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QUESTION WORKBOOK

Operational amplifiers

Electronics · Year 13

AQA 3.13.2

17 questions · 51 marks

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SECTION A · Warm-up

A1 State the four properties of an ideal operational amplifier. [2]

A2 Write down the open-loop relation for an operational amplifier, and explain what is meant by saturation. [2]

A3 State what negative feedback gives away in an operational amplifier circuit, and give two things it buys. [2]

A4 Explain what is meant by the virtual earth in an inverting amplifier. [2]

A5 State two differences between an inverting and a non-inverting amplifier, other than the equations for their gains. [2]

A6 State the relationship between the closed-loop gain of an amplifier and its bandwidth, and state what happens to the bandwidth when the gain is increased by a factor of ten. [2]

SECTION B · Standard

B1 An operational amplifier has an open-loop gain of 1.0×10^5 and its output saturates at ±13 V. Calculate the difference between its input voltages that is just enough to drive the output to the positive rail, and state what happens for any larger difference. [3]

B2 An inverting amplifier uses R_{in} = 4.7 kΩ and R_f = 82 kΩ. Calculate its closed-loop gain and its output for an input of 0.25 V. [3]

B3 A non-inverting amplifier uses R_1 = 2.2 kΩ with R_f = 33 kΩ. Calculate its closed-loop gain and its output for an input of 0.60 V. [3]

B4 An inverting amplifier has R_{in} = 22 kΩ and R_f = 56 kΩ, and its input is 0.44 V. Calculate the current into the inverting input node and hence the output voltage, working from the currents rather than from the gain equation. [3]

B5 An operational amplifier has a gain-bandwidth product of 1.0 MHz. Calculate the bandwidth available at a closed-loop gain of 200, and the bandwidth at a closed-loop gain of 25. [3]

B6 An inverting amplifier with R_{in} = 6.0 kΩ and R_f = 120 kΩ runs from supplies that let its output saturate at ±13 V. Determine the output for an input of 0.90 V, and the largest input the amplifier can handle linearly. [3]

B7 An operational amplifier with an open-loop gain of 1.0×10^5 and rails at ±13 V is used with no feedback as a comparator. Its non-inverting input is at 2.62 V and its inverting input is held at a reference of 2.50 V. State the output voltage, and justify it. [2]

SECTION C · Stretch

C1 A sensor delivers a 15 mV peak signal that must be amplified to 3.0 V peak and must stay flat to 25 kHz. The available op-amps have a gain-bandwidth product of 1.0 MHz and saturate at ±13 V. Calculate the overall gain needed, show that a single stage cannot provide it at that bandwidth, and design a two-stage inverting chain that can, checking the bandwidth of each stage and the output against the rails. [7]

C2 An inverting amplifier is to have a gain of −25 and an input resistance of 4.7 kΩ. Calculate the feedback resistance required, state the gain obtained if the nearest preferred value of 120 kΩ is fitted instead, and calculate the percentage error in the gain. [4]

C3 A comparator runs from ±13 V rails and senses light from a 12 V sensing supply. Its inverting input is fed from the junction of two equal 10 kΩ resistors connected across that 12 V supply. Its non-inverting input is fed from the junction of a light-dependent resistor connected to +12 V and a 4.7 kΩ resistor connected to 0 V. Calculate the reference voltage, calculate the LDR resistance at which the output changes state, and state which way the output moves as the light level falls.

[4]

C4 An operational amplifier has an open-loop gain of 1.0×10^5 and a gain-bandwidth product of 1.0 MHz. Calculate the frequency up to which the open-loop gain holds up, and explain why a designer who wants a flat response to 100 kHz cannot have a closed-loop gain of 1000. [4]