Design your own bioimpedance meter

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BIOMEDICAL ENGINEERING GROUP

5TH CLABIO
LATIN AMERICAN BIOIMPEDANCE
FLORIANOPOLIS – BRAZIL - 2024

https://clabio.tec.br/

REALIZAÇÃO

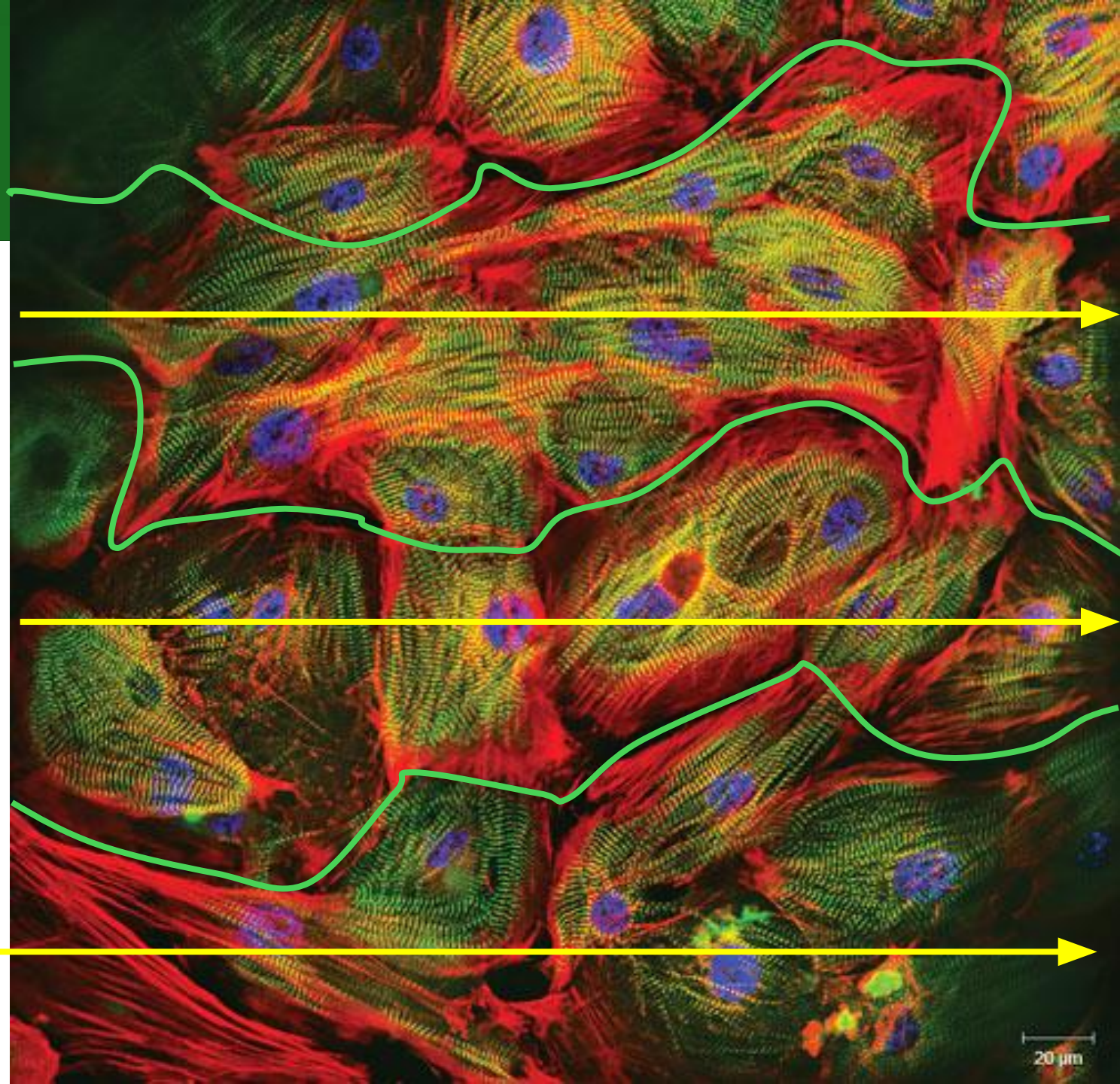
UDESC UNIVERSIDADE DO ESTADO DE SANTA CATARINA

APOIO

Universidad de la República Uruguay
núcleo de ingeniería biomédica

PATROCÍNIO

UDESC UNIVERSIDADE DO ESTADO DE SANTA CATARINA
IFMBE
ABEE-SC
UNIVERSITY OF OSLO
CONFEA Conselho Federal de Engenharia e Agronomia
CREA-SC Conselho Regional de Engenharia e Agronomia de Santa Catarina
mútua SC Caixa de Assistência dos Profissionais do Crea



SIMULATIONS in LTSpice

Bioimpedance meter

- **LTSpice**
  - ✔ https://www.analog.com/en/resources/design-tools-and-calculators/ltspice-simulator.htm
  - ✔ Draw the **circuit 1** according to this guide
- **Current source effects**
  - ✔ Output current and impedance bandwidth
  - ✔ Load range
- **Measuring Front-End**
  - ✔ Gain bandwidth
  - ✔ Input impedance of the instrumentation amplifier

Current source

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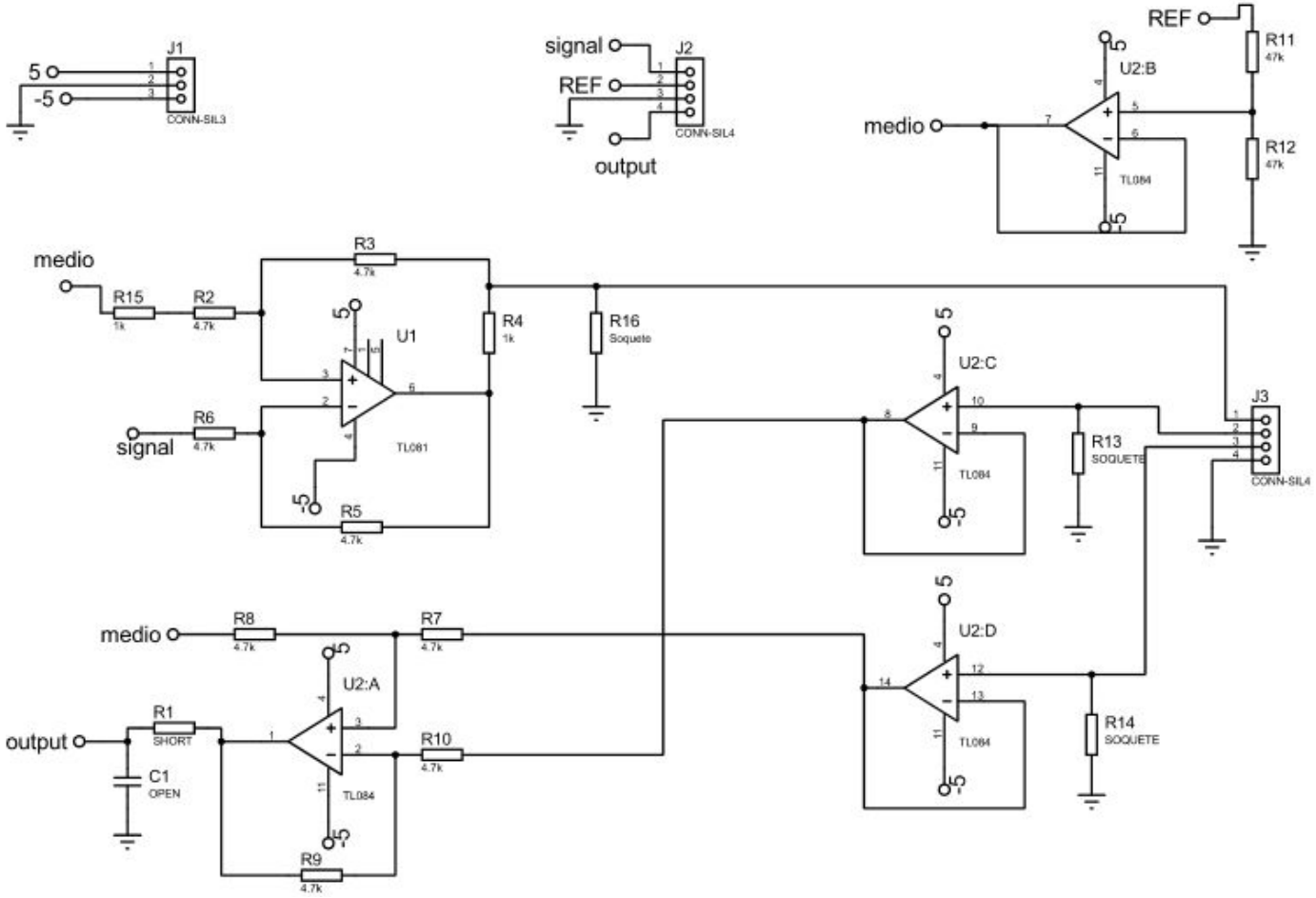
Simulation 1

METHODS:

i) Connect the REF to ground;
ii) Set the function generator (FG) to have a sinewave of 1 Vpp;
iii) Connect the FG to the input signal of the circuit board;
iv) Connect the 1 kΩ resistor (load) at R16 in the circuit board;
v) Measure the voltage across the load by using the oscilloscope and fill out the Table;
vi) Repeat the previous item by connecting the 1 nF capacitor in parallel to the load at R16 and fill out the Table;
vii) Calculate the load for both cases and then the errors in percentage.

Frequency [kHz]	Vout [Vpp] @ 1 kΩ	Vout [Vpp] @ 1 kΩ // 1 nF	Calculated load [kΩ]	Error [%]
0.1				
1				
10				
100				
1000				

What does happen with the output impedance of the current source?



Current source

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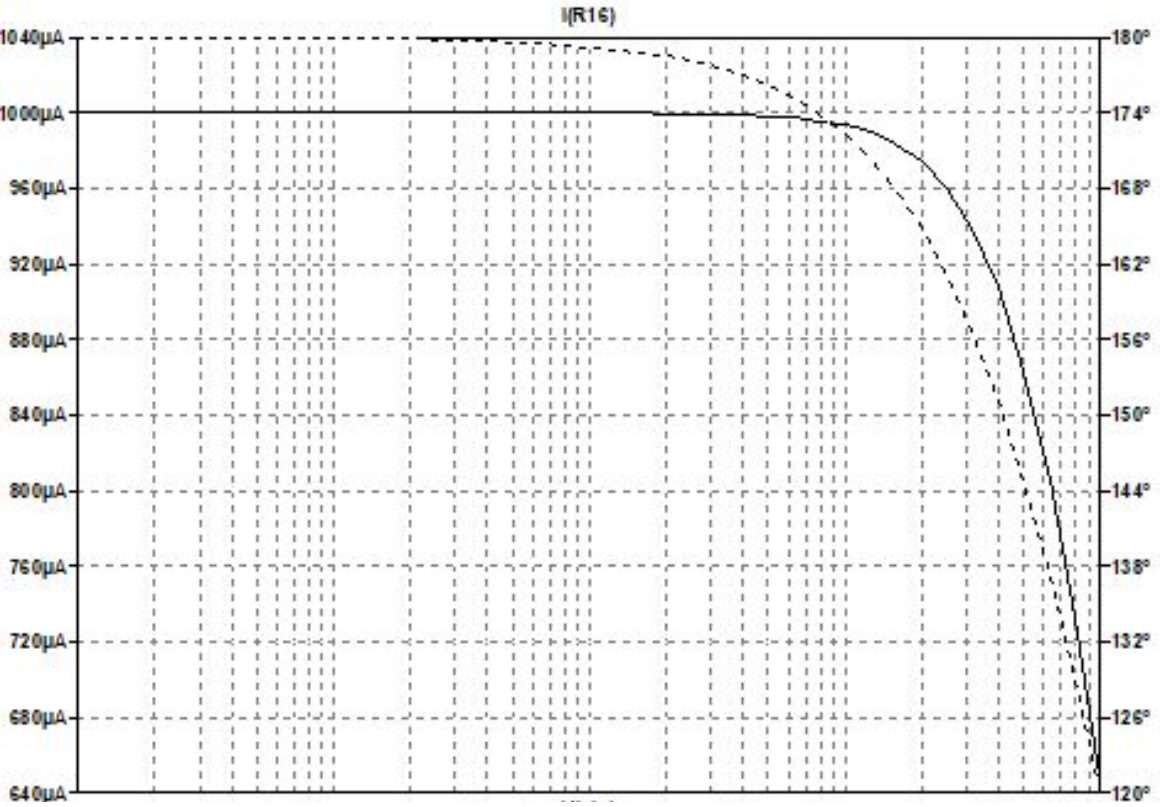
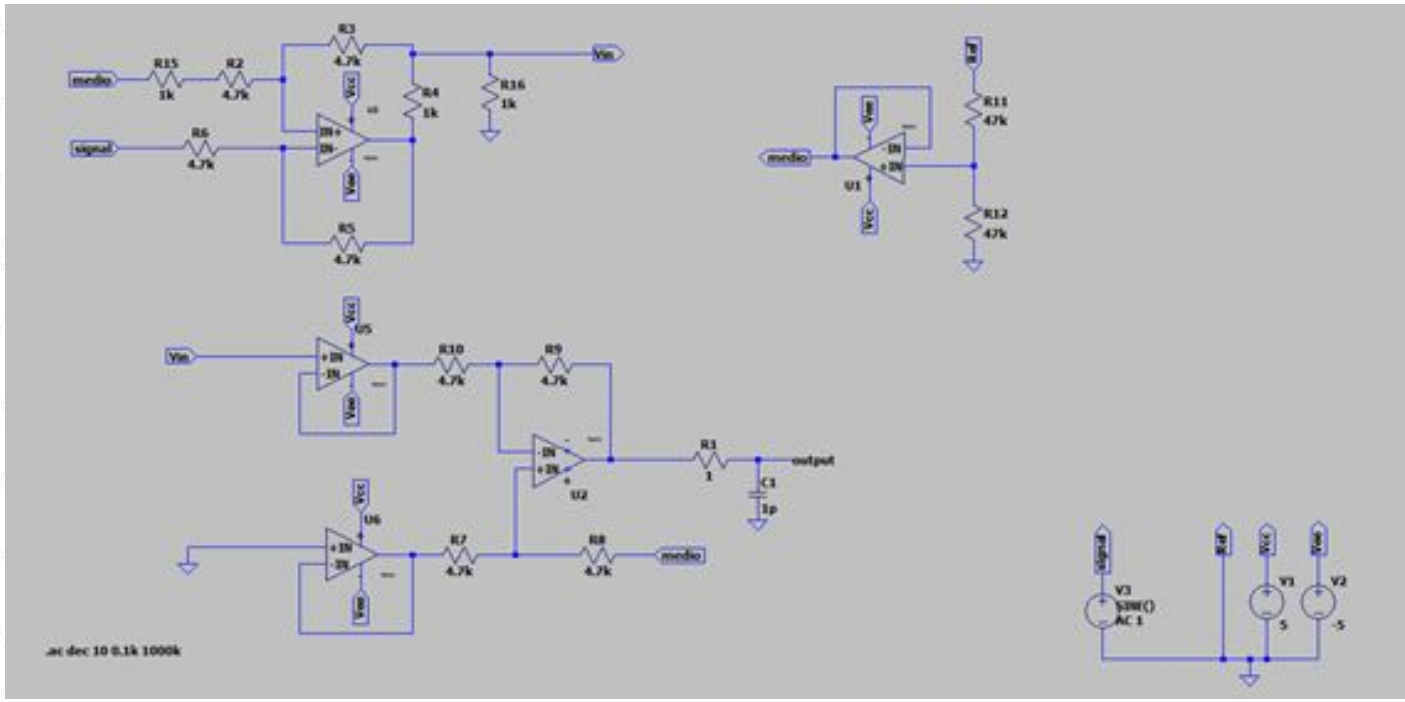
Simulation 1



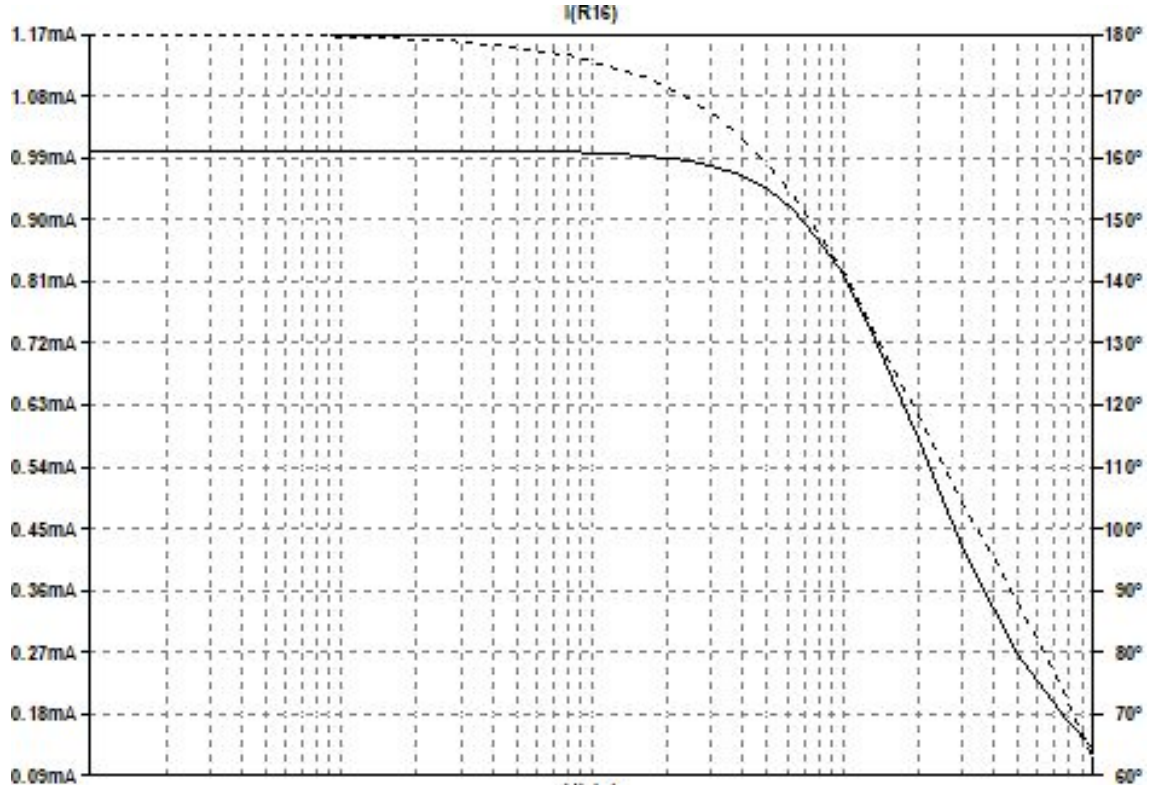
Load = 1 kΩ



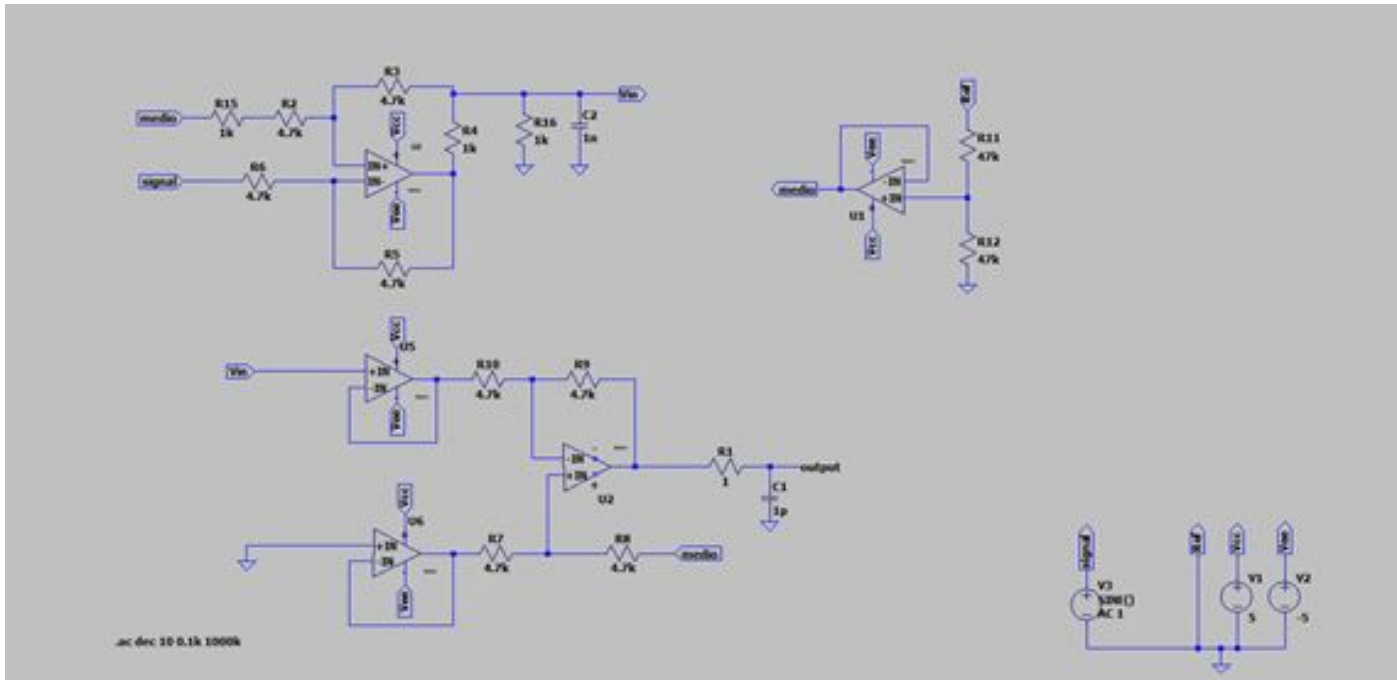
What does happen with the output impedance of the current source?

Current source

Simulation 1



Load = 1 kΩ // 1 nF



What does happen with the output impedance of the current source?

Current source

Bioimpedance meter

Simulation 1

Frequency [kHz]	Vout [V] @RL	Vout[V]@1k//1n	Iout RL	Iout 1k//1n	Calculated load		Error (%)	
					RL	RL//C	RL	RL//C
0.1	1	1	1000u	1000u	1k	1k	-	-
1	1	1	1000u	1000u	1k	1k	-	-
10	1	1	1000u	1000u	1k	1k	-	-
100	998m	821.8m	993u	817u	1005	1005	0.5	0.5
1000	611m	121m	647u	129u	944	937	5.6	6.3

What does happen with the output impedance of the current source?

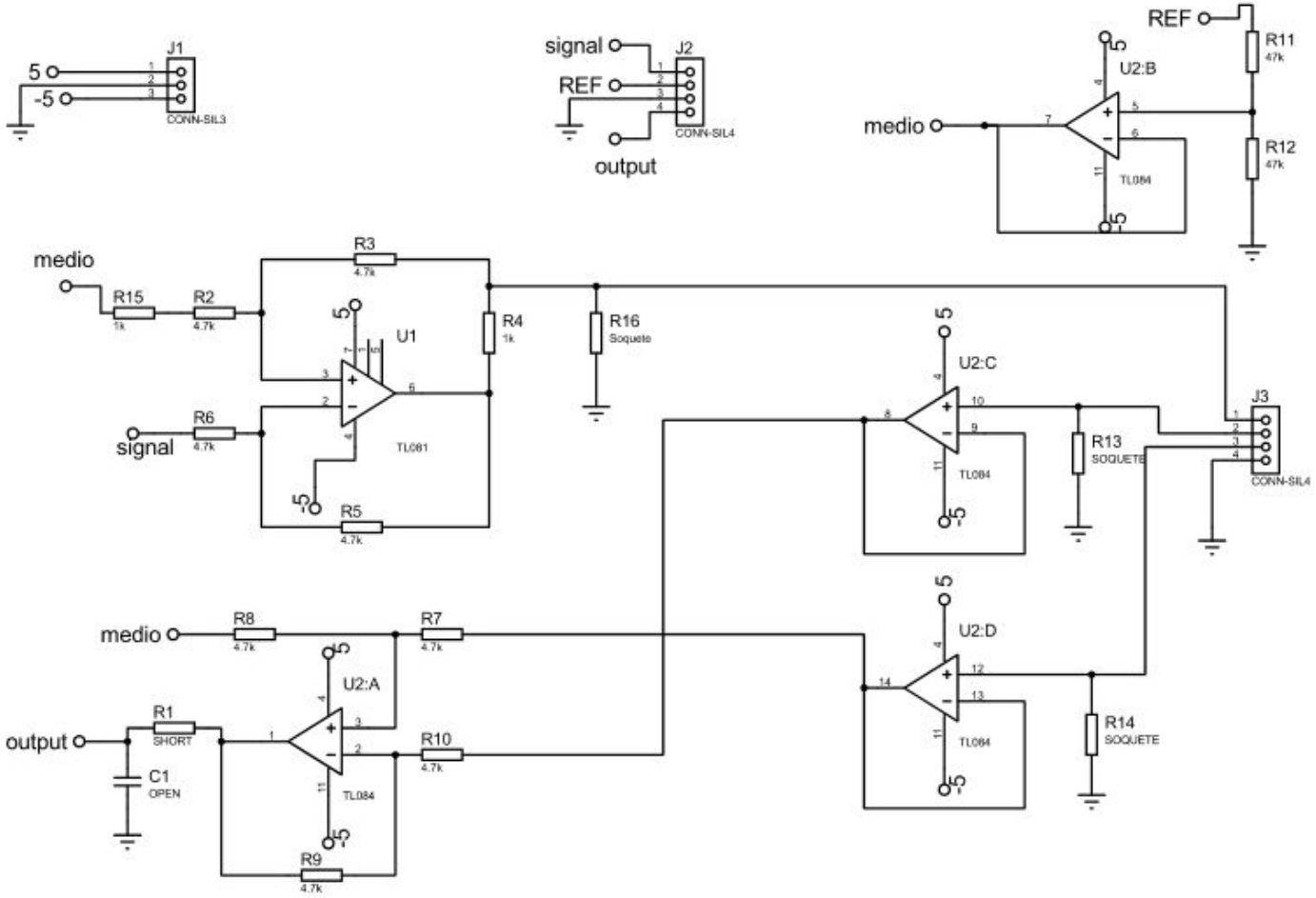
Simulation 2

METHODS:

i) Connect the REF to ground;
ii) Set the function generator (FG) to have a sinewave of 1 Vpp at 100 kHz;
iii) Connect the FG to the input signal of the circuit board;
iv) Measure the voltage across the loads at R16 by using the oscilloscope and fill out the Table;
v) Calculate the output current and then the errors in percentage;

Frequency [kHz]	Vout [Vpp]				Calculated Iout [mApp]	Error [%]
	100 Ω	1kΩ	4.7 kΩ	10 kΩ		
0.1						
1						
10						
100						
1000						

What does happen with the output impedance of the current source?



Current Source

Bioimpedance meter

Simulation 2

Frequency·[kHz]	Vout·[V]				Iout·(App)			
	R100	R1k	R4.7k	R10k	R100	R1k	R4.7k	R10k
0.1	100m	1	4.72	10	1000u	1000u	1000u	1000u
1	100m	1	4.72	10	1000u	1000u	1000u	1000u
10	100m	1	4.72	10	1000u	1000u	1000u	1000u
100	100m	998m	4.44	8.21	1000u	993u	941.51u	783u
1000	81.8m	611m	1.18	1.31	867.8u	647u	266.6u	139u

What does happen with the output impedance of the current source?

Simulation 2

Frequency [kHz]	Calculated load							
	R100	Error(%)	R1k	Error(%)	R4.7k	Error%	R10k	Error(%)
0.1	100	-	1k	-	4.72k	0.4	10k	-
1	100	-	1k	-	4.72k	0.4	10k	-
10	100	-	1k	-	4.72k	0.4	10k	-
100	100	-	1005	0.5	4.47k	4.9	10.5k	5
1000	94	6	944	5.6	4,42k	5.95	9.42k	5.8

What does happen with the output impedance of the current source?

Instrumentation amplifier

Bioimpedance meter

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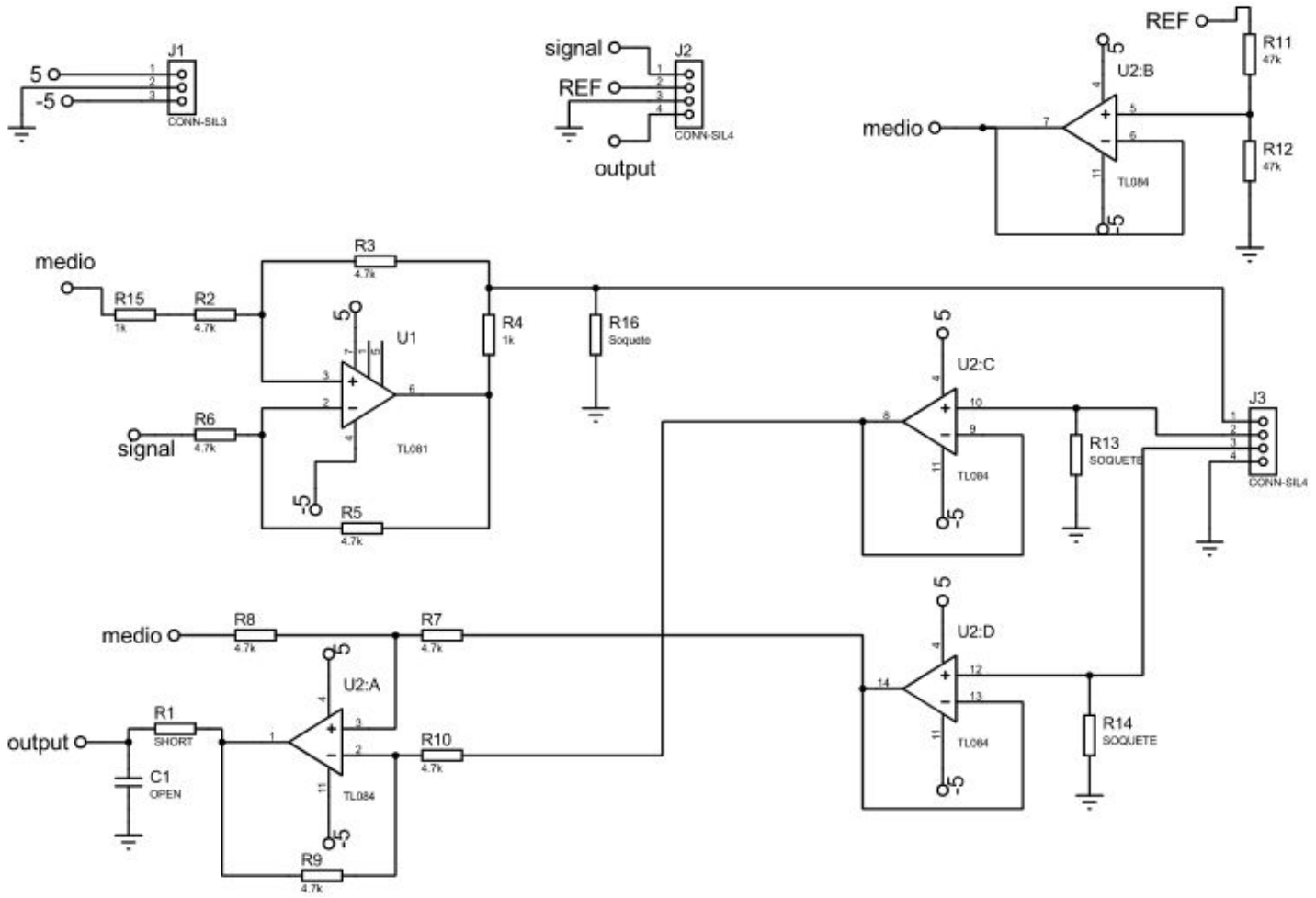
Simulation 3

METHODS:

i) Connect the REF to ground;
ii) Set the function generator (FG) to have a sinewave of 1 Vpp at 100 kHz;
iii) Connect the FG to the input signal of the circuit board;
iv) Connect the 1 kΩ resistor (load) at R16 in the circuit board;
v) Connect the 10 MΩ resistors (**Rin**) at R13 and R14 in the circuit board;
vi) Measure the output voltages by using the oscilloscope and fill out the Table;
vii) Calculate the load and then the errors in percentage;

Frequency [kHz]	Vout [Vpp] Rin= 0 Ω	Vout [Vpp] Rin= 10 MΩ	Calculated load [kΩ]	Error [%]
0.1				
1				
10				
100				
1000				

What does what happen with the input impedance of the instrumentation amplifier?



Instrumentation amplifier

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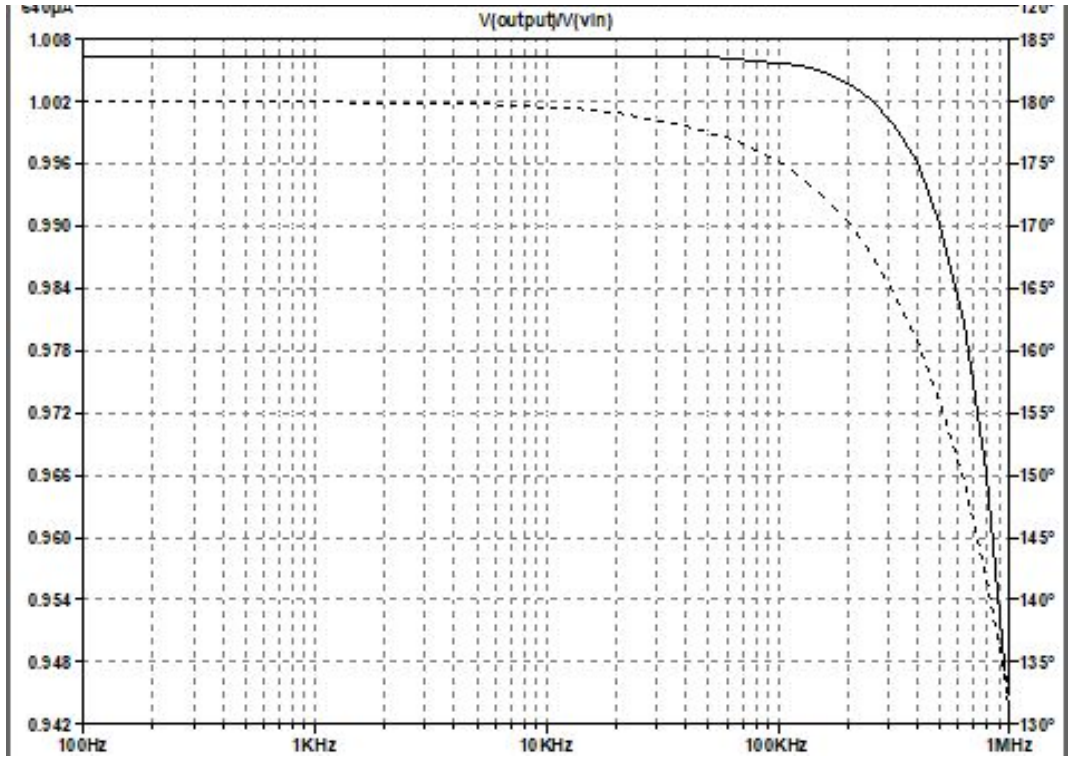
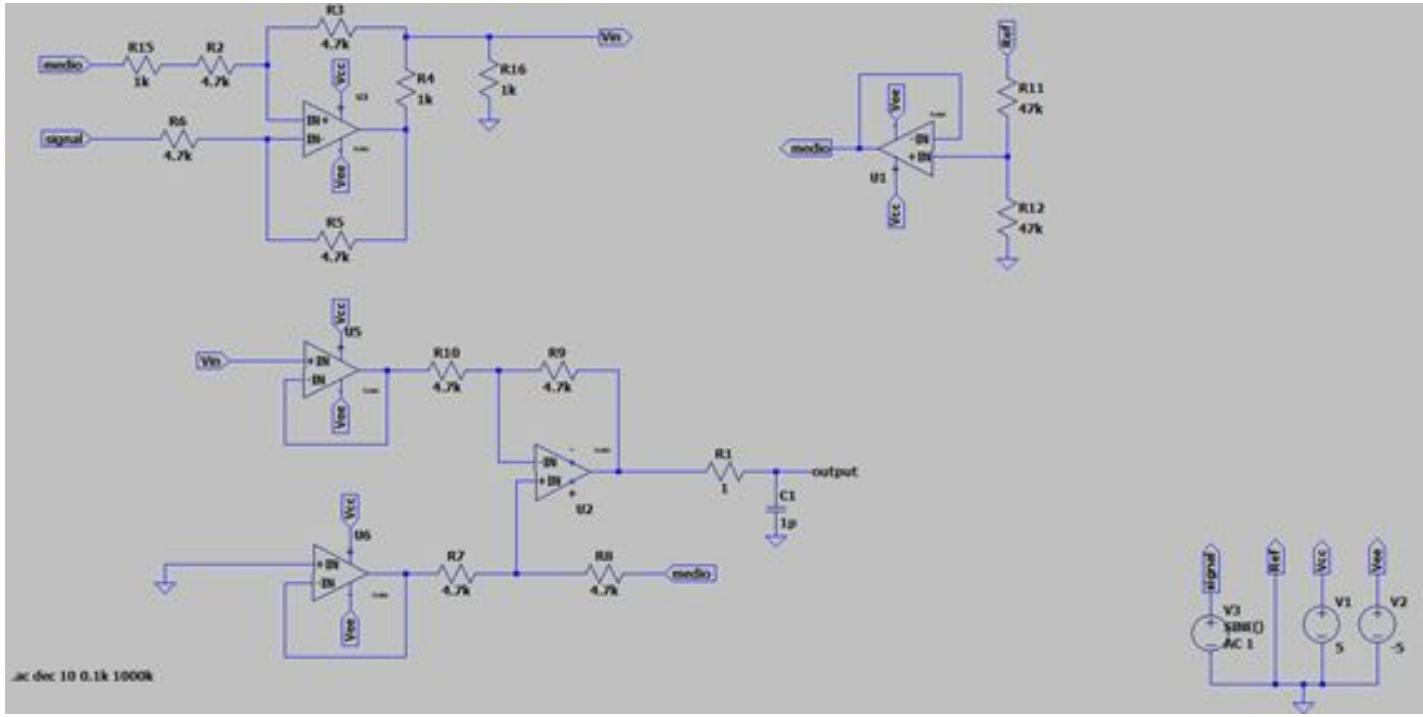
Simulation 3



Zin = infinite



What does what happen with the input impedance of the instrumentation amplifier?

Instrumentation amplifier

Bioimpedance meter

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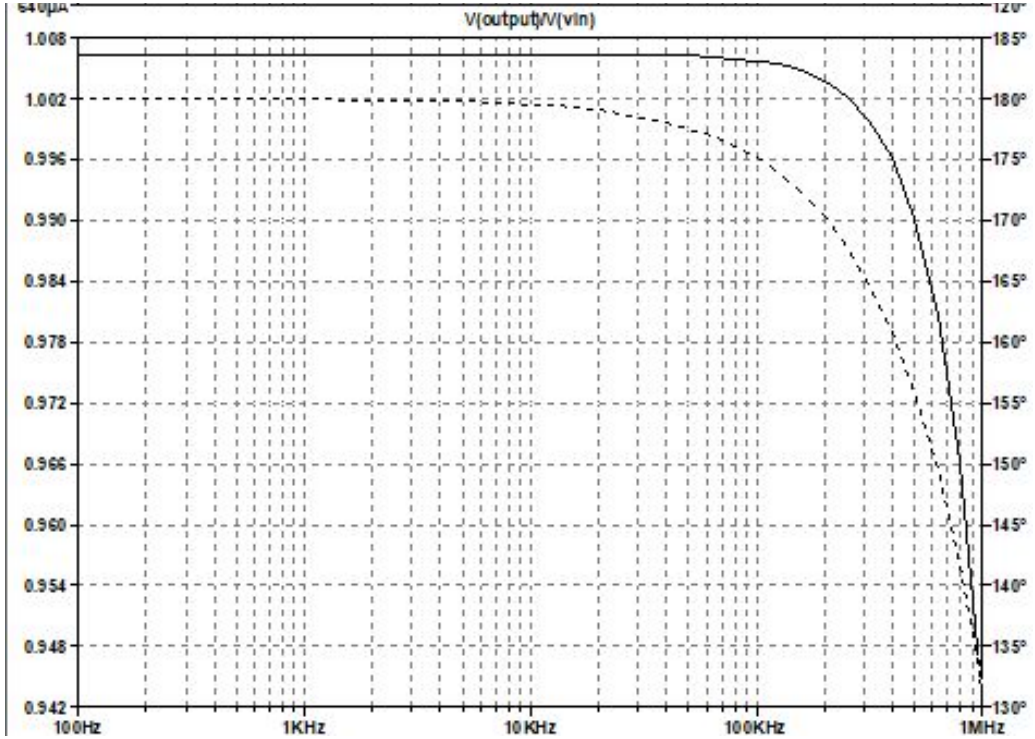
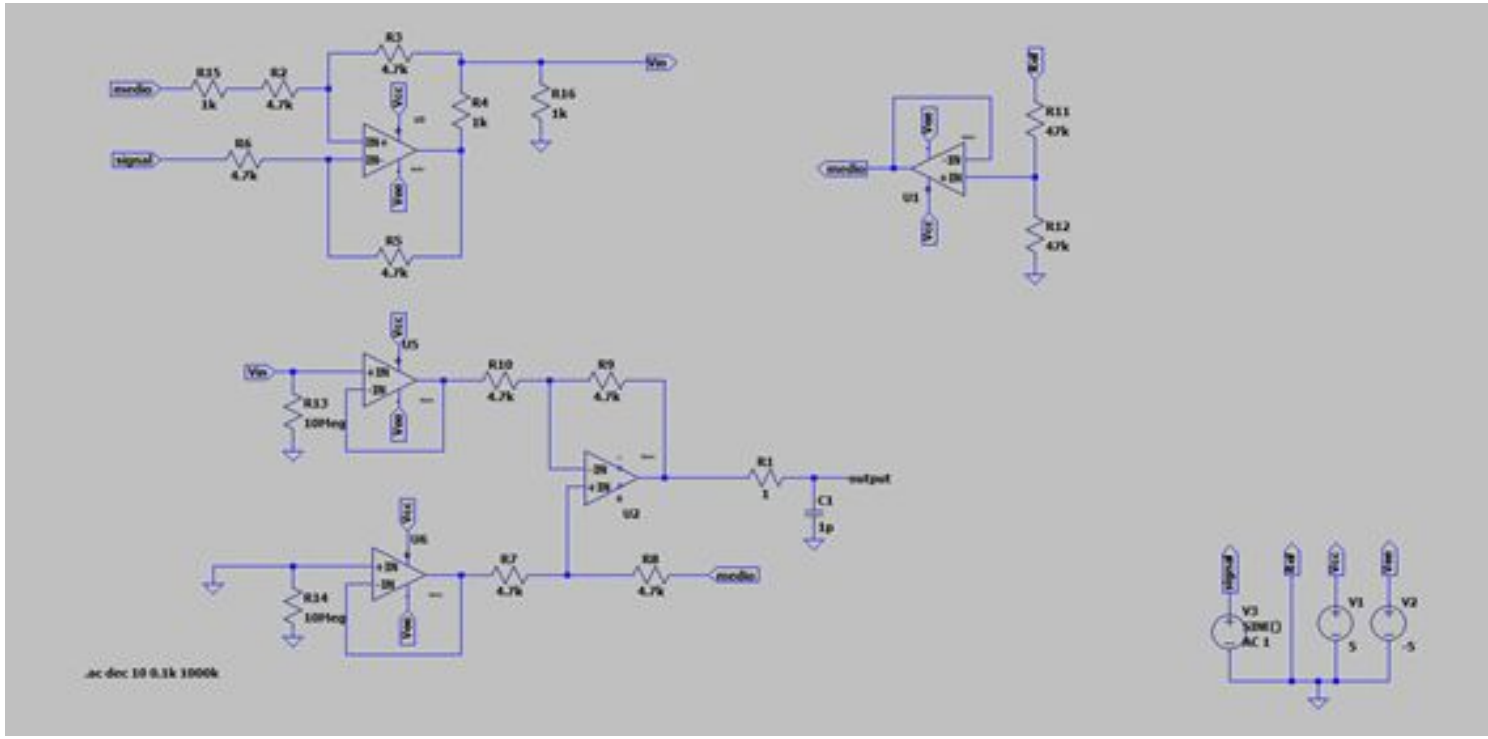
Simulation 3

Zin = 10 MΩ





What does what happen with the input impedance of the instrumentation amplifier?

Instrumentation amplifier

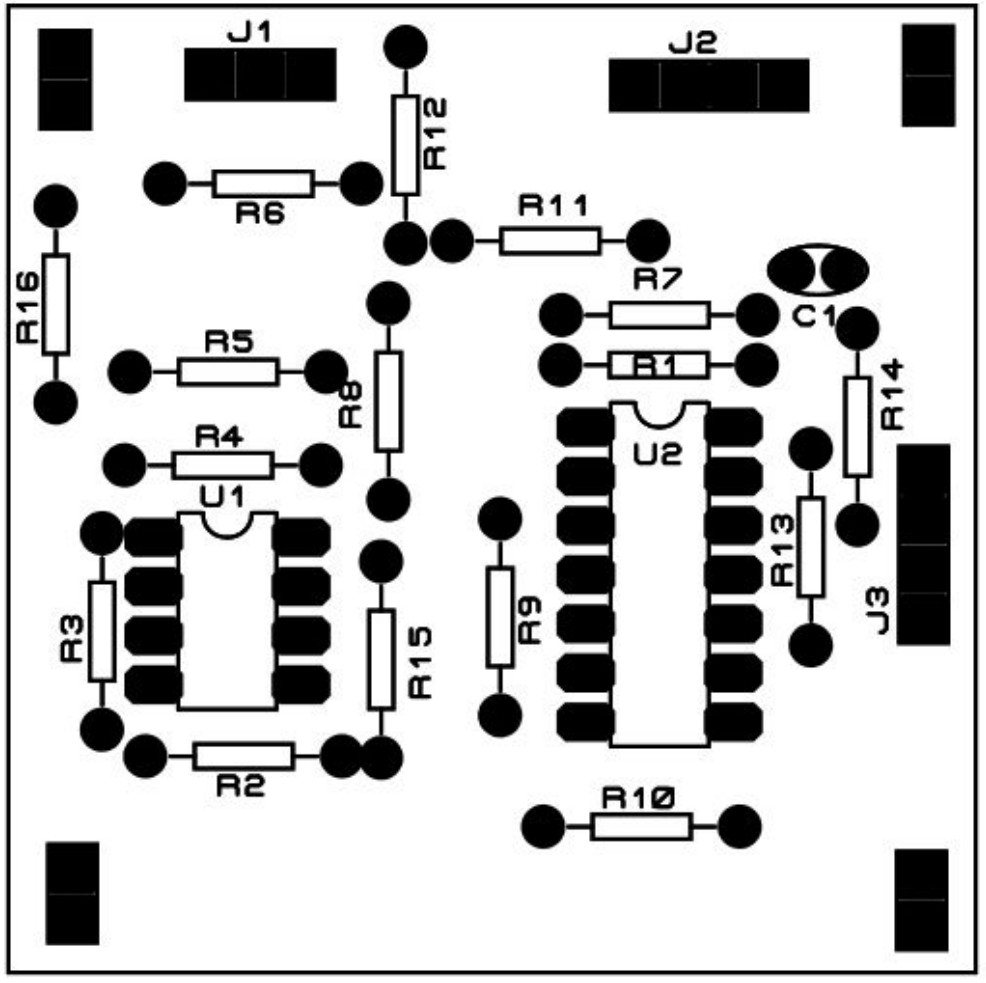
Simulation 3

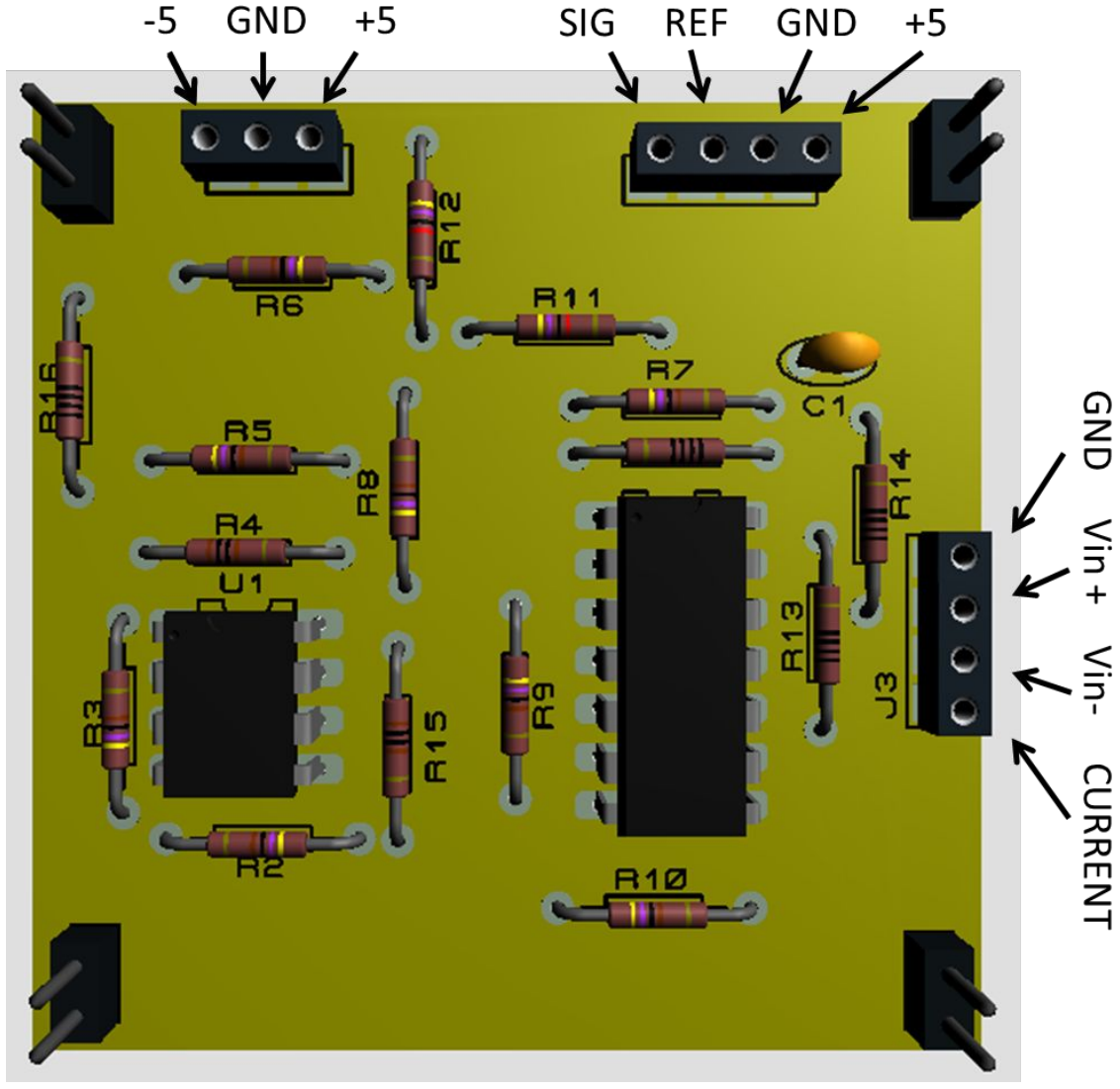
Frequency [kHz]	Vout [V] Rin=0	Vout[V] Rin =10M	Iout RL	Calculated load	
				RL	Error %
0.1	1	1	1000u	1k	-
1	1	1	1000u	1k	-
10	1	1	1000u	1k	-
100	1	1	993u	1007	0.7
1000	943m	943m	647u	1457	45.7

What does what happen with the input impedance of the instrumentation amplifier?

Circuit Design

Bioimpedance meter





End of part 02

Bioimpedance Meter

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