ENEE2360

Analog Electronics

T5A: Diode ac small signal analysis

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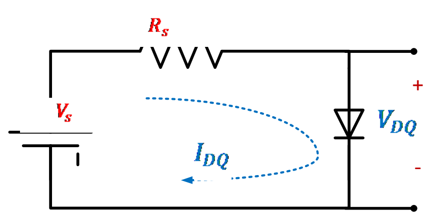
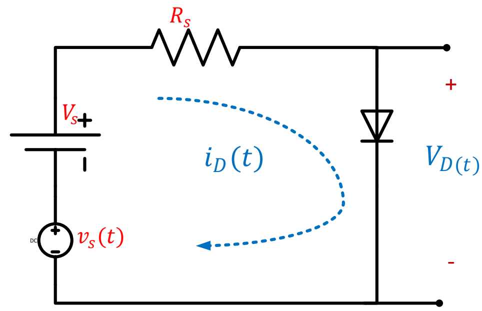
Ac Small Signal Analysis



- $I_{DQ} = I_S\left(e^{\frac{V_{DQ}}{\eta V_T}} - 1\right)$
- **And since the diode is forward biased**
- $I_{DQ} \approx I_S(e^{\frac{V_{DQ}}{\eta V_T}})$

now

- $i_D(t) = I_{DQ+}\, i_d(t)$
- $V_D(t) = V_{DQ} + v_d(t)$
- $i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}} - 1)$



- And since the diode is forward biased
- $i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}})$
- $i_D(t) = I_S(e^{\frac{V_{DQ} + v_d(t)}{\eta V_T}})$
- $i_D(t) = I_S e^{\frac{V_{DQ}}{\eta V_T}} . e^{\frac{v_d(t)}{\eta V_T}}$
- $i_D(t) = I_{DQ}(e^{\frac{v_d(t)}{\eta V_T}})$
- using e^x = 1+x ; x is very small

$$i_D(t) = I_{DQ}\,(1 + \frac{v_d(t)}{\eta V_T}) = I_{DQ+} \frac{v_d(t)}{\eta V_{T/I_{DQ}}}$$

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but $i_D(t) = I_{DQ+}\, i_d(t)$

$\therefore\ i_d(t) = \frac{v_d(t)}{\eta V_{T/I_{DQ}}} = \frac{v_d}{r_d}$

where $r_d = \frac{\eta V_T}{I_{DQ}} = \frac{V_T}{I_{DQ}}$

$\therefore$ **If V_S(t) = V_S+ vs(t)**

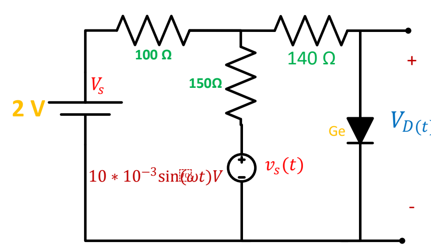
V_S= Dc component

vs(t)= ac component

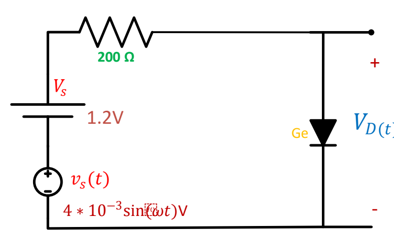
and the amplitude of vs(t) is small and the diode is always on ; we could use the superposition theorem to find the response ($V_{D(t)}$, $i_D(t)$) .

Example

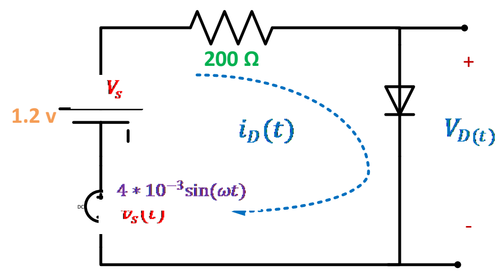
Find $V_D(t)$



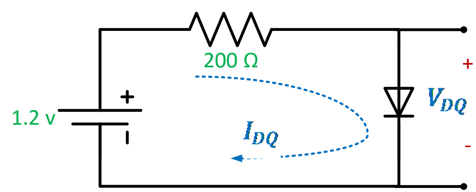
Using Thevenin's Theorem



Since we have a dc source (1.2 V) and an ac signal (4×10^{-3} sinwt V) and the diode is always on ; we use superposition theorem to find $V_D(t)$



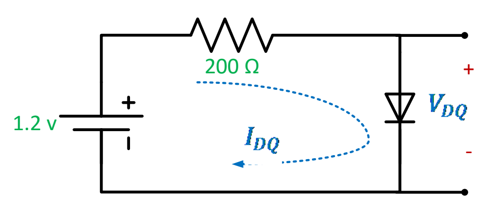
1) to find V_{DQ} (DC Analysis)

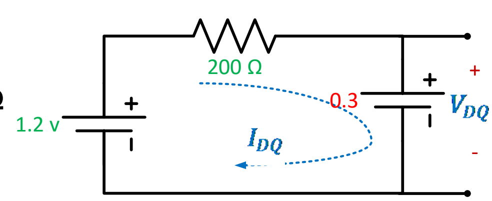


$\therefore V_{DQ}$ = 0.3 v

and $I_{DQ} = \frac{1.2v - 0.3v}{200}$ = 4.5 mA

$\therefore r_d = \frac{V_T}{I_{DQ}} = \frac{25.69mv}{4.5mA}$ = 5.69 Ω





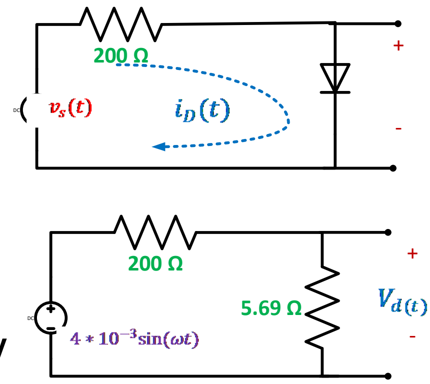
2) To find $V_d(t)$ (ac small signal)

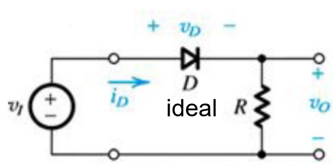
$$v_d(t) = \frac{5.69}{200+5.69} \cdot 4\times10^{-3} \sin wt \text{ V}$$

$$v_d(t) = 0.1165 \times10^{-3} \sin wt \text{ V}$$

$$\therefore V_D(t) = V_{DQ} + v_d(t)$$

$$V_D(t) = (0.3 + 0.1165 \times10^{-3} \sin wt) \text{ V}$$

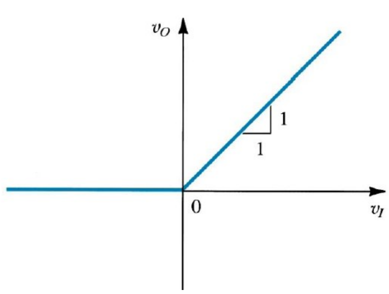




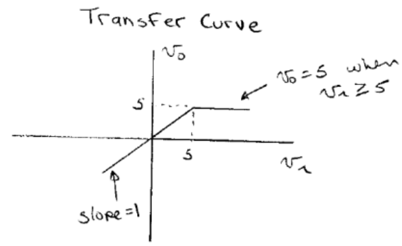
A) when $V_i(t) > 0$, Diode is on (short circuit)
$\therefore V_o(t) = V_i(t)$

B) when $V_i(t) < 0$, Diode is off (open circuit)
$\therefore V_o(t) = 0$

Transfer characteristic curve



Design a diode circuit that have the given characteristic curve



Solution