DEPARTMENT OF ELECTRNICS & COMMUNICATION ENGINEERING, KITSW

COURSE: **U14EI 205 - BASIC ELECTRONICS ENGINEERING**	**ECE-I, Semester-II, 2015-16**

ASSIGNMENT-4 HINTS &SOLUTIONS

1. **Show that the percentage regulation of both HWR and FWR is $(R_f / R_L)100\%$, where R_f is diode forward resistance (or R_d), R_L is load resistance**

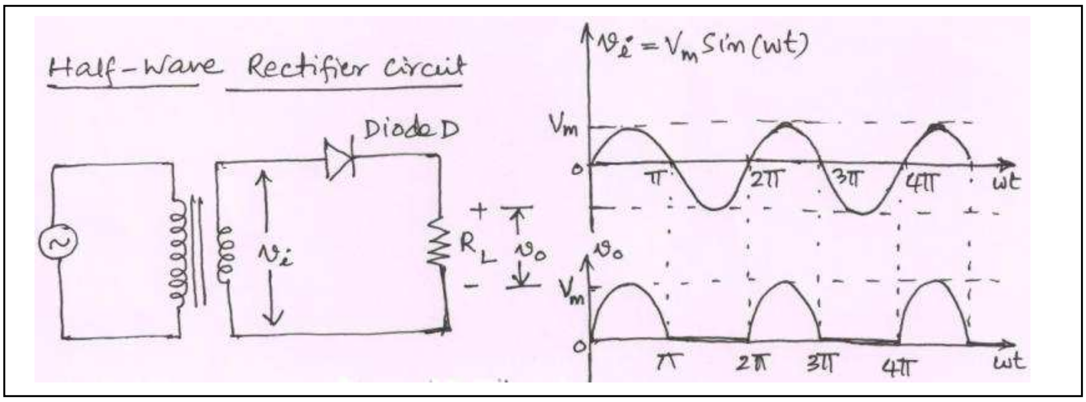
   [*Writing something about HWR or FWR without drawing ckt , input and output waveforms, the answer is incomplete: Similarly the case with other answers*

   You are expected to cover: (i) Ckt diagram of HWR, (ii) Input v_i and Output voltage v_o waveforms of HWR, (iv) derive the values of V_{dc} (v) $V_{no-load} = V_{dc} = V_m / \pi, V_{full-load} = (V_{dc} - I_{dc} R_f)$ or $I_{dc} R_L$, (vi) use them in $\%regulation = [(V_{no-load} - V_{full-load}) / (V_{full-load})]100\%$ (vi) what must be ideal regulation (vii) comment on derived % regulation, (viii) Repeat for FWR]

- Rectifier: Rectifier is a circuit that converts AC voltage into DC voltage
  - DC is a constant voltage signal.
  - Diode rectifiers convert the AC into unidirectional pulsating signal (*not pure DC*)

Half-wave rectifier:

The circuit diagram of half-wave rectifier is shown below



<u>During positive half cycle of the input signal $v_i = V_m \sin(\omega t)$</u>

- The diode D is forward biased and acts as a short.
- Hence a current i_L flows through the load R_L and produces load voltage v_0

<u>During negative half cycle of the input signal $v_i = V_m \sin(\omega t)$</u>

- The diode D is reverse biased and acts as open.
- Hence practically no current flows through the load R_L and no voltage across the load.

- The output of HWR is not a perfect DC, but at least unidirectional.
- Show that $V_{dc} = \frac{V_m}{\pi}$ *(refer to class notes)*
- Voltage Regulation
  - Variation of DC output voltage as a function of DC load current is called regulation
  - The percentage regulation is defined as

$$\% regulation = \frac{V_{no-load} - V_{full-load}}{V_{full-load}} 100\%$$

  - For an ideal power supply, the % regulation is ZERO

For HWR :

$$V_{dc} = I_{dc} \cdot R_L = \left(\frac{I_m}{\pi}\right) \cdot R_L \quad ; \quad \text{Here } I_m = \frac{V_m}{R_f + R_L}$$

$$\therefore V_{dc} = \frac{V_m \cdot R_L}{\pi (R_L + R_f)} = \frac{V_m}{\pi}\left[1 - \frac{R_f}{R_L + R_f}\right]$$

$$\Rightarrow V_{dc} = \frac{V_m}{\pi} - \frac{V_m}{\pi} \times \frac{1}{R_L + R_f} \times R_f$$

$$\Rightarrow V_{dc} = \frac{V_m}{\pi} - I_{dc} \cdot R_f \qquad \text{—— (1)}$$

Now for HWR

$$V_{no-load} = \frac{V_m}{\pi}$$

$$V_{full-load} = \frac{V_m}{\pi} - I_{dc} \cdot R_f \ \text{(or)}\ I_{dc} \cdot R_L$$

$$\therefore \% \text{Regulation} = \frac{V_{no-load} - V_{full-load}}{V_{full-load}} \times 100\%$$

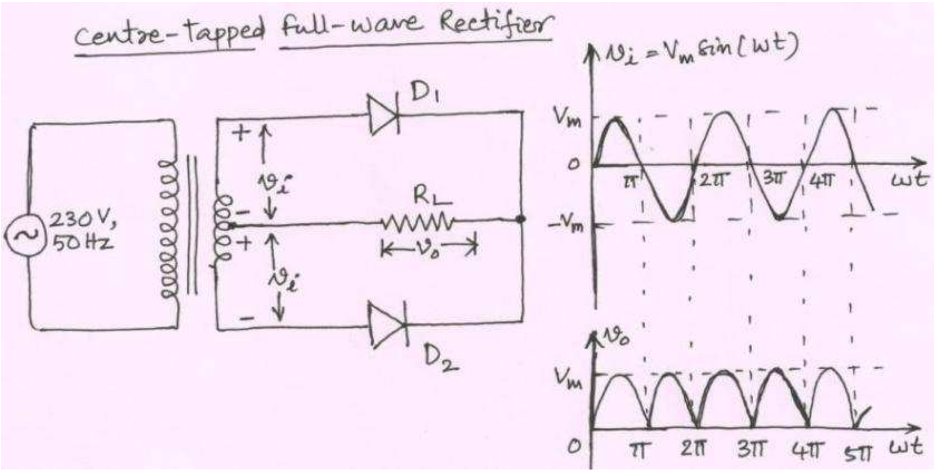
$$= \frac{\left(\frac{V_m}{\pi}\right) - \left(\frac{V_m}{\pi} - I_{dc} \cdot R_f\right)}{I_{dc} \cdot R_L} \times 100\%$$

$$= \frac{I_{dc} \cdot R_f}{I_{dc} \cdot R_L}$$

$$\% \text{Regulation}_{HWR} = \frac{R_f}{R_L} \times 100\%$$

Full-wave rectifier:

The circuit diagram of full-wave rectifier is shown below



During positive half cycle of the input signal $v_i = V_m \sin(\omega t)$

- The diode D1 is forward biased and acts as a short.
- So, the current i_L flows through the load R_L and produces load voltage v_0
- The diode D2 is reverse biased and acts as open.

During negative half cycle of the input signal $v_i = V_m \sin(\omega t)$

- The diode D1 is reverse biased and acts as open.
- The diode D2 is forward biased and acts as a short.
- So, the current i_L flows through the load R_L and produces load voltage v_0

- *show that* $V_{dc} = \frac{2V_m}{\pi}$ *(refer to class notes)*

For Full-wave Rectifier

$$V_{dc} = I_{dc} \cdot R_L = \left(\frac{2 I_m}{\pi}\right) R_L \quad ; \text{Here } I_m = \frac{V_m}{R_L + R_f}$$

$$\therefore V_{dc} = \frac{2 V_m \cdot R_L}{\pi (R_L + R_f)} = \frac{2V_m}{\pi}\left[1 - \frac{R_f}{R_L + R_f}\right]$$

$$V_{dc} = \frac{2V_m}{\pi} - \frac{2V_m}{\pi} \times \frac{1}{(R_L + R_f)} \times R_f$$

$$V_{dc} = \frac{2V_m}{\pi} - I_{dc} \cdot R_f \quad \text{——— (1)}$$

Now $V_{no\text{-}load} = \frac{2V_m}{\pi}$

$V_{full\text{-}load} = \frac{2V_m}{\pi} - I_{dc} \cdot R_f$ (or) $I_{dc} \cdot R_L$

$$\therefore \% \text{ Regulation} = \frac{V_{no\text{-}load} - V_{full\text{-}load}}{V_{full\text{-}load}} \times 100\,\%$$

$$= \frac{\left(\frac{2V_m}{\pi}\right) - \left(\frac{2V_m}{\pi} - I_{dc} \cdot R_f\right)}{I_{dc} \cdot R_L}$$

$$= \frac{I_{dc} \cdot R_f}{I_{dc} \cdot R_L}$$

$$\Rightarrow \% \text{ Regulation}_{FWR} = \frac{R_f}{R_L} \times 100\,\%$$

2. **Explain the effect of inductor as filter. Show how output of a FWR changes with variation in inductance value. Derive an expression for the ripple factor of FWR with inductor filter.**

   [*You are expected to cover: (i) what is the need for filter, (ii) Behavior of Inductor to ac and dc , mention that "Inductor opposes any change in the current that flows through it", (iii) Draw ckt diagram of FWR with L-filter, (iv) Input* v_i *,Output* v_o *waveform of FWR, Output* v_o *waveform of FWR with L-filter (v) derive expression for ripple factor with L-filter, (vi) whether L-filter can be used for light loads or heavy loads*]

   (refer to class notes)

3. **Derive an expression for the ripple factor of FWR with Capacitor filter.**

   [*You are expected to cover: (i) what is the need for filter, (ii) Behavior of capacitor to ac and dc (iii) Draw ckt diagram of FWR with C-filter, (iv) Input* v_i *,Output voltage* v_o *waveform of FWR, Output voltage* v_o *waveform of FWR with C-filter (v) derive the expression for ripple factor with C-filter, (vi) comment on whether C-filter can be used for light loads or heavy loads*]

   (refer to class notes)

4. **Derive an expression for the ripple factor of FWR with L Section or LC filter.**
   [*You are expected to cover: (i) what is the need for filter, (ii) Behavior of Inductor and capacitor to ac and dc (iii) Draw ckt diagram of FWR with LC-filter, (iv) Input* v_i *,Output voltage* v_o *waveform of FWR, Output voltage* v_o *waveform of FWR with LC-filter (v) derive the expression for ripple factor with LC-filter, (vi) comment on dependency of ripple factor on Load resistance*]
   (refer to class notes)

5. Derive an expression for the ripple factor of FWR with Π or CLC filter.
   [*You are expected to cover: (i) what is the need for filter, (ii) Behavior of Inductor and capacitor to ac and dc (iii) Draw ckt diagram of FWR with CLC-filter, (iv) Input* v_i *,Output voltage* v_o *waveform of FWR, Output voltage* v_o *waveform of FWR with CLC-filter (v) derive the expression for ripple factor with CLC-filter, (vi) comment on dependency of ripple factor on Load resistance*]
   (refer to class notes)

6. Explain how a Zener diode can be used as Voltage Regulator
   [*You are expected to cover: (i) Explain the need for voltage regulation, (ii) what is Zener diode, (iii) draw V-I characteristic of Zener of diode (iv) Explain its operation during breakdown (v) mention manufacture specifications of zener, and define knee current, calculation of maximum zener current from specifications, (vi) Draw the ckt diagram of zener voltage regulator,(vii) mention why* R_s *is used (viii) Explain how this ckt provides line regulation, (ix) Explain how this ckt provides lord regulation*]

   (refer to class notes)

7. Explain the principle of operation of a Photo Diode
   [*You are expected to cover: (i) what is photodiode and how it is different from conventional diode, (ii) semiconductor materials used (iii) ckt symbol, (iv) In which mode it is operated (v) V-I characteristics at different light intensities, (vi) mention dark current, (vii) give construction details*]

   (refer to class notes)

8. Explain the principle of operation of a LED
   [*You are expected to cover: (i) what is LED and how it is different from conventional diode, (ii) principle of operation: emission of photons (ii) semiconductor materials used (iii) ckt symbol, (iv) In which mode it is operated (v) different semiconductor materials used and their colour of emission (vi) V-I characteristics for different colours*]

   (refer to class notes)

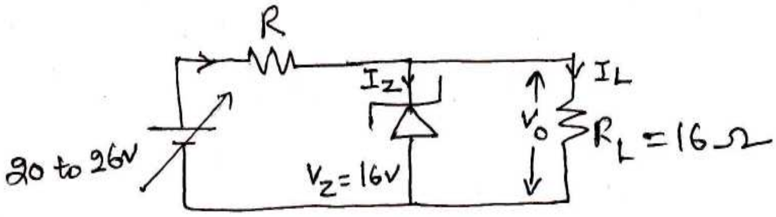
9. **A 9.1 V Zener diode is specified with a maximum power dissipation of 364 mW. What is the maximum current the diode can handle ? [** $Ans: I_{z-\max} = 40mA$ **]**

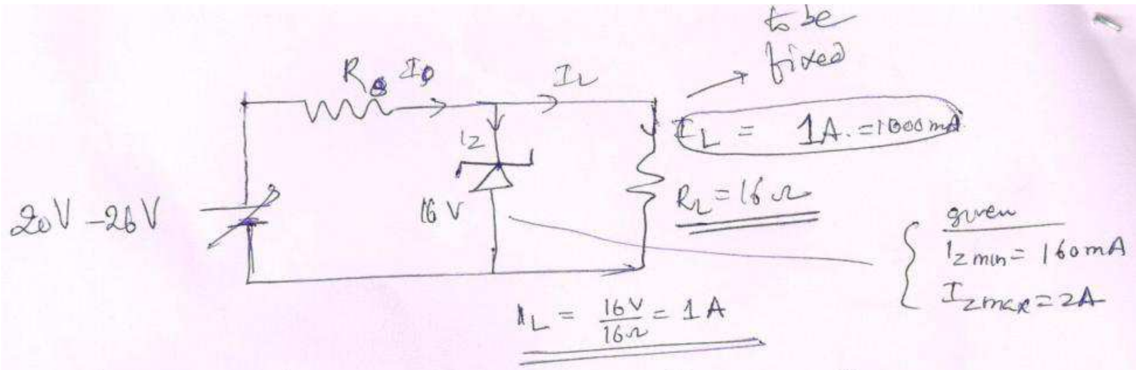
Solution:

$$V_z = 9.1V,\ P_{z-\max} = 364\,mW,$$

$$\text{We know},\ P_{z-\max} = V_z\ I_{z-\max} \Rightarrow I_{z-\max} = \frac{P_{z-\max}}{V_z}\ ;\ \therefore I_{z-\max} = \frac{364\,mW}{9.1\,V} = 40\ mA$$

10. The Zener shown has V_Z=16V.The voltage across load stays at 16V as long as the Zener current I_Z is maintained between 160mA and 2A.Find the value of the series resistance so that the output remains at 16V if the input varies between 20V to 26V .[*Ans: R=3.44* Ω *]*





$I_L = \frac{16V}{16\Omega} = 1\,A$

$V_{i(min)}$: 20V : $I_{(min)} = I_{z(min)} + I_L$

$\left(\frac{20-16}{R_{max}}\right) = 160\,mA + 1000\,mA = 1160\,mA$

$R_{min} = \frac{4}{1160} \times 10^3 = 3.44\Omega$

V_{imax} : 26 V

$I_{(max)} = I_{z(max)} + I_L$

$\left(\frac{26-16}{R_{max}}\right) = (2000 + 1000)\,mA = 3000\,mA$

$R_{min} = \frac{10}{3000\,mA} = \frac{10}{3} = 3.33\,\Omega$

$3.33\Omega \leq R < 3.44\Omega$