Temperature dependence

Temperature dependence

- Semiconductors exhibit **different types of temperature coefficients**.
- A component that becomes **less resistive** with temperature has a **negative temperature coefficient.**
- A component that becomes **more resistive** with temperature has a **positive temperature coefficient**.

- The Zener diodes have a **negative temperature coefficient** while avalanche diodes have a **positive temperature coefficient**.

- The polarity of the temperature coefficient is easy to spot in a graph of resistance versus temperature.
- As temperature increases, a positive slope indicates a positive temperature coefficient. A negative slope indicates a negative temperature coefficient.

Negative Temperature Coefficient

- An increase in the temperature of a semiconducting material results in an **increase in charge-carrier concentration**.

- This results in a **higher number of charge carriers** available for recombination, increasing the conductivity of the semiconductor.

- The increasing conductivity causes the resistivity of the semiconductor material to decrease with the rise in temperature, resulting in a **negative temperature coefficient of resistance**.

Positive Temperature Coefficient

- In the case of conductors, when temperature increases resistivity increases as electrons collide more frequently with vibrating atoms.

- This reduces drift speed of electrons (and thus current reduces). Thus, conductors have **positive temperature coefficient of resistance**.

- Temperature coefficient affects from major power circuit components can enhance or reduce efficiency.

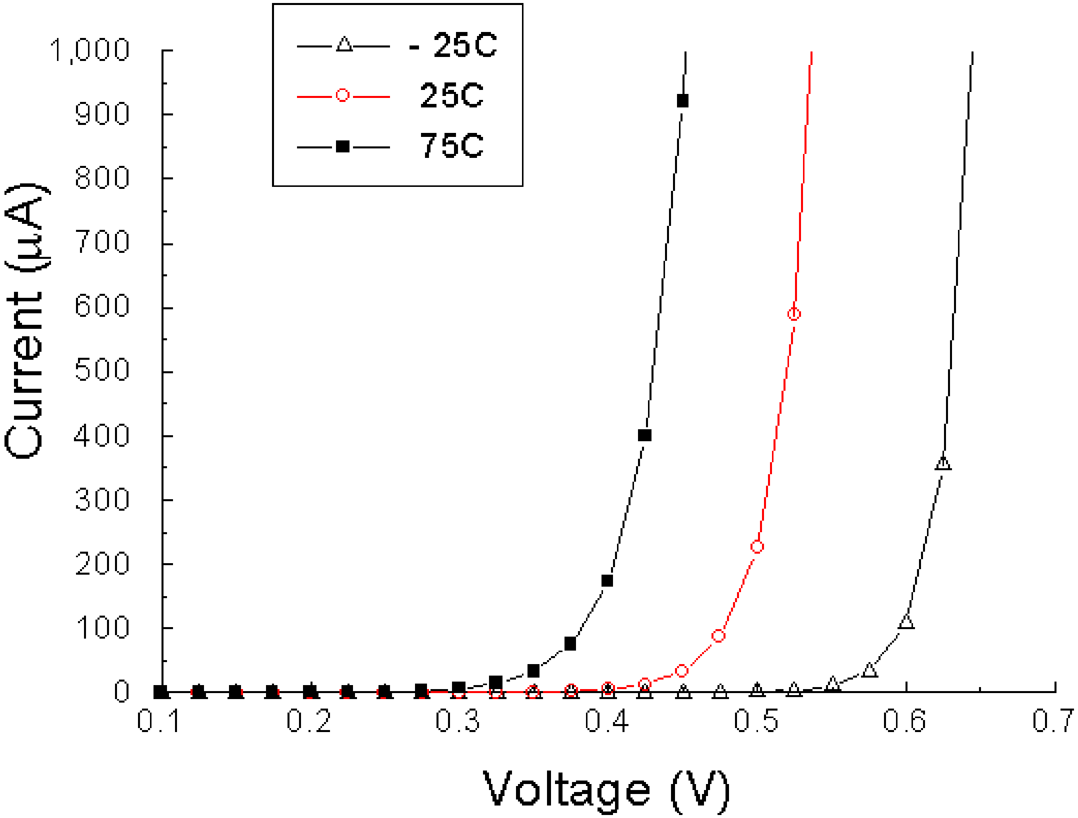
Temperature dependence

- the voltage drop across a forward-biased pn-junction changes with Temperature Effect on Semiconductor Diode by approximately -1.8 mV/°C for a silicon device, and by -2.02 mV/°C for germanium.

- A diode V_F at any temperature can be calculated from a knowledge of V_F at the starting temperature (V_{F1} at T_1), the temperature change (ΔT), and the voltage/temperature coefficient (ΔV_F/°C).

$$V_{F2} = (V_{F1} \text{ at } T_1) + [\Delta T \times (\Delta V_F/^\circ C)]$$

Temperature dependence

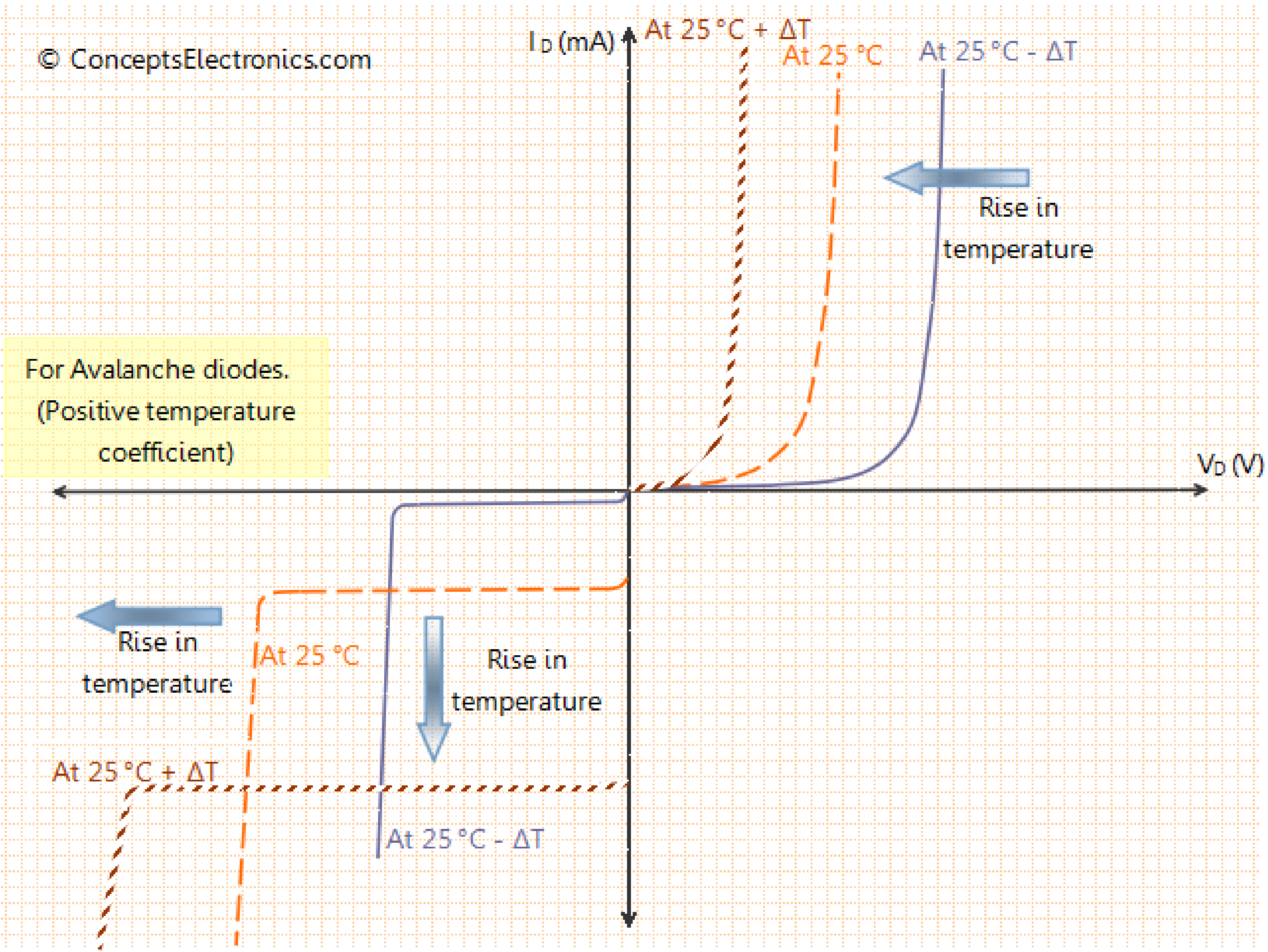


$$I = I_0 (e^{qV/kT} - 1)$$

$$I_0 = Aqn_i^2 \left(\frac{D_p}{L_p N_d} + \frac{D_n}{L_n N_a} \right)$$

What causes the I-V curves to shift to lower V at higher T ?

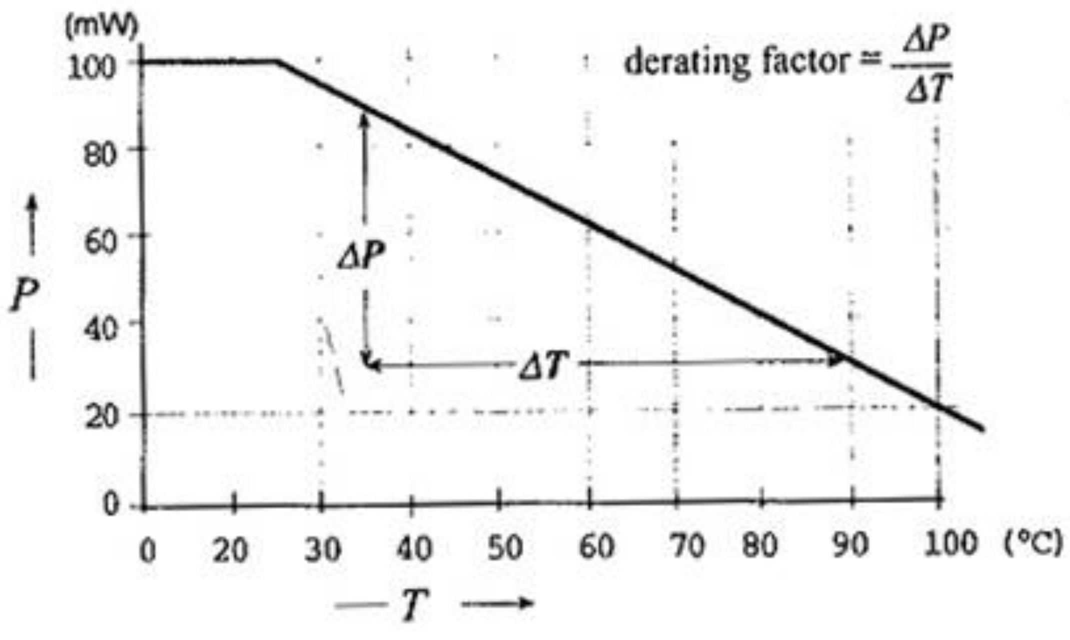
Temperature dependence



Effect of temperature on avalanche diodes

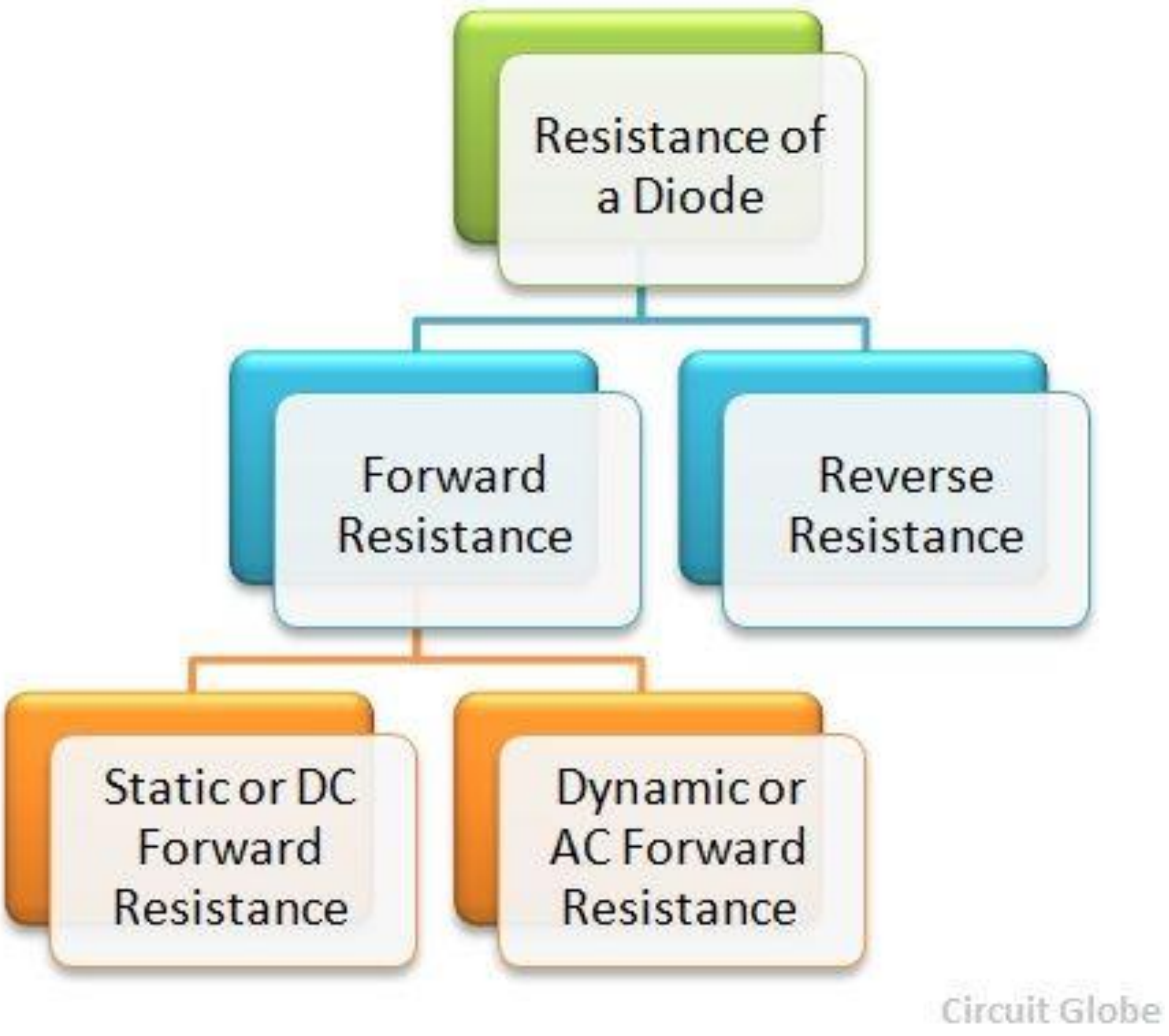
Diode Power Dissipation

- The power dissipation in a diode is simply calculated as the device terminal voltage multiplied by the current level.
- Device manufacturers specify a maximum power dissipation for each type of diode. If the specified level is exceeded, the device will overheat and it may short-circuit or open-circuit.
- When the Temperature Effect on Semiconductor Diode exceeds the specified level, the device maximum power dissipation must be derated.



Diode Resistance

Diode Resistance



DC or Static Resistance

- The resistance of the diode at the operating point can be found simply by finding the corresponding levels of V_D and I_D and applying the following Equation

$$\boldsymbol{R_D = \frac{V_D}{I_D}}$$

- The dc resistance levels at the knee and below will be greater than the resistance levels obtained for the vertical rise section of the characteristics.
- The resistance levels in the reverse-bias region will naturally be quite high.
- The dc resistance of a diode is independent of the shape of the characteristic in the region surrounding the point of interest.

AC or Dynamic Resistance

- If a sinusoidal rather than dc input is applied, the situation will change completely.
- The varying input will move the instantaneous **operating point up and down** a region of the characteristics and thus defines a specific **change in current and voltage**.
- With no applied varying signal, the point of operation would be the Q-point appearing on determined by the applied dc levels.
- The designation Q-point is derived from the word quiescent, which means “still or unvarying.”
- A straight-line drawn tangent to the curve through the Q-point will define a particular change in voltage and current that can be used to determine the ac or dynamic resistance for this region of the diode characteristics.

$$\boldsymbol{r_D = \frac{\Delta V_D}{\Delta I_D}}$$

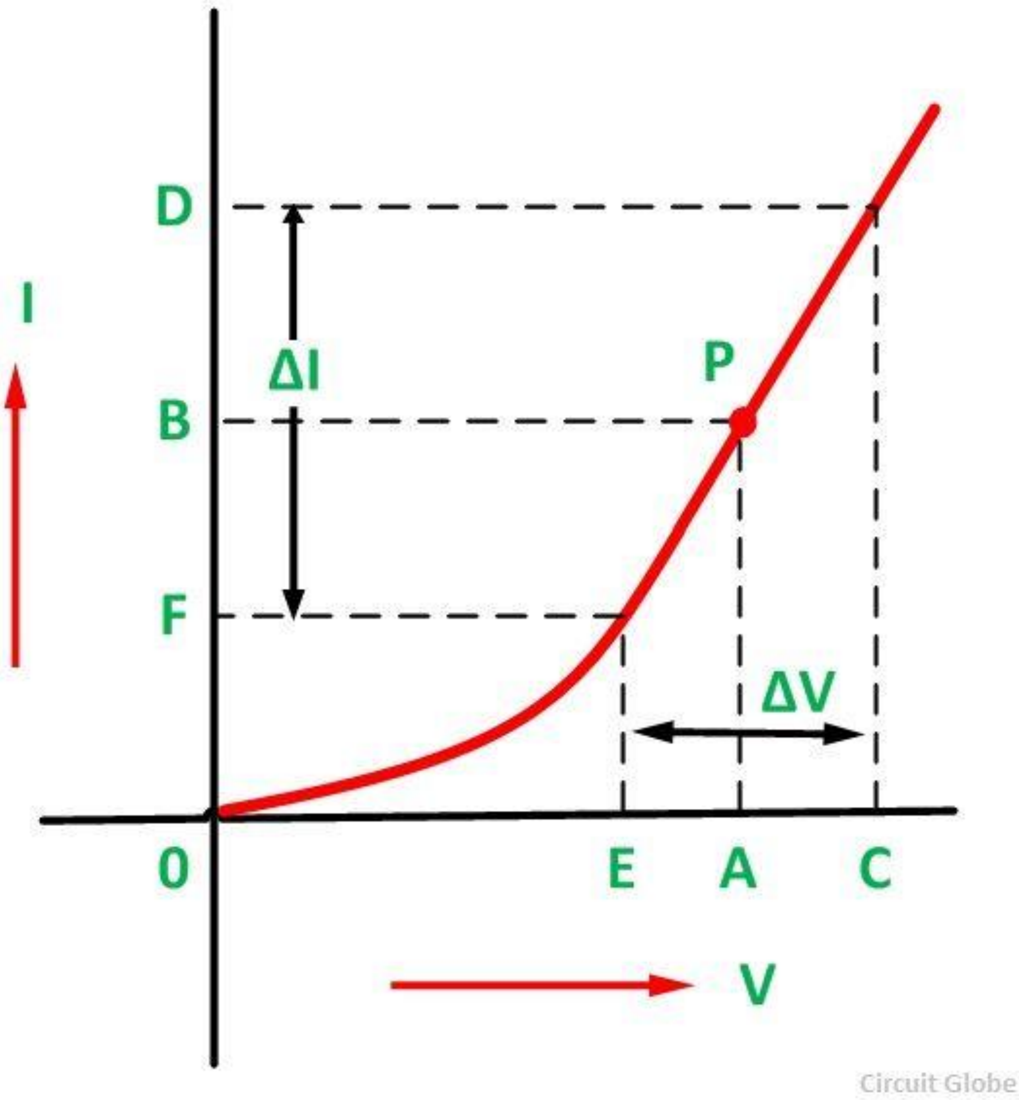
Diode Resistance

DC or Static Resistance

$$R_F = \frac{OA}{OB}$$

AC or Dynamic Resistance

$$r_f = \frac{CE}{DF} = \frac{\Delta V}{\Delta I}$$



Diode Equivalent Circuits

- An equivalent circuit is a combination of elements properly chosen to best represent the actual terminal characteristics of a device, system, or such in a particular operating region.
- In other words, once the equivalent circuit is defined, the device symbol can be removed from a schematic and the equivalent circuit inserted in its place without severely affecting the actual behavior of the system.
- The result is often a network that can be solved using traditional circuit analysis techniques.

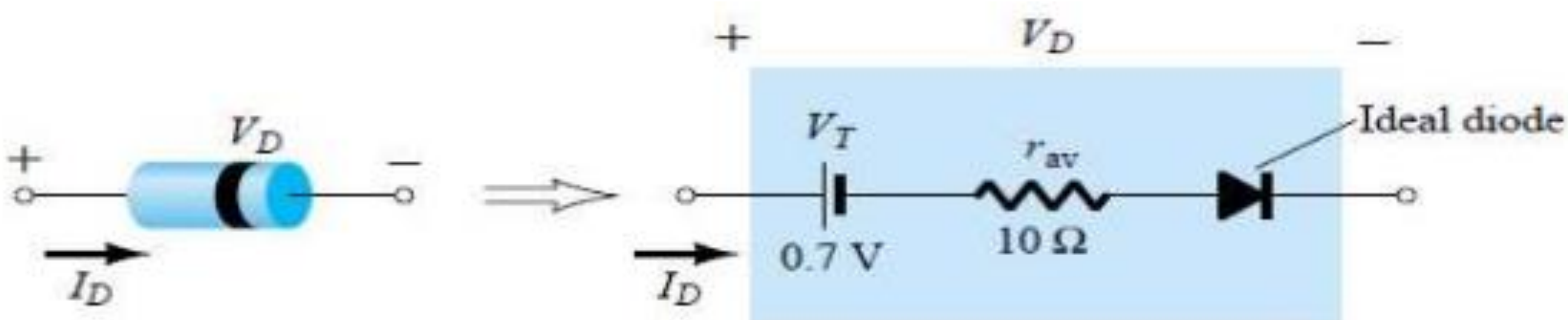
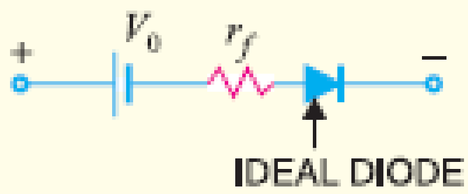
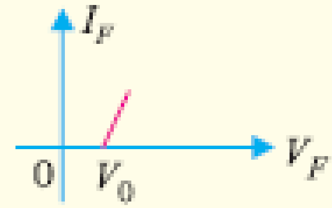
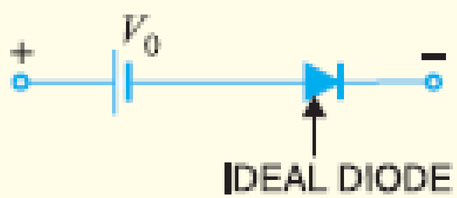
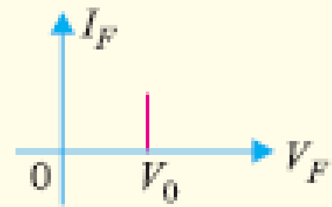


Figure 1.32 Components of the piecewise-linear equivalent circuit.

6.5 Crystal Diode Equivalent Circuits

It is desirable to sum up the various models of crystal diode equivalent circuit in the tabular form given below:

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