National Exams December 2016

07-Elec-A5, Electronics

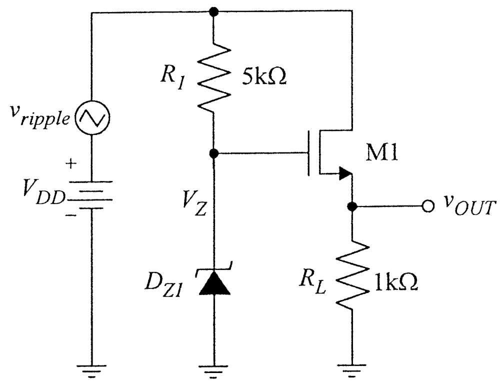
3 hours duration

Notes:

1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a **CLOSED BOOK EXAM**.
   Any non-communicating calculator is permitted.
3. Answer all **FIVE** (5) questions.
4. All questions are worth 20 marks each.
5. Please start each question on a new page and clearly identify the question number and part number, e.g. Q4(a).
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.
7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are ±15V.
8. If questions require an answer in essay format, clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

QUESTION (1)

Given $V_Z = 6.8\text{V}$ at $I_Z = 5\text{mA}$, $r_Z = 20\Omega$, and
for M1, $I_{ZK} = 0.1\text{mA}$ for D_{ZI}. $V_{TH} = 1\text{V}$,
$K = 2\text{mA/V}^2$, and $\lambda = 0$.
$V_{DD} = 20\text{V}$ and $v_{ripple} = \pm 1\text{V}$



(a) Determine the average dc output voltage V_{OUT}.

(b) What is the ripple voltage at the output?

(20 points)

Useful formulae: for n-channel MOSFET

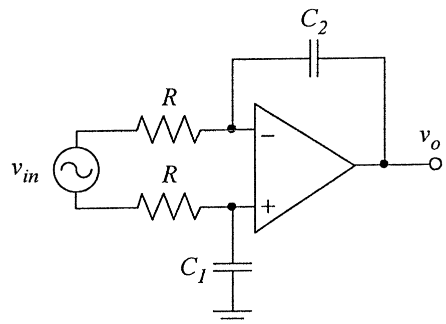
$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \qquad \text{triode region}$$

$$i_{DS} = \frac{1}{2}K(v_{GS} - V_{TH})^2(1 + \lambda v_{DS}) \qquad \text{saturation region}$$

QUESTION (2)

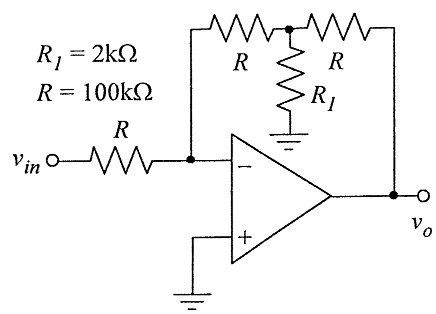
(a) Assuming the op amp is ideal, derive an expression for the output voltage v_o, if the input voltage is given by $v_{in} = V_I \sin(\omega t)$

(10 points)



(b) In the circuit shown, the input offset voltage of the op amp is ±5 mV, otherwise the amplifier can be considered ideal. Find the output offset voltage.

(10 points)



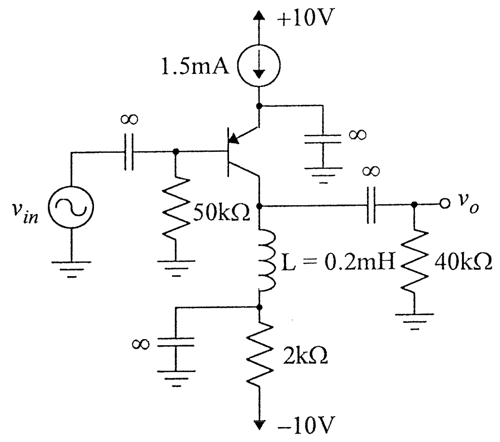
QUESTION (3)

The transistor has $\beta = 100$ and $r_o = 40\text{k}\Omega$

(a) Determine the DC voltages at the base, emitter and collector of the transistor V_B, V_E and V_C.

(b) Draw a small-signal model of the circuit and use it to determine the approximate amplitude of the output voltage if v_{in} is a 10mV, sinusoidal signal of 500 kHz. Note that $\omega L << 20\text{k}\Omega$ at 500kHz.

(20 Points)



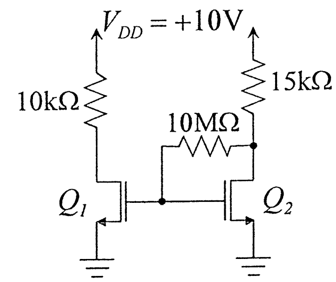
QUESTION (4)

The two MOSFETs are identical with $V_{TH} = 2\text{V}$, $K = 0.1\text{mA/V}^2$, and $\lambda = 0$.

a) Find I_D and V_G of Q_2 (8 points)

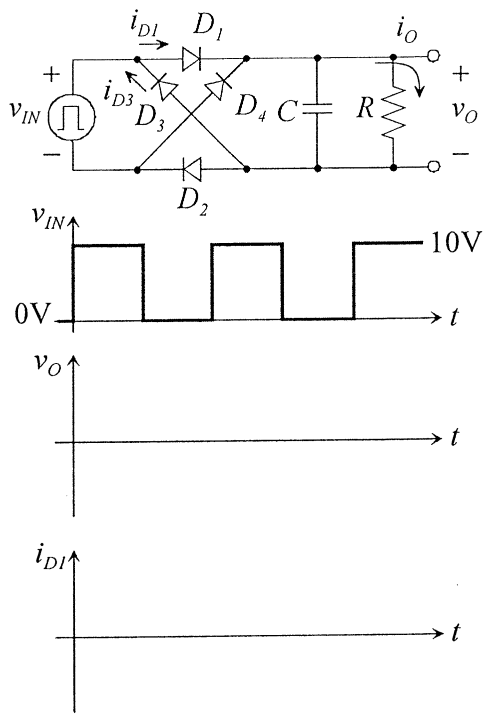
b) Find I_D and V_D of Q_1 (8 points)

c) Find g_m of Q_1 and Q_2 (4 points)



QUESTION (5)

The diodes are ideal except with an on-voltage of 0.7V. The input voltage source v_{IN} is a 100Hz, 50% duty cycle square-wave with voltage levels of 0V and +10V. The load resistance, $R = 100\Omega$.



a) If the ripple voltage, $V_r = 0.5$V, sketch the output waveform for several input cycles. What is the average DC output voltage v_O. (6 points)

b) What would be the minimum value of C (in µF) required to keep $V_r \leq 0.5$V ? (4 points)

c) Sketch the current waveform for i_{D1} flowing through diode D_1. Indicate the time interval that the capacitor is charging. (6 points)

d) What is the overall average current (i_{D3}) flowing through diode D_3? (4 points)