Xi'an Jiaotong-Liverpool University
西交利物浦大学

Coursework #1 EEE109

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Student Name:

Student ID :

Be cautious of following the rules:

(1) Handwriting only;

(2) Submit electronic copy via LMO in PDF format only;

(3) Do not be late: 0 mark after five working days;

(4) Wrong Submission: if you submit a wrong file, and you find out in five working days. Students can resubmit the correct file, but late submission. If you find out after five days and I can not help you!;

(5) Student can write the answer on this document (the blank area is enough for writing) or a new exercise book;

(6) May luck be with you!

1 Question 1 (10 Marks)

Silicon is doped with 5×10^{16} arsenic $atoms/cm^{-3}$. Consider the following questions:

(a) Is the material n- or p-type? (2 marks)

(b) Calculate the electron and hole concentration at T=300K (4 marks)

(c) Calculate the electron and hole concentration at T=350K (4 marks)

Table 1.3 Semiconductor constants

Material	Eg (eV)	B ($cm^{-3}\,K^{-3/2}$)
Silicon (Si)	1.1	5.23×10^{15}
Gallium arsenide (GaAs)	1.4	2.10×10^{14}
Germanium (Ge)	0.66	1.66×10^{15}

2 Question 2 (15 Marks)

Consider the Zener Diode circuit shown in Figure 1. Consider the following parameters: $V_{\mathrm{I}} = 20\mathrm{V}$, $V_{\mathrm{Z}} = 10\mathrm{V}$, $R_{\mathrm{i}} = 220\Omega$ and $P_{\mathrm{Z}}\,(\mathrm{max}) = 440\mathrm{mW}$.

(a) If the load resistor is $R_{\mathrm{L}} = 380\Omega$. Please calculate the load current I_{L}, zener diode current I_{Z}, and input current I_{I} (6 marks)

(b) Determine the value of R_{L} that will establish $P_{\mathrm{Z}}(\mathrm{max})$ (5 marks)

(c) Repeat part of (b) if $R_{\mathrm{i}} = 175\Omega$ (4 marks)

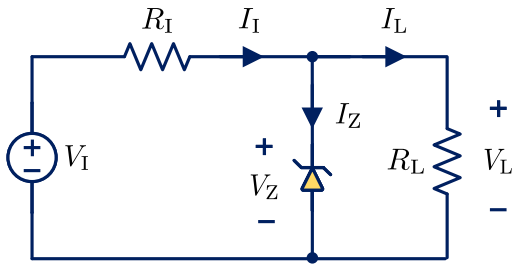


Figure 1: zener diode circuit

3 Question 3 (10 Marks)

The input voltage source is a square wave, as shown in Figure 2.

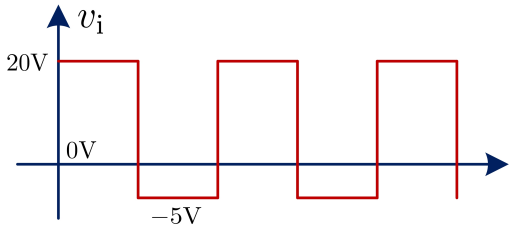


Figure 2: input voltage source

(a) Plot the waveform of output voltage v_o in circuit shown in Figure 3. Assume the turn-on voltage of the diode is $v_\gamma = 0.6\mathrm{V}$. Please mark the maximum and minimum values on your figure. (5 marks)

(b) Plot the waveform of output voltage v_o in circuit shown in Figure 4. Assume the turn-on voltage of the diode is $v_\gamma = 0.6\mathrm{V}$. Please mark the maximum and minimum values on your figure. (5 marks)

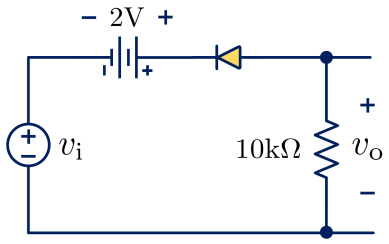


Figure 3: circuit I

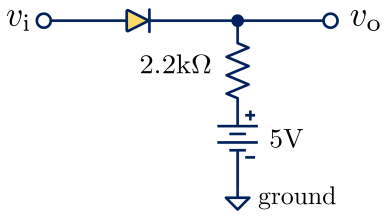


Figure 4: circuit II

4 Question 4 (15 Marks)

The two diodes circuit is shown in Figure 5. Calculate the output voltage v_o and the diode current I_{D1} and I_{D2} for the following voltage conditions:

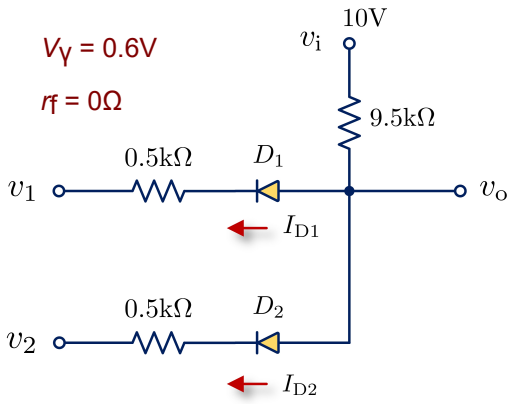


Figure 5: two diodes circuit

(a) $v_1 = 10\text{V}$ and $v_2 = 0\text{V}$ (5 marks)

(b) $v_1 = v_2 = 10\text{V}$ (5 marks)

(c) $v_1 = v_2 = 0\text{V}$ (5 marks)

5 Question 5 (15 Marks)

A full wave rectifier circuit with battery charging is shown in Figure 6. Assume $V_{\mathrm{B}} = 9\mathrm{V}$,$V_{\gamma} = 0.7\mathrm{V}$ and $v_{\mathrm{s}} = 15\sin\left[2\pi\left(60\right)t\right]\left(\mathrm{V}\right)$.

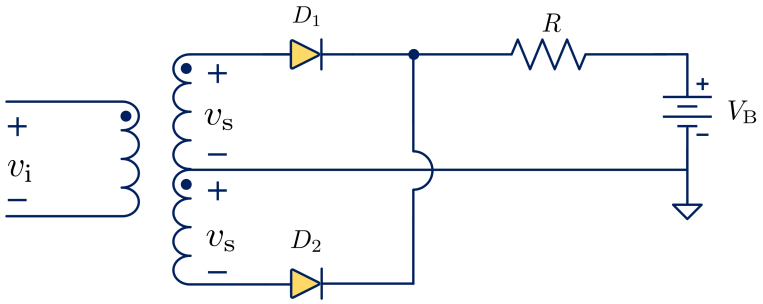


Figure 6: full wave rectifier circuit with battery charging

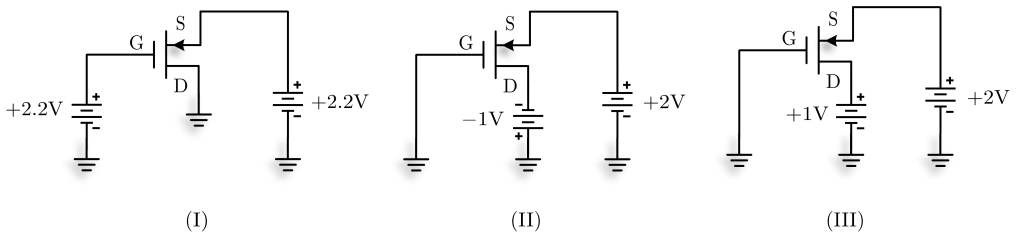
(a) Determine the resistance of R such that the peak battery charging current is $1.2A$ (5 marks)

(b) Determine the average battery charging current (5 marks)

(c) Determine the fraction of time that each diode is conducting (5 marks)

6 Question 6 (15 Marks)

The threshold voltage of each transistor in Figure 7 is $V_{\mathrm{TP}} = -0.4\mathrm{V}$. Please determine the region of operation of the transistor in:



(I) (II) (III)

Figure 7: three transistor circuits

(a) The transistor in (I) (5 marks)

(b) The transistor in (II) (5 marks)

(c) The transistor in (III) (5 marks)

7 Question 7 (10 Marks)

An npn transistor with $\beta = 80$ ic connected in a common-base configuration, as shown in Figure 8.

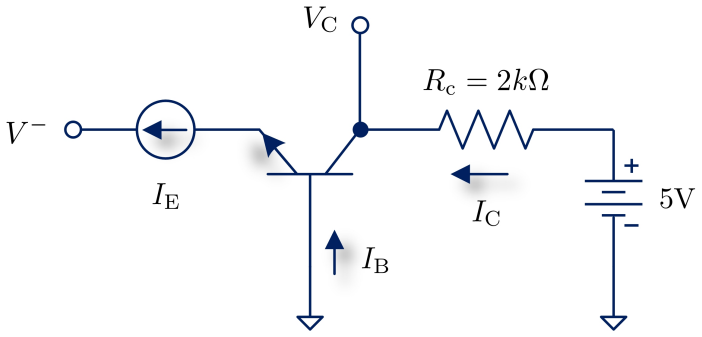


Figure 8: npn with common base configuration

(a) The emitter is driven by a constant-current source with $I_E = 1.2$mA. Determine the value of I_B, I_C, α and V_C (5 marks)

(b) Repeat part (a) for $I_E = 0.8$mA (5 marks)

8 Question 8(10 Marks)

Consider the circuit shown in Figure 9. Use the Thevenin Equivalent Circuit to solve the following questions.

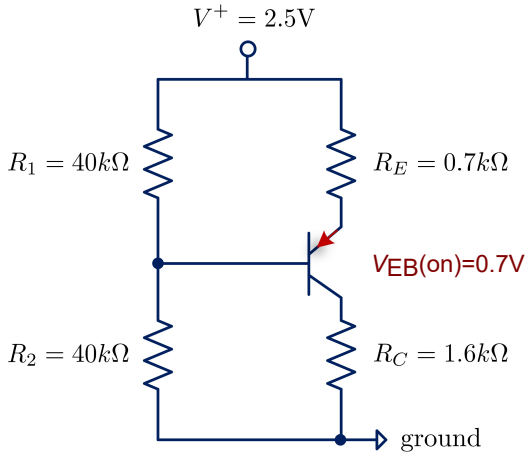


Figure 9: BJT circuit

(a) Please determine the value of R_{TH}, V_{TH}, I_{BQ}, I_{CQ}, and V_{ECQ} for $\beta = 90$ (5 marks)

(b) Determine the percent change in I_{CQ} and V_{ECQ} if for β is changed to for $\beta = 150$ (5 marks)