Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – II • EXAMINATION – WINTER • 2013

Subject code: 1720302 **Date: 27-12-2013**

Subject Name: Advance Instrumentation

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Figures to the right indicate full marks.**
3. **Make suitable assumptions wherever necessary and mention it clearly in your solution.**
4. **Consider design parameters of 741 opamp when not mentioned explicitly in question.**
5. **Necessary circuit diagrams are must while deriving for equations.**
6. **Show all node voltages and branch currents used in your derivations.**

Q.1 Derive the equation of feedback factor β for the circuit in figure 1 if rd = 2 MΩ and r0 = 75 Ω. Justify whether it is positive feedback circuit or negative feedback circuit. **14**

Q.2 **(a)** Find the gain of the circuit in figure 2 known as dual op-amp instrumentation amplifier with variable gain. Consider virtual short condition. **07**

(b) Illustrate slew rate with necessary waveforms and derivations. An opamp shown in figure 3 has an input bias current of 20 μA and a compensation capacitance Cc of 30 pF, and slew rate of 0.633V/μs, find its response vo(t) to a step input of -0.5 V. Consider R1 = 3KΩ and R2 = 12KΩ. **07**

OR

(b) Explain frequency compensation using loop-gain reduction method with the help of necessary diagrams and equations. **07**

Q.3 Draw the circuit diagram of strain-gauge bridge, having four strain-gauges, connected with instrumentation amplifier (IA), referred to as a load cell, and having calibration facility to account for gauge resistances and reference voltage tolerances. **14**

(i) Derive the relationship of output voltage with gain of IA, reference voltage, and fractional change in resistance δ.

(ii) Let the strain-gauges be of 100Ω, ± 1 % types and their maximum power dissipation limited to 20 mW to avoid excessive self heating. Assume that V_{REF} =10V ± 5%, specify suitable values for R1 through R4 used for calibration.

(iii) Outline the calibration procedure.

OR

Q.3 Draw the circuit diagram of single op-amp bridge amplifier having transducer connected to only one arm of the bridge. **14**

(i) Derive the relationship of output voltage with fractional change in resistance δ. What is the disadvantage of this bridge?

(ii) Let the transducer Pt. RTD having a temperature coefficient of 0.00392/ ^{o}C is connected to one arm of the bridge and let V_{REF}=10 V. Specify values for resistors and gain A suitable for achieving an output sensitivity of 0.15 V/ ^{o}C near 0 ^{o}C. To avoid self heating in the RTD, limit its power dissipation to less than 0.15 mW.

(iii) Compute output voltage at 100 ^{o}C.

Q.4 **(a)** Draw the circuit diagrams of Howland and Improved Howland circuits and prove the advantage of Improved Howland circuit over Howland circuit by suitable example. **07**

(b) Explain the effect of finite gain bandwidth product on integrator circuits with the help of diagrams and equations. **07**

OR

Q.4 Derive the equations of Adm, Acm, and $CMRR_{dB}$ for difference amplifier shown in figure 4. If the resistance R1 = 1.01 KΩ, R2 = 99.7 KΩ, R3 = 0.995 KΩ, R4 = 102 KΩ, estimate Adm, Acm, and $CMRR_{dB}$. **14**

Q.5 **(a)** Draw the circuit diagram of second order high-pass KRC filter and derive equations for dc gain, ω0, and Q. Design a filter with f_0 = 500 Hz and Q = 2 using unity gain circuit. **07**

(b) For the circuit diagram shown in figure 5 derive the equation to find output dc noise voltage. Suggest a way to reduce this noise voltage. Justify your suggestion. If R1=33KΩ, R2=3.3MΩ, op amp input bias current of 80 nA and input offset current of 20 nA then calculate output dc noise voltage when (i) Rp=0 and (ii) Rp= R1 || R2. **07**

OR

Q.5 **(a)** Draw the circuit diagram of second order band-pass KRC filter and derive equations for dc gain, and ω0. Design a filter with f_0 = 1000 Hz and bandwidth of 200 Hz. What is its resonance gain? **07**

(b) The difference amplifier of figure 6 uses a 741 opamp having CMRR of 90dB and perfectly matched resistances R1=15KΩ and R2=150KΩ. If the inputs are tied together and driven with a common signal v_I (i.e v1 = v2 = v_I) then estimate the typical change in vo if (i) vi is slowly changed from 0 to 10V and (ii) vi is a 10 KHz, 10 V peak to peak sine wave. Consider CMRR at 10 KHz of 57 dB. **07**

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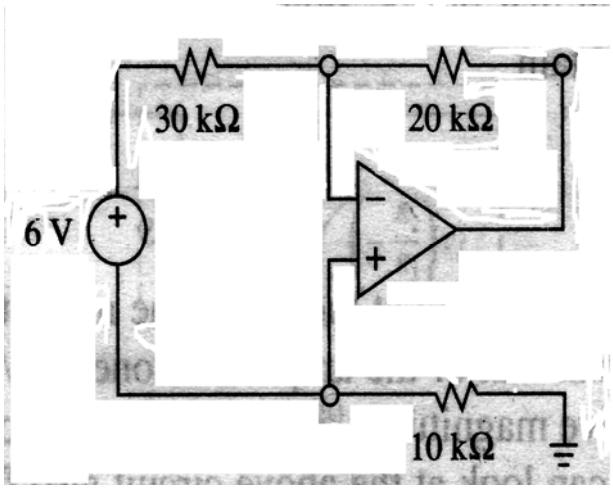

Figure-1

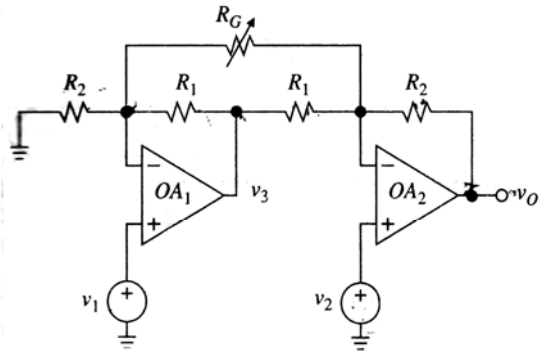

Figure-2

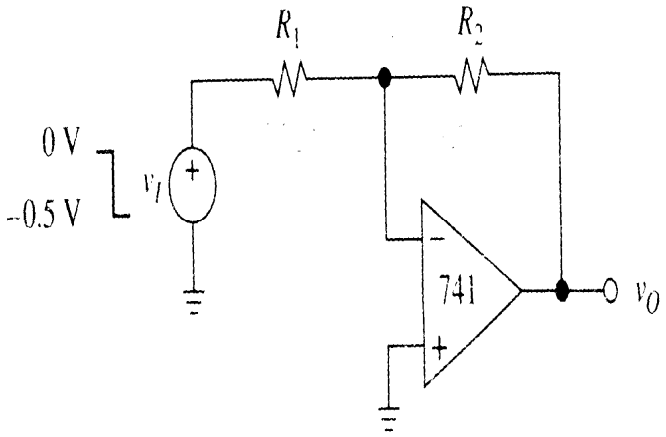

Figure-3

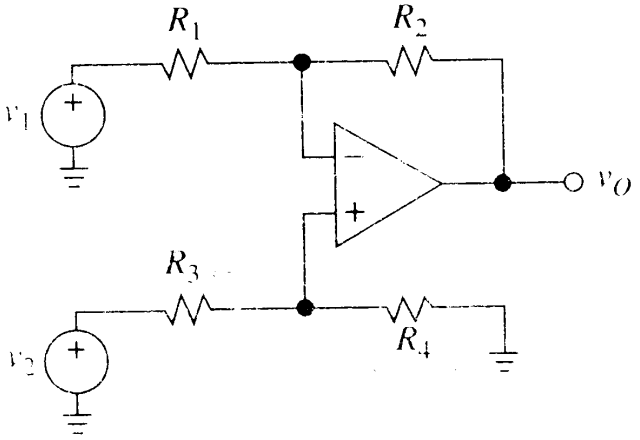

Figure-4

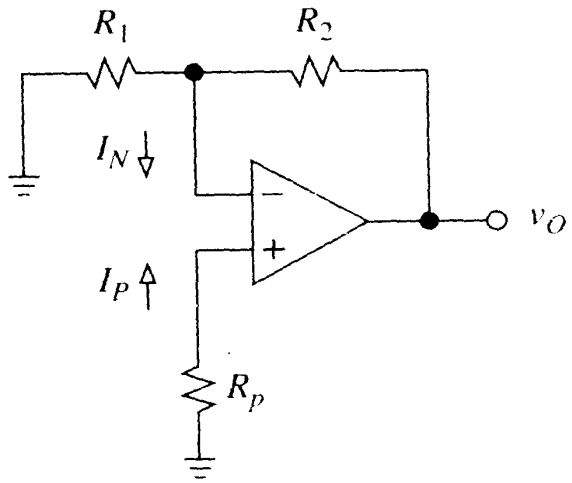

Figure-5

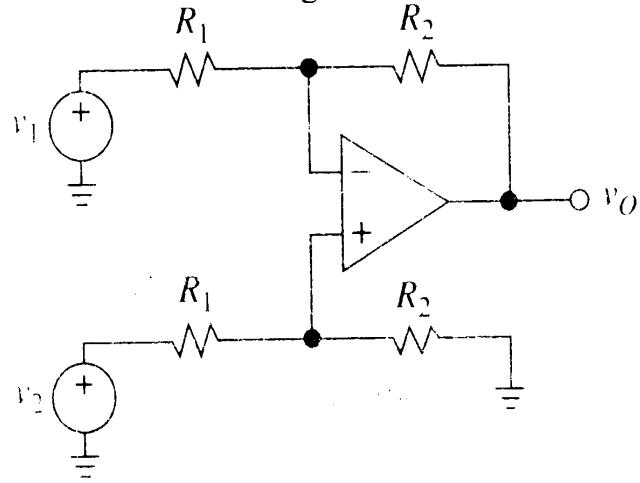

Figure-6