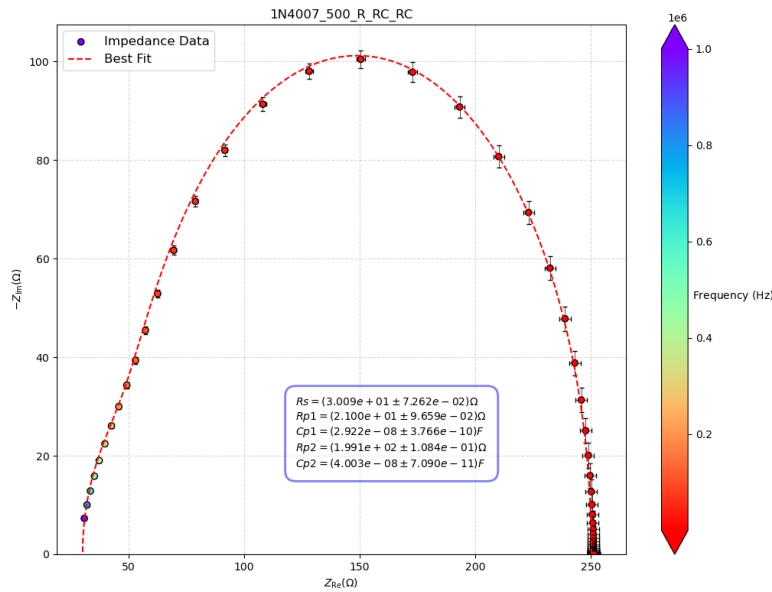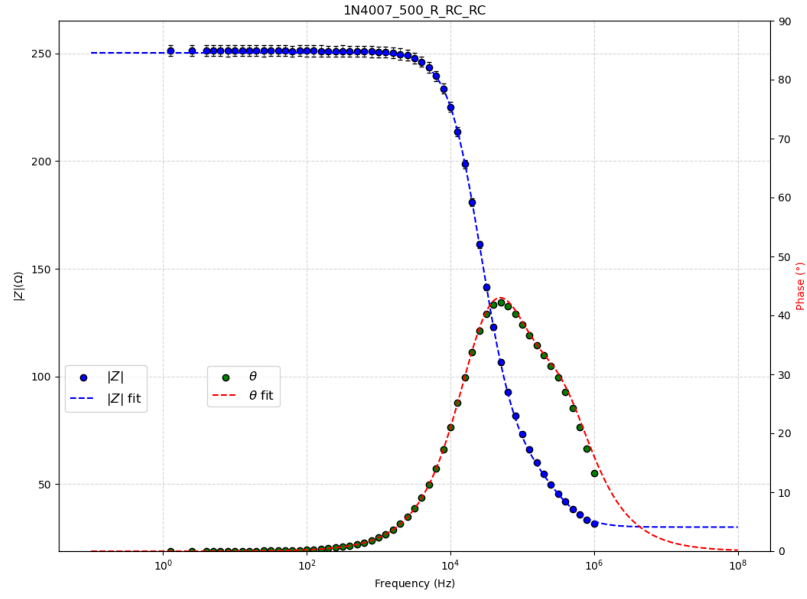# Impedance Spectroscopy

This repository contains the code for my bachelor thesis work on using impedance spectroscopy to characterize a p-n junction diode.

Using Complex Nonlinear Least Squares (CNLS) fitting, the impedance data is fitted to an equivalent model of the diode. In this case, we are using a model with a *series* resistor `Rs`, and two *parallel* `RC` circuits. Each parameter represents a physical property of the diode.

Example Results

1N4007_500_R_RC_RC

```
                              Migrad
┌──────────────────────────────────────┬──────────────────────────────────────┐
│ FCN = 491.1 (χ²/ndof = 4.5)          │              Nfcn = 350              │
│ EDM = 3.48e-05 (Goal: 0.0002)        │                                      │
├──────────────────────────────────────┼──────────────────────────────────────┤
│            Valid Minimum             │     Below EDM threshold (goal x 10)  │
├──────────────────────────────────────┼──────────────────────────────────────┤
│         No parameters at limit       │            Below call limit          │
├──────────────────────────────────────┼──────────────────────────────────────┤
│              Hesse ok                │          Covariance accurate         │
└──────────────────────────────────────┴──────────────────────────────────────┘
```

FCN = 491.1 (x^2/ndof = 4.5) Nfcn = 350
EDM = 3.48e-05 (Goal: 0.0002)

	Valid Minimum	Below EDM threshold (goal x 10)
	No parameters at limit	Below call limit
	Hesse ok	Covariance accurate

	Name	Value	Hesse Err	Minos Err-	Minos Err+	Limit-	Limit+	Fixed
0	Rs	30.09	0.07			0		
1	Rp1	21.0	0.1			0		
2	Cp1	29.2e-9	0.4e-9			0		
3	Rp2	199.13	0.11			0		
4	Cp2	40.03e-9	0.07e-9			0		

	Rs	Rp1	Cp1	Rp2	Cp2
Rs	0.00527	0.002	23.67461875e-12	-0.006	2.969984534e-12
Rp1	0.002	0.00933	4.89857649e-12	-0.007	5.746666402e-12
Cp1	23.67461875e-12	4.89857649e-12	1.42e-19	-24.34833093e-12	11e-21
Rp2	-0.006	-0.007	-24.34833093e-12	0.0118	-4.440994157e-12
Cp2	2.969984534e-12	5.746666402e-12	11e-21	-4.440994157e-12	5.03e-21