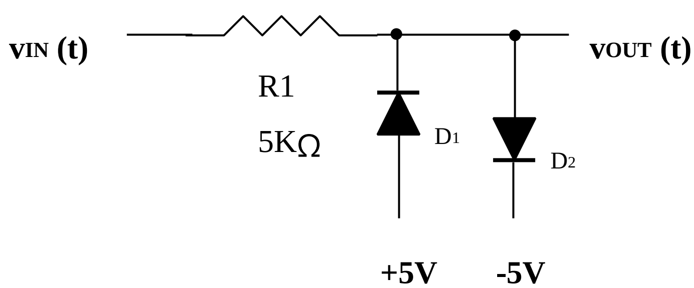
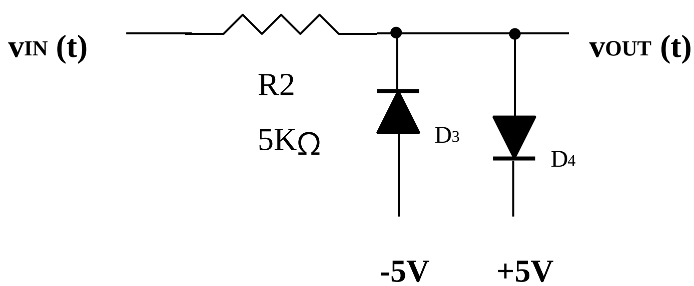
Noble Huang (Mulia Widjaja)		
SANTA CLARA UNIVERSITY	ELEN 115 – Spring 2023	S. Krishnan
Homework #6		

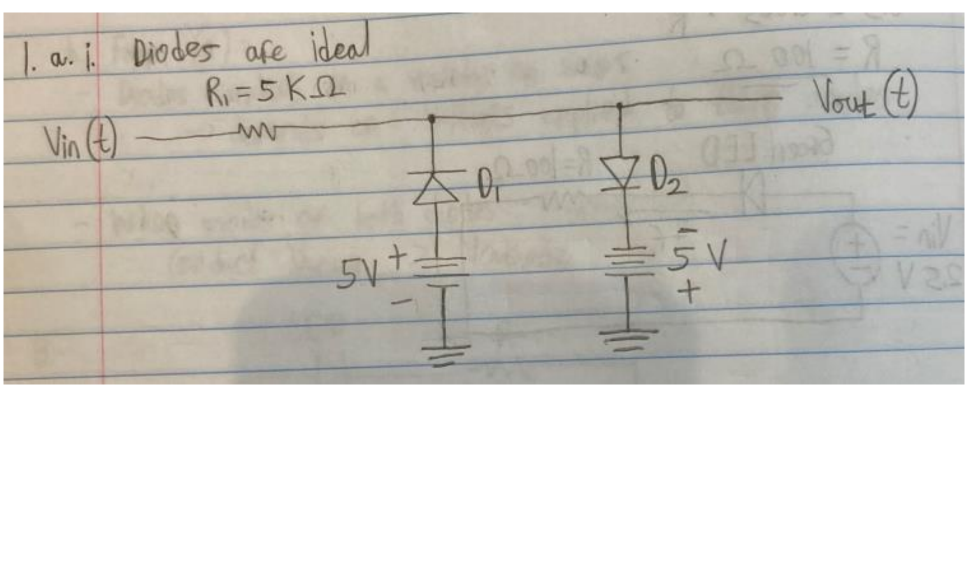
1. For each circuit, the diodes are ideal.
   - (i) Clearly explain how the circuit functions by showing conditions when each diode is on and when it is off.
   - (ii) For his design plot the transfer characteristic v_{INB} versus v_{IN} indicating the values of all significant points and the values of the slopes of all segments
   - (iii) Which of these circuits **DOES** function as a diode clamp that keeps the output voltage between -5 and +5 volts. **Explain your answer.**
   - (iv) Which of these circuits **DOES NOT** function as a diode clamp that keeps the output voltage between -5 and +5 volts. **Explain your answer.**

(a)

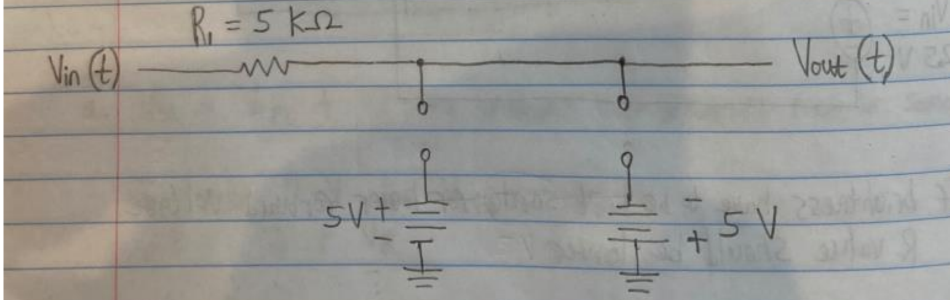


(b)



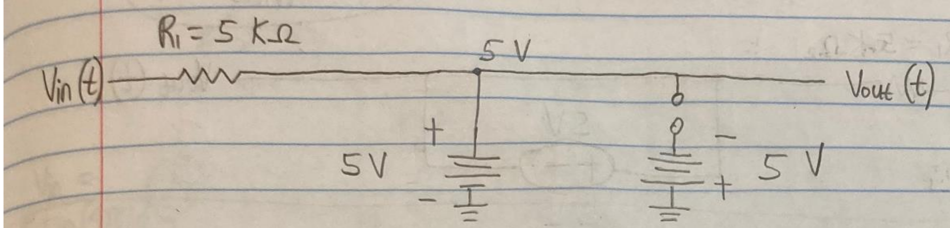


Case #1: D_1 = OFF D_2 = OFF



When both diodes are off, Vin goes directly in Straight line with Vout (t) → $V_{out}(t) = V_{in}(t)$

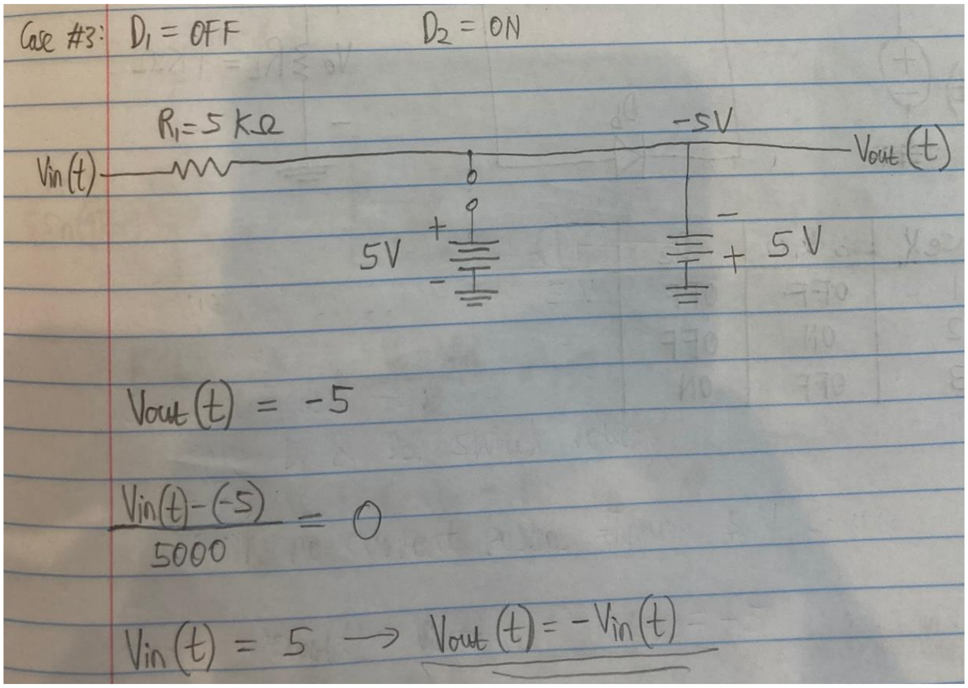
Case #2: D_1 = ON D_2 = OFF



$$V_{out}(t) = 5$$

$$\frac{5 - V_{in}(t)}{5000} = 0$$

$V_{in}(t) = 5 \longrightarrow \underline{V_{out}(t) = V_{in}(t)}$



2. A young design engineer decides to try a new configuration for a rectifier. His attempt is the circuit shown in Figure 2 where identical diodes D_a and D_b are used. Assume diodes are ideal.

   The designer gives the input $v_{in} = 5\sin 4\pi t$ to the circuit.

   (i) For each half cycle indicate the ON and OFF state of the diodes.
   (ii) Draw the input voltage and the corresponding output voltage v_O vs. time.
   (iii) Find the average value of the output voltage.
   (iv) Is this rectifier efficient? Explain your answer.
   (v) Find the peak diode current in each diode.
   (vi) Find the maximum reverse voltage seen by each diode.

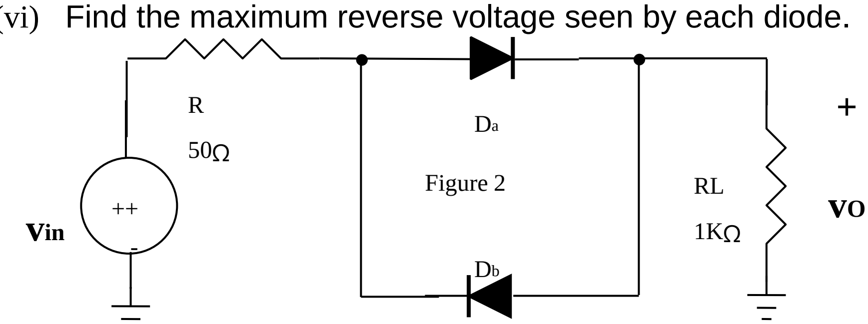
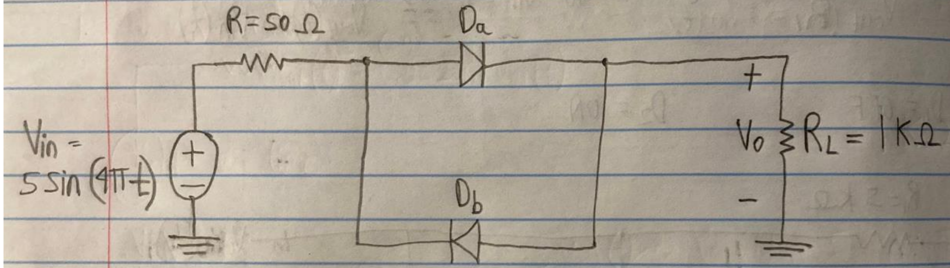


Figure 2

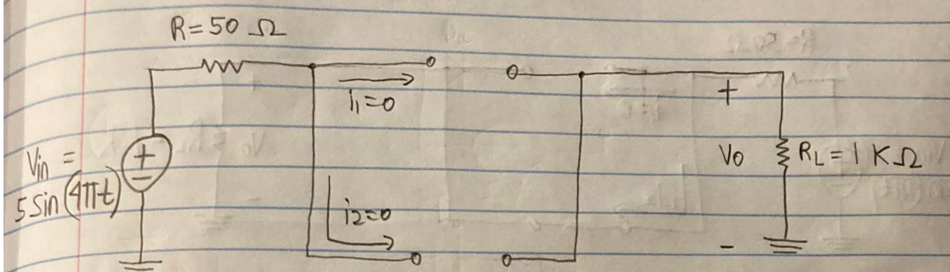
2. New Config for a Rectifier:

- D_a, D_b : Identical
- Diodes : Ideal
- $V_{in} = 5\sin(4\pi t)$



Case	D_1	D_2
1	OFF	OFF
2	ON	OFF
3	OFF	ON

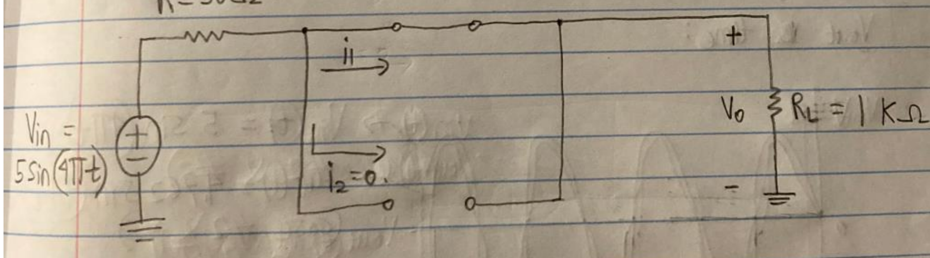
Case #1: D_a = OFF D_b = OFF



Due to no current flowing:

$V_o = 0$

Case #2: D_a = ON D_b = OFF

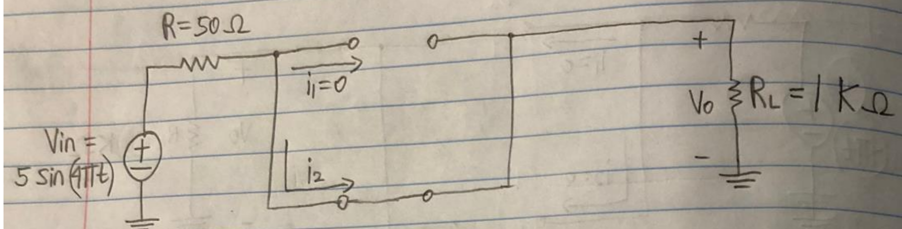


KCL: $\frac{V_o}{R_L} + \frac{V_o - V_{in}}{R} = 0$

$$R \cdot V_o + R_L \cdot V_o - R_L \cdot V_{in} = 0$$
$$(R + R_L)\, V_o = R_L \cdot V_{in}$$

$$V_o = \frac{R_L}{R + R_L} V_{in} = \frac{1000}{1050} V_{in} = 0.9524\, V_{in}$$

Case #3: D_a = OFF D_b = ON

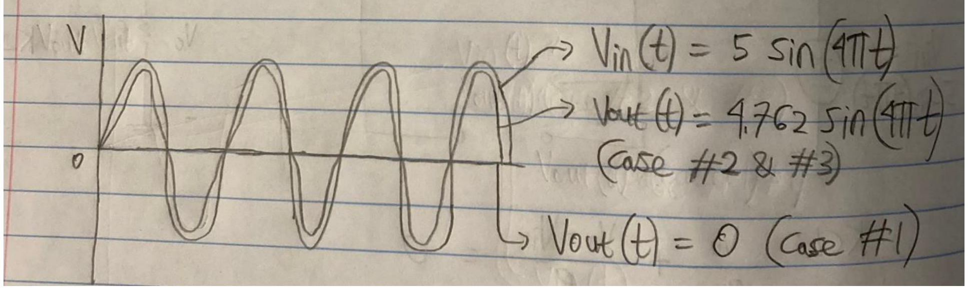


Case #3 :
essentially same with Case #2 :
Current flows through i_2 wire, similar to i_1 wire in Case #2.

Hence:

$V_{out}(t) = 0.9524\ V_{in}(t)$

Vout vs. time:



3. **4.74**

4.74 The circuit in Fig. P4.74 implements a complementary-output rectifier. Sketch and clearly label the waveforms of v_O^+ and v_O^-. Assume a 0.7-V drop across each conducting diode. If the magnitude of the average of each output is to be 12 V, find the required amplitude of the sine wave across the entire secondary winding. What is the PIV of each diode?

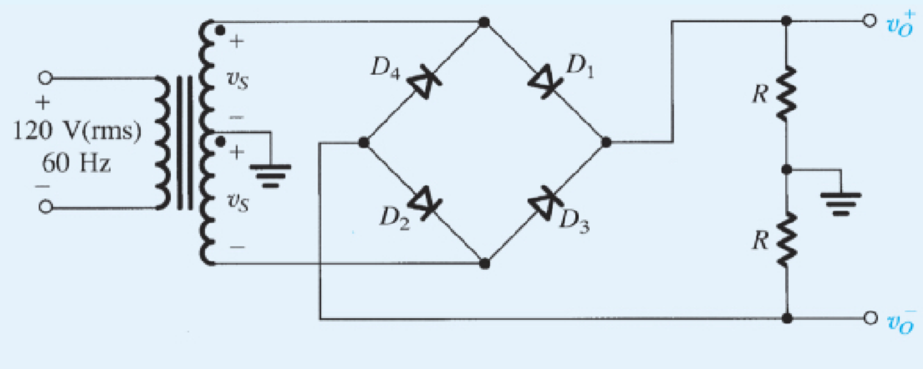
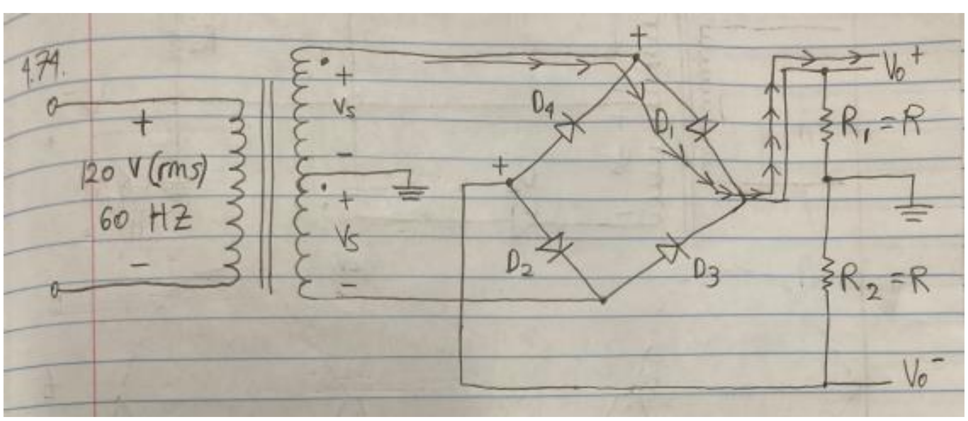
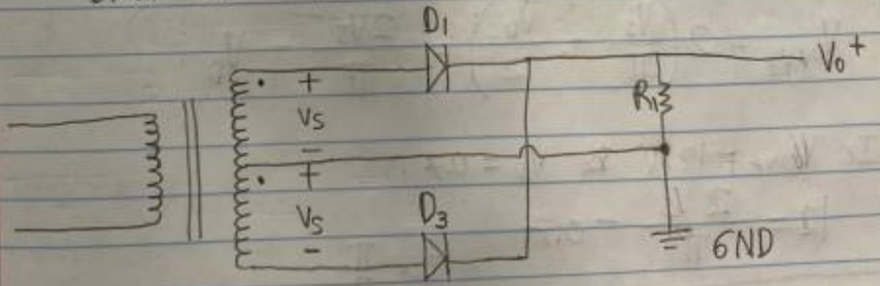


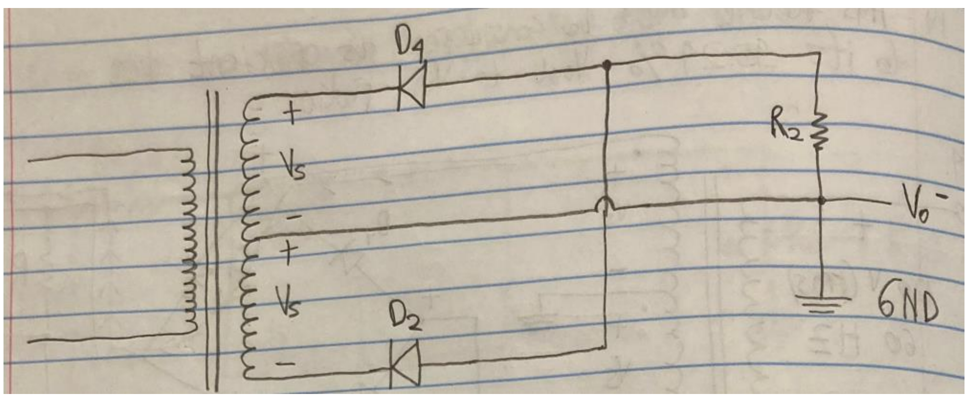
Figure P4.74

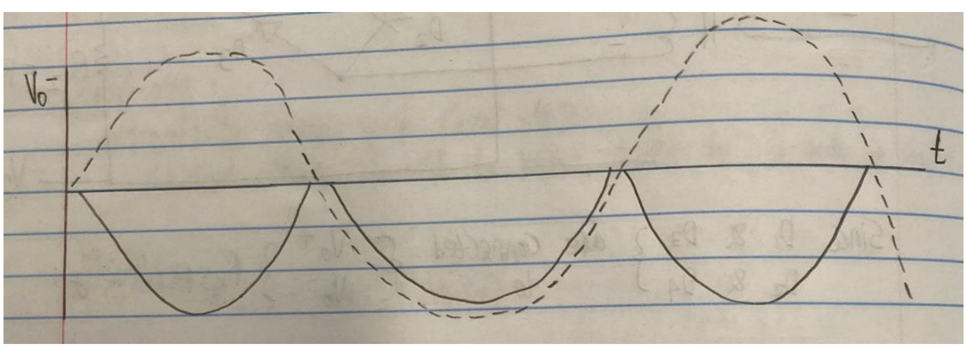


Since $\left.\begin{matrix} D_1 \text{ \& } D_3 \\ D_2 \text{ \& } D_4 \end{matrix}\right\}$ are connected to $\left\{\begin{matrix} V_o^+ \\ V_o^- \end{matrix}\right\}$ Respectively:

Break the circuit into 2 separate circuits:







As per lecture formula:

$$V_{oavg} = 2\left(\frac{V_s}{\pi} - \frac{V_D}{2}\right) = \frac{2V_s}{\pi} - V_D$$

If $V_{oavg} = 12\text{ V}$ & $V_D = 0.7$:

$$12 = \frac{2V_s}{\pi} - 0.7 \quad \cdot \frac{\pi}{2}$$

$$6\pi = V_s - 0.35\pi$$

$$V_s = 6.35\pi$$

Since this is a full-wave rectifier:

$$\begin{aligned} PIV &= 2V_s - V_D \\ &= 2(6.35\pi) - 0.7 \\ &= 12.7\pi - 0.7 \\ &= \underline{39.1982\text{ V}} \end{aligned}$$

4. A designer has to build a regulator circuit as shown in Figure 4 to provide an output voltage v_{OUT} of 5V using one of two types of diodes. Given that **both types of diodes** have a voltage of 0.715V at 1mA current. For the diode **of TYPE A** the voltage changes by 0.1V/decade change in current while for the diode **of TYPE B** the voltage increases by 0.1V when the current through it doubles. **Do not assume the values for V_T.**

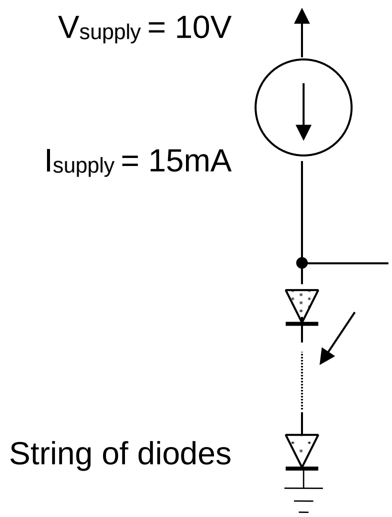
(i) Which type of diode should the designer pick for building an efficient regulator? Clearly explain the reasons for your choice.

(ii) How many diodes of the type chosen in (a) would be in the string to obtain the required v_{OUT} at nominal I_{supply} and no load condition.

(iii) Find the **percentage change** in $\mathbf{v_{OUT}}$ when a load current of 5mA is drawn from the circuit.

Figure 4

VOUT



4. Step #1: Gather the Data

2 Types of Diodes:

- Type A (0.1 V / decade):
  → Decade: Current raised by a factor of 10
  → Volts raised by 0.1 V

- Type B (0.1 V when current doubles):
  → Double: Current raised by a factor of 2
  → Volts raised by 0.1 V

Both Diodes:
→ 0.175 V @ 1 mA

Vout Needed:
→ 5 V

Step #2: Set up Initial Formula

$$i = I_S e^{V/V_T}$$

$$i_1 = i_2 = i_3 = \ldots = i_n = i$$

$$V_1 + V_2 + \ldots + V_n = V_{out} = 5\ V$$

Step #3: Efficiency

I would define efficiency as **drawing power** as low as possible.

0.1 V of voltage increase every time the current doubles is more efficient than 0.1 V/decade.

Below is a power table with the current predicted to change every time current doubles:

Time (s)	Current (A)	Voltage (V)	Power (W)
1	1	0.1	0.1
2	2	0.2	0.4
3	4	0.3	1.2
		TOTAL	1.7

Furthermore, below is a power table with the current predicted to change every decade of current:

Time (s)	Current (A)	Voltage (V)	Power (W)
1	1	0.1	1
2	10	0.2	20
3	100	0.3	300
		TOTAL	321

In this power table above, I am simulating that for every second, the current changes by a factor of 2 and 10 in Table #1 and #2, respectively. Accordingly to the current, the voltages increase by 0.1 V. When I totaled the powers generated by the diodes for every second, the power drawn by Type A diode is obviously far less than that drawn by Type B.

ii. $n = \frac{V_{in} - V_{out}}{V_D}$

$= \frac{10-5}{0.715} = \underline{\underline{7 \text{ diodes}}}$

iii. $V_D = V_T \cdot \ln\left(\frac{I}{I_S}\right)$

$0.625 = V_T \cdot \ln\left(\frac{1 \text{ mA}}{10^{-12} \text{ A}}\right)$

$0.734 = V_T \cdot \ln\left(\frac{6 \text{ mA}}{10^{-12} \text{ A}}\right)$

$\Delta V_{out} = V_{D2} - V_{D1} = 0.109 \text{ V}$

% ΔV_{out}

$= \frac{\Delta V_{out}}{V_{out}} \cdot 100\ \%$

$= \frac{0.109}{5} \cdot 100\% = 2.18\%$