

Impedance, admittance, Nyquist, Bode, Black, etc...

I- Impedance or admittance Nyquist's diagrams

Impedance Z and admittance Y are two inverse transfer functions linked by the following very simple relation:

$$Z = \frac{1}{Y} \quad (1)$$

Let us consider the electrical circuit shown in Fig. 1 corresponding to circuit #1 of the Test Box-3 [1].

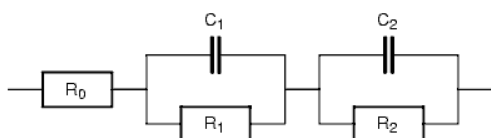


Fig. 1: Voigt circuit made of three Rs and two Cs.

The experimental Nyquist diagram of the impedance Z is shown in Fig. 2 [1]. Since frequency values are lost in the Nyquist diagram, it is useful to indicate the frequency of some characteristic points (top of the semi-circles).

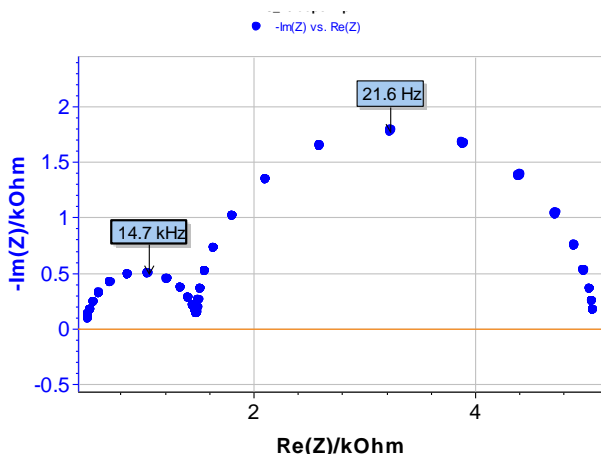


Fig. 2: Nyquist impedance diagram of the electrical circuit shown in Fig. 1. Arrow always indicates increasing frequencies.

Obviously the high frequency semi-circle is smaller than the low frequency semi-circle.

To highlight the high frequency part of the diagram, it is better to plot the admittance diagram instead of the impedance diagram as it is shown in Fig. 3.

The admittance diagram in Fig. 3 shows the high frequency semi-circle better. Does the graph of the admittance contain more information than the graph of the impedance? No, the admittance diagram only presents information differently.

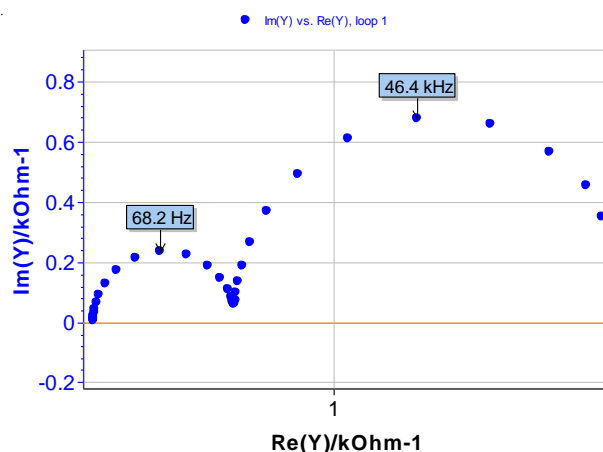


Fig. 3: Nyquist admittance diagram of the electrical circuit shown in Fig. 1.

II- Impedance or admittance Bode diagrams

To be convinced of that, we can plot the impedance and admittance Bode diagrams as shown in Fig. 4. Let us recall that plotting the Bode diagram of a transfer function H consists of plotting the decimal logarithm of the magnitude of H given by:

$$|H| = \sqrt{(\text{Re } H)^2 + (\text{Im } H)^2}$$

and the phase of H given by:

$$\varphi_H = \arctan \frac{\text{Im } H}{\text{Re } H}$$

versus the decimal logarithm of frequency or radial frequency.

According to Eq. (1), it is obvious that

$$\log|Y| = -\log|Z|$$

and

$$\varphi_Y = -\varphi_Z$$

The graphs showing magnitude and phases on Fig. 4 are symmetrical with respect to the horizontal axis. There is no more information in an admittance diagram than in an impedance diagram.

II- Impedance or admittance Black diagrams

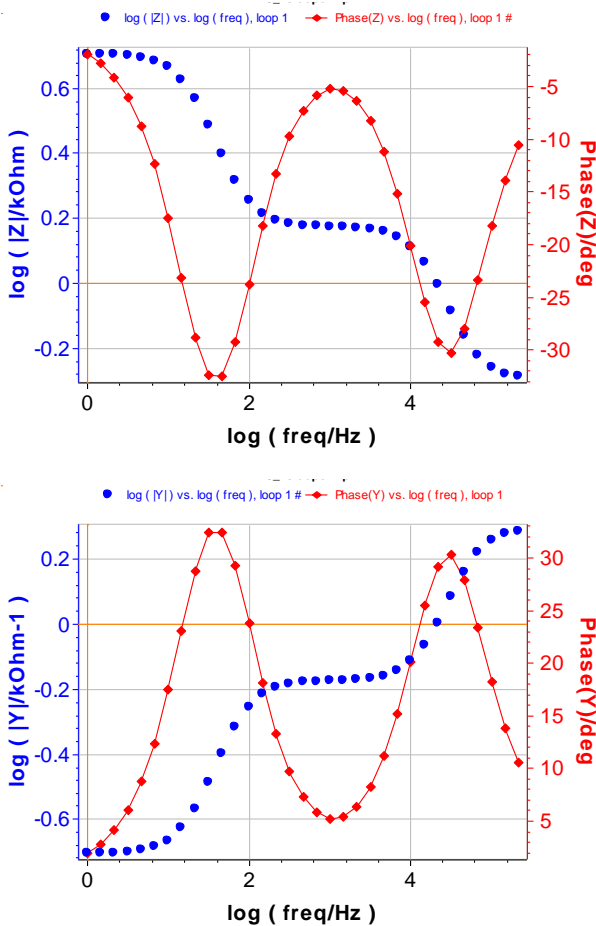


Fig. 4: Bode impedance and admittance diagrams of the electrical circuit shown in Fig. 1.

Electricians use other representations, such as Black diagrams, for example, where the decimal logarithm of the magnitude is plotted versus the phase (Fig. 5).

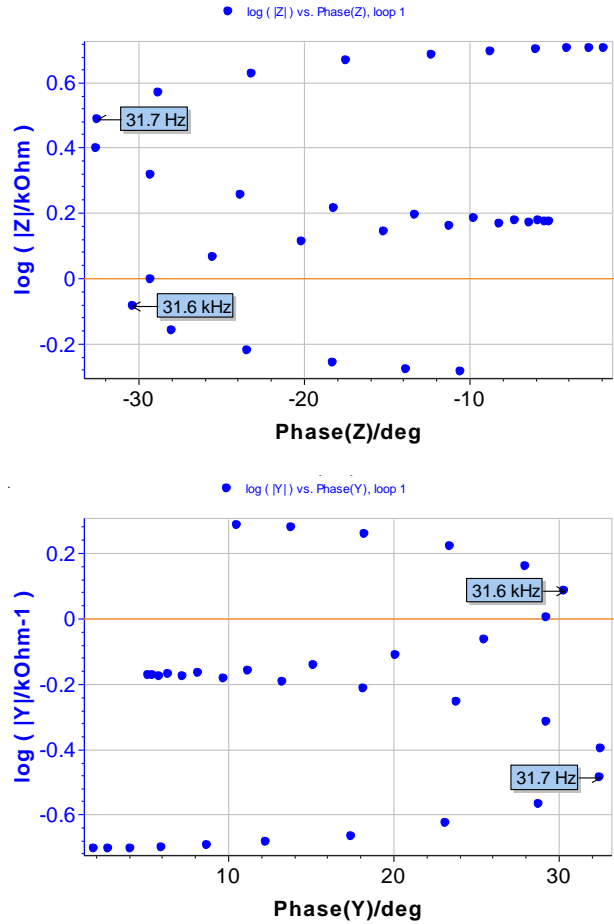


Fig. 5: Black impedance and admittance diagrams of the electrical circuit shown in Fig. 1.

As with the Nyquist diagram, frequency values are lost in Black Adiadagram. Therefore, it is useful to indicate the frequency of some characteristic points.

Reference:

- [1] Bio-Logic Application Note #9 (<http://www.bio-logic.info>)