5TH CLABIO
LATIN AMERICAN BIOIMPEDANCE
FLORIANOPOLIS – BRAZIL - 2024

Remotion of the Hook effect from bioimpedance readings using the 3-point method and iteration

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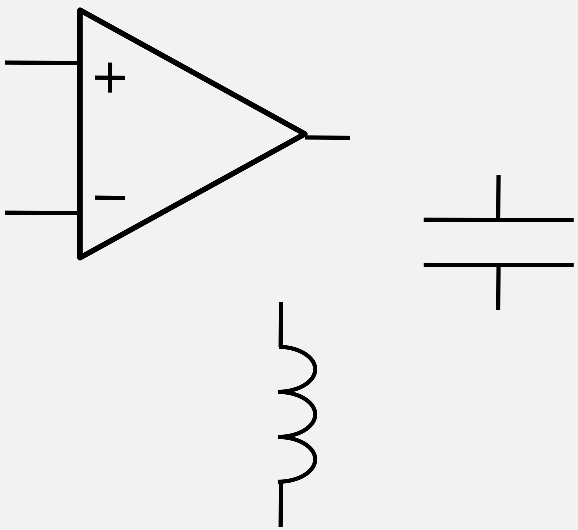
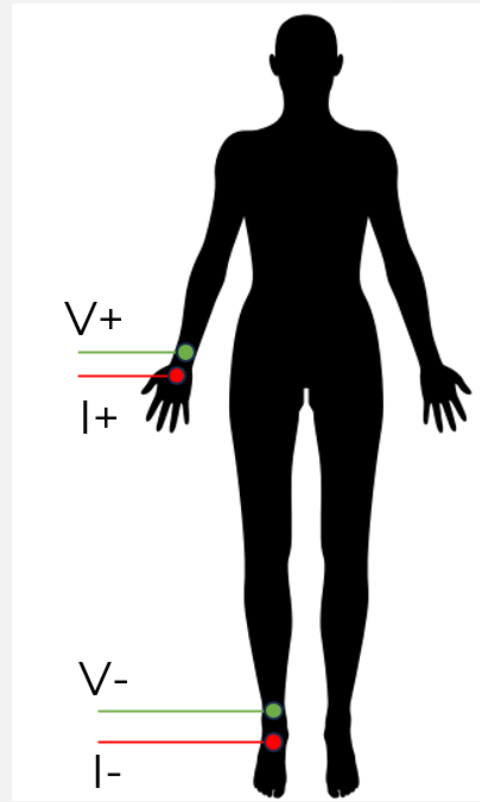
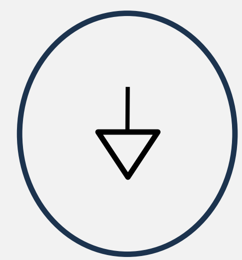
Introduction

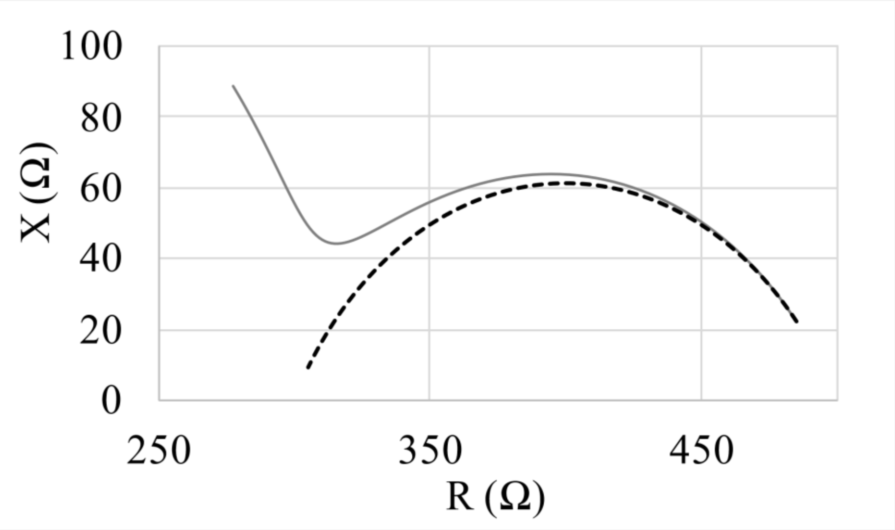


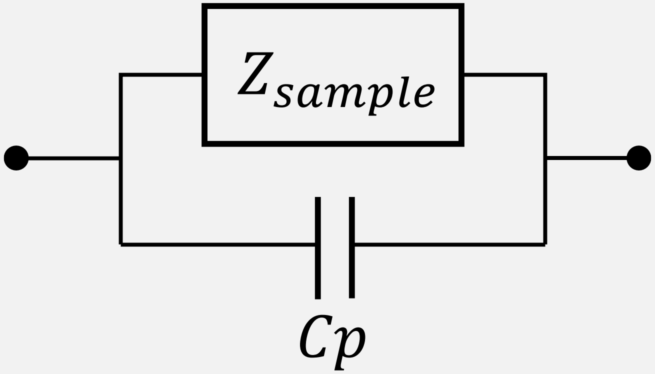




Impedance measurements may exhibit deviations
due to parasitic effects

Introduction





$$\boldsymbol{Z}_{meas} = \frac{\boldsymbol{Z}_{sample}\boldsymbol{Z}_{C}}{\boldsymbol{Z}_{sample} + \boldsymbol{Z}_{C}}$$

$$\boldsymbol{Z}_{sample} = R_{\infty} + \frac{R_0 - R_{\infty}}{1 + (j2\pi \boldsymbol{f}\tau)^{\alpha}}$$

Hook effect: Deviations caused by parasitic capacitances.

Introduction

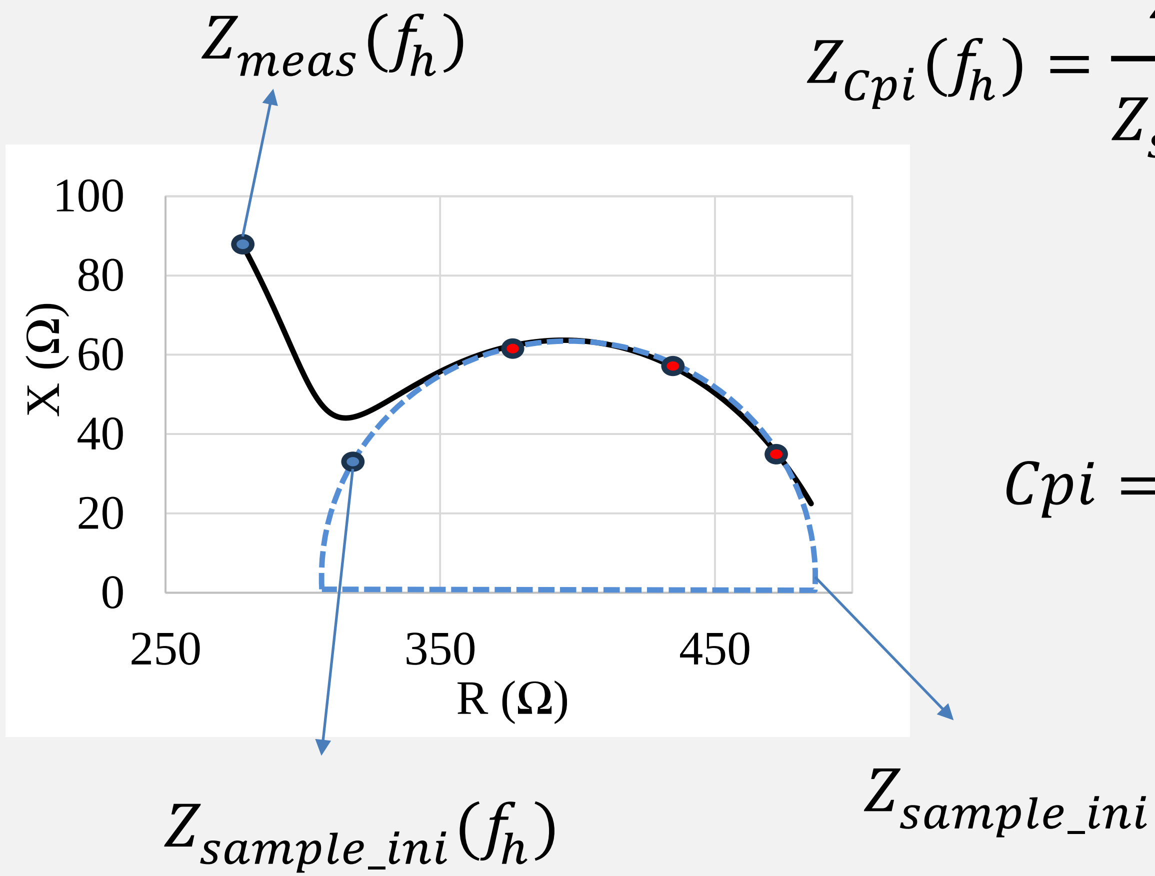
Methods for hook effect correction

$$\boldsymbol{Z} = \boldsymbol{Z_m} e^{i\omega TD}$$ *Tdelay* Scharfetter H *et al* 1997

$$\boldsymbol{Z} = \boldsymbol{Z_m} e^{-Log[1-\boldsymbol{Z_m} * jwCp]}$$ *Tdelay(w)* Buendia R *et al* 2010

Other methods based on nonlinear square fitting

Proposed method

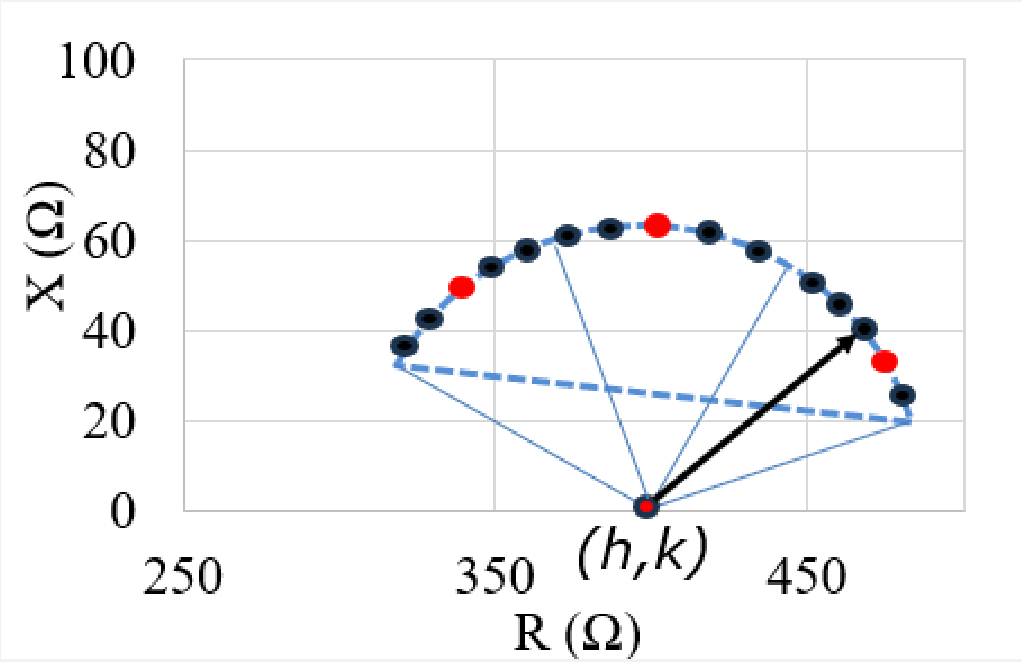


$$Z_{Cpi}(f_h) = \frac{Z_{meas}(f_h) Z_{sample\_ini}(f_h)}{Z_{sample\_ini}(f_h) - Z_{meas}(f_h)}$$

$$Cpi = \frac{1}{2\pi f} imag\left(Z_{Cpi}(f_h)\right)$$

Estimation of the initial capacitance value

Proposed method



$$Z_{sample} = \frac{Z_{meas} Z_C}{Z_C - Z_{meas}}$$

swept from $Cpi/5$ to $5Cpi$ in 250 steps

For each Cp, $\boldsymbol{Z}_{sample}$ is calculated.

Then the 3P method is applied to $\boldsymbol{Z}_{sample}$

Select the combination with the least SD of the radii calculated from each point to the centre *(h, k)*

Results

Errors for simulated models

Parameters errors (%) and values of the models.

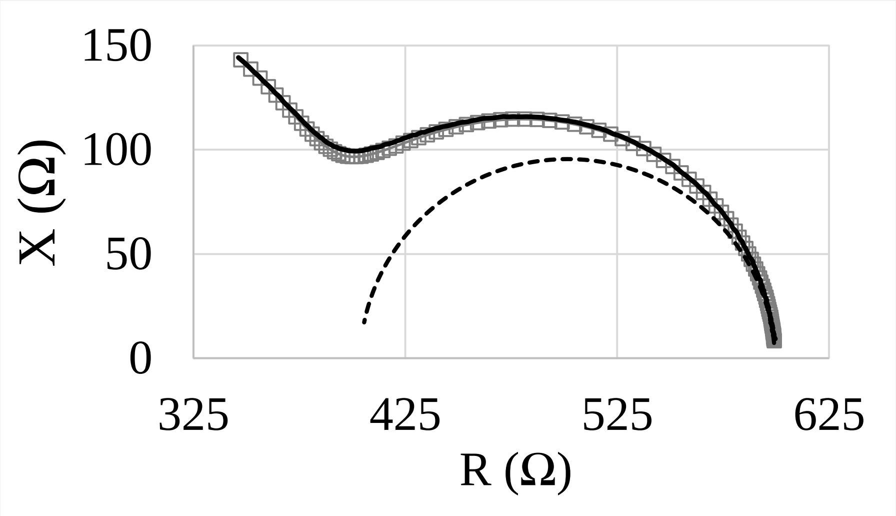
	% error vs. Theoretical values					Parameter values				
Parameter	R_0	R_∞	α	τ	Cp	R_0 $[\Omega]$	R_∞ $[\Omega]$	α	τ $[s]$	Cp $[pF]$
Model 1	0.00341	-0.00077	0.00604	0.00911	0.27254	500	300	0.7	1.0E-05	15
Model 2	0.01621	-0.00366	0.02873	0.04337	0.12977	500	300	0.7	1.0E-05	150
Model 3	0.03682	-0.00020	0.00664	0.09125	0.08472	500	300	0.7	5.0E-07	100
Model 4	0.00000	0.00000	0.00000	0.00000	-	200	100	0.7	5.0E-06	0

Results

Errors vs. *Tdelay(w),* applied to data obtained from Ayllon *et al* 2016 and a measurement taken with Mark3-modified device

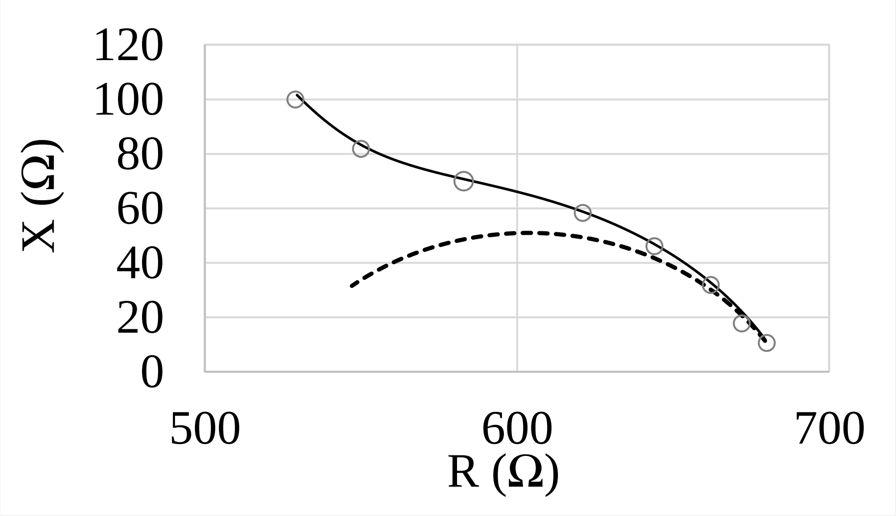
% error vs. *Tdelay(ω)*				
Parameter	R_0	R_∞	α	τ
Ayllon *et al* 2016 type A	-0.00121	0.00002	-0.00016	0.03830
Ayllon *et* al 2016 type B	-0.00010	0.00009	-0.00052	0.00129
Ayllon *et al* 2016 type C	-0.00045	0.00037	-0.00242	-0.01122
Mark3-modified	0.00189	0.00350	-0.02032	0.04706

Results



Ayllon Type A

Mark3-modified



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Discusion

- The method presented here shows a very good agreement when compared to the theoretical values, showing errors below 0.03% (**Table 1**)
- When *Cp* is absent, the exact values were found
- in comparison to the *Tdelay(ω)*, it shows very low errors
- iterative search for *Cp* needs neither values of admittance at very high frequencies, nor the fitting of conductance, unlike other methods

Conclusion

- The proposed method that allows the remotion of the hook effect by iteratively searching the capacitance Cp and using 3P method is presented.
- Due to the very good agreement with the Tdelay(ω) method, it seems to be a good alternative to extract the Cole model parameters in spectra affected by parasitic capacitance effects.
- it could be easily implemented in low-cost processors.

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