Indian Institute of Space Science and Technology
Department of Avionics
AV 211 Analog Electronic Circuits
End Semester Examination

Time: 3 hours **Max. marks:** 50

There is a choice between Qn. 4 & Qn. 5 and between Qn. 7 & Qn. 8. All other questions are compulsory.

1. It is required to design a Class B power amplifier to deliver an average output power of 20W to an 8Ω load. The power supplies are to be selected such that they are about 5V greater than the peak output voltage. (You can consider a sinusoidal signal.) This avoids transistor saturation and the associated non-linear distortion. The amplifier runs on bipolar supply.

   (a) Determine the power supply voltages required (to the nearest volt in the appropriate direction). (2 marks)

   (b) Determine the peak current drawn from each supply while delivering 20 W to the load. (1 mark)

   (c) What is the total supply power drawn when the amplifier supplies a power of 20W to the load? You can assume ideal Class-B operation. (*The DC fourier component of a half-wave rectified sinewave of amplitude A is* A/π.) (2 marks)

   (d) Calculate the efficiency corresponding to a 20W output. (1 mark)

   (e) Draw the complete circuit and add suitable elements to provide short circuit protection and thermal stability and provide the component values. You can assume that the transistor turns on at 4A ~~0.6V~~. Explain how the short-circuit protection and thermal stability are achieved by your design. (2 marks)

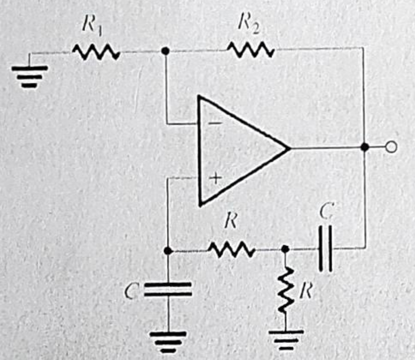
   (f) When the transistor turn-on voltage of 0.6V is considered, sketch the waveforms of the input voltage, emitter currents and output voltage. Define cross-over distortion. (2 marks)

2. Consider two signals $v_1(t) = 2 + 0.7\sin(2\pi 50t) + 0.004\sin(2\pi 2900t)$ and $v_1(t) = 2 + 0.7\sin(2\pi 50t) - 0.004\sin(2\pi 2900t) + 0.01\sin(2\pi 3500t)$. Write down the differential signal components and the common mode signal components. (2 marks)

3. Design an op-amp RC low pass filter with a low frequency gain of close to 25 V/V with a cut-off frequency of around 20 kHz. You are required

to choose standard resistor values from Figure 1 only (provided at the end of the question paper). The available capacitor values are 470nF, 100nF, 47nF, 10nF, 4.7nF, 1nF, 0.1nF, 0.01 nF. With these components, what is the actual gain and 3-dB frequency that you obtain? (5 marks)

4. Consider the circuit shown below. Derive the loop gain $L(s)$, $L(j\omega)$, the frequency at which the phase is 0, the required R_2/R_1 for sustained oscillations. (10 marks)

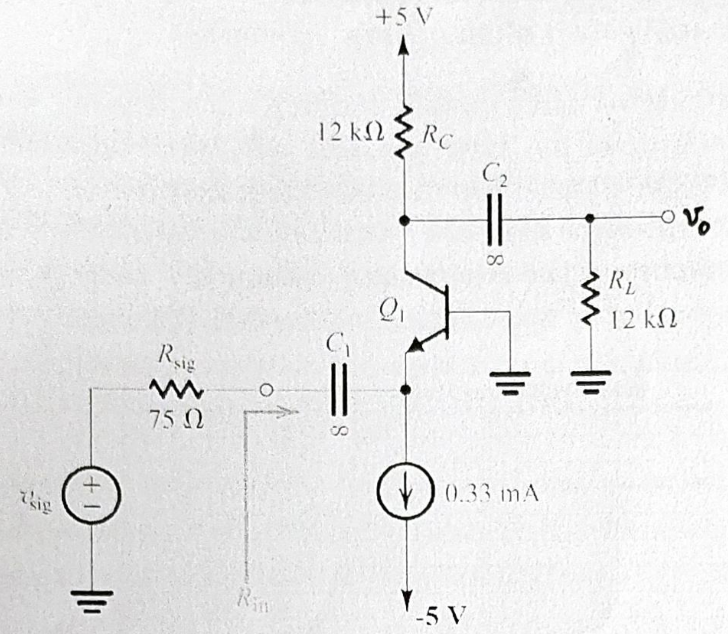


OR

5. Draw the circuit of a Colpitts oscillator. Draw the equivalent circuit diagram and derive the conditions for oscillations and the frequency of oscillation. You may neglect C_μ and r_π of the BJT for simplified analysis. (10 marks)

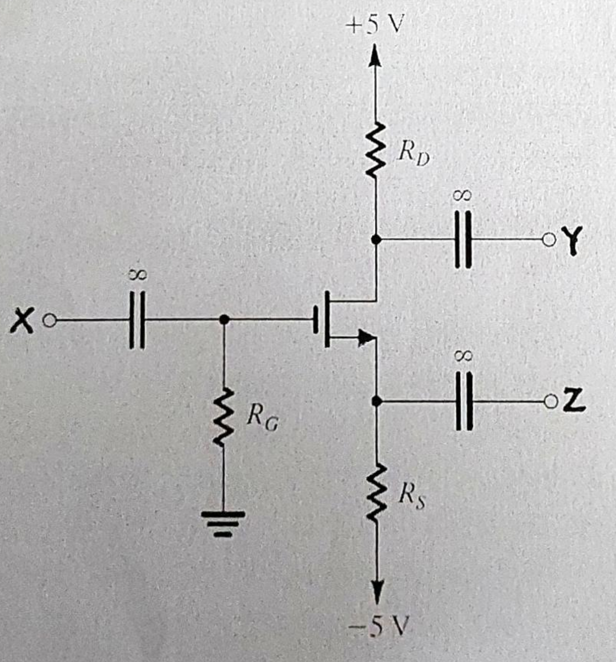
6. A pulse of 10ms is required to be generated using a 555 timer, every time a trigger occurs. The trigger goes from V_{CC} to 0V for a brief period of time. Design a suitable circuit for the same. Draw the complete circuit. Derive the expressions for the time period. Use resistors only from the standard resistor values in Figure 1, provided at the end of the question paper. The available capacitor values are 47μF, 10μF, 4.7μF, 1μF, 470nF, 100nF, 47nF, 10nF, 4.7nF, 1nF. Using these components, what is the actual time period that you obtain? (8 marks)

7. For the circuit given below, take $\alpha = 0.99$. Draw the complete small signal circuit. What is the input resistance R_{in}? Derive and calculate the overall gain $\frac{v_o}{v_{sig}}$. (8 marks)



OR

8. Consider the circuit shown below. Draw the small signal equivalent circuit and derive the gain $\frac{Y}{X}$ and the gain $\frac{Z}{X}$. (8 marks)



9. An opamp is said to have an input bias current of 100nA with an input offset current of 8nA. The opamp's offset voltage is measured to 12 mV. The datasheet specifies an open loop gain of 10^5 with a gain bandwidth product of 10 MHz. Define each of these terms and illustrate

them in terms of the terminal characteristics (voltages or currents at each terminal as applicable) of an opamp. (3 marks)

10. Draw an ideal integrator using opamp and derive its transfer function. What is the drawback of it? How is a real integrator designed using an opamp? Derive its transfer function and comment on the choice of components that will make it as close to an ideal integrator. Compare the frequency response of the two designs. (4 marks)

Standard Resistor Values (±5%)						
1.0	10	100	1.0K	10K	100K	1.0M
1.1	11	110	1.1K	11K	110K	1.1M
1.2	12	120	1.2K	12K	120K	1.2M
1.3	13	130	1.3K	13K	130K	1.3M
1.5	15	150	1.5K	15K	150K	1.5M
1.6	16	160	1.6K	16K	160K	1.6M
1.8	18	180	1.8K	18K	180K	1.8M
2.0	20	200	2.0K	20K	200K	2.0M
2.2	22	220	2.2K	22K	220K	2.2M
2.4	24	240	2.4K	24K	240K	2.4M
2.7	27	270	2.7K	27K	270K	2.7M
3.0	30	300	3.0K	30K	300K	3.0M
3.3	33	330	3.3K	33K	330K	3.3M
3.6	36	360	3.6K	36K	360K	3.6M
3.9	39	390	3.9K	39K	390K	3.9M
4.3	43	430	4.3K	43K	430K	4.3M
4.7	47	470	4.7K	47K	470K	4.7M
5.1	51	510	5.1K	51K	510K	5.1M
5.6	56	560	5.6K	56K	560K	5.6M
6.2	62	620	6.2K	62K	620K	6.2M
6.8	68	680	6.8K	68K	680K	6.8M
7.5	75	750	7.5K	75K	750K	7.5M
8.2	82	820	8.2K	82K	820K	8.2M
9.1	91	910	9.1K	91K	910K	9.1M

Figure 1: Standard resistor values