Electronic Devices

Lecture 6
P-N Junction

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Diode Models

The diode as a circuit elements:

- Ideal Diode Model
- Large Signal model
- Small Signal model

Small Signal Diode Model

The diode current

$$I_D = I_s e^{\frac{V_D}{\eta V_T}}$$

The diode voltage:

$$V_D(t) = V_D + v_d(t)$$

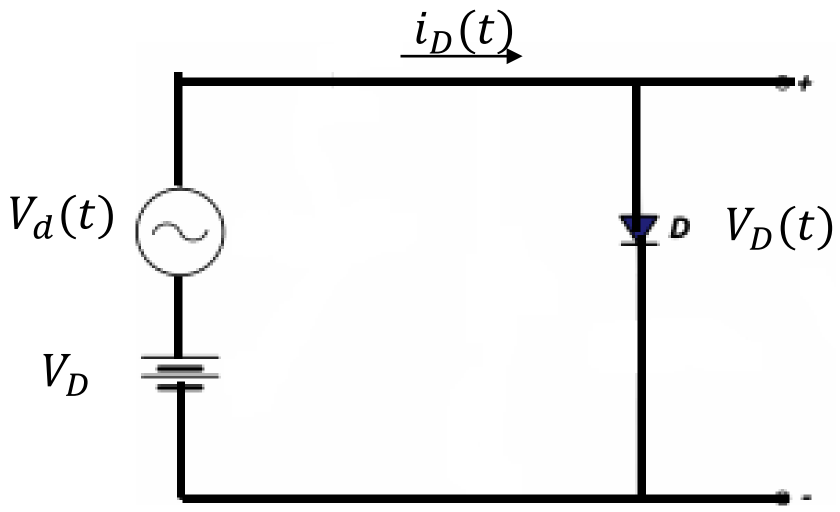
The diode current :

$$i_D(t) = I_s\, e^{\frac{V_D}{\eta V_T}}$$

$$i_D(t) = I_s\, e^{\frac{(V_D + v_d)}{\eta V_T}}$$

$$i_D(t) = I_s\, e^{\frac{V_D}{\eta V_T}}\, e^{\frac{v_d}{\eta V_T}} = I_D\, e^{\frac{v_d}{\eta V_T}}$$

$$i_D(t) = I_D\, e^{\frac{v_d}{\eta V_T}}$$



$$\frac{v_d}{\eta V_T} << 1$$

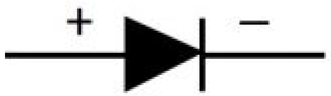
$$i_D(t) \approx I_D \left(1 + \frac{v_d}{\eta V_T}\right)$$

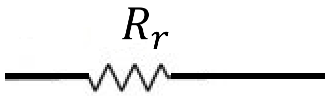
$$i_D(t) \approx I_D + \frac{I_D}{\eta V_T} v_d \quad \text{-------}\rightarrow \frac{I_D}{\eta V_T} = \frac{1}{r_d}$$

$$i_D(t) \approx I_D + i_d \, ,$$

$$r_d = \frac{\eta V_T}{I_D}$$

Small Signal Model



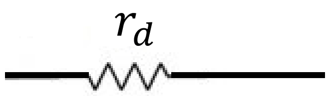


Reverse biased

$R_r \gg 100\text{K}\Omega \longrightarrow \infty$

Open Circuit

OFF



Forward biased

$$r_d = \frac{\eta V_T}{I_D}$$

ON

Example:

The circuit shown

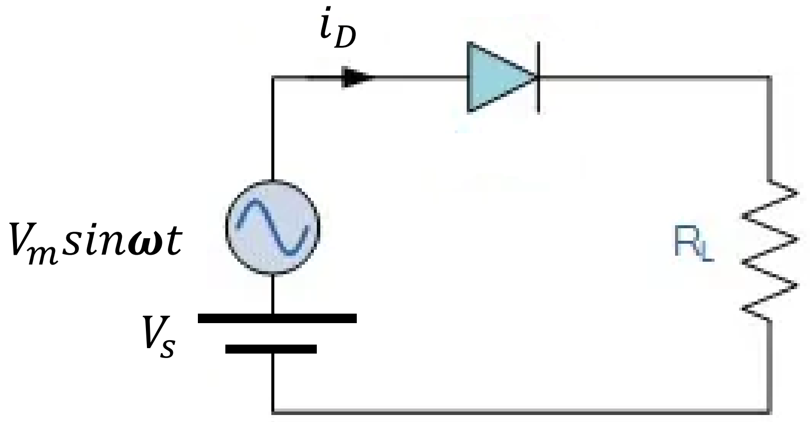
V_s = 9V, V_m = 0.2V, R_L =2KΩ

In Large signal model:

R_F =10Ω, V_γ=0.6v , R_r =∞, η=2.

Determine:

The total voltage across R_L

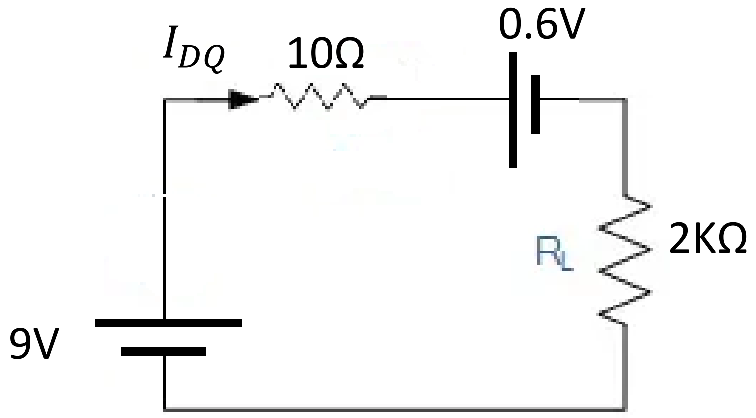


Solution

Assume diode is ON

For the large signal model

$$I_{DQ} = \frac{9-0.6}{2000+10} = 4.18mA$$

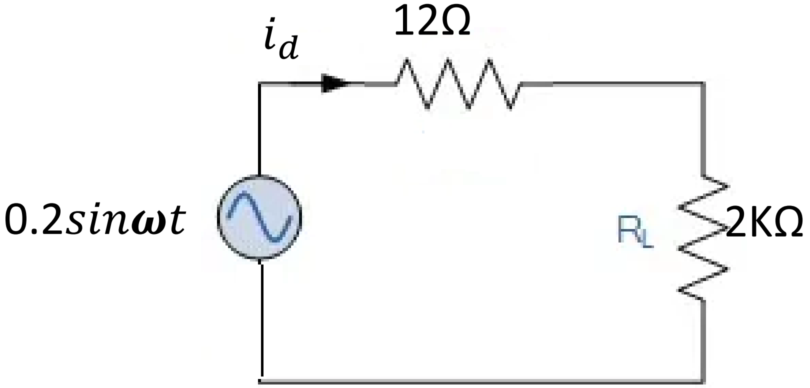


$V_{0Q=}$ I_{DQ} R_L = 4.18m x 2000 = 8.36V

$$r_d = \frac{\eta V_T}{I_D} = \frac{2\ x\ 25}{4.18} = 12\ \Omega$$

For small signal model

$$i_d = \frac{0.2sin\omega t}{2000+12}$$



$V_{0ac=}$ i_d R_L = 0.199 $sin\omega t$

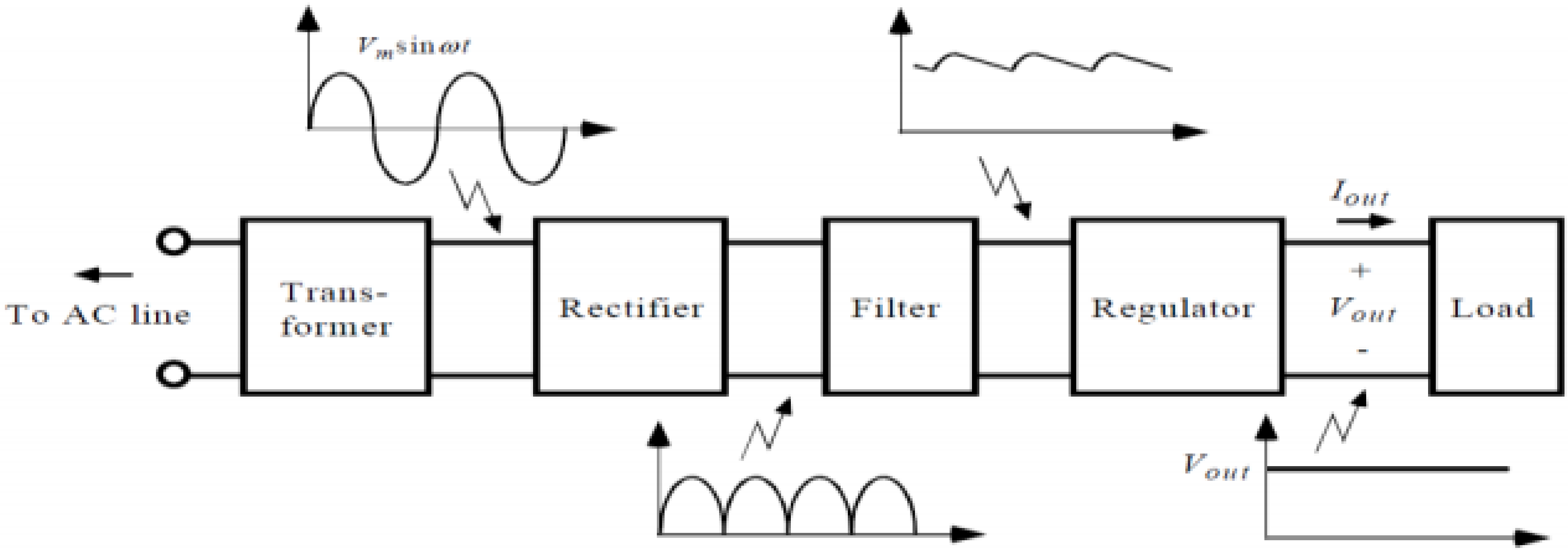
Total output voltage=8.36 + 0.199 $sin\omega t$ v

Diode Applications

- Rectifying
- Clipping
- Clamping

Rectifiers

- Rectifier circuit rectifies the Ac signal into DC signal, the most known example is the power supply.



Components of a typical linear power supply

Rectifier

- A basic rectifier converts an AC voltage to a pulsating DC voltage.
- A filter then eliminates AC components of the wave form to produce a nearly constant DC voltage output.
- Rectifier circuits are used in virtually all electronic devices to convert the 220V 50Hz AC power line source to the DC voltages required for operation of electronic devices.
- In rectifier circuits, the diode state changes with time and a given piecewise line model is valid only a certain time interval.

Rectifier Circuits

- Half wave rectifier
- Full wave rectifier
- Bridge rectifier.