VIRTUAL SYMPOSIUM IN PLANT OMICS SCIENCE

Low-Cost and Portable Potentiostat for Electrochemical Impedance Spectroscopy Measurements

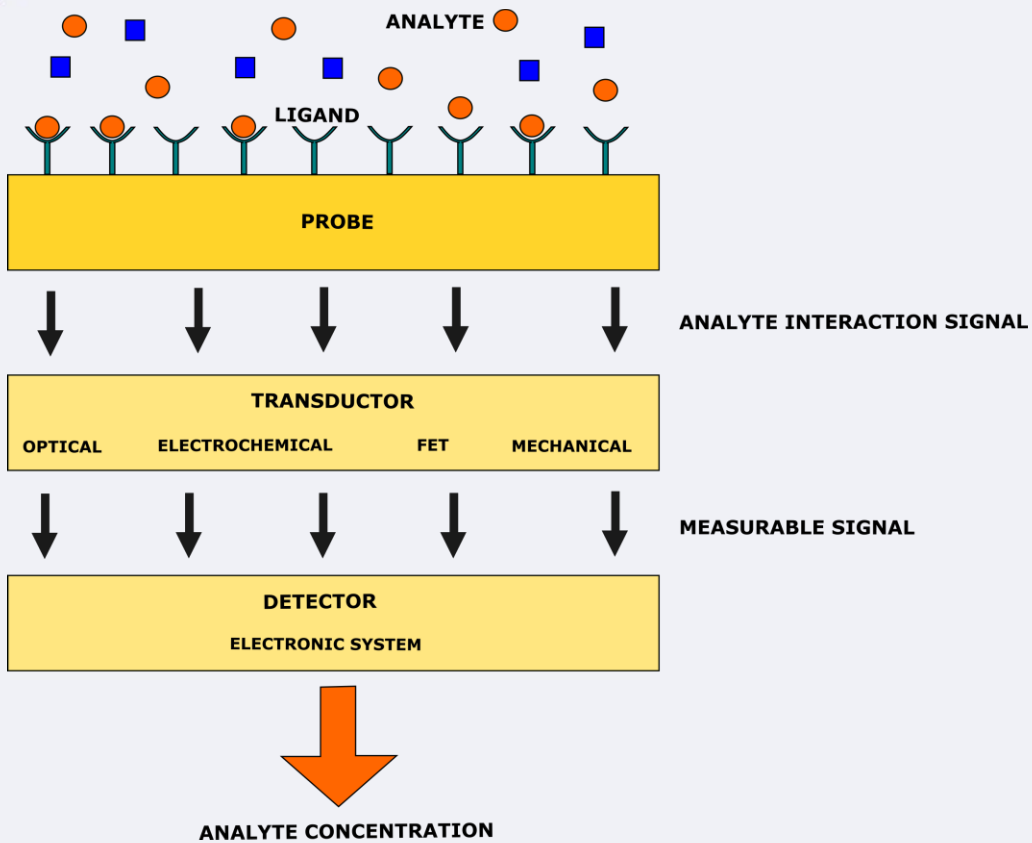
Sammy Alejandro Perdomo Ospino

Profesors:
Andrés Jaramillo Botero
Drochss Pettry Valencia

VIRTUAL SYMPOSIUM IN PLANT OMICS SCIENCE

Background

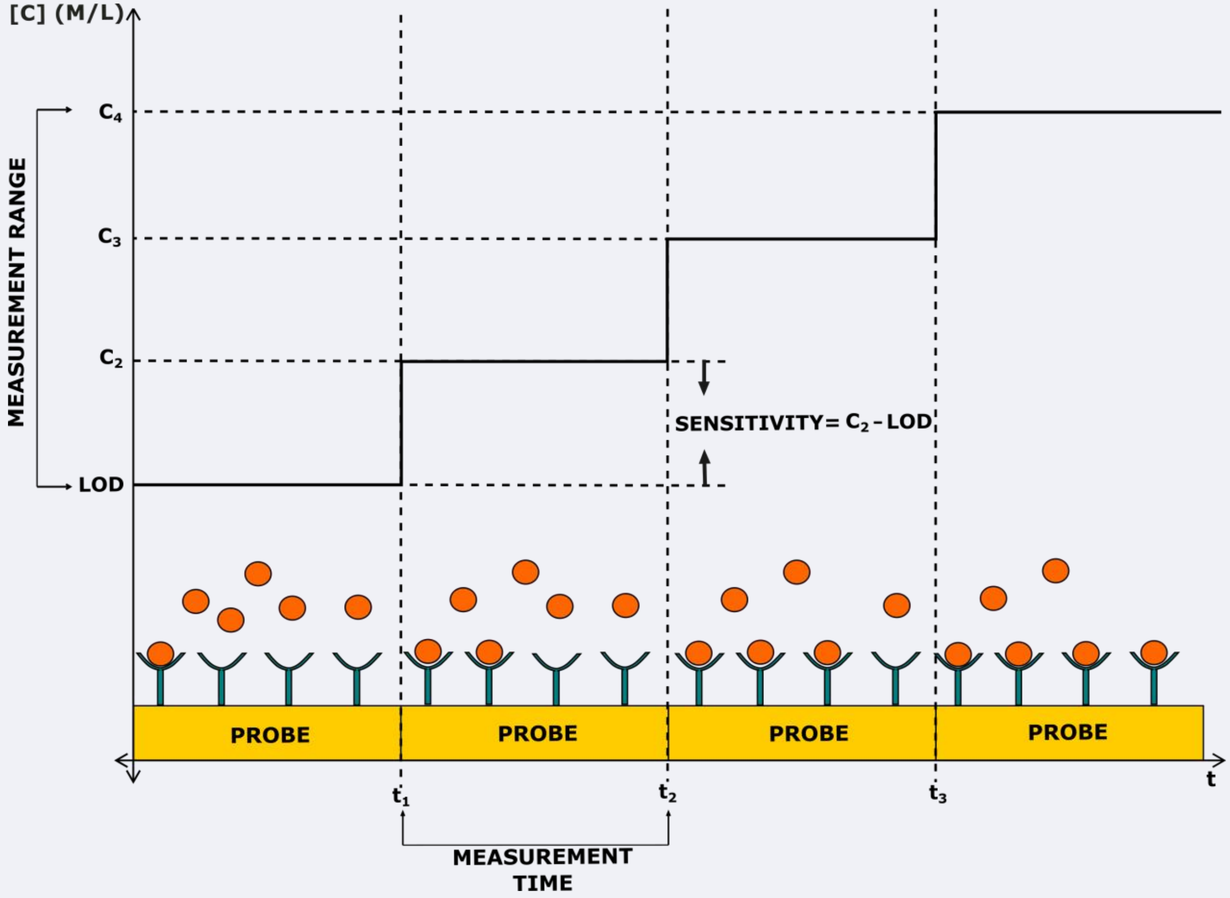
Bio-Nanosensors



Nanostructured materials provide an unprecedented opportunity to measure ultra-low concentrations (<nM/L) of target analytes, which in turn, enables improved understanding of complex biological processes

Background

Bio-Nanosensors



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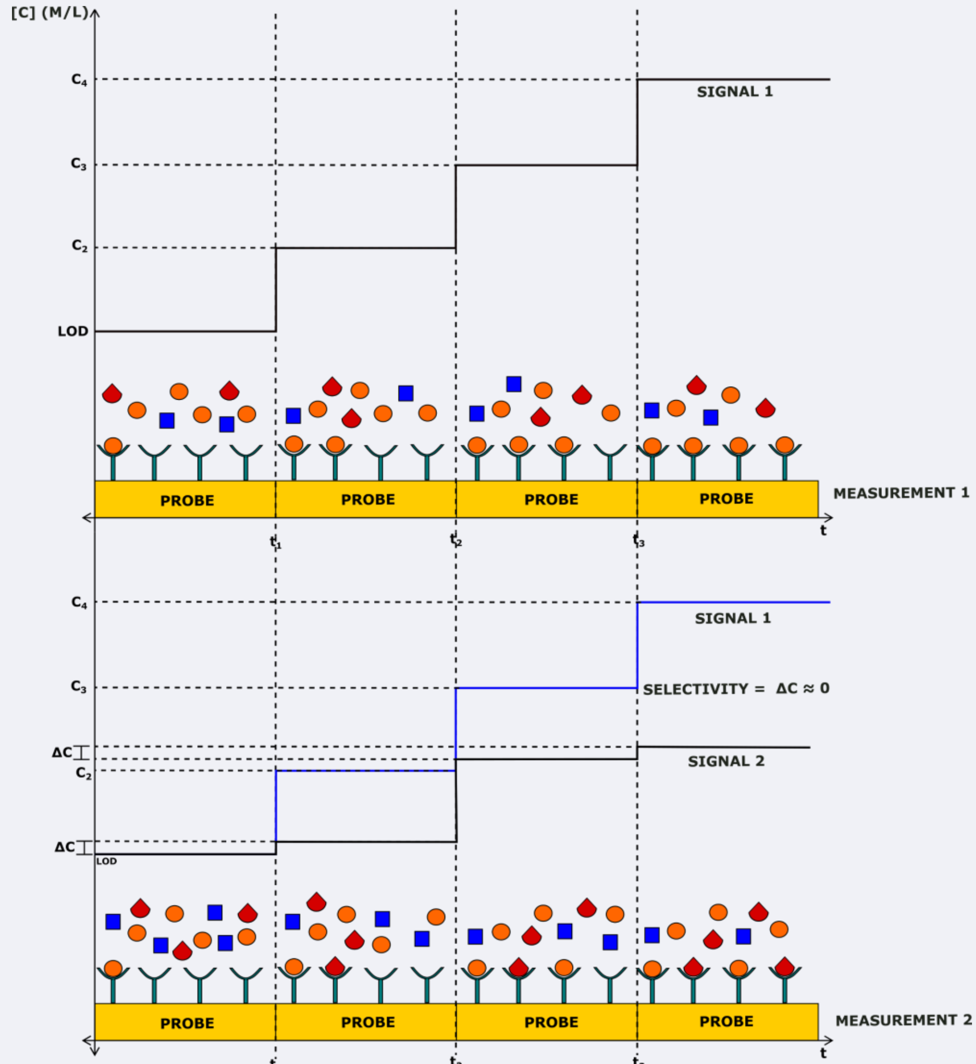
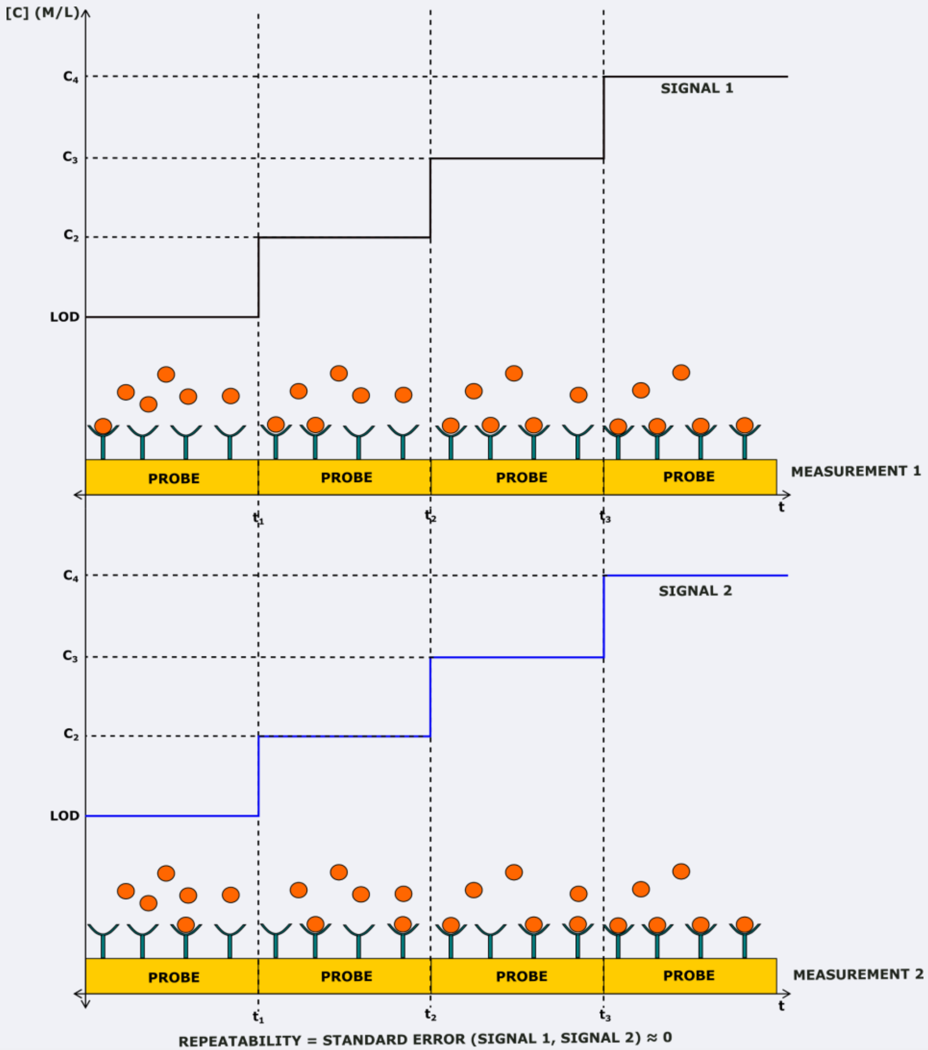
Background

Bio-Nanosensors



Background

Bio-Nanosensors



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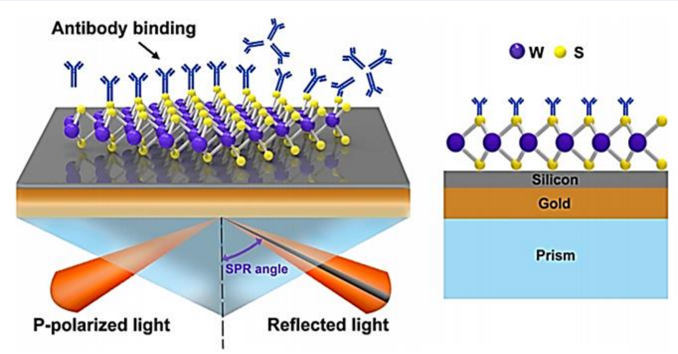
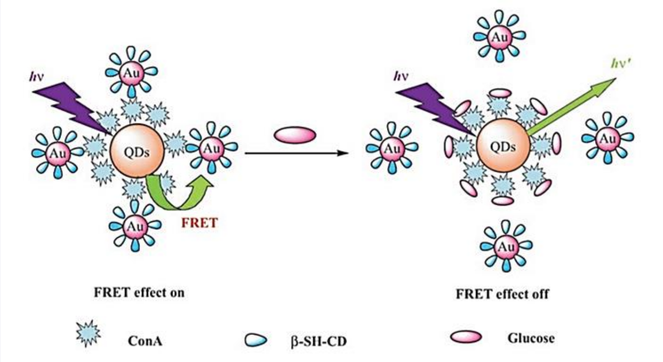
Background

Optical-Nanosensors



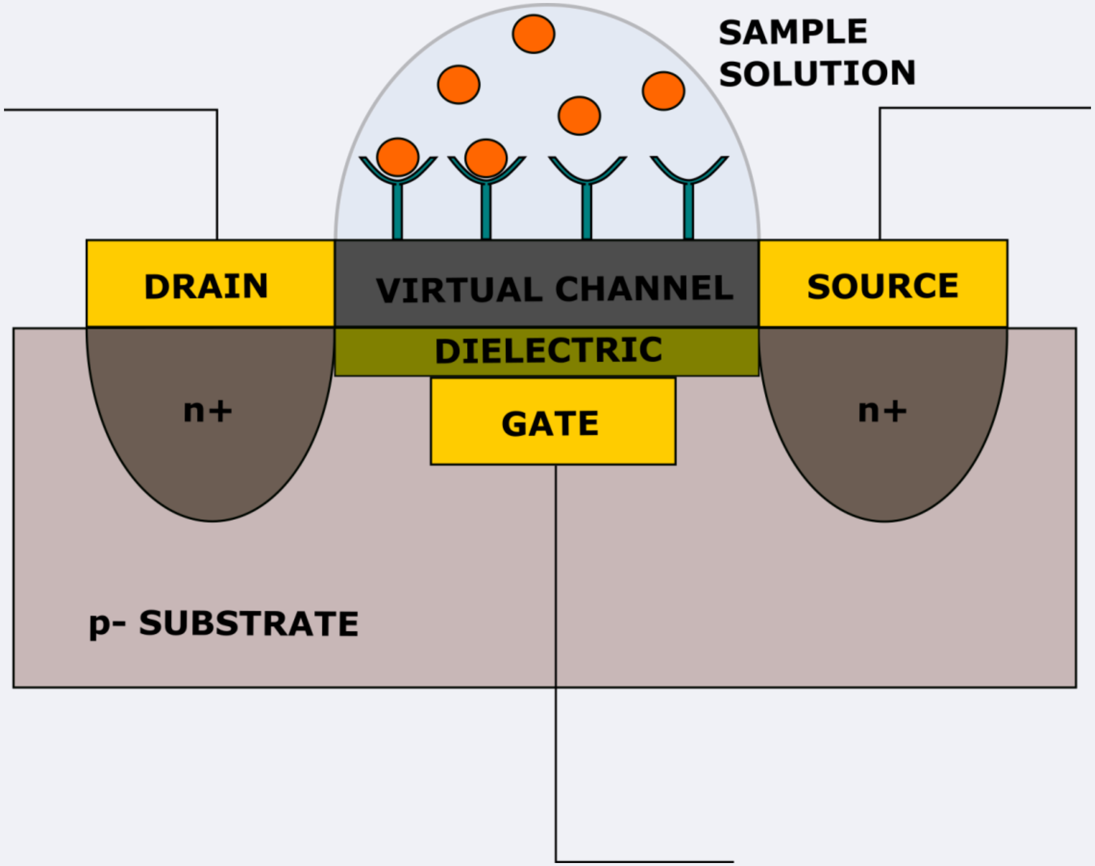
Schematic diagram of silicon-WS2/nanosheets-enhanced SPR biosensor. A gold thin film is attached at the bottom of the SF10 prism followed by silicon nanosheet and 2D MX2 layer that is in directly contact with the analyte (Ouyang et al., 2016)



Chemical structure of the QDs-ConA-β-CDs-AuNPs FRET biosensor. The sensing mechanism is based on the switching off of FRET through the highly specific recognition of ConA by glucose. In the presence of glucose, the AuNPs-β-CDs segment of the bio-nanosensor is displaced by glucose which competes with β-CDs on the binding sites of ConA, resulting in the fluorescence recovery of the quenched QDs (Tang et al., 2008)

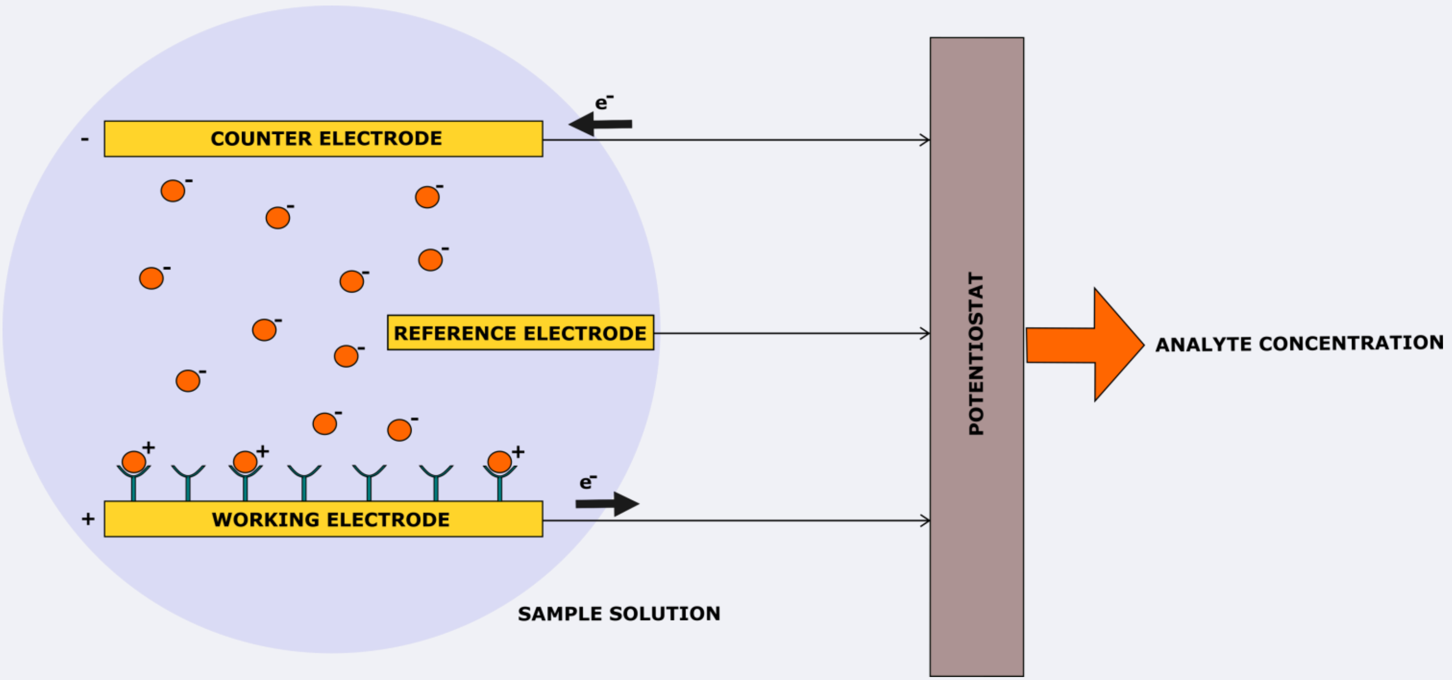
Background

FET-Nanosensors



Background

Electrochemical-Nanosensors



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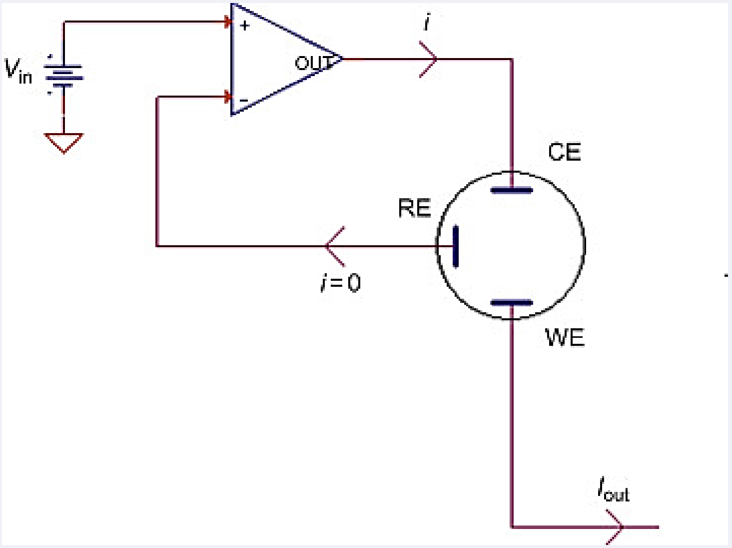
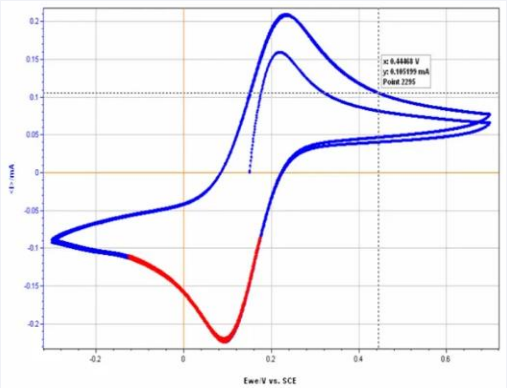
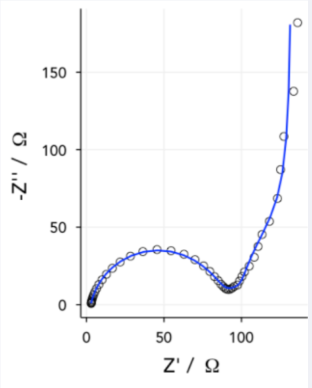
Potentiostat







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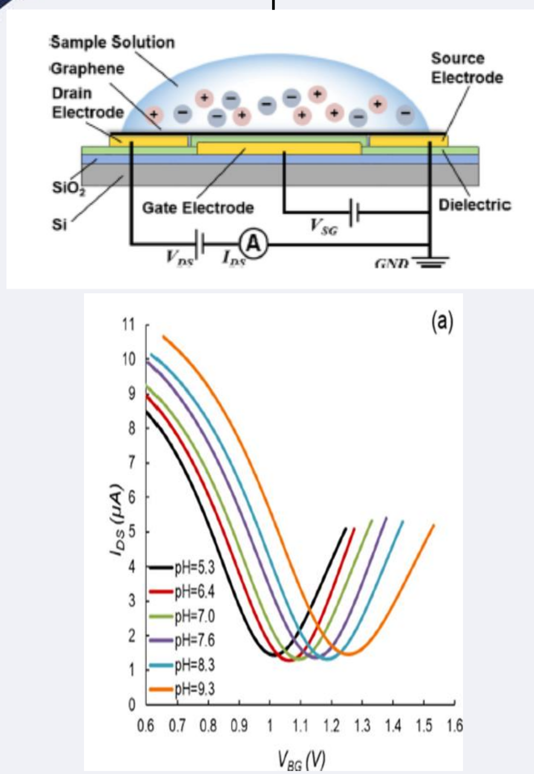
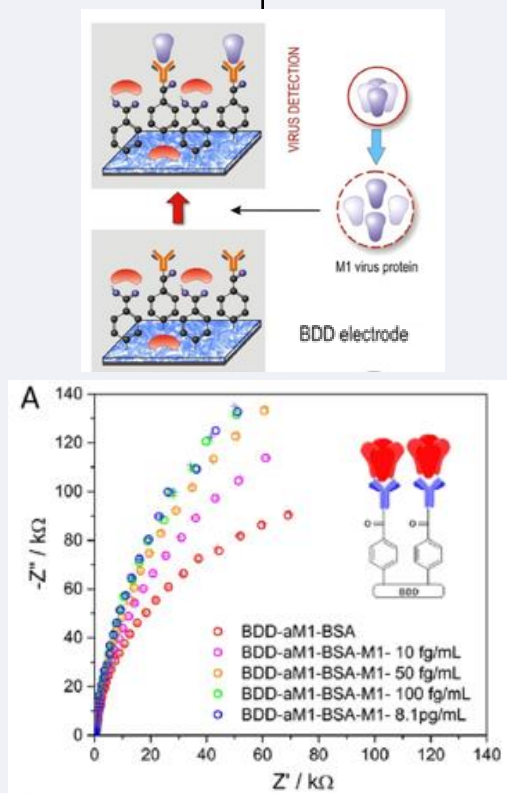
Problem

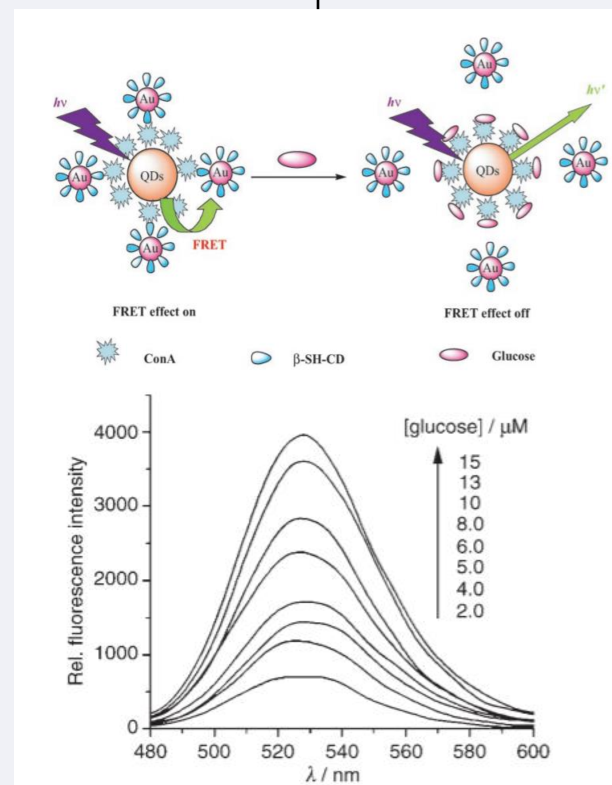
How can these technologies be integrated into a single, low-cost and portable measuring device?



(Zhu et al., 2015)



(Nidzworski et al., 2017)

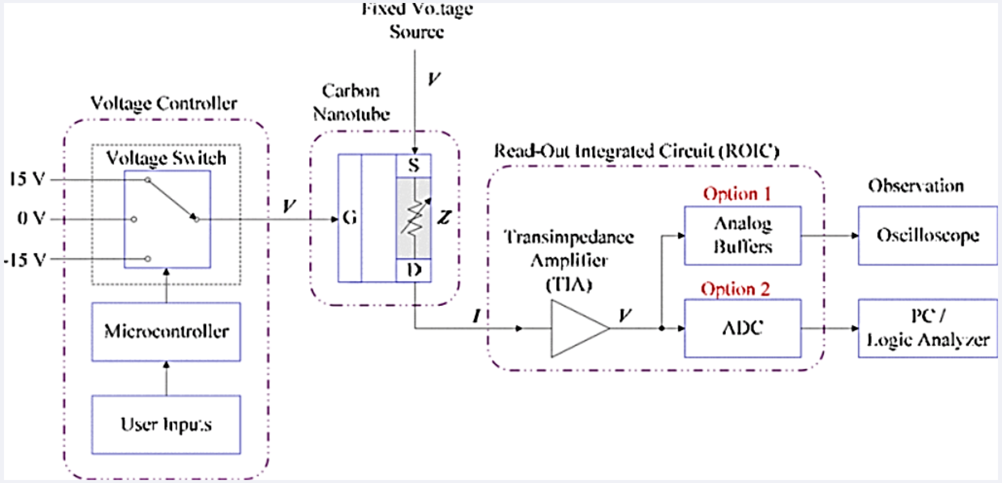


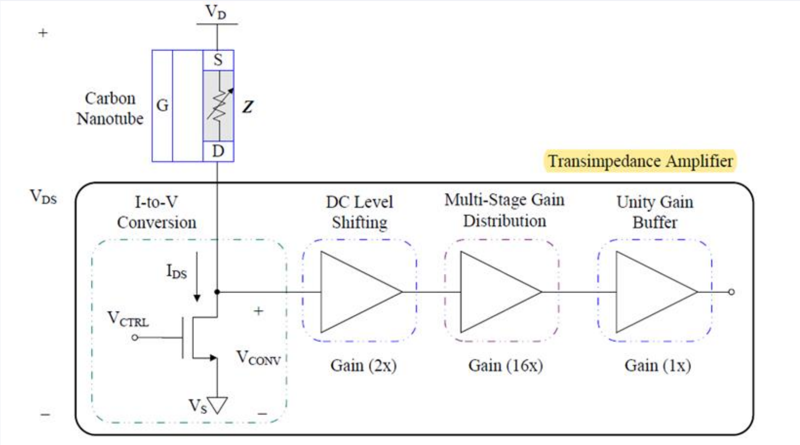
(Tang et al., 2008)

VIRTUAL SYMPOSIUM IN PLANT OMICS SCIENCE

State of the art

(Lee et al., 2011)





VIRTUAL SYMPOSIUM IN PLANT OMICS SCIENCE

State of the art

(Yue et al., 2015)

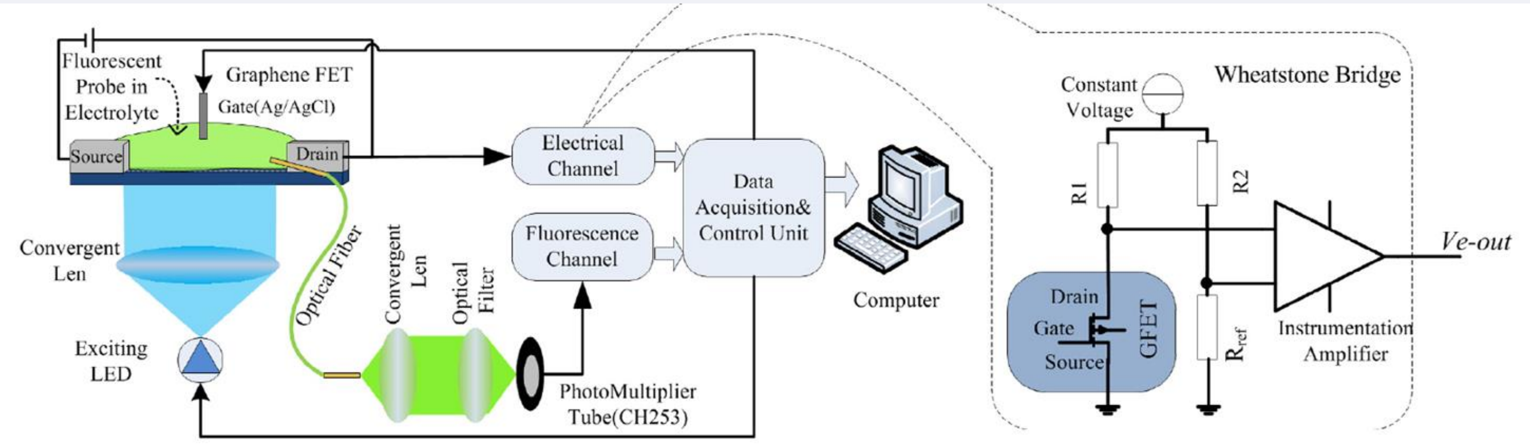
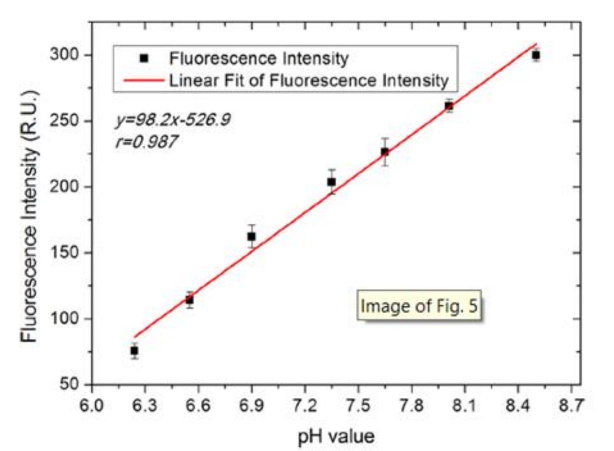
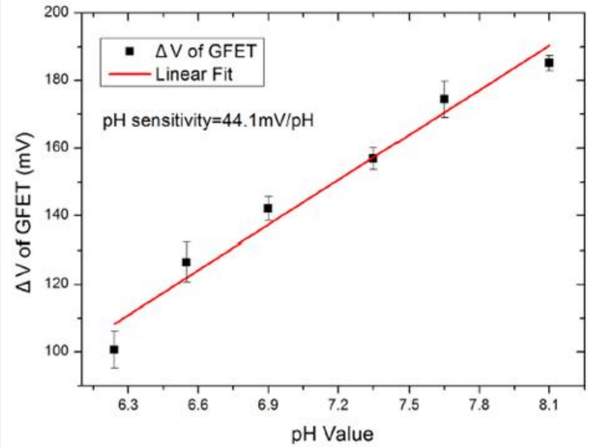
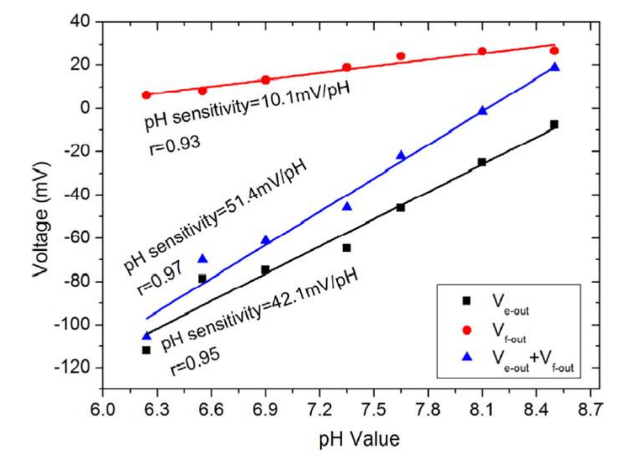


Fig. 2. Schematic of Double Read-Out System for GFETs.



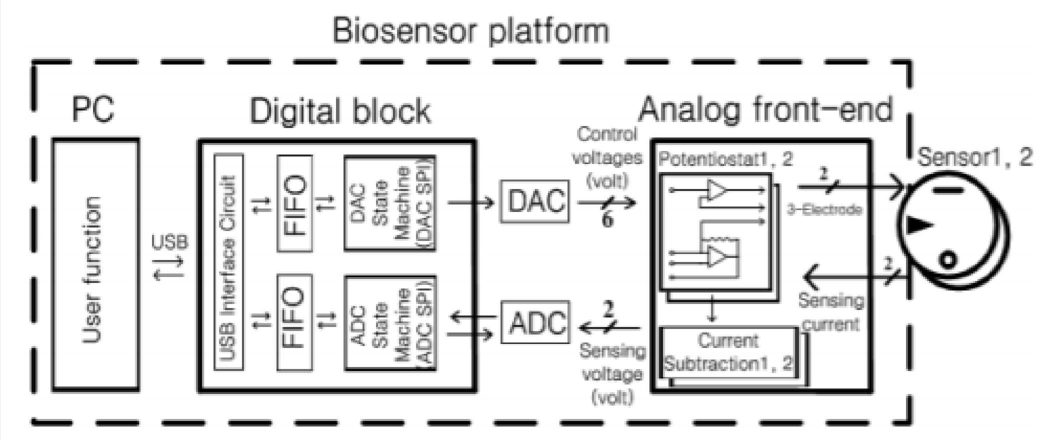


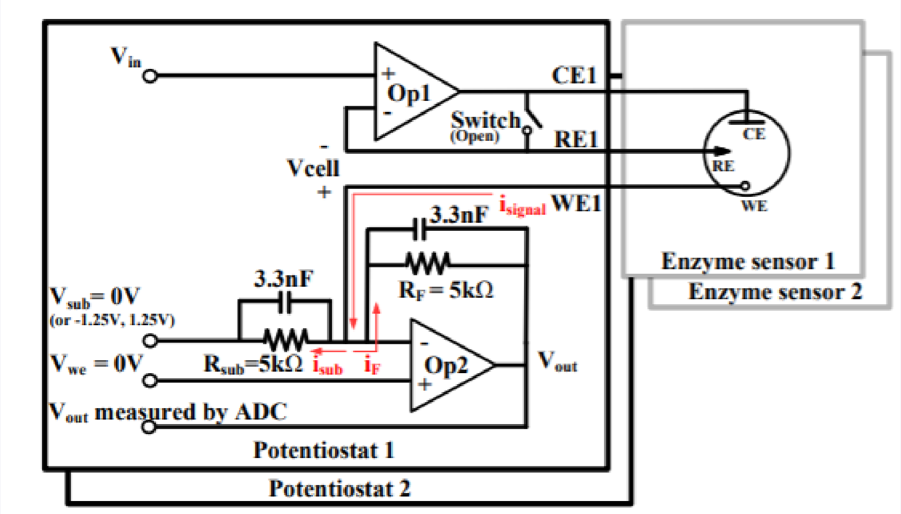


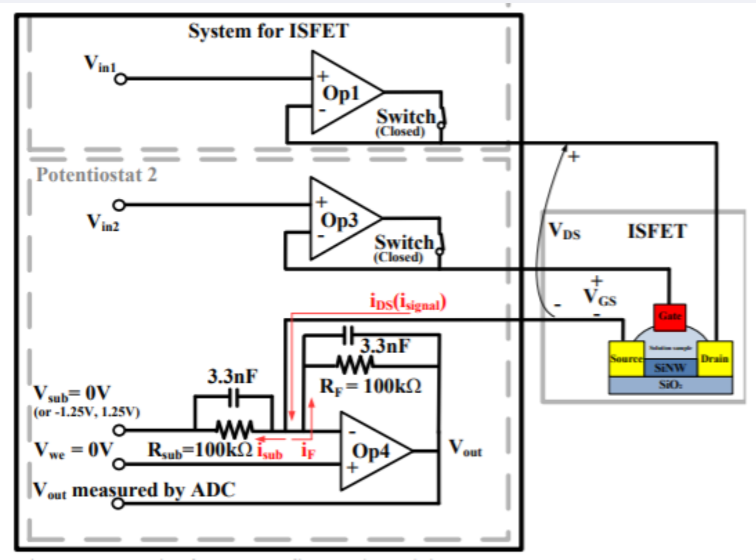
VIRTUAL SYMPOSIUM IN PLANT OMICS SCIENCE

State of the art

(Lee et al., 2016)







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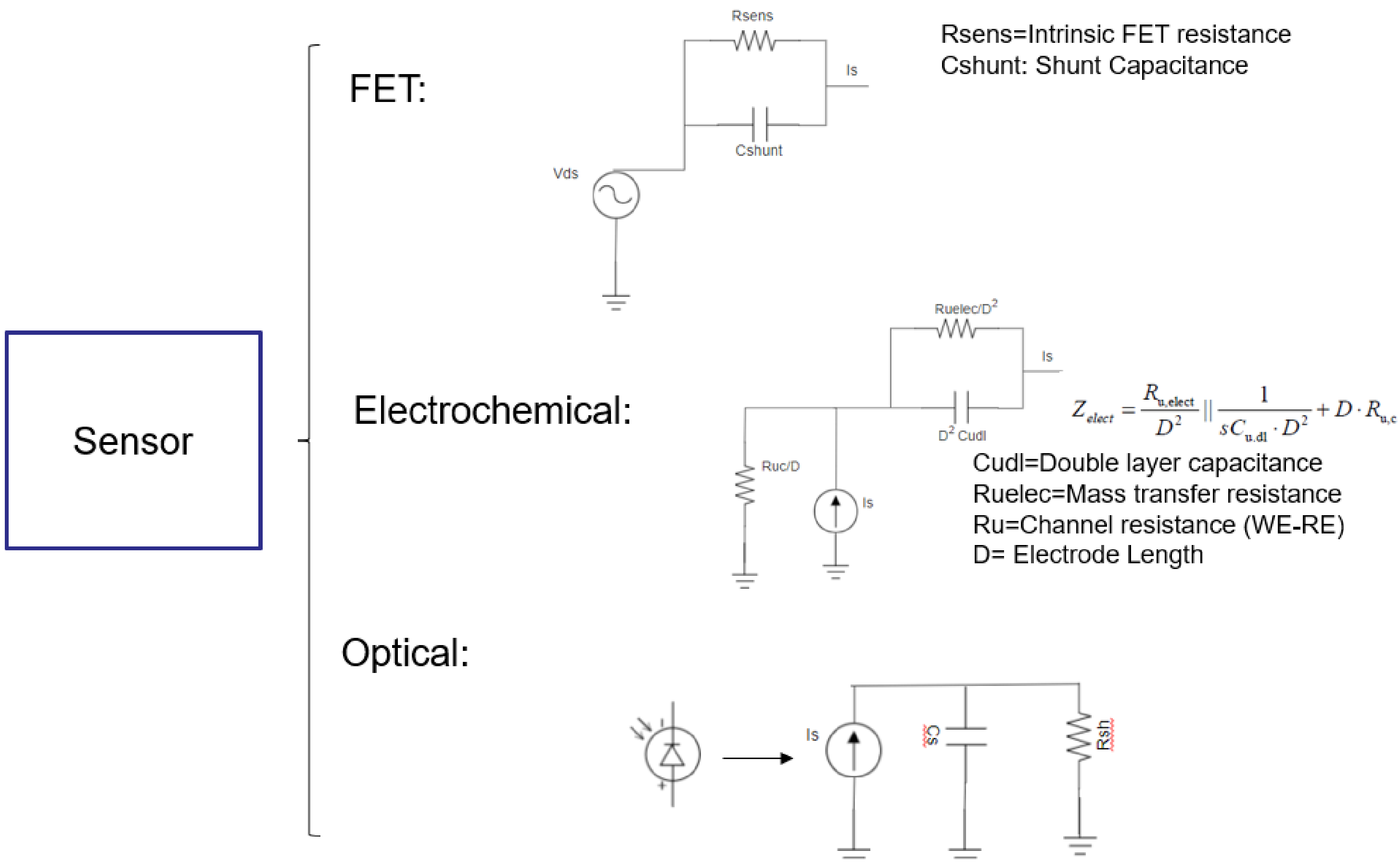
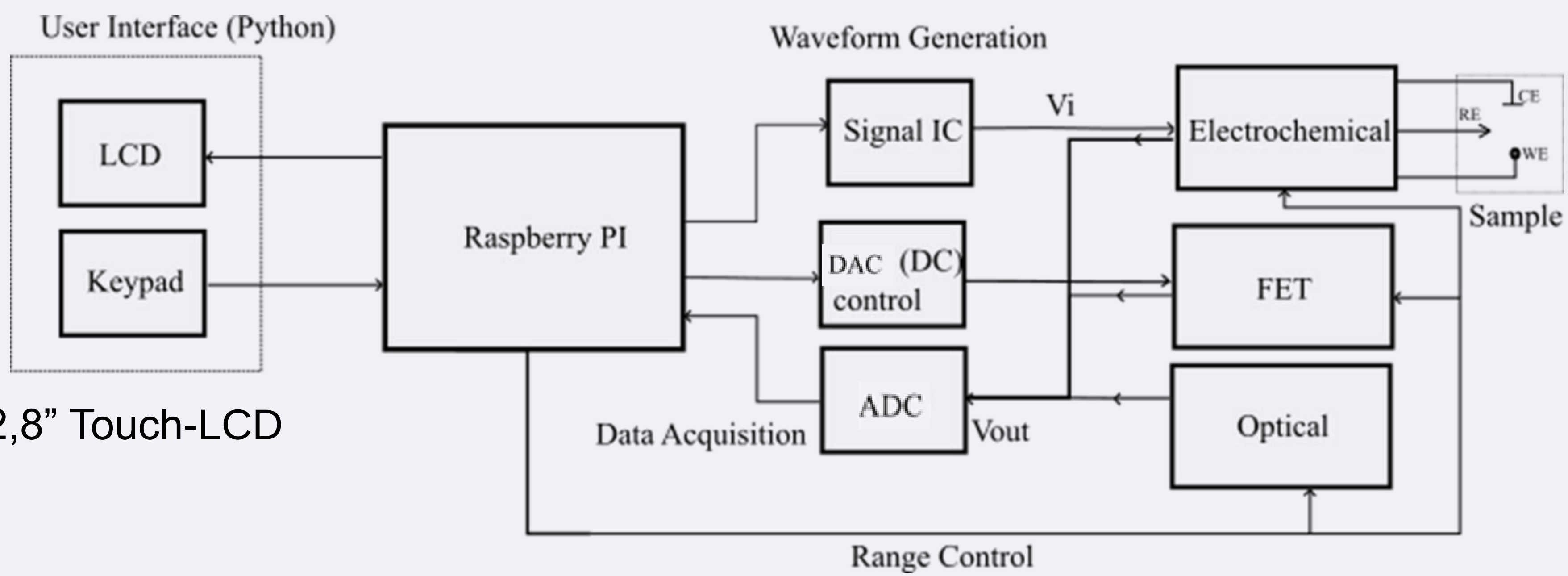
Methodology

Sensors: Equivalent Circuit



$$Z_{elect} = \frac{R_{u,elect}}{D^2} \,||\, \frac{1}{sC_{u,dl} \cdot D^2} + D \cdot R_{u,c}$$

Methodology



2,8” Touch-LCD

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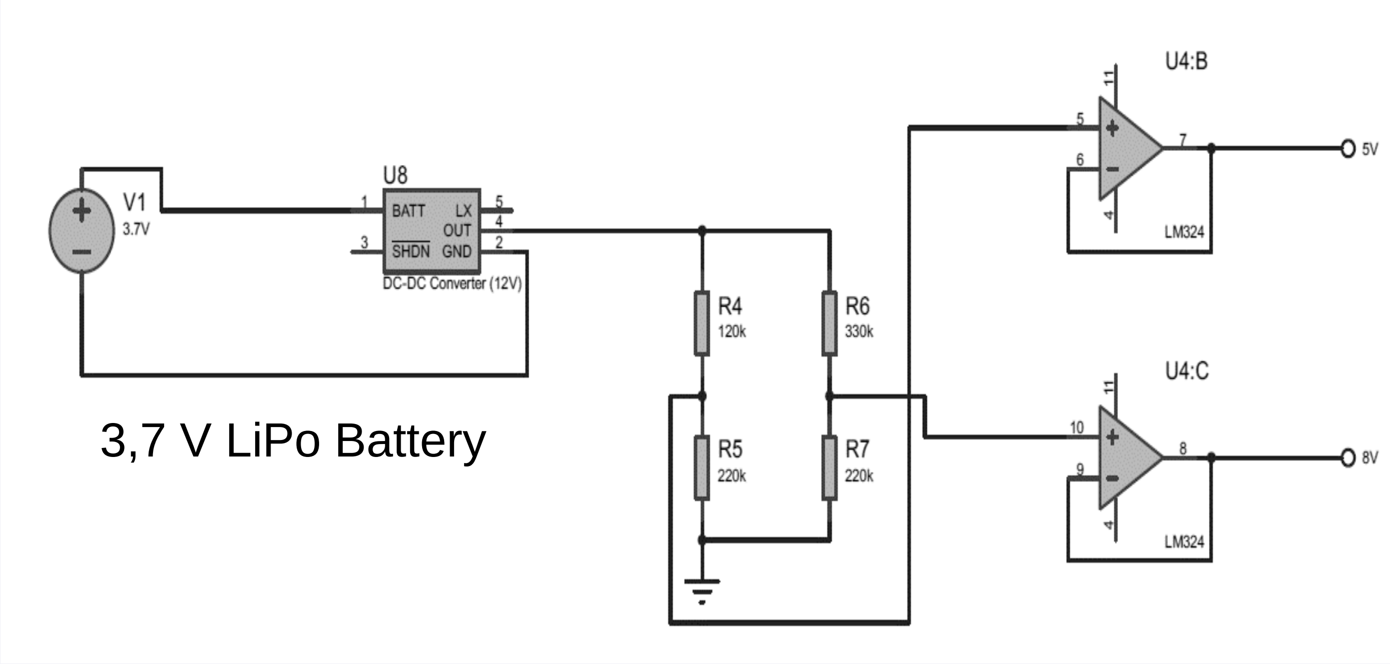
Methodology

Power Circuit:



Methodology

Electrochemical Module: Specifications

	Value
DC potential range	0V a +1.73V
Voltage	5V
Max Current	60mA
Sampling	100kSPS
EIS	yes
DC resolution	20mV-30mV
Current range	1.8 nA – 0.2uA 0.2uA-10uA 10uA-0.1mA 0.1mA-10mA 10mA-60mA

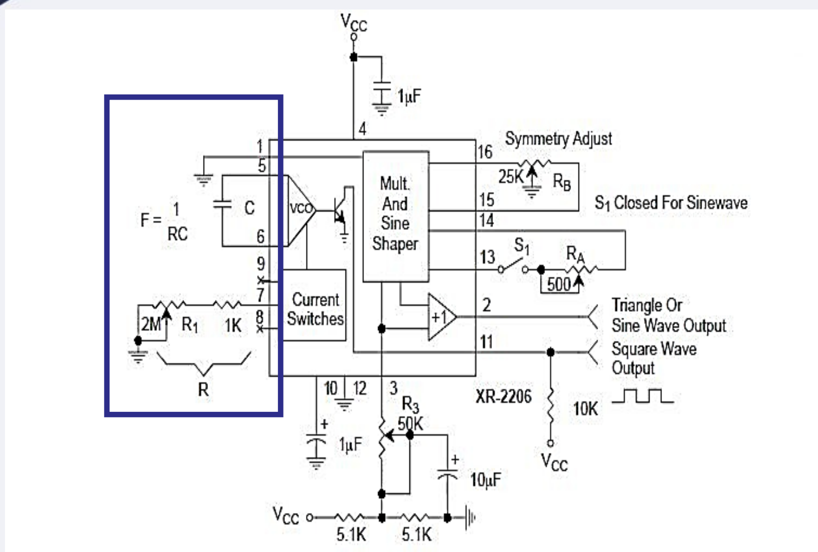
EIS	
Frequency range	0.1 – 80kHz
Frequency Resolution	0.02Hz f<10hz , o, 0.3Hz 10hz<f< 200hz, 5Hz 200hz<f<4khz, 90Hz 4kHz<f<80kHz
Ac amplitude range	38 mV-650m (Vp-p)

Storage	**12GB**
Bandwidth	80kHz
Dimensiones	90mm × 60.5mm × 50mm
Temperature	0 a +40 C
Electrode channel	1
Display	2.8” TFT Touch
LCD resolution	320 x 240 pixels

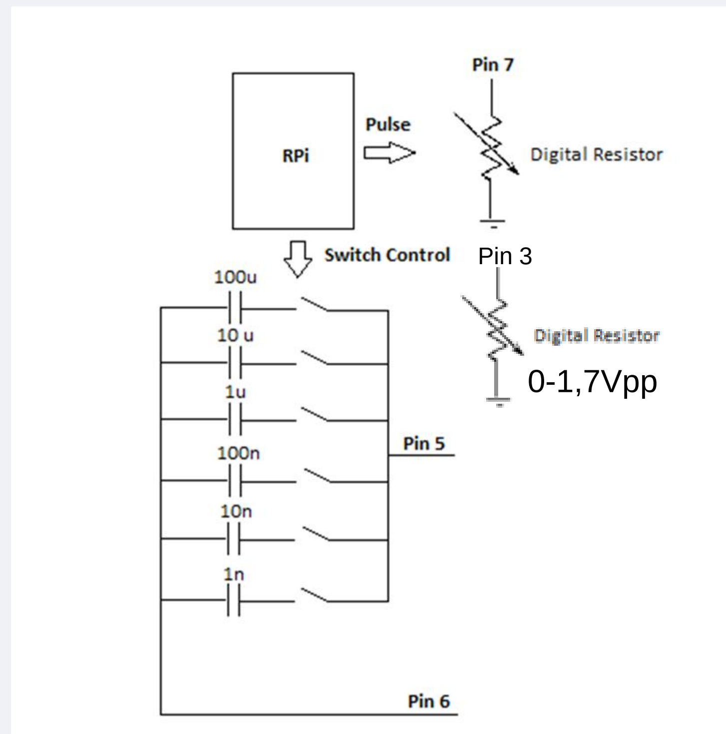
Methodology

Electrochemical Module: Signal Generator

XR2206 Module



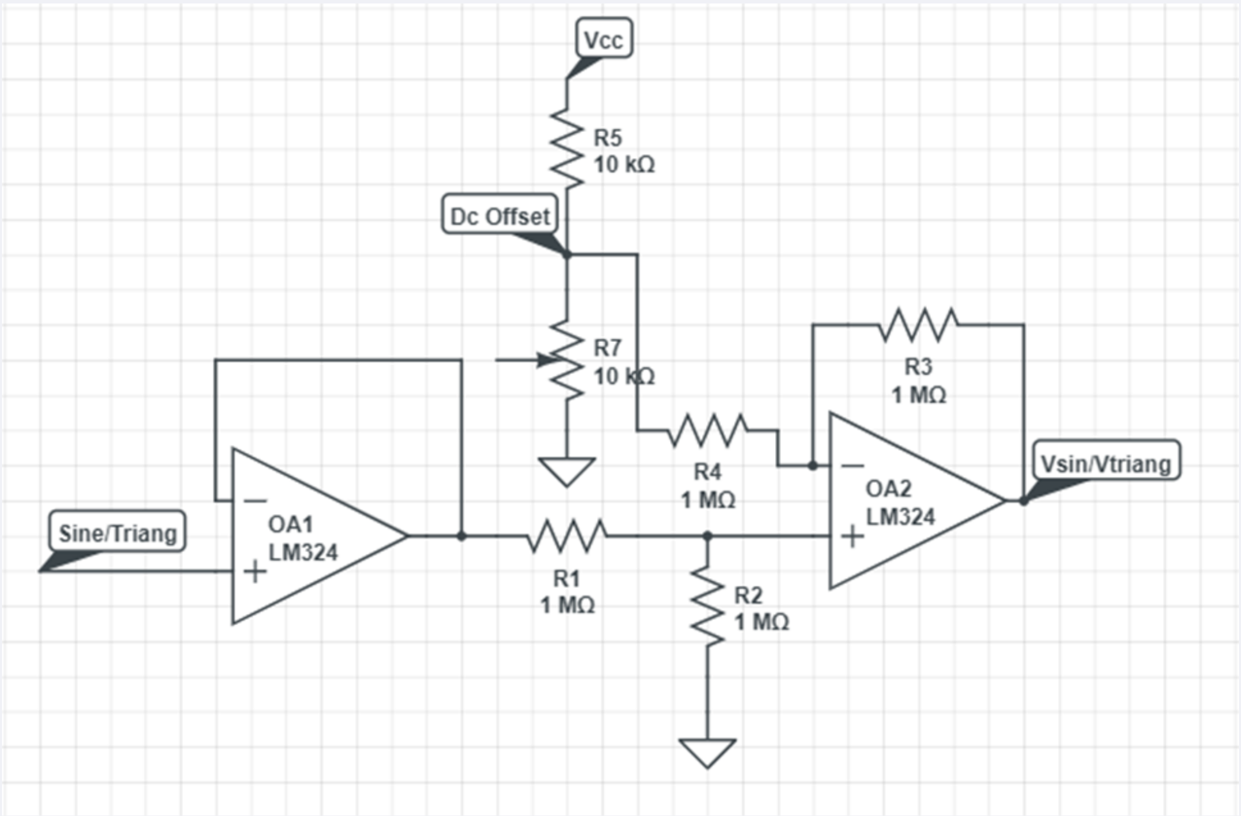
Rango Frecuencia	Capacitor	Rango Resistencia	Potenciómetro
0,1 - 1	100uF	100k-10k	100k
1 - 10	10uF		
10 - 100	1uF		
100 – 1k	100nF		
1k – 10 k	10nF		
10 k – 100 k	1nF		



Frequency and Amplitude control

Methodology

Electrochemical Module: Signal Generator



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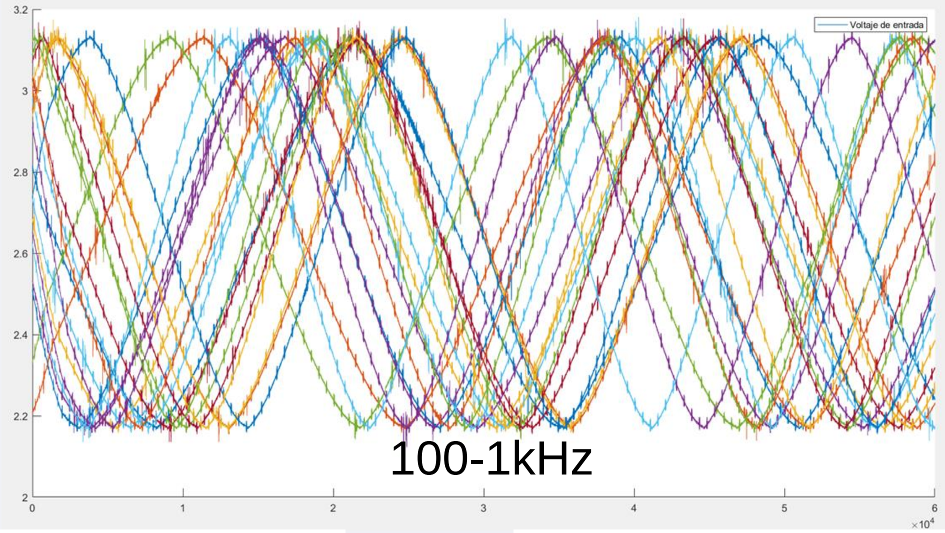
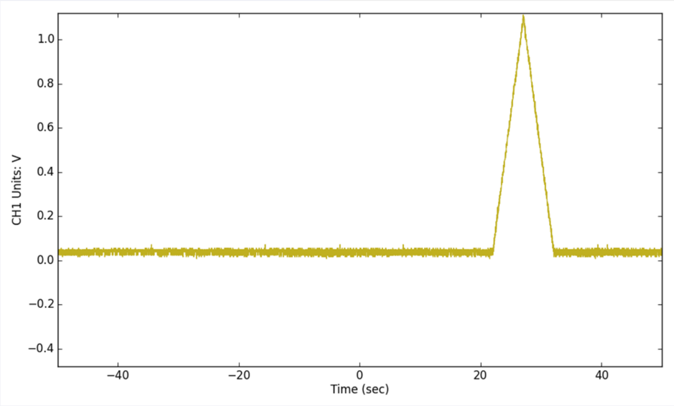
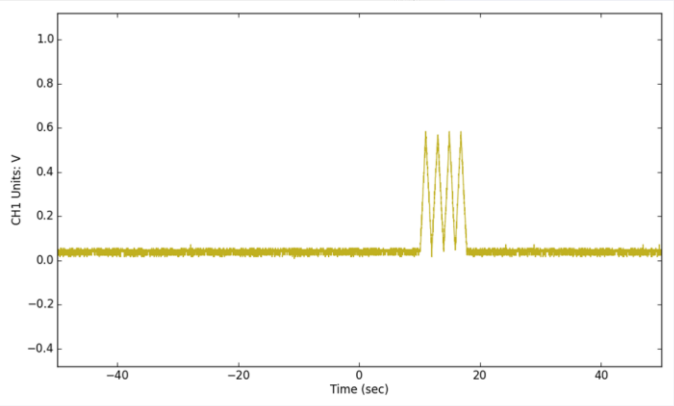
Methodology

Electrochemical Module: Signal Generator



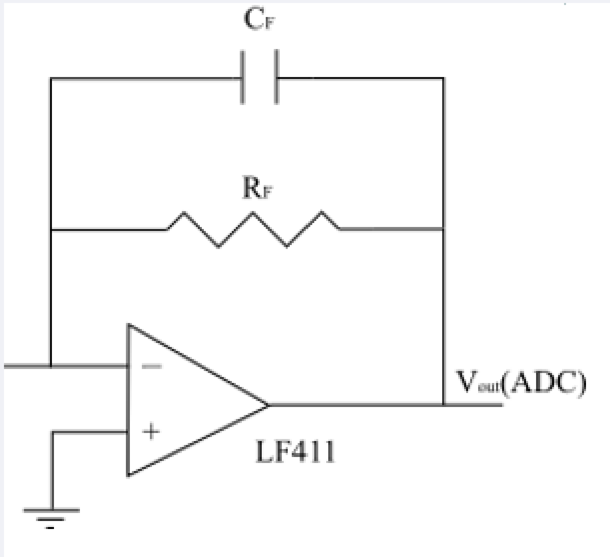


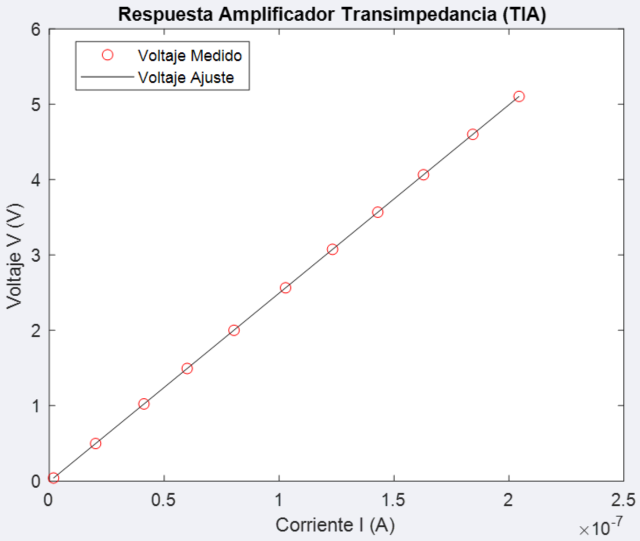


Methodology

Electrochemical Module: Current to Voltage

Transimpedance Amplifier (TIA)



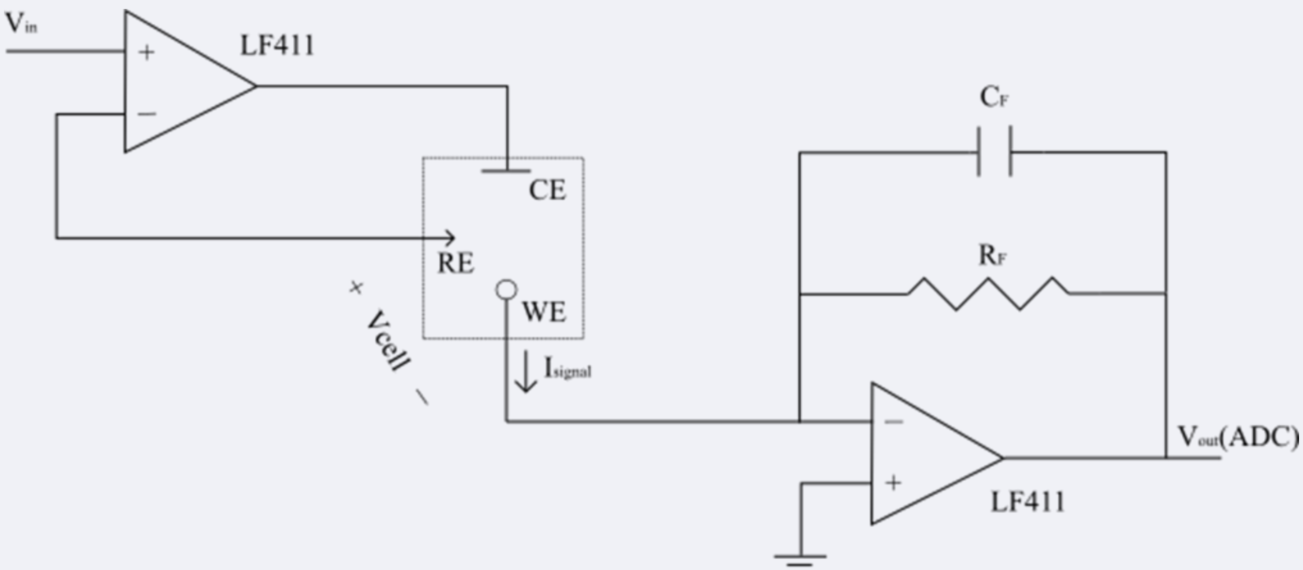


$$V = 2.4999x10^{-7}\ I - 0.0061$$

$$\frac{\Delta V}{\Delta I} = 2.4999x10^{-7}\frac{V}{A} \approx 25\ \frac{mV}{nA}$$

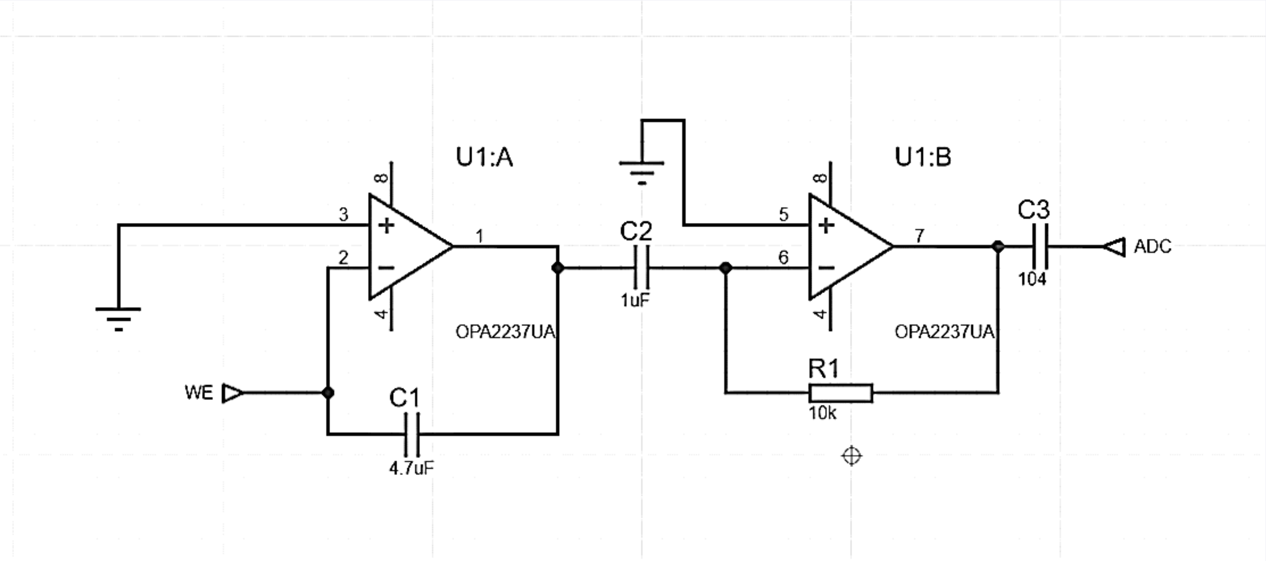
Methodology

Electrochemical Module: Front-end-Voltammetry



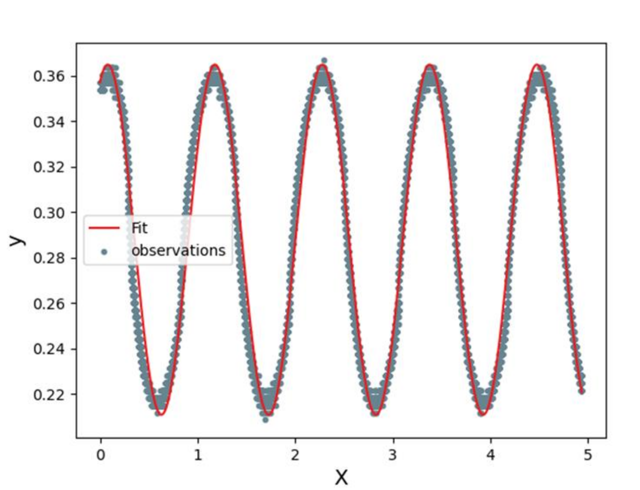
Methodology

Electrochemical Module: Front-end-Electrochemical Impedance Spectroscopy (EIS)



Methodology

Electrochemical Module: Signal Processing

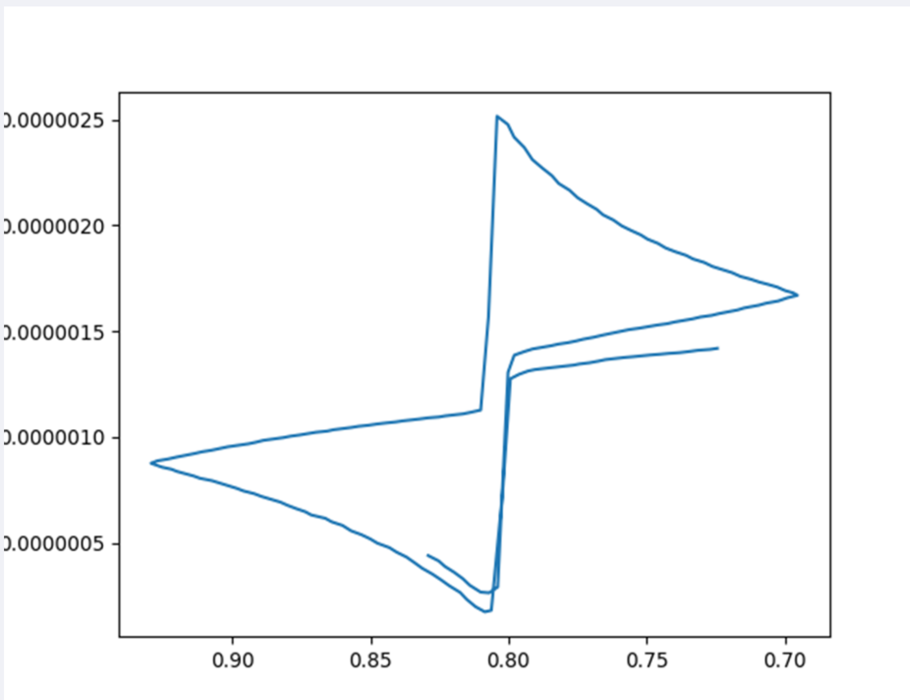


Curve Fit - Gradient Descent (Python)

I(A)	V(V)	Z(ohm)	Fase(°)	Z(Re)	Z(Im)
1.000000000000000000e+00	1.000000000000000000e+00	1.000000000000000000e+00	1.000000000000000000e+00	1.000000000000000000e+00	1.000000000000000000e+00
7.746405266127863454e-02	3.905954551607767683e-06	1.983229749291191911e+04	9.162659062532748067e+01	5.629506466920224739e+02	1.982430605132874553e+04
7.203081801319023703e-02	4.038656690183523444e-06	1.783534069342176008e+04	6.531386991610409609e+01	7.448878921022517716e+03	1.620535653635465678e+04
7.790983515413925364e-02	4.110311384701928642e-06	1.895472820967045118e+04	6.424635204309090852e+01	8.235878745369420358e+03	1.707196599088836592e+04
7.998101473082215584e-02	4.009244404397646619e-06	1.994914918209846292e+04	7.086944504684257140e+01	6.537770660843567384e+03	1.884744300630281577e+04
6.650454540989321484e-02	3.875815539763882215e-06	1.715885204741831694e+04	6.400792198175938097e+01	7.519813222162304555e+03	1.542331393342509546e+04
7.978049653901905791e-02	4.299627841381889858e-06	1.855520977215037419e+04	3.347961864716734226e+01	1.547656843055185345e+04	1.023580183976568151e+04
4.036191083987562822e-02	4.025939550294864417e-06	1.002546370496781856e+04	1.804108915558066428e+02	1.002520590564055601e+04	7.189609959363603764e+01
7.928628614339117142e-02	4.412881519280866077e-06	1.796700994508274380e+04	2.582361034863949101e+01	1.617281257553326213e+04	7.826466620600601345e+03
8.055589797970651167e-02	4.304573075341936291e-06	1.871402728441484578e+04	1.633442783895567914e+02	1.792886683440919660e+04	5.363818717653050044e+03
7.884342250058348767e-02	4.317314036164977276e-06	1.826214675146013542e+04	3.319187056092516741e+01	1.528253134432235129e+04	9.997511674495348416e+03
7.370684638765859220e-02	4.514343500994004129e-06	1.632725696913166394e+04	4.042375860931480247e+01	1.242944256659583698e+04	1.058717514825149192e+04
7.689090462348974198e-02	4.698522766839434840e-06	1.636491051318499922e+04	2.784379287569026360e+02	2.401352220703106468e+03	1.618776709792543261e+04
7.218693863882380546e-02	4.770528890102789016e-06	1.513185231695943367e+04	2.419336289981302457e+02	7.119446442025471697e+03	1.335239442577253249e+04
7.862604937337587530e-02	4.064071913752652989e-06	1.934661862338324863e+04	1.092099981697955968e+00	1.934310430211346829e+04	3.687385472106564634e+02
7.956931524067901995e-02	4.338071947460812190e-06	1.834209211012579908e+04	4.766264754749172994e+01	1.235329913025208771e+04	1.355833115006607659e+04
8.034326659505638957e-02	5.021905099900956875e-06	1.599856329356780043e+04	2.190902589271545082e+02	1.241734280609517373e+04	1.008779584915413579e+04
7.994268491481675010e-02	5.063773742202451411e-06	1.578717553048613627e+04	8.261242735296913509e+01	2.029922952238011931e+03	1.565612736401813709e+04
7.229883014040369704e-02	5.099449249597466622e-06	1.417777226552665888e+04	8.362150719719133463e+01	1.575092260706881689e+03	1.409000747989149386e+04
7.927043585857677932e-02	5.277049631049463951e-06	1.502173399927110586e+04	6.682452545173531178e+01	5.911779947527506920e+03	1.380953837739948358e+04
7.897345423894464034e-02	4.940688862913611875e-06	1.598430025249001301e+04	1.783330003154480039e+02	1.597753539319975425e+04	4.649917427239481071e+02

Preliminary Results

Electrochemical Module: Preliminary Results
Voltammetry



- Electrode: Screen-Printed-Electrode
- Sample: ferricyanide
- Voltage: 10mV
- Offset: 0.8V
- Frequency: 1Hz
- Scan Rate: 10mV/s.
- Scans: 1.

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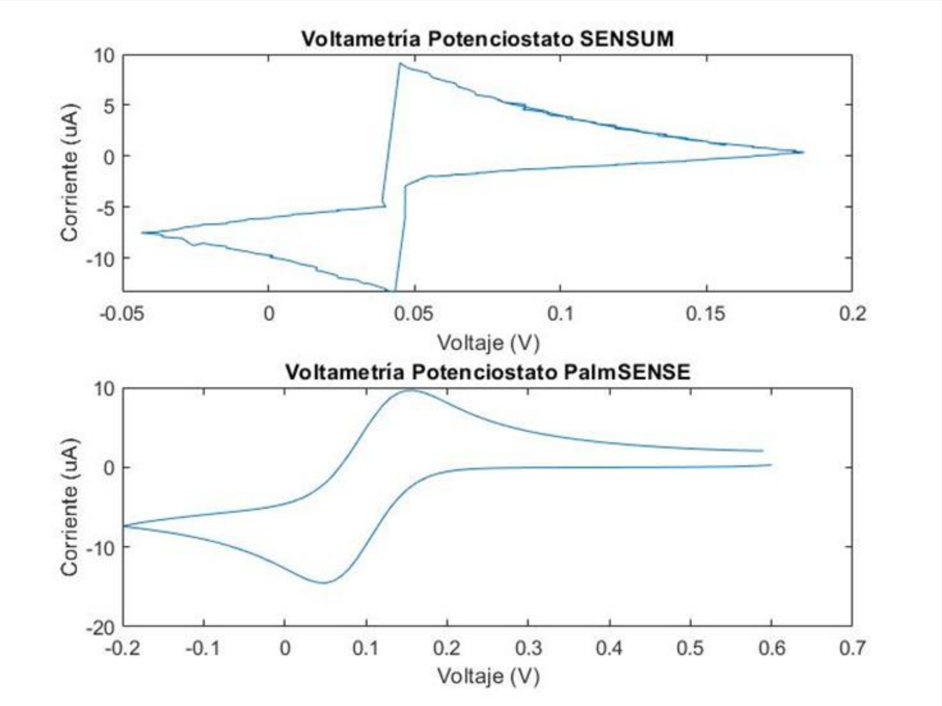
Preliminary Results

Electrochemical Module: Preliminary Results Voltammetry



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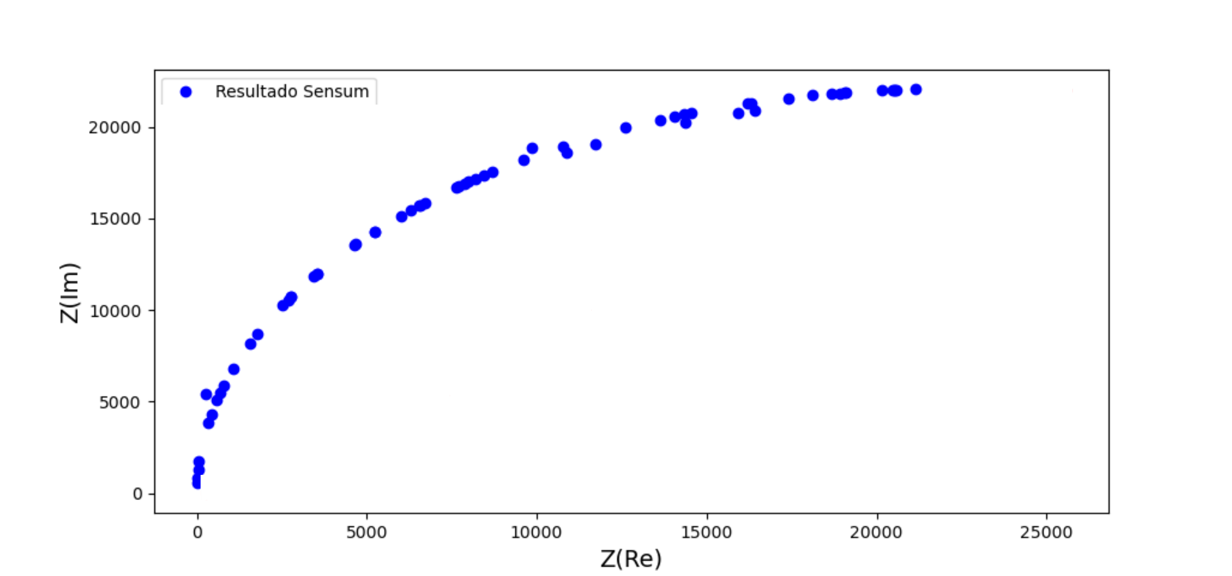
Preliminary Results

Electrochemical Module: Preliminary Results EIS

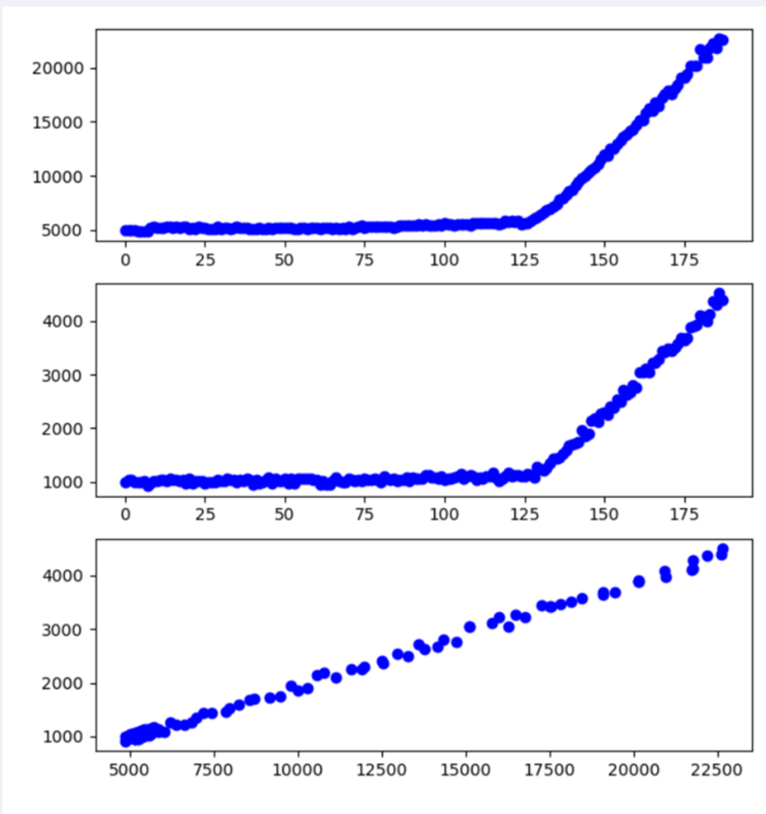


- Electrode:Screen-Printed-Electrode
- Sample: ferricyanide
- Voltage: 30mV
- Offset: 0.2V
- Frequency: 0.9 Hz-10 kHz

Preliminary Results

Electrochemical Module: Preliminary Results EIS

Sensum



Palmsense

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samperdomo16@javerianacali.edu.co

ajaramil@caltech.edu

drochss.valencia@javerianacali.edu.co

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THANK YOU!

Referencias

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