ELT-61306: Basics of Medical Electronics March 5, 2014
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Calculator is allowed

1. (20 points) Figure 1 represents the interface of a silver-silvercloride ($Ag - AgCl$) electrode with a saline (Cl^- , Na^+) electrolyte.

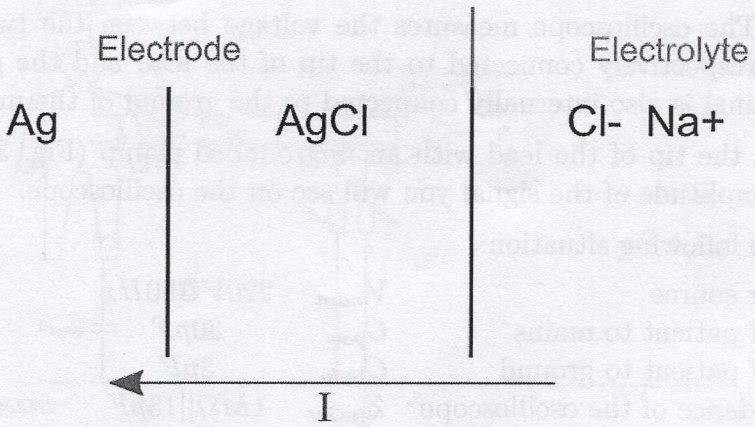

Figure 1: Interface electrode-electrolyte for a Ag-AgCl electrode in a saline solution.

Describe the processes taking place when a current flows from electrolyte to electrode.

Tip: You should mention at leas: (If an electric current is a flow of electric charges) what is the particle, charge, and direction that defines the current in the electrode? What is the particle, charge, and direction that defines the current in the electrolyte. The chemical reaction in the interface $Ag - AgCl$ only for the mentioned current direction. Is is an oxidation or reduction reaction?. The chemical reaction in the interface $Ag - electrolyte$ only for the mentioned current direction.

2. (10 points) Imaging the previous electrode is place on a patient, and the current only flows in the mentioned direction. If this situation is prolonged for a long time, what will be the negative effects for the patient?

3. (15 points) Calculate the formula for the gain in the following differential amplifier.

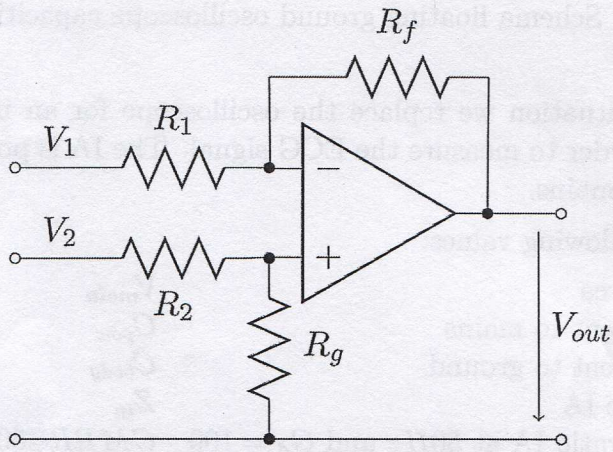

Figure 2: Differential amplifier.

4. (15 points) Enumerate the four types of EMC coupling and one way of reducing the effects for each of them.

5. (10 points) The oscilloscope measures the voltage between the two ends of its input impedance, respectively connected to the tip of the lead and the ground clamp. The ground terminal is also internally connected to the ground of the mains.

   If you touch the tip of the lead with an ungrounded clamp (Fig. 3), calculate the approximate amplitude of the signal you will see on the oscilloscope.

   Consider the following situation:

Main power source	V_{main}	$220V@50Hz$
Coupling of patient to mains	C_{pow}	$30pF$
Coupling of patient to ground	C_{body}	$3pF$
Input impedance of the oscilloscope	Z_{inOsc}	$1M\Omega \| \| 15pF$

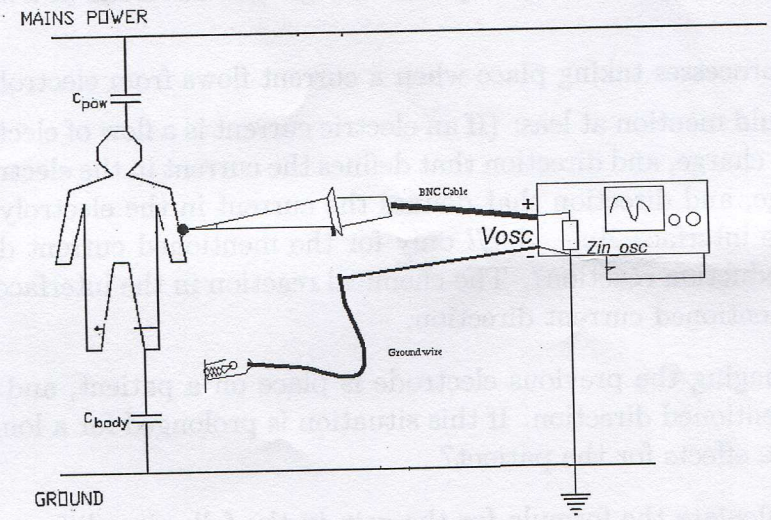

Figure 3: Schema floating ground oscilloscope capacitive coupling.

6. In the previous situation we replace the oscilloscope for an instrumentation amplifier (IA) (Fig. 4) in order to measure the ECG signal. The IA is powered by a power supply connected to the mains.

   Consider a the following values:

Main power source	V_{main}	$220V@50Hz$
Coupling of patient to mains	C_{pow}	$30pF$
Coupling of patient to ground	C_{body}	$3pF$
Input impedance IA	Z_{in}	$10G\Omega \| \| 150pF$
Common mode ratio IA at $50Hz$ and $G_d = 100$	$CMRR@50Hz$	$120dB$
Resistive value interface skin-electrode	Z_e	$20k\Omega \pm 10\%$

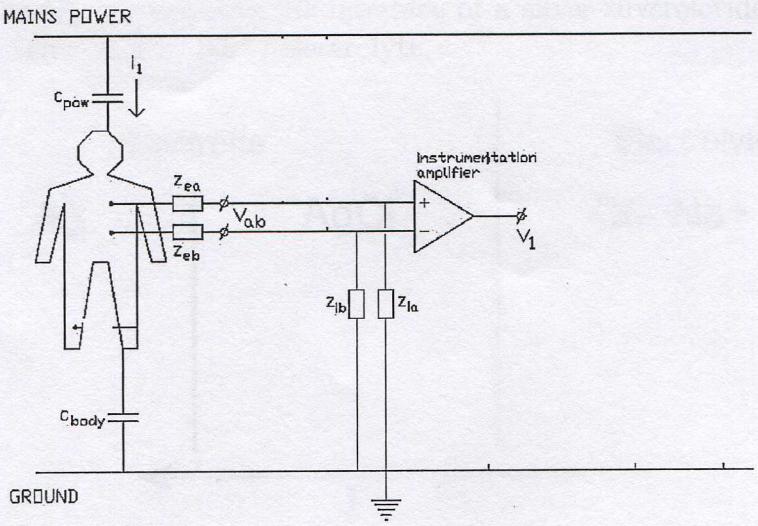

Figure 4: Schema floating ground oscilloscope capacitive coupling.

(a) (5 points) What is the voltage (amplitude of the coupled signal) at the body due to the capacitive coupling with the mains?

(b) (5 points) What is the amplitude of the common mode voltage measured at the inputs of the IA?

(c) (5 points) What is the amplitude of the error at the output of the IA due to the common mode voltage measured at the inputs of the IA?

(d) (5 points) What is the amplitude of the differential voltage measured at the inputs of the IA for the worst case?

(e) (5 points) What is the amplitude of the error at the output of the IA due to the differential voltage measured at the inputs of the IA?

(f) (5 points) There are 3 way this error can be reduce, explain them.