Electronic Devices – EE090

Lecture 3-3&3-4 Quiz Solution

March 2020

	Lecture 3-3

Q:

Question 3.3

a) Compute I_1, (V_{D2}, I_2), (V_{D3}, I_3) in Fig. 1 using Iterative analysis with initial $V_{D1} = 0.65V$, $n = 1$, $I_S=10^{-15}A$, $V_S = 3V$, and $R = 1.6K\Omega$.

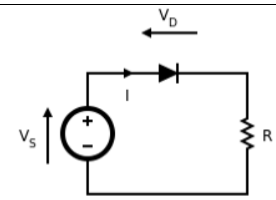


Fig. 1

b) The circuit is depicted in Fig. 2.

(i) Use Ideal-diode model to determine I_D and V_D.

(ii) Use Constant voltage drop model to determine I_D and V_D. Given $V_{DO} = 0.7V$

(iii) Use Piece-wise linear model to determine I_D and V_D. Given $V_{DO} = 0.7V$ and $r_D = 15\ \Omega$.

Hint: Use Thevenin equivalent circuit for V_{DC}, R_1 and R_2 before applying the models.

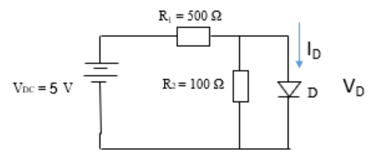


Fig. 2

c) The constant-voltage-drop model is used for the diode (D) in Fig. 3 with $V_{Do} = 0.7V$. The ideality factor $n = 1$.

(i) Find the current i_D.

(ii) Find the voltage v_D.

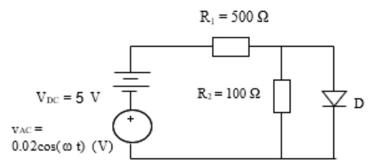


Fig. 3

d) A zener diode exhibits a constant voltage $V_{Zo} = 6.8$ V for current not less than $I_{zmin} = 6mA$. It is to be used in the design of a shunt regulator shown in Fig. 4. The load current is i_L and $r_{zmin} = 0$.

(i) If I_S varies from 30mA to 40 mA and I_L varies from 5mA to 20mA. Determine minimum value of R.

(ii) Compute maximum power dissipated by the Zener diode with I_s, I_L and R given in (a).

Hint: You use $i_z \geq i_{zmin}$

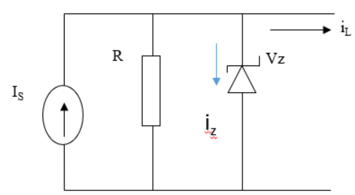


Fig. 4

Ans:

a.

- $V_{D1} = \boxed{0.65\ V}$

$$I_1 = (V_s - V_{D1})/R = (3 - 0.65)/(1.6 * 10^3) = \boxed{1.47\ mA}$$

- $V_{D2} = nV_T ln\frac{I_1}{I_S} = 1 * 25 * 10^{-3} ln\frac{1.47*10^{-3}}{10^{-15}} = \boxed{0.7004\ V}$

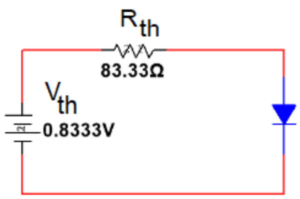
$$I_2 = (V_s - V_{D2})/R = (3 - 0.7004)/\ (1.6 * 10^3) = \boxed{1.4373\ mA}$$

- $V_{D3} = nV_T ln\frac{I_2}{I_S} = 1 * 25 * 10^{-3} ln\frac{1.4373*10^{-3}}{10^{-15}} = \boxed{0.6998\ V}$

$$I_3 = (V_s - V_{D3})/R = (3 - 0.6998)/\ (1.6 * 10^3) = \boxed{1.4376\ mA}$$

b.

Thevenin equivalent circuit:



$$V_{th} = V_{DC}\frac{R2}{R1+R2}$$

$$R_{th} = R1 \,//\, R2$$

(i) $V_D = 0\ V$

$$I_D = \frac{0.8333}{83.33} = 0.01\ A = 10\ mA$$

(ii) $V_D = V_{D0} = 0.7\ V$

$$I_D = \frac{0.8333 - 0.7}{83.33} = 1.6\ mA$$

(iii)

$$I_D = \frac{0.83 - 0.7}{83.3 + 15} = 1.322mA$$

$$V_{D_0} = 0.7 + 15x1.322x10^{-3} = 0.72\ V$$

c

- DC analysis:

$V_D = 0.7\ V$

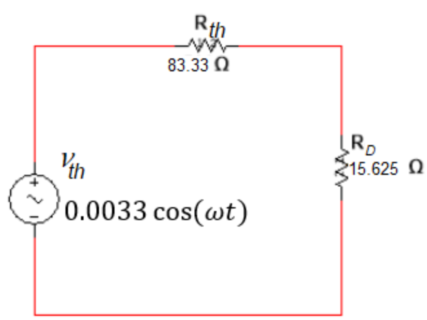
$I_D = 1.6\ mA$

From question b (ii)

- AC analysis:

$$r_D = \frac{nV_T}{I_D} = \frac{25 * 10^{-3}}{1.6 * 10^{-3}} = 15.625\ \Omega$$

$$v_{th} = 0.02\cos(\omega t) * \frac{100}{500 + 100} = 0.0033\cos(\omega t)$$



$$i_d = \frac{v_{th}}{R_{th} + R_D} = 0.0337\cos(\omega t)\ [mA]$$

$$v_d = i_d * R_D = 0.526\cos(\omega t)\ [mV]$$

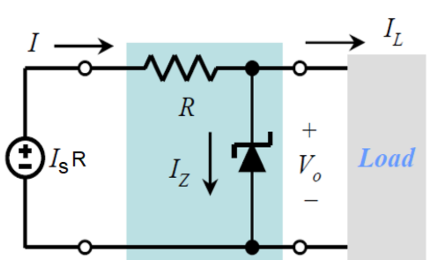
Finally:

$$(i)\quad i_D = I_D + i_d = 1.6 + 0.0337\cos(\omega t)\ [mA]$$

$$(ii)\ v_D = V_D + v_d = 700 + 0.526\cos(\omega t)\ [mV]$$

d.

Using source transformation, we get:



(i) $I_Z \geq I_{Zmin} \rightarrow \frac{I_S R - V_{Z0}}{R} - I_L \geq I_{Zmin}$

$$\rightarrow I_s - \frac{V_{Z0}}{R} \geq I_{Zmin} + I_L$$

$$\rightarrow \frac{V_{Z0}}{R} \leq I_s - I_{Zmin} - I_L$$

$$\rightarrow R \geq \left(\frac{V_{Z0}}{I_s - I_{Zmin} - I_L}\right)_{max}$$

Then:

$$(I_s - I_{Zmin} + I_L\ )\ must\ be\ minimun$$

$$\rightarrow R = \frac{V_{Z0}}{I_{s\_min} - I_{Zmin} + I_{L\_max}}$$

$$= \frac{6.8}{30m - 6m - 20m} = 1700\ \Omega$$

(ii) $P_{z\_max} = V_{Z0} * I_{z\_max}$

$$= V_{Z0} * \left(I_s - \frac{V_{Z0}}{R} - I_L\right)_{max}$$

$$= V_{Z0} * \left(I_{s\_max} - \frac{V_{Z0}}{R} - I_{L\_min}\right)$$

$$= 6.8 * \left(40m - \frac{6.8}{1700} - 5m\right)$$

$$= 0.21\ W$$

Lecture 3.4

Question 3.4

a) An AC input 20sin(100πt) volts is at the primary winding of the 2:1 transformer as shown in Fig.1. The secondary winding connects to a half-wave rectifier with an ideal diode. Determine DC equivalent (or average voltage) at the output V_{out}.

Hint: You use *intergal over one period* of the output waveform $V_{av} = \frac{1}{T}\int_0^T V_{out}dt$

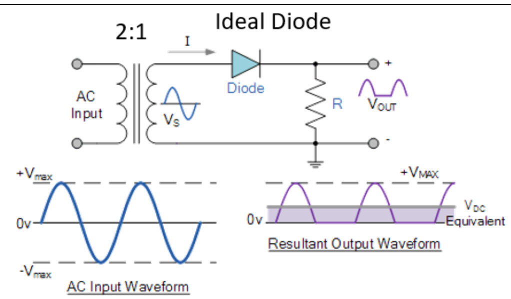
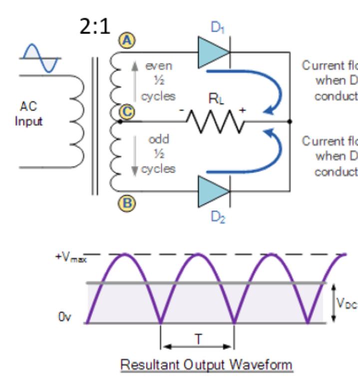


Fig. 1

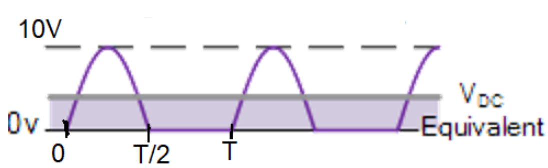
b) An AC input 20sin(100πt) volts is at the primary winding of the 2:1 transformer as shown in Fig.2. The secondary winding connects to a full-wave rectifier with ideal diodes. Determine DC equivalent (or average voltage) at the output V_{out} (voltage drop on R_L).

Hint: You use *intergal over one period* of the output waveform $V_{av} = \frac{1}{T}\int_0^T V_{out}dt$



Ans

a.



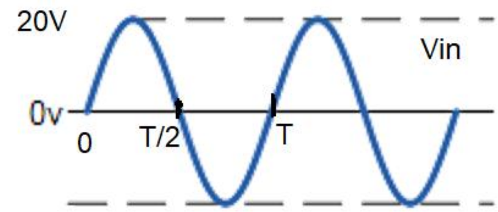
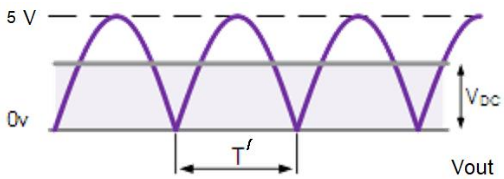
$$\omega = 100\pi \rightarrow T = 0.02$$

Using 2:1 transformer

-> $Vs = \frac{Vac\_input}{2} = 10sin(\omega t)$ [V]

$$V_{out\_average} = \frac{1}{T}\int_0^T V_{out}dt$$

$$= \frac{1}{T}\int_0^{T/2} 10sin(\omega t)dt + \frac{1}{T}\int_{T/2}^{T} 0 = \frac{10}{\pi}\ [V]$$

b.	  $T' = \frac{T}{2} = 0.01$ Using 2:1 transformer and center-tap rectifier -> $V_{out} = \frac{Vac\_input}{4} = 5sin(\omega t)$ [V] $V_{out\_average} = \frac{1}{T'}\int_0^{T'} V_{out}dt = \frac{1}{T'}\int_0^{T'} 5sin(\omega t)dt = \frac{10}{\pi}\ [V]$