

BME 311

Biomedical Instrumentation I



05 – Instrumentation Amplifier
Question



Faculty of Engineering

Department of Biomedical Engineering

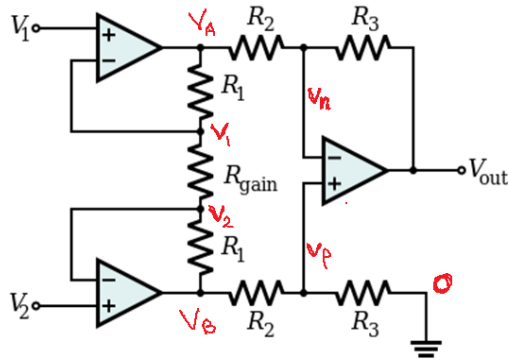
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ECG -1



In the circuit above, the noise and signal for ECG are modelled. Find V_{out} for a differential gain of 50 and CMRR of 40db.

Instrumentation amplifier



$$\frac{(V_1 - V_2)}{R_g} = \frac{(V_A - V_1)}{R_1} = \frac{(V_2 - V_B)}{R_1}$$

$$V_1 \frac{R_1}{R_g} - V_2 \frac{R_1}{R_g} = V_A - V_1$$

$$V_1 \left(\frac{R_1}{R_g} + 1 \right) - V_2 \frac{R_1}{R_g} = V_A$$

$$V_2 \left(\frac{R_1}{R_g} + 1 \right) - V_1 \frac{R_1}{R_g} = V_B$$

$$V_p = \frac{V_B \cdot R_3}{(R_2 + R_3)} \Rightarrow V_n, \quad \frac{V_A - V_n}{R_2} = \frac{V_n - V_{out}}{R_3}, \quad V_A \frac{R_3}{R_2} - V_n \frac{R_3}{R_2} = V_n - V_{out}$$

$$V_{out} = V_n \left(\frac{R_3}{R_2} + 1 \right) - V_A \frac{R_3}{R_2}, \quad V_{out} = V_n \left(\frac{R_3 + R_2}{R_2} \right) - V_A \frac{R_3}{R_2}$$

$$V_{out} = \frac{V_B \cdot R_3}{(R_2 + R_3)} \cdot \frac{(R_3 + R_2)}{R_2} - V_A \frac{R_3}{R_2}, \quad V_{out} = (V_B - V_A) \left(\frac{R_3}{R_2} \right)$$

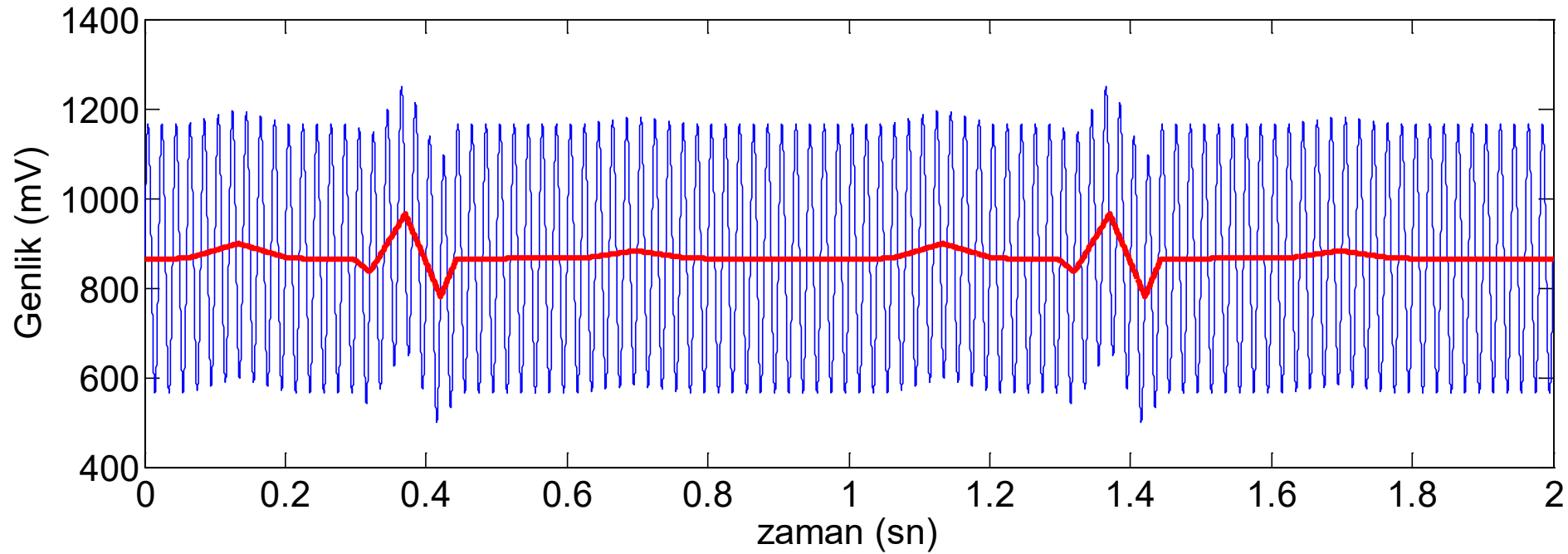
$$V_{out} = \left(V_2 \left(\frac{R_1}{R_g} + 1 \right) - V_1 \frac{R_1}{R_g} - V_1 \left(\frac{R_1}{R_g} + 1 \right) + V_2 \frac{R_1}{R_g} \right) \frac{R_3}{R_2}$$

$$V_{out} = \left(V_2 \left(\frac{2R_1}{R_g} + 1 \right) - V_1 \left(\frac{2R_1}{R_g} + 1 \right) \right) \frac{R_3}{R_2}$$

$$V_{out} = (V_2 - V_1) \left(\frac{2R_1}{R_g} + 1 \right) \left(\frac{R_3}{R_2} \right)$$

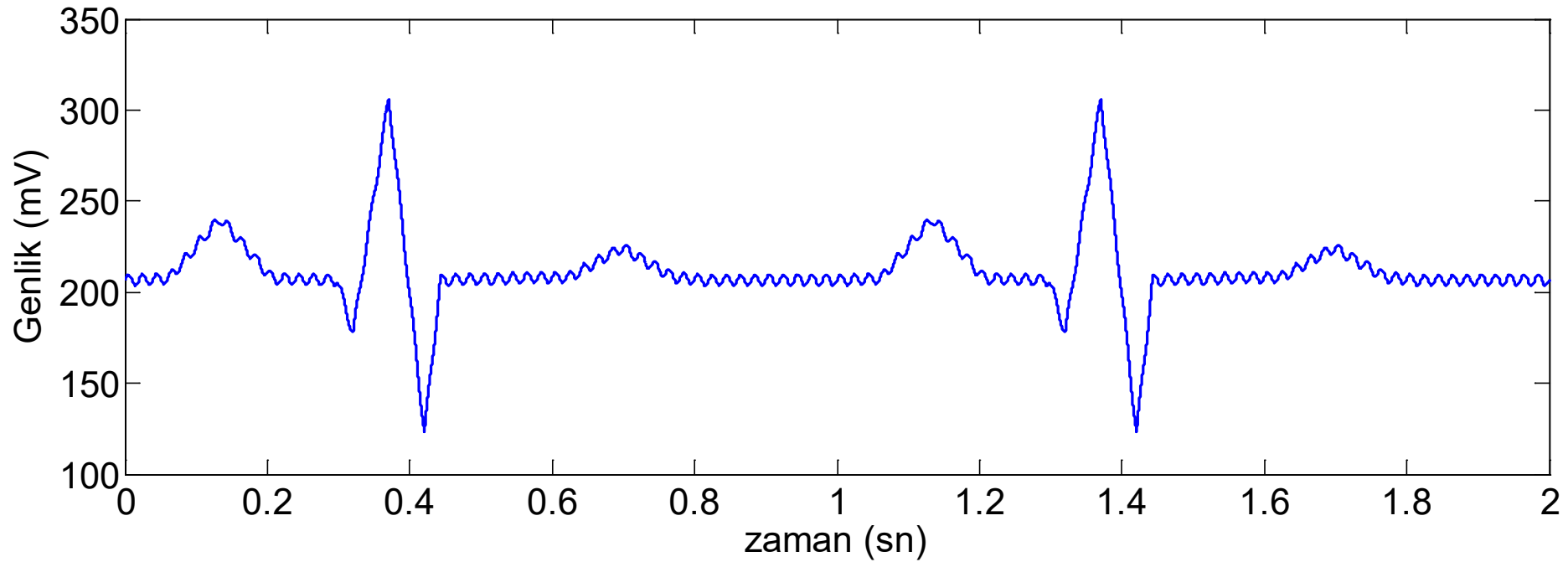
ECG

$$V_{out} = 50mV_{pp}, 1Hz + 300mV_{pp}, 50Hz + 765mV$$



ECG

$$V_{out} = 50mV_{pp}, 1Hz + 3mV_{pp}, 50Hz + 106.65mV$$



Question 3



- What is the gain of the instrumentation amplifier shown below

Question 5



- What is the gain of the instrumentation amplifier shown below