

# Smart Sensors for IoT

October 18, 2023  
Exercise session no.5

## Exercises 1: ECG Measurement system

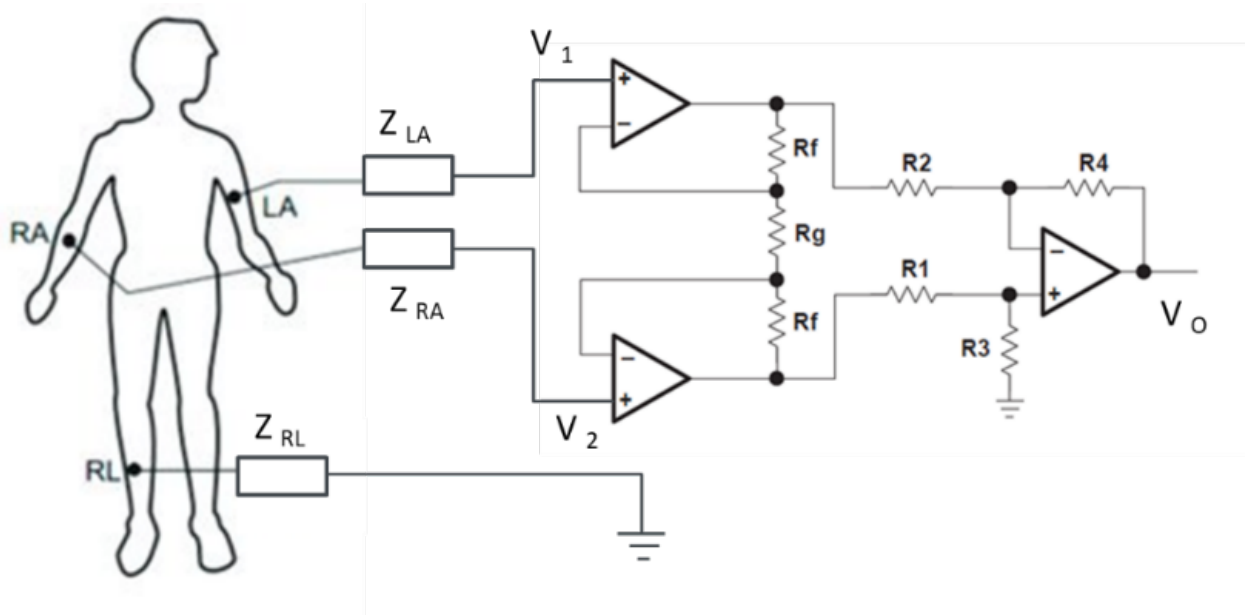


Figure 1: ECG measurement circuit schematic.

You would like to design an ECG measurement system as the one in fig.1. You possess an INA118 instrumentation amplifier from *Texas Instrument* (you can find on moodle the datasheet of the *INA118 Precision, Low-Power Instrumentation Amplifier*). You would like to create a system with a total low-frequency gain of  $A_{dm} = G = 120$ .

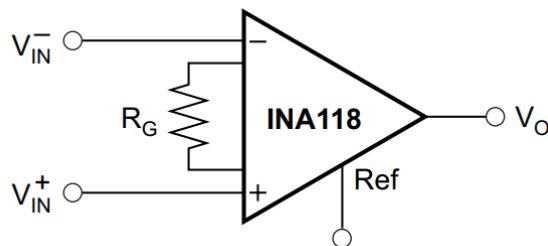


Figure 2: Schematic of instrumentation amplifier INA118.

### Exercise 1.1

Using the information in the IA datasheet, calculate:

1. The gain resistance  $R_g$
2. The common-mode gain  $A_{cm}$  at freq = 50Hz.
3. The common-mode gain  $A_{cm}$  at freq = 10kHz

### Exercise 1.2

The power supply line (220V, 50Hz) creates a capacitive coupling on the lead wires of the electrodes. Because of unequal impedances of the left-arm lead wire ( $Z_{LA} = 110\text{k}\Omega$ ) and the right-arm one ( $Z_{RA} = 90\text{k}\Omega$ ), any variation deriving from the power line will produce uneven signal variations downstream of the RC networks (V1 and V2), resulting in a differential error signal.

1. Knowing that  $C1 = 0.15\text{pF}$  and  $C2 = 0.15\text{pF}$  are the coupling capacitances from nodes V1 and V2 to the power line, and that on average the ECG signal is around 1mV, find out how the capacitive coupling will affect (in percentage) the ECG signal (at the input of the IA).
2. Describe a possible solution to reduce this effect.