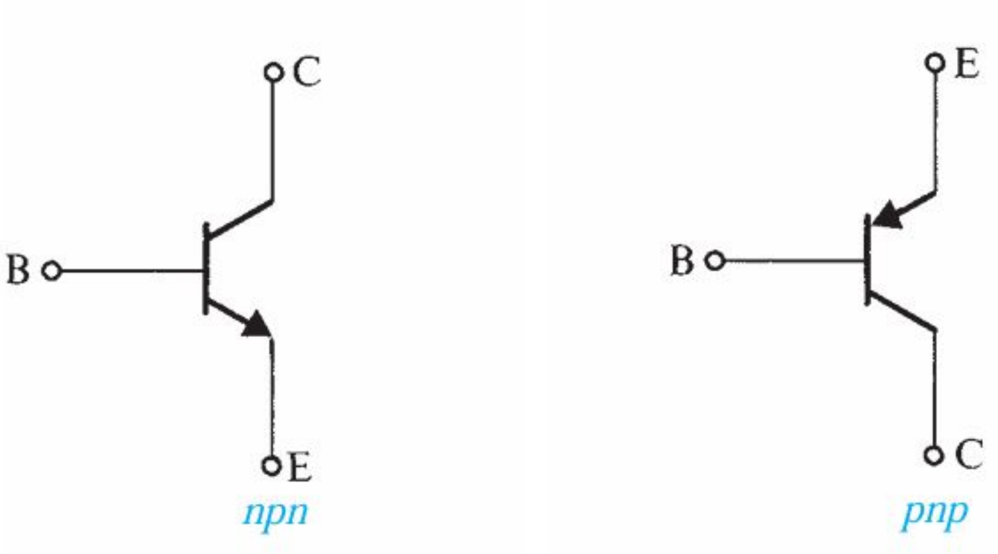
✔ **Unipolar either** electron or hole takes part in current conduction for example MOSFET.

Review (Electronic Circuits and Devices)

BJT: The transistor consists of two p-n junctions, the emitter–base junction (EBJ) and the collector–base junction (CBJ). Depending on the bias condition (forward or reverse) of each of these junctions, different modes of operation of the BJT are obtained.







Length: LC>LE>LB and Doping : NE > NC >NB
That’s why BJT is not symmetrical

Arrow indicate the Emitter terminal

Review (Electronic Circuits and Devices)

Modes of BJT

EB Junction	CB Junction	Mode	Use
Forward	Reverse	Active	Amplifier
Forward	Forward	Saturation	Switch
Reverse	Reverse	Cut off	Switch
Reverse	Forward	Reverse Active	No use

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Review (Electronic Circuits and Devices)

V_{BC}

Reverse Active:
Emitter and Collector Switch their roles

$$V_{BC} = 0.7V, \frac{I_E}{I_B} = \beta_R$$

Saturation:

$$V_{BE} = 0.8\,V, V_{CE} = 0.1\ - 0.2\,V$$

Checking condition:

$$\frac{I_C}{I_B} = \beta_{forced} < \beta_F\ (\,forward)$$

V_{BE}

Cutoff:

$$\boldsymbol{V_{BE} < 0\ and\ V_{BC} < 0}$$

$$I_E = I_C = I_B = 0$$

Active:

$$V_{BE} > 0\ and\ V_{BC} < 0$$

$$V_{BE} = 0.7\,V, \frac{I_C}{I_B} = \beta_F$$

Typical β values: 50, 80, 100, 200
(fixed and depend on model of BJT)

Review (Electronic Circuits and Devices)

Equation of BJT for Active mode only:

$$I_E = I_C + I_B$$

$$\alpha = \frac{I_C}{I_E}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$I_E = (1 + \beta)I_B$$

$$\beta = \frac{I_C}{I_B}$$

$$\alpha = \frac{\beta}{\beta+1}$$

$$I_C = \beta I_B$$

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