National Exams December 2012

07-Elec-B5, Advanced Electronics

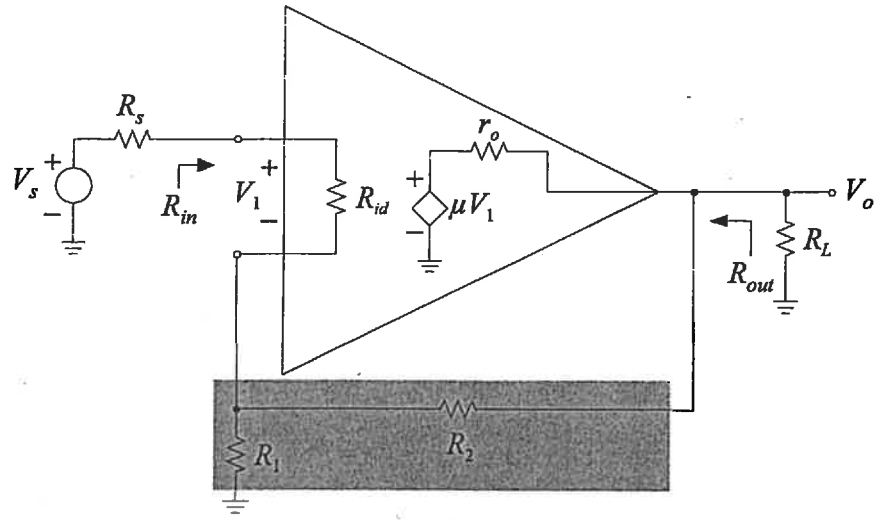
3 hours duration

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.
   One of two calculators is permitted any Casio or Sharp approved models.
3. Any **5 (FIVE)** questions constitute a complete paper. The first five questions as they appear in the answer book will be marked.
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)

The following op amp has a finite gain, finite input resistance and non-zero output resistance.



$\mu = 10^4$ V/V

$R_{id} = 100$ kΩ

$r_o = 1$ kΩ

Given:

$R_L = 2$ kΩ

$R_s = 10$ kΩ

$R_1 = 1$ kΩ

$R_2 = 1$ MΩ

Using feedback theory, determine the following parameters:

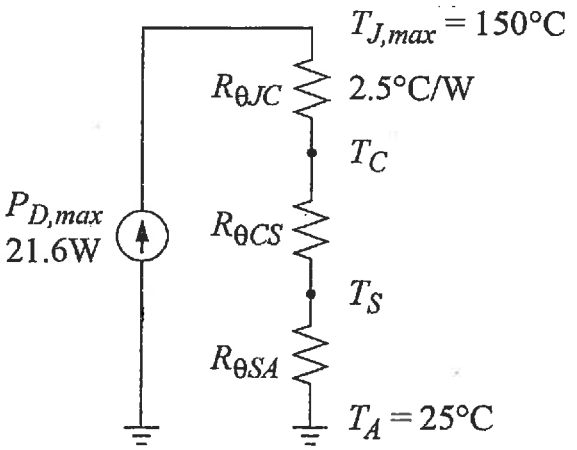
a) voltage gain, V_O/V_S (8 points)

b) input resistance, R_{in} (6 points)

c) output resistance, R_{out} (6 points)

QUESTION (2)

In a particular power amplifier design, the power transistor needs to dissipate 21.6W, and the data sheet for this transistor specified a die to case thermal resistance of $R_{\theta JC} = 2.5$°C/W. If the ambient temperature is $T_A = 25$°C, what is the maximum allowable case-to-ambient thermal resistance, $R_{\theta CA} = R_{\theta CS} + R_{\theta SA}$? (20 points)



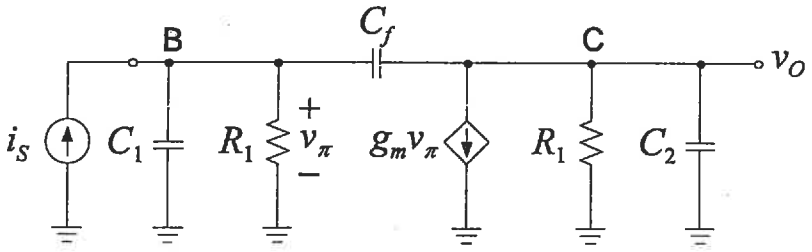
Note:

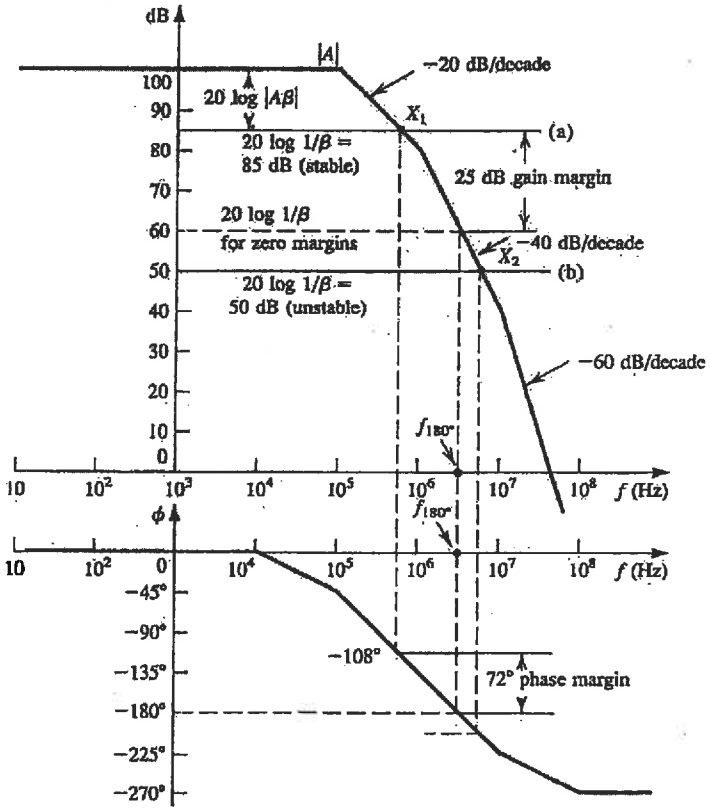
$R_{\theta CS}$ = case-to-heat sink thermal resistance

$R_{\theta SA}$ = heat sink-to-ambient thermal resistance

QUESTION (3)

An op amp has an open-loop transfer function (without C_f) and the corresponding equivalent circuit as shown below. The open-loop first pole and second pole locations are at 0.1 MHz and 1 MHz, respectively. The first pole is caused by the input circuit of that stage, and that the second pole is introduced by the output circuit. Compensate this op amp using C_f such that it will be stable. Provide justification for your choice of C_f. What will be the frequencies of the new first and second poles? What will be the new phase margin? (20 points)





Source: Sedra and Smith, Microelectronics

Given:

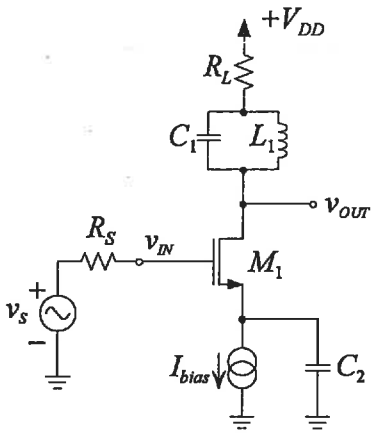
$C_1 = 100$ pF

$C_2 = 5$ pF

$g_m = 40$m A/V

QUESTION (4)

In the following tuned amplifier circuit, transistor M_1 is biased with I_{bias} =2 mA. The transistor parameters are given as K= 1 mA/V^2, V_{TH} = 1 V, C_{gs} = 10 pF, C_{gd} = 1 pF, and $\lambda = 0$.



For: V_{DD} = 10 V,
L_1 = 1 µH
C_1 = 200 pF, $C_2 = \infty$
R_S = 1 kΩ, R_L = 2 kΩ

a) What is the center frequency, ω_o of this amplifier? (4 points)

b) What is the gain v_{OUT}/v_S at $\omega = \omega_o$? (8 points)

c) What is the 3dB bandwidth of this tuned amplifier? (8 points)

Useful formulae: for n-channel MOSFET

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

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

QUESTION (5)

An analog signal in the range -0 to + 10 V is to be converted to an 8-bif digital signal.

a) What is the resolution of the conversion in volts? (4 points)

b) What is the digital representation of an input of 6 V? (4 points)

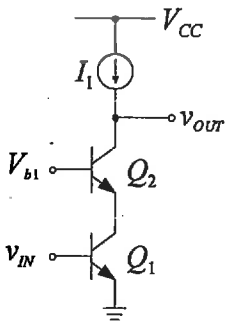
c) What is the representation of an input of 6.2 V? (4 points)

d) What is the error made in the quantization of 6.2 V in absolute terms and in percentage of the input? And as a percent of full scale? (4 points)

e) What is the largest possible quantization error as a percentage of full scale? (4 points)

QUESTION (6)

The bipolar circuit is biased with a current of I_1 = 1mA. Determine the voltage gain v_{OUT}/v_{IN}. (20 points)



Given:

$\beta = 100$
$V_A = 5$ V