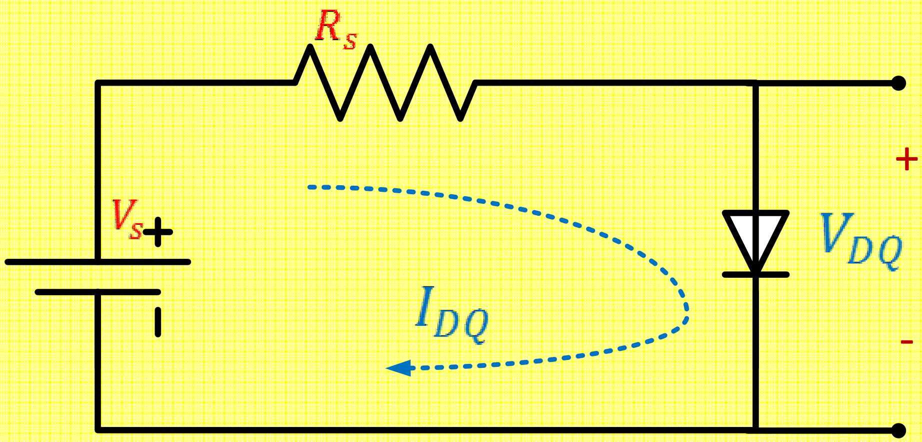
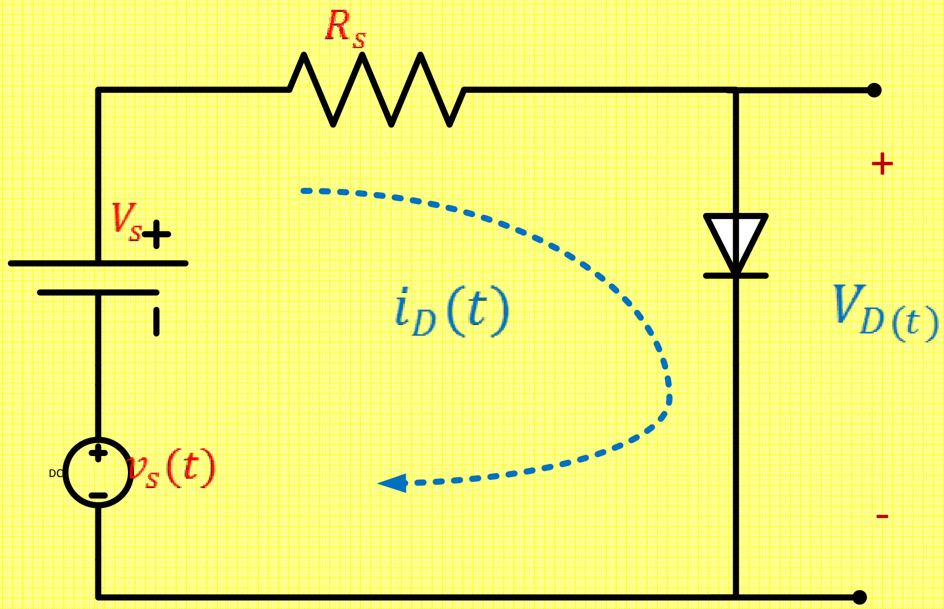
Ac Small Signal Analysis

- $I_{DQ} = I_S\left(e^{\frac{V_{DQ}}{\eta V_T}} - 1\right)$
- $I_{DQ} = I_S(e^{\frac{V_{DQ}}{\eta V_T}})$



now

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



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

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

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

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

V_S= Dc component

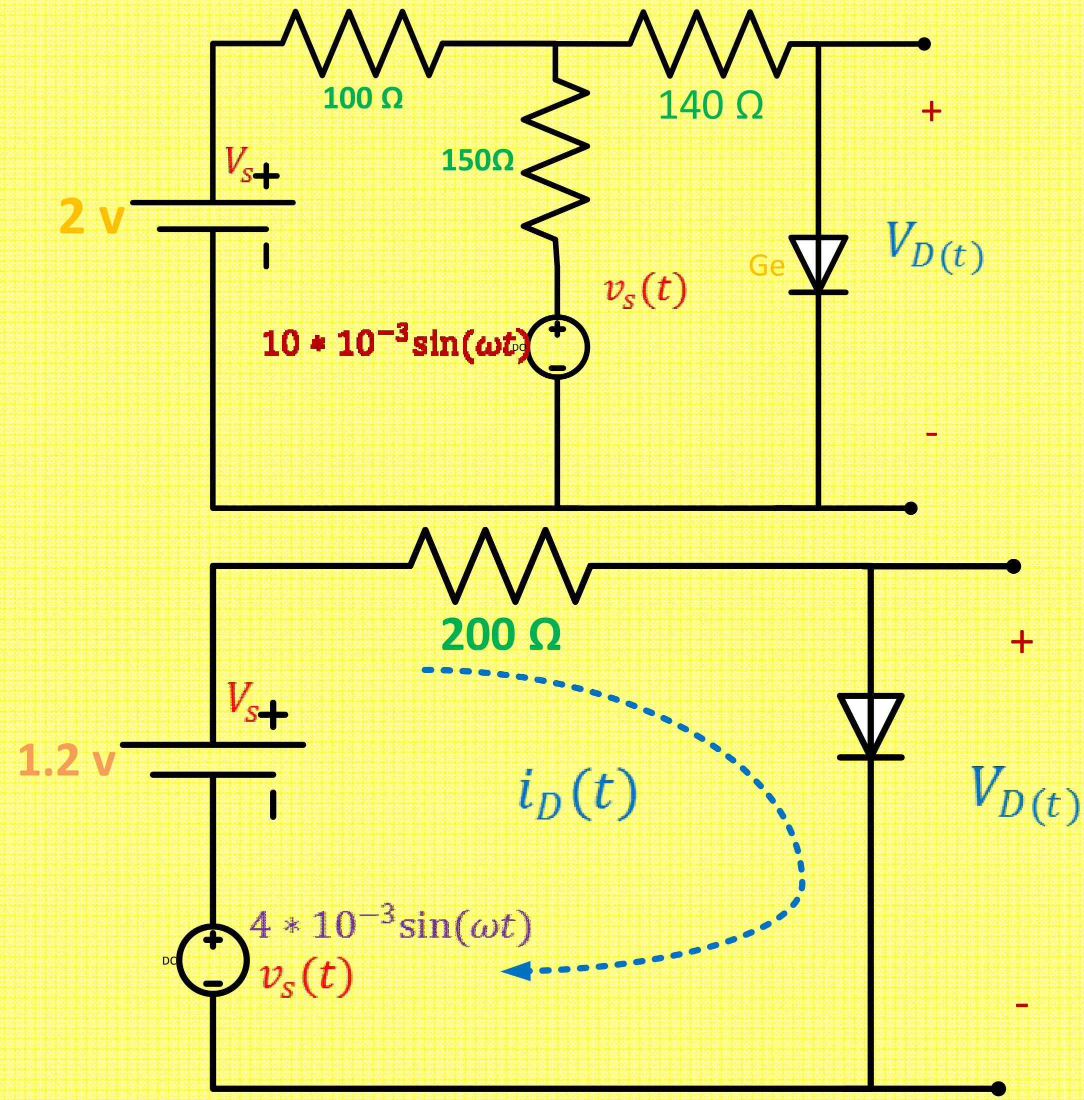
vs(t)= ac component

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

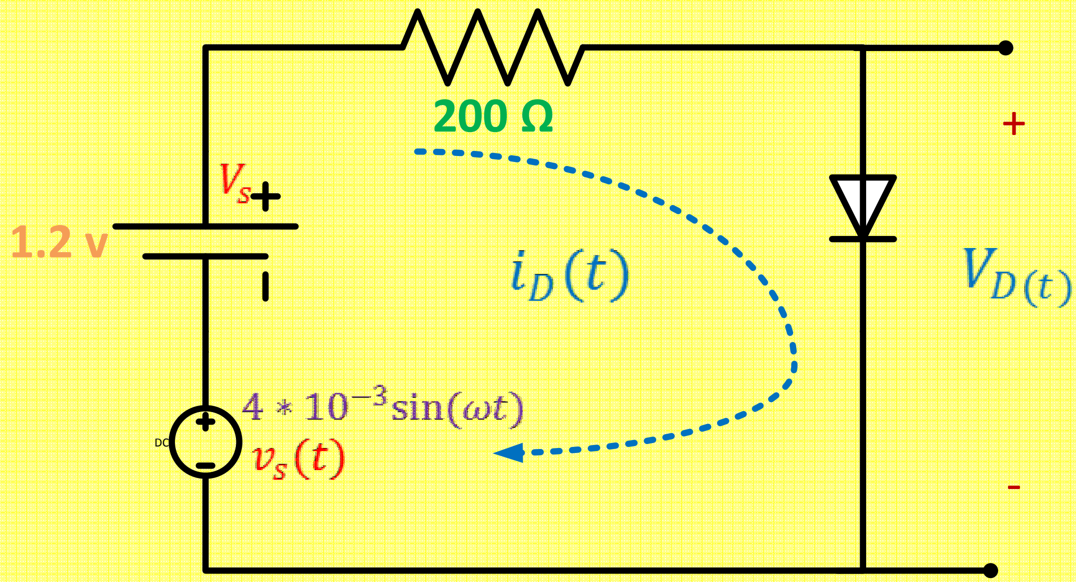
Example

Find $V_D(t)$

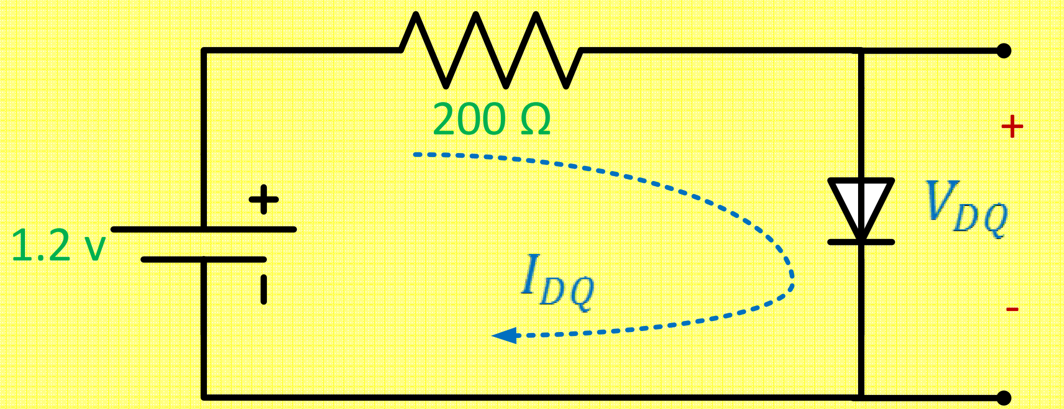
Using Thevenin's Theorem



Since we have a dc source (1.2 v) and an ac signal ($4x10^{-3}$ sinωt v) and the diode is always on ; we use superposition theorem to find $V_D(t)$



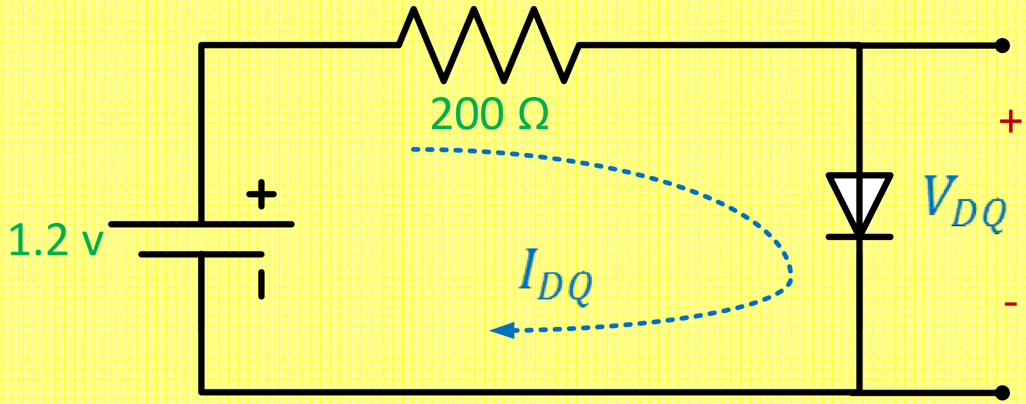
1) to find V_{DQ} (DC Analysis)

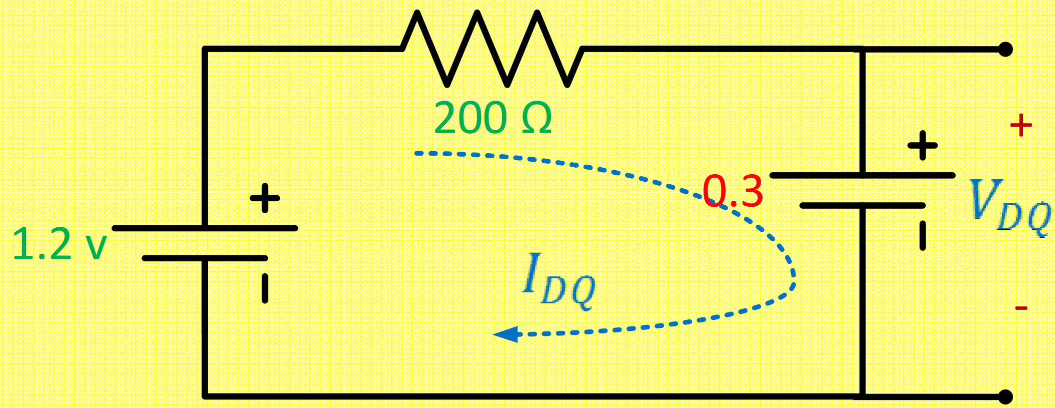


$\therefore\ V_{DQ}$ = 0.3 v

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

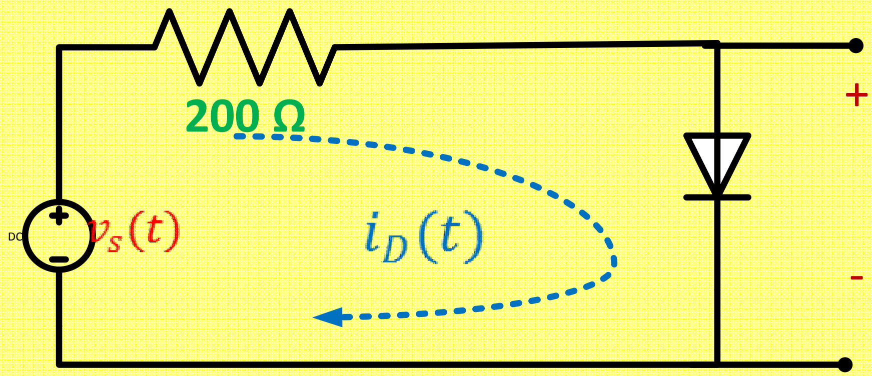
$\therefore r_d = \frac{V_T}{I_{DQ}} = \frac{25.69mv}{4.5mA}$ = 5.69 Ω





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

v_d(t) = $\frac{5.69}{200+5.69}$. $4x10^{-3}$ sinωt v



v_d(t) = $0.1165\ x10^{-3}$ sinωt v

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

$V_D(t)$= (0.3 +0.1165 $x10^{-3}$ sinωt) v