Exercises
Session 5 (sections 4.5 and 4.6)

1 Current and potential electrodes

Let us consider the setup in Figure 1 where two devices (device A and device B), each having two electrodes, are applied on the skin and connected together by an unshielded wire. Each device has its own floating power supply (i.e., the common grounds of devices A and B are not generally at the same potential).
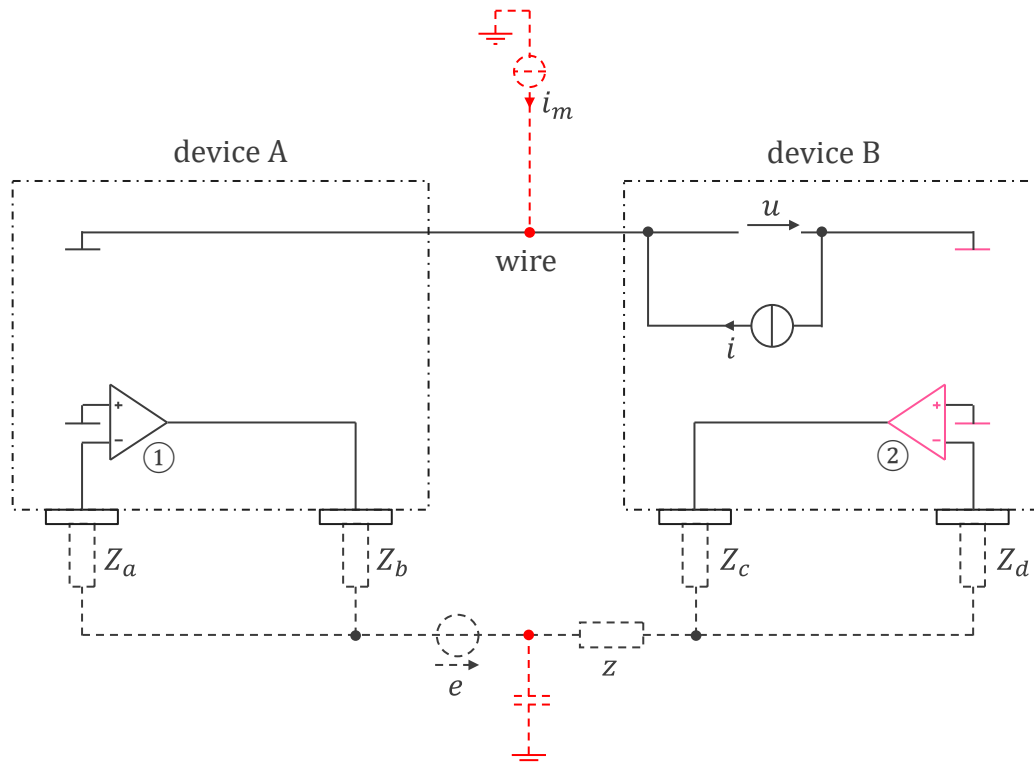

Figure 1: Setup

Exercise statement

In Figure 1, identify the current and potential electrodes as well as the paths taken by the currents i and i_m.

2 Functional block diagram of operational amplifiers

Exercise statement

Redraw the circuit in Figure 1 by replacing the operational amplifiers with their functional block diagrams (see section 2.5.1 of 'Sensors in medical instrumentation' textbook).

3 Mains disturbance

Exercise statement

Express the voltage u resulting from the mains disturbance i_m.

Determine the numerical value of this disturbance on u assuming that:

- $i_m = I \cos 2\pi f t$ with $I = 1\ \mu A$ and $f = 50\ \text{Hz}$
- the OPA GBWP (gain bandwidth product of the operational amplifiers) is 1 MHz
- $Z_a = Z_b = Z_c = Z_d$ are a capacitance $C = 47\ \text{nF}$ in parallel with a resistance $R = 51\ \text{k}\Omega$

4   Impedance measurement error

The circuit in Figure 1 is also able to measure the body impedance z, which is equal to u/i when the operational amplifiers have infinite bandwidth (GBWP), i.e., $\tau \simeq 0$.

Exercise statement

Determine the measurement error at 50 kHz due to the use of real operational amplifiers with a GBWP of 1 MHz and same skin/electrode impedance as exercise 3 above.