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Amrita School of Engineering, Coimbatore

B.Tech Mid-Term Examinations – May 2022

Second Semester

Electrical & Electronics Engineering

19EEE114 Electronic Circuits

Answer Key

Duration: Two hours　　　　　　　　　　　　　　　　Maximum: 50 Marks

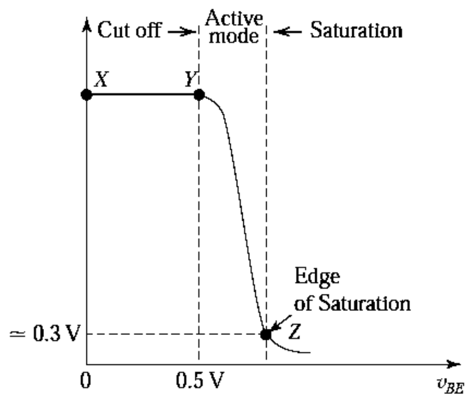
Course Outcomes (COs):

CO	Course Outcomes
CO01	Understanding of the characteristics of electronic devices
CO02	Ability to construct biasing circuits for transistor applications.
CO03	Ability to analyze frequency response of transistor amplifiers using small signal models.
CO04	Ability to design clipper, clamper, multivibrator and oscillator circuits.
CO05	Ability to develop feedback amplifier, voltage regulator and power amplifier circuits.
CO06	Ability to demonstrate electronic circuit performance through hardware and simulation.

Answer all questions

1) Consider the common emitter amplifier skeleton circuit shown below. Assume room temperature and neglect the Early effect. Sketch a voltage transfer characteristic indicating the cut-off, active and saturation regions. Label the plot with an arbitrary Q point in the active region.

Solution:　　　　　　　　　　　　　　　　**(2 marks) [CO02] [BTL 2]**



2) Why does the gain of common emitter amplifier reduce at very low and very high frequencies?

Solution:　　　　　　　　　　　　　　　　**(2 marks) [CO03] [BTL 2]**

The coupling and by pass capacitors offer high capacitive reactance at low frequencies - the input signal is attenuated and the gain is less.

At high frequencies, the reactance offered by base-emitter and base-collector junction capacitance is less – which in parallel with output resistance reduces the gain with increase in frequency.

3) A Zener diode whose nominal voltage is 10 V at 10 mA has an incremental resistance of 50 Ω. Determine the voltage if the diode current is 5 mA. **(2 marks) [CO01] [BTL 3]**

Solution: $V_Z = V_{Z0} + I_Z r_Z$

$10 = V_{Z0} + 50\ \Omega \times 10\ \text{mA}$

$V_{Z0} = 9.5\ \text{V}$ **(1 mark)**

For $I_Z = 5$ mA, $V_Z = 9.5 + 5\ \text{mA} \times 50 = 9.75$ V **(1 mark)**

4) What causes the Early effect in BJT? Give the collector current equation with Early effect and derive an expression for collector resistance. **(3 marks) [CO01] [BTL 2]**

Solution:

At a given value of v_{BE}, increasing v_{CE} increases the reverse-bias voltage on the collector–base junction, and thus increases the width of the depletion region **(1 mark)**

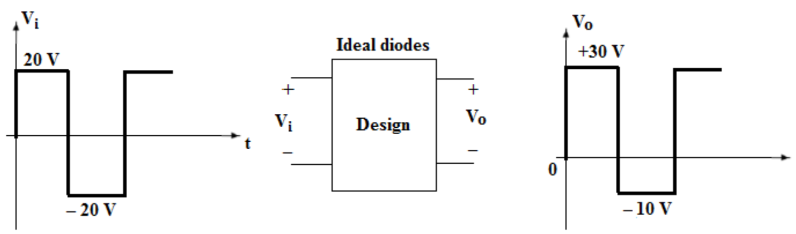
$$i_C = I_S e^{v_{BE}/V_T}\left(1 + \frac{v_{CE}}{V_A}\right)$$

(1 mark)

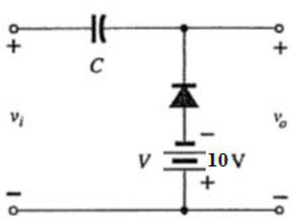
$$r_o \equiv \left[\left.\frac{\partial i_C}{\partial v_{CE}}\right|_{v_{BE} = \text{constant}}\right]^{-1} \qquad r_o = \frac{V_A + V_{CE}}{I_C}$$

(1 mark)

5) Design a clamper to perform the function indicated in figure shown below. **(3 marks) [CO04] [BTL 4]**



Solution:



6) A BJT whose emitter current is fixed at 1 mA has a base-emitter voltage of 0.69 V at 25 ^{0}C. What base-emitter voltage is expected at 100 ^{0}C. **(3 marks) [CO01] [BTL 3]**

Solution:

V_{BE} decreases by 2 mV for every 1^{0}C rise in temperature **(1 mark)**

At 100^{0}C, $V_{BE} = 0.69 - (2\ \text{mV} \times 75)$

$= 0.54$ V **(2 marks)**

7) A source signal of *12sin(100πt)* is connected to the bridge rectifier circuit to charge a dc battery.

(a) What is the peak value of the rectified voltage? **[CO04] [BTL 3]**

Solution: 12 – (2 x 0.7) = 10.6 V **(1 mark)**

(b) Calculate the dc output voltage across the load.

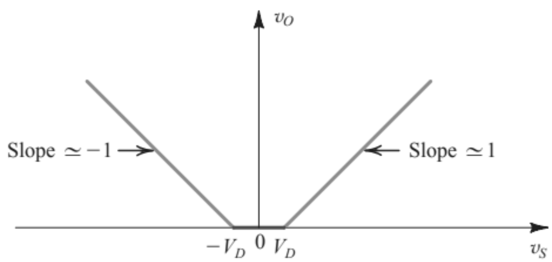
Solution: $2V_m/\pi = 2x10.6/\pi = 6.75$ V **(1 mark)**

(c) What is the PIV of the diode?

Solution: PIV = V_m = 12 V **(1 mark)**

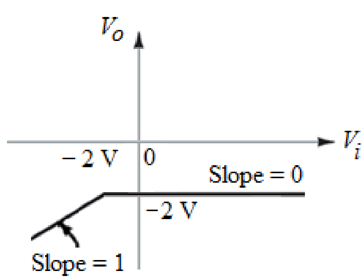
(d) Draw the voltage transfer characteristics of the rectifier circuit.

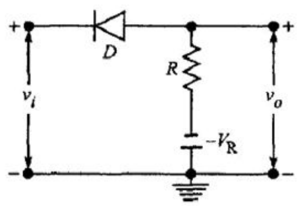
Solution: **(1 mark)**

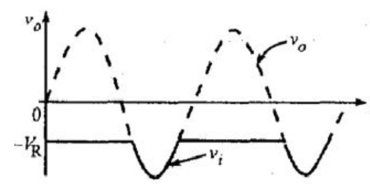


8) Design a clipper circuit using silicon diodes for the transfer characteristics shown below. Also draw the output waveform considering an input sine wave of $v_i = 10\ sin(\omega t)$ V.

Solution: **(4 marks) [CO04] [BTL 4]**

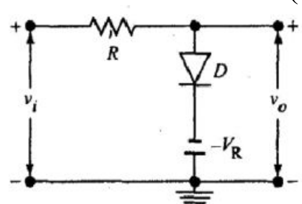


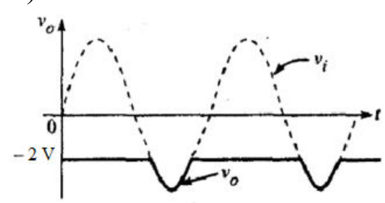




(2 + 2 marks)

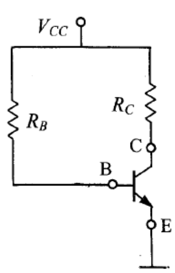
(OR)

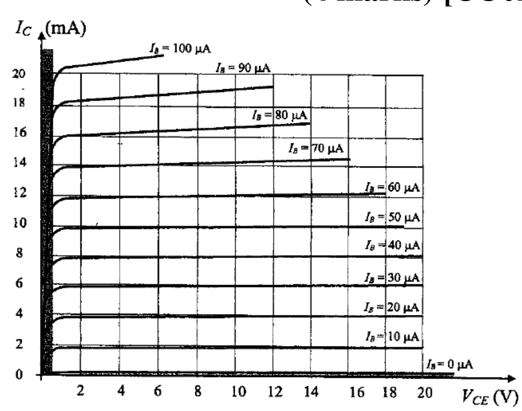




9) Use the Collector Characteristic Curves for I_B, I_C, & V_{CE} to determine values for R_B and R_C for the BJT circuit below. Set the quiescent point at I_{CQ} = 8 mA and V_{CEQ} = 9.5 V with V_{CC} = 16 Volts.

(4 marks) [CO02] [BTL 3]





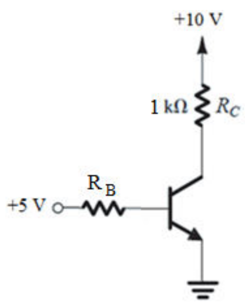
Solution:

$\beta = I_c/I_B = 8mA/40uA = 200$

$R_B = 382.5\ k\Omega$ **(2 marks)**

$R_c = 812.5\ \Omega$ **(2 marks)**

10) The transistor in the circuit below is specified to have β in the range of 50 to 150. Find the value of R_B that results in saturation with an overdrive factor of at least 10. **(4 marks) [CO02] [BTL 3]**



Solution:

$V_C = V_{CEsat} \approx 0.2$ V

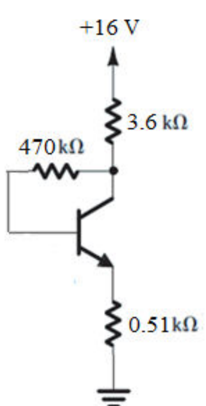
$I_{Csat} = (10 - 0.2) / 1 = 9.8$ mA **(1 mark)**

$I_{B(EOS)} = I_{Csat}/\beta_{min} = 9.8/50 = 0.196$ mA **(1 mark)**

I_B = Overdrive factor x 0.196 = 1.96 mA **(1 mark)**

$R_B = \frac{5-0.7}{1.96} = 2.19\ k\Omega \approx 2.2\ k\Omega$ **(1 mark)**

11) Determine the Q point for the transistor shown in the circuit. Consider a current gain of 120. **(4 marks) [CO02] [BTL 3]**



Solution:

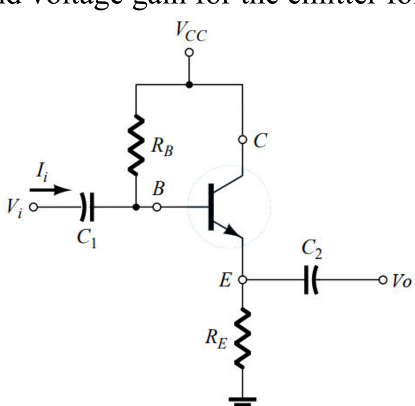
$$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta(R_C + R_E)} = \frac{16\text{ V} - 0.7\text{ V}}{470\text{ k}\Omega + (121)(3.6\text{ k}\Omega + 0.51\text{ k}\Omega)}$$ **(2 marks)**

$= \mathbf{15.88\ \mu A}$

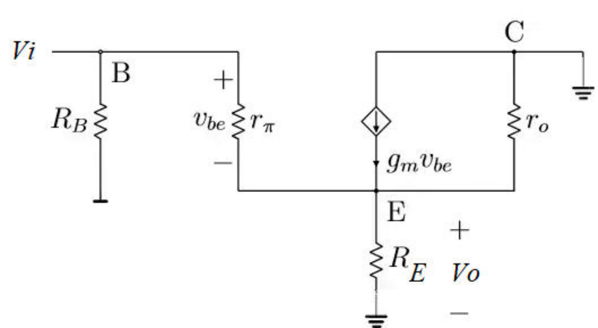
$$I_C = \beta I_B = (120)(15.88\ \mu\text{A})$$
$= \mathbf{1.91\ mA}$ **(1 mark)**

$$V_C = V_{CC} - I_C R_C$$
$= 16\text{ V} - (1.91\text{ mA})(3.6\text{ k}\Omega)$
$= \mathbf{9.12\ V}$ **(1 mark)**

12) With small signal equivalent circuit derive an expression for input resistance, output resistance and voltage gain for the emitter follower configuration given below. **(5 marks) [CO03] [BTL 3]**



Solution:



(2 marks)

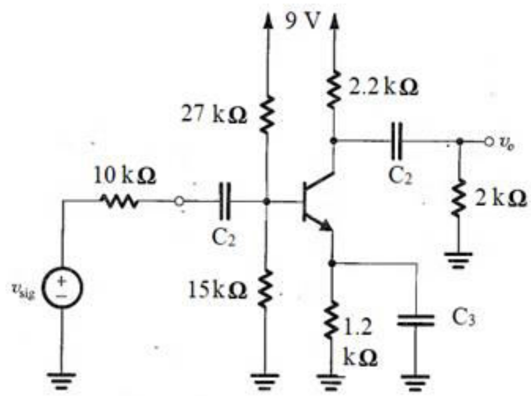
Refer Lecture notes

Input resistance, $R_{in} = R_B \| (r_\pi + (\beta+1) R_E)$ **(1 mark)**

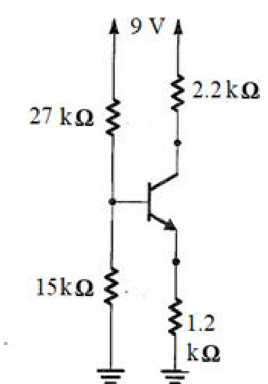
Output resistance, $R_{out} = (r_o \| r_\pi + R_B)$ **(1 mark)**

Voltage gain, $A_v = \dfrac{(\beta+1) R_E}{r_\pi + (\beta+1) R_E} \approx 1$ **(1 mark)**

13) The transistor in the circuit shown has β=100 and V_A= 100. The capacitors are DC blocks and AC short circuits. Assume room temperature.



(a) Draw the DC circuit for Q-point analysis and determine I_C, and V_C. What is the mode of operation of the transistor? **(3 marks)**



Solution:

$V_{BB} = V_{CC} (R_2/R_1+R_2) = 3.21$ V

$R_B = R_1 \| R_2 = 9.64$ kΩ

$I_E = \dfrac{V_{BB} - V_{BE}}{R_E + R_B/(1+\beta)} = 1.94$ mA

$I_C = \alpha\, I_E = 0.99 \times 1.94 = 1.92$ mA **(2 mark)**

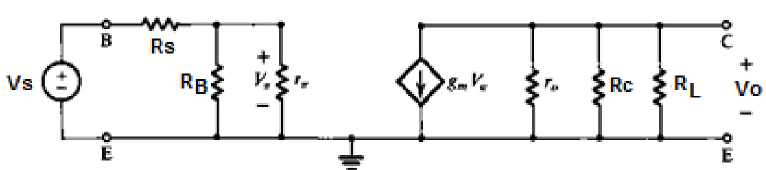
$V_c = V_{cc} - I_cR_c = 4.77$ V

$V_E = I_ER_E = 2.33$ V

$V_{CE} = V_C - V_E = 2.4$ V transistor is in active mode **(1 mark)**

(b) Estimate the small-signal parameters g_m, r_o, and r_π. **(3 marks)**

Solution:



$g_m = I_C / V_T = 76.8$ mA/V **(1 mark)**

$r_o = V_A/I_C = 52.1$ kΩ **(1 mark)**

$r_\pi = \beta/gm = 1.3$ kΩ **(1 mark)**

(c) Calculate the input resistance, output resistance, voltage gain and overall voltage gain of the circuit. **(4 marks) [CO03] [BTL 3]**

Solution:

Input resistance, Rin = $R_B \,||\, r_\pi$ = 9.64||1.3 = 1.15 kΩ **(1 mark)**

Output resistance, Rout = $R_C \,||\, r_o$ = 2.2 || 52.1 = 2.11 kΩ **(1 mark)**

Voltage gain, Av = $-gm(r_o||R_C||\, R_L)$ = -76.8 x 1.027 = -78.87 V/V **(1 mark)**

Overall voltage gain, Gv = $\frac{Rin \times Av}{(Rs+Rin)}$ = -8.13 V/V **(1 mark)**

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Course Outcome / Bloom's Taxonomy Level (BTL) Mark Distribution Table

CO	Marks	BTL	Marks
CO01	**8**	BTL 1	**-**
CO02	**14**	BTL 2	**7**
CO03	**17**	BTL 3	**36**
CO04	**11**	BTL 4	**7**
CO05	**-**	BTL 5	**-**
CO06	**-**	BTL 6	**-**