



QUESTION WORKBOOK

Operational amplifiers

Electronics · Year 13

AQA 3.13.2.1, 3.13.3.2, 3.13.4.1, 3.13.4.2, 3.13.4.4

17 questions · 51 marks

PRINT EDITION

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 $R_{in} = 4.7 \text{ k}\Omega$ and $R_f = 82 \text{ k}\Omega$. Calculate its closed-loop gain and its output for an input of 0.25 V . [3]

- B3** A non-inverting amplifier uses $R_1 = 2.2 \text{ k}\Omega$ with $R_f = 33 \text{ k}\Omega$. Calculate its closed-loop gain and its output for an input of 0.60 V . [3]

- B4** An inverting amplifier has $R_{in} = 22 \text{ k}\Omega$ and $R_f = 56 \text{ k}\Omega$, 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 $R_{in} = 6.0 \text{ k}\Omega$ and $R_f = 120 \text{ k}\Omega$ runs from supplies that let its output saturate at $\pm 13 \text{ V}$. 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 $\pm 13 \text{ V}$ 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 have a bandwidth of at least 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 $4.7 \text{ k}\Omega$. Calculate the feedback resistance required, state the gain obtained if the nearest preferred value of $120 \text{ k}\Omega$ is fitted instead, and calculate the percentage error in the gain. [4]

- C3** A comparator runs from $\pm 13\text{ V}$ rails and senses light from a 12 V sensing supply. Its inverting input is fed from the junction of two equal $10\text{ k}\Omega$ resistors connected across that 12 V supply. Its non-inverting input is fed from the junction of a light-dependent resistor connected to $+12\text{ V}$ and a $4.7\text{ k}\Omega$ 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]