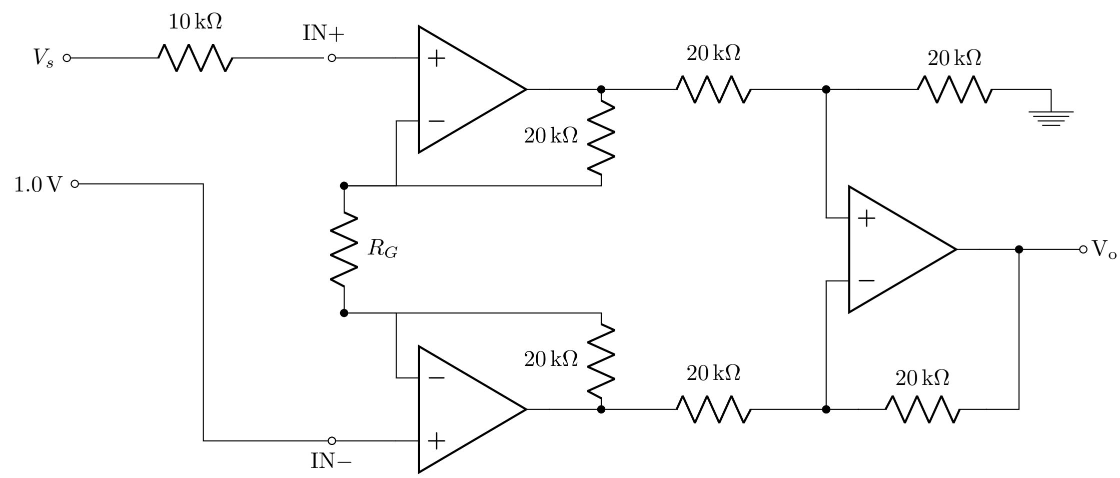
Instructions:

- This quiz lasts 30 minutes. Answer all questions (on both sides of the sheet)
- You may have a 8.5" × 11" sheet of notes and a non-network-connected calculator

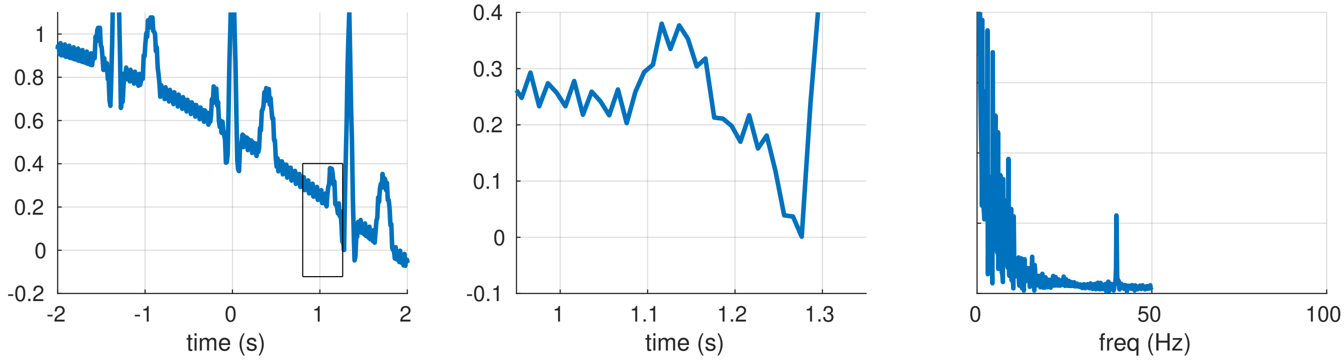
Q1a: An instrumentation amplifier is connected to a sensor which gives [in Volts]: $V_s = 1.0 + 0.002\sin(\omega t)$, where $\omega = 2\pi(1\,\text{kHz})$. The output impedance of the sensor is $20\,\text{k}\Omega$. Initially, assume all components are ideal.

1. (5 marks) Calculate R_G so that the output [in Volts], $V_o = 10\sin(\omega t)$.
2. (5 marks) As the temperature increases, the internal resistors in the instrumentation amplifier change (and become unbalanced) so that CMRR = 80 dB. Calculate the new V_o.
3. (5 marks) Sketch V_o if the slew rate, $SR = 50\,\text{V/ms}$. (Assume again that CMRR = ∞)



Q2a: (15 marks) The graph below shows the an ECG signal measured by an ADC. The centre graph is a zoomed-in version of the region in a black box on the right. There is an interference from 60 Hz power-line noise.

1. (5 marks) Label the P,Q,R,S and T waves in the ECG. Briefly explain (1 sentence) what happens during the P wave.
2. (5 marks) Based on the figures, there is at least one problem with the ADC configuration chosen. Is there a problem with the i) ADC range, ii) ADC resolution, iii) Sampling frequency? Briefly justify (1 sentence) why.
3. (5 marks) For the parameter (ADC range, ADC resolution, or Sampling frequency) that you have identified above, estimate (±10%) its value in the ADC system.



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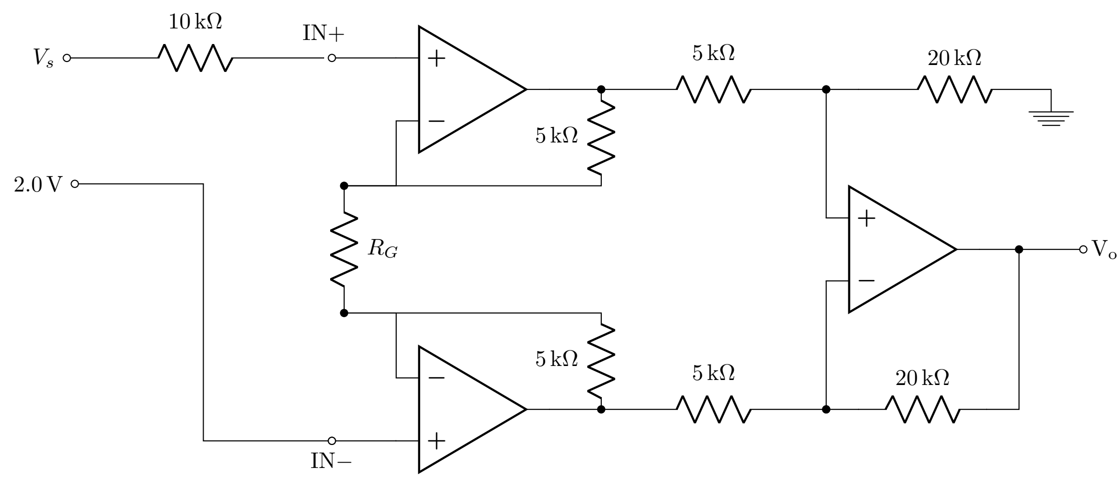
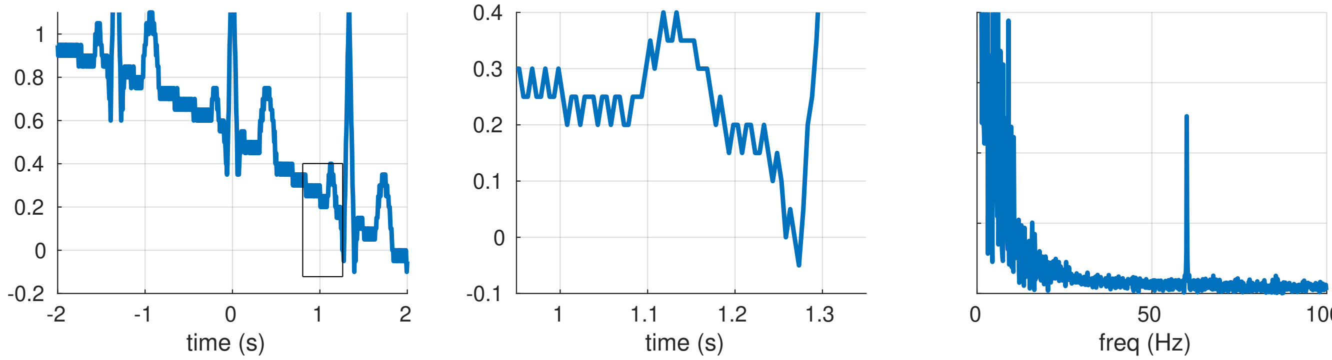
Q1b: An instrumentation amplifier is connected to a sensor which gives [in Volts]: $V_s = 2.0 + 0.002\sin(\omega t)$, where $\omega = 2\pi(1\,\text{kHz})$. The output impedance of the sensor is $5\,\text{k}\Omega$. Initially, assume all components are ideal.

1. (5 marks) Calculate R_G so that the output [in Volts], $V_o = 2.5\sin(\omega t)$.
2. (5 marks) As the temperature increases, the internal resistors in the instrumentation amplifier change (and become unbalanced) so that CMRR = 70 dB. Calculate the new V_o.
3. (5 marks) Calculate V_o if the input bias current, $I_B = 100\,\text{nA}$. (Assume again that CMRR = ∞)



Q2b: (15 marks) The graph below shows the an ECG signal measured by an ADC. The centre graph is a zoomed-in version of the region in a black box on the right. There is an interference from 60 Hz power-line noise.

1. (5 marks) Label the P,Q,R,S and T waves in the ECG. Briefly explain (1 sentence) what happens during the QRS.
2. (5 marks) Based on the figures, there is at least one problem with the ADC configuration chosen. Is there a problem with the i) ADC range, ii) ADC resolution, iii) Sampling frequency? Briefly justify (1 sentence) why.
3. (5 marks) For the parameter (ADC range, ADC resolution, or Sampling frequency) that you have identified above, estimate (±10%) its value in the ADC system.

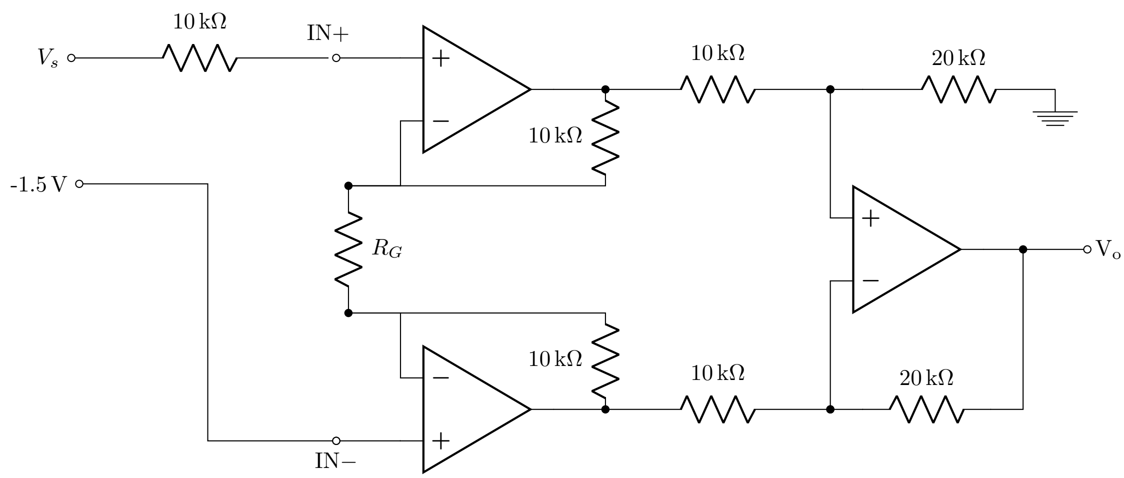


Instructions:

- This quiz lasts 30 minutes. Answer all questions (on both sides of the sheet)
- You may have a 8.5" × 11" sheet of notes and a non-network-connected calculator

Q1c: An instrumentation amplifier is connected to a sensor which gives [in Volts]: $V_s = -1.5 + 0.002\sin(\omega t)$, where $\omega = 2\pi(1\,\text{kHz})$. The output impedance of the sensor is $10\,\text{k}\Omega$. Initially, assume all components are ideal.

1. (5 marks) Calculate R_G so that the output [in Volts], $V_o = 1.5\sin(\omega t)$.
2. (5 marks) As the temperature increases, the internal resistors in the instrumentation amplifier change (and become unbalanced) so that CMRR = 60 dB. Calculate the new V_o.
3. (5 marks) Calculate V_o if the G·BW product, $f_T = 150\,\text{kHz}$. (Assume again that CMRR = ∞)



Q2c: (15 marks) The graph below shows the an ECG signal measured by an ADC. The centre graph is a zoomed-in version of the region in a black box on the right. There is an interference from 60 Hz power-line noise.

1. (5 marks) Label the P,Q,R,S and T waves in the ECG. Briefly explain (1 sentence) what happens during the T wave.
2. (5 marks) Based on the figures, there is at least one problem with the ADC configuration chosen. Is there a problem with the i) ADC range, ii) ADC resolution, iii) Sampling frequency? Briefly justify (1 sentence) why.
3. (5 marks) For the parameter (ADC range, ADC resolution, or Sampling frequency) that you have identified above, estimate (±10%) its value in the ADC system.