101CDE 2018/19 Academic Year, Semester 2 Coursework

Section 1: PN Junction (30 Marks in Total)

1.1 Basic Semiconductor Concept (4 Marks)

1.1.1 Please give two example elements which can be used for **P-type doping**, and describe the common characteristics of the two example elements. (2 Marks)

1.1.2 Please give two example elements which can be used for **N-type doping**, and describe the common characteristics of the two example elements. (2 Marks)

1.2 PN Junction (Diode) Basic (10 Marks)

1.2.1 Please describe how the depletion zone of PN junction is built (within 200 words). (3 Marks)

1.2.2 Please describe how the depletion zone changes if forward and reverse bias voltages are applied on a PN junction respectively (3 Marks)

1.2.3 Please draw the ebullient circuits and corresponding Voltage verses Current curves of a diode when considering it as 1) ideal diode, 2) practical diode with voltage drop, 3) practical diode with voltage drop and resistance (4 Marks)

1.3 PN Junction (Diode) Applications (10 Marks)

1.3.1 If the diode has a forward voltage drop $V_D = 0.6V$ and $R_D = 10\Omega$, use the practical diode DC model to calculate current flowing in the circuit in Fig 1.3.1. (3 Marks)

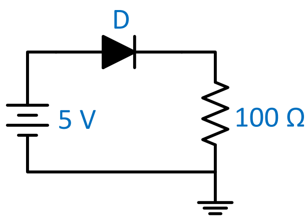
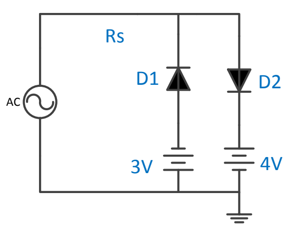
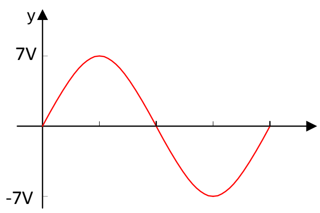
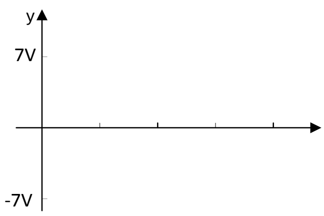


Fig 1.3.1

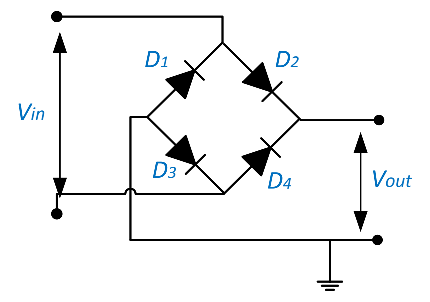
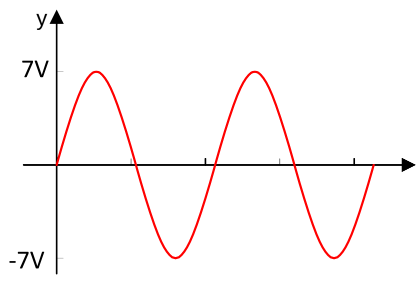
1.3.2 Please identify the name of the circuits in Table 1.3.2 and sketch the output signal waveforms of following circuits when the circuit with input signals shown below (ignore the forward voltage drop of the diodes): (3 Marks)

Table 1.3.2

?	Input Signal	Output Signal
		 ?

1.3.3 Please identify and explain, with the help of diagrams, the type of rectifier shown in Table 1.3.3. If an input signal is applied (Table 1.3.3) to the circuit shown in Table 1.3.3, draw an output waveform and identify which diodes are conducted during difference period in one signal cycle (please notice that you need to consider the forward voltage drop of diodes in Table 1.3.3 is 0.7V when you conduct the output waveform). Calculate the approximate RMS voltage value of the rectifier output. (4 Marks)

Table 1.3.3

Which type of rectifier is it?	**Input Signal**
	

1.4 AC/DC Converter (6 Marks)

Please sketch a block diagram of an AC/DC power supply and describe the name of the main functional blocks in the design. Also, please identify which functional blocks use diodes and how diodes are biased in the identified functional blocks. (6 Marks)

Section 2: Bipolar Junction Transistor (35 Marks in Total)

2.1 BJT Bias Circuit (10 Marks)

Please draw two BJT DC bias circuits that help to stabilise the Q point (operation) of the common emitter connected BJT circuit. Also, please explain why we need to stabilise Q point and explain why the two circuits can help stabilising the Q point. (10 Marks)

2.2 BJT DC Model (15 Marks)

For the given BJT circuit in Fig 2.2

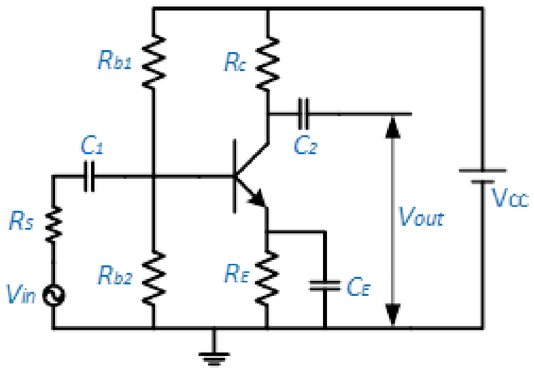


Fig 2.2

2.2.1 Please draw the DC load line of the circuit given in Fig 2.2, calculate I_C and V_{CE}, then mark the corresponding Q point on the DC load line. ($R_{b1} = 20k\Omega$, $R_{b2} = 10k\Omega$, $R_C = 4k\Omega$, $R_E = 5k\Omega$, $V_o = 0.7V$, $V_{CC} = 20V$) (8 Marks)

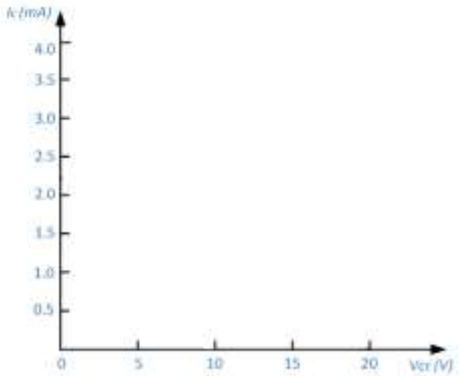


Fig 2.2.1

2.2.2 Please draw the AC load line according to the determined Q point in 2.2.1 and describe the main difference between the AC load line and DC load line, explain the reason for the difference. (7 Marks)

2.3 BJT AC Model/Hybrid-pi Model (10 Marks)

Assume the h_{fe} of BJT transistor in Fig 2.2 is 150, Please draw the AC model (hybrid-pi model) of the above circuit in Fig 2.2 and calculate AC voltage gain of given circuit respect V_S. (the internal impedance of AC sthe ignal source V_{in} is $R_S = 1k\Omega$, and load impedance is $R_L = 1.5k\Omega$ which is connected between Collector and ground, Common emitter transistor input impedance $h_{ie} = 1k\Omega$, Small signal transistor output conductance $h_{oe} = 20\mu S$) (10 Marks)

Section 3: Field Effect Transistor (35 Marks in Total)

3.1 Semiconductor basic of FET (10 Marks)

Please use the N channel JFET and N channel enhancement MOSFET as examples to explain why FET is voltage control current components, use the sketch if necessary. Then, explain why FET is often used as input circuits of oscilloscopes, electronic voltmeters and other measuring and testing equipment. (10 Marks)

3.2 FET DC Model (15 Marks)

For the circuit shown in Fig 3.2, the transistor parameters are I_{DSS} = 12 mA, V_T = −3.5 V. Let $R1$ + $R2$ = 100 $k\Omega$, R_S = 0.5 $k\Omega$, V_{DD} = 10 V.

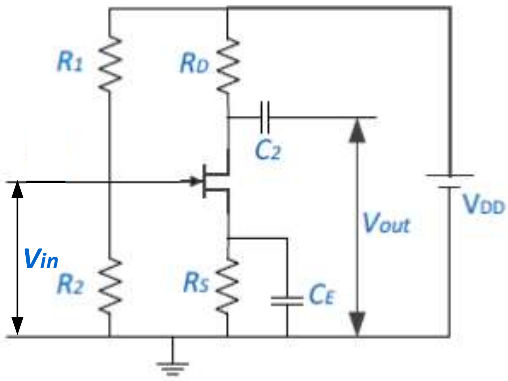


Fig 3.2

3.2.1 Determine the resistors R_1, R_2, R_D values that make JFET in Fig 3.2 works in Saturation Region with I_D = 5 mA and V_{DS} = 5V (10 Marks)

3.2.2 For the circuit in Fig 3.2, please give one solution to make JFET work in Linear Region (just give the description, no need for calculation). (5 Marks)

3.3 FET AC Model/Hybrid-pi Model (10 Marks)

Sketch the small signal model of the circuit in Fig 3.2, and calculate the voltage gain of the small signal according to resistor values determined in 3.2.1. (10 Marks)

Boost Section (maximum 15% boost)

Performance Boost Task:
Design a BJT based amplifier which includes the following features:

1. Using NPN BJT
2. Using Emitter Stabilisation DC bias method
3. Have one AC input signal
4. Using necessary capacitors to separate the AC and DC signals

You need to decide the Vcc, values of resistors and amplitude of input AC signal. The recommended frequency of the AC signal is 60Hz, and values of the necessary capacitors are 1uF (student have the freedom to choose the frequency of AC signal and value capacitors during practice).

Please show the following results:

1. A designed simulation circuit in Multisim (5%)
2. B-E Characteristics: How I_B changes with V_{BE} (2.5%)
3. C-E Characteristics: How I_C changes with V_{CE} (2.5%)
4. An amplified small AC signal from B-E side to C-E side and compare the simulated voltage gain and theoretical calculation. (5%)