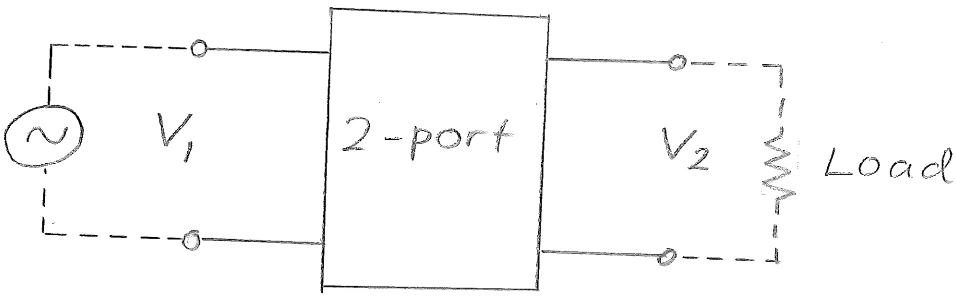
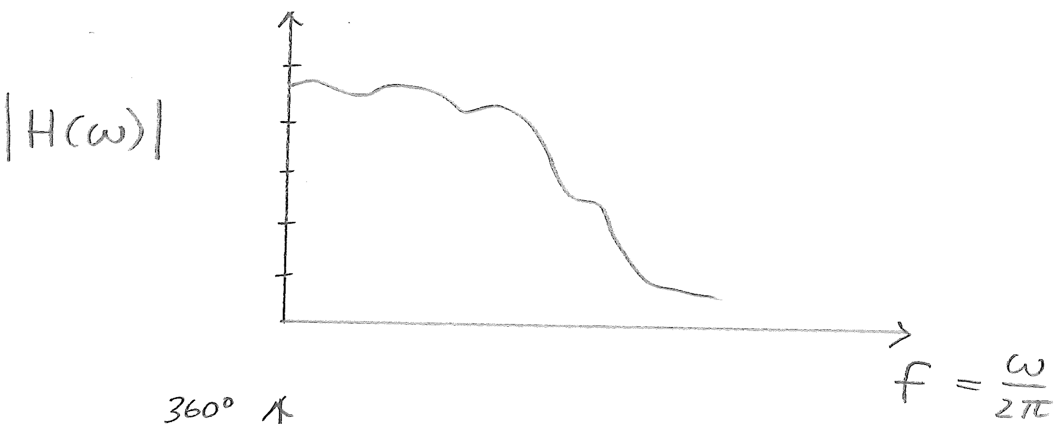
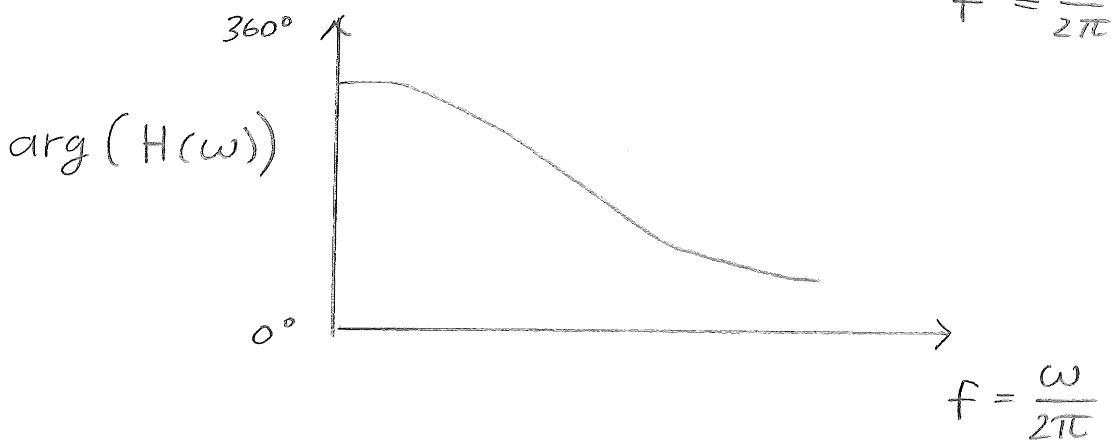
Impedance measurements using myDAQ (exploiting the Bode Analyzer)

① In general, "Bode plot" is the frequency response graph of 2-ports. Normally it has nothing to do with impedance ...

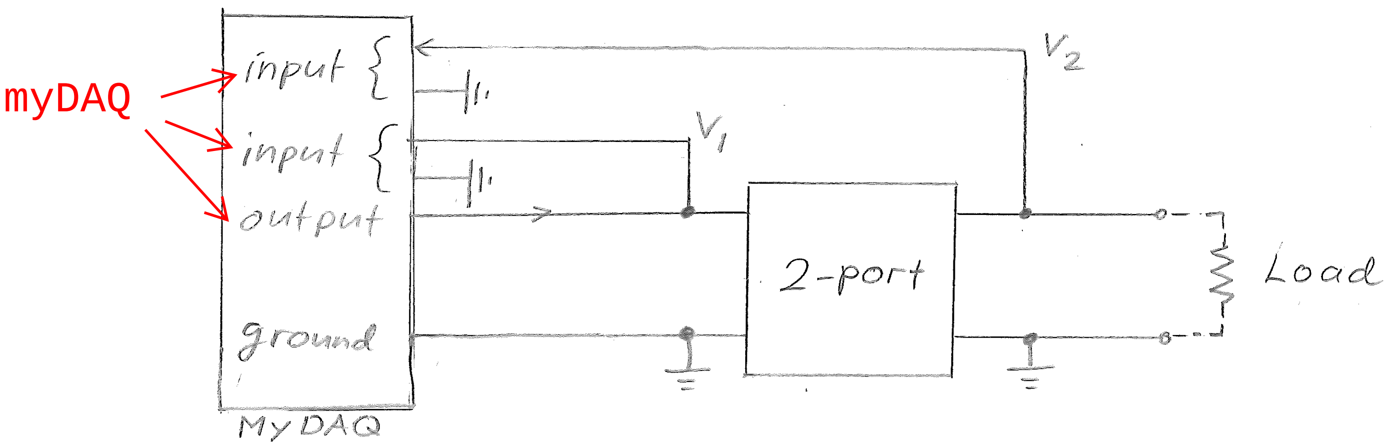


Frequency response $H(\omega) = \dfrac{V_2}{V_1}$.





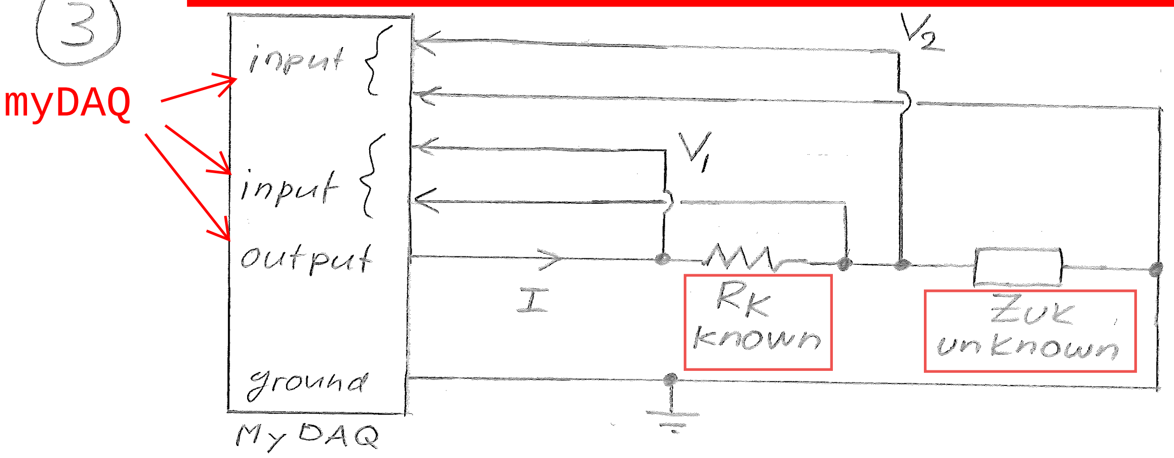
(2) Frequency response is the ratio of two voltages (output vs. input). It is easy to measure with myDAQ:



Frequency response $H(\omega) = \frac{V_2}{V_1}$

Settings: Impedance measurement with myDAQ

(3)



The Bode Analyzer measures:

$$H(\omega) = \frac{V_2}{V_1} = \frac{Z_{UK} I}{R_K I} = \frac{Z_{UK}}{R_K}$$

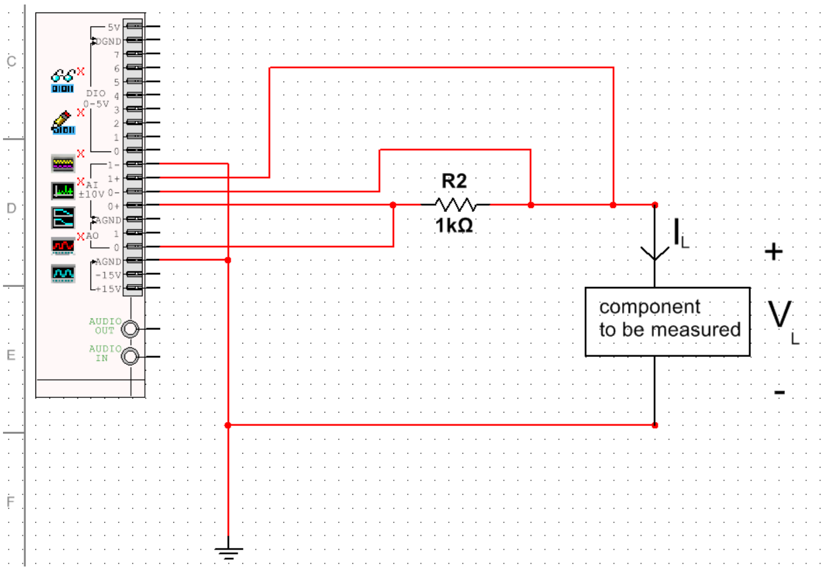
$$\Longrightarrow \boxed{Z_{UK} = H(\omega) \cdot R_K}$$

For example $R_K = 1.0\ k\Omega$

Detailed Settings: Impedance measurement with myDAQ

Measuring impedance with myDAQ

You can use the myDAQ Bode Analyzer to measure the impedance of a component. The figure below shows how.



To calculate the impedance Z_L of a component, we excite the component with a sinusoidal signal and determine the ratio between the component voltage phasor V_L and current phasor I_L. The load voltage is measured directly. To determine the current, we use a series resistor R_2 and measure its voltage.

The Bode Analyzer instrument determines the transfer function $H(f)$ by calculating the ratio between two voltage phasors:

$$H(f) = \frac{V_{AI1}}{V_{AI0}}.$$

Voltage V_{AI1} is measured between AI1+ and AI1- and voltage V_{AI0} is measured between AI0+ and AI0-.

In the figure, V_{AI1} is the measured voltage of the component, V_L, and V_{AI0} is the measured voltage of resistor R2. The impedance of the component can then be obtained by using the measured transfer function as follows:

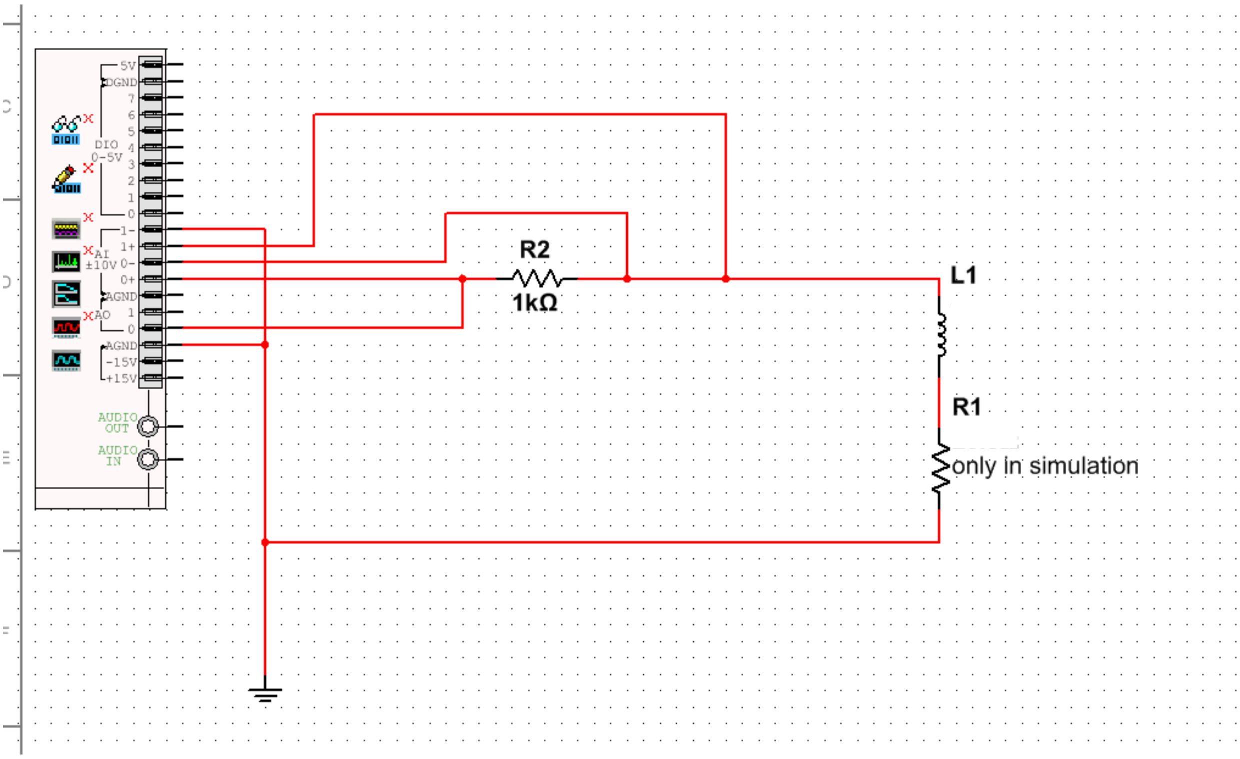
$$H(f) = \frac{V_{AI1}}{V_{AI0}} = \frac{V_L}{R_2 I_L} = \frac{1}{R_2} Z_L,$$

from which it follows that

$$Z_L = R_2 H(f).$$

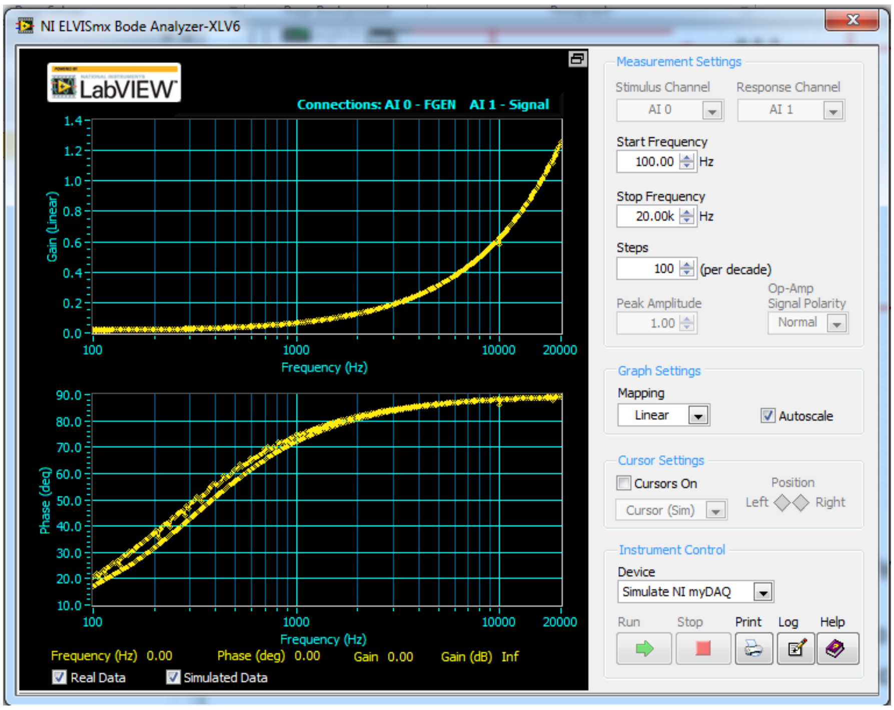
Comparing measured and simulated impedances

In the other example, we measure the impedance of the 10-mH inductor. We can also compare the result to the impedance of a circuit which consists of an ideal inductor and a resistor. Build the circuit in Multisim and on the breadboard. NOTE: When building the circuit on the breadboard, leave R1 out.



Enable the function generator and **ope**n the Bode Analyzer. Simulate and measure the transfer function.

Select Linear mapping in the Bode Analyzer window. To get the magnitude of the impedance, multiply the value of Gain (Linear) by R2. The phase of the impedance can be read directly from the Phase (deg) figure.



Example of using myDAQ to measure component impedance

Readings from Bode plot at 10 kHz (see Fig. 2):

* Gain (in linear scale) 0.06
* Phase angle (in degrees) 80.96
* Reference impedance $R_2 = 1000\ \Omega$

Hence,

$$\begin{aligned} Z &= R_2 * 0.06\angle 80.96 = 1000 * 0.06\angle 80.96\ \Omega \\ &= 60\angle 80.96\ \Omega \end{aligned}$$

In component form:

$$\begin{aligned} R_Z &= 60 * \cos(80.96) \approx 9.4\ \Omega \\ X_Z &= 60 * \sin(80.96) \approx 59.25\ \Omega \end{aligned}$$

Inductive reactance: (deduced from the phase angle)

$$\begin{aligned} X_Z &= \omega L \ \Rightarrow\ L = \frac{X_Z}{\omega} \\ &= \frac{59.25\ \Omega}{2 * \pi * 10000\ \text{rad}} = 0.94\ \text{mH} \end{aligned}$$

Conclusion: the unknown impedance in Fig. 1 consists of about 10-Ω resistor and 1-mH inductor.

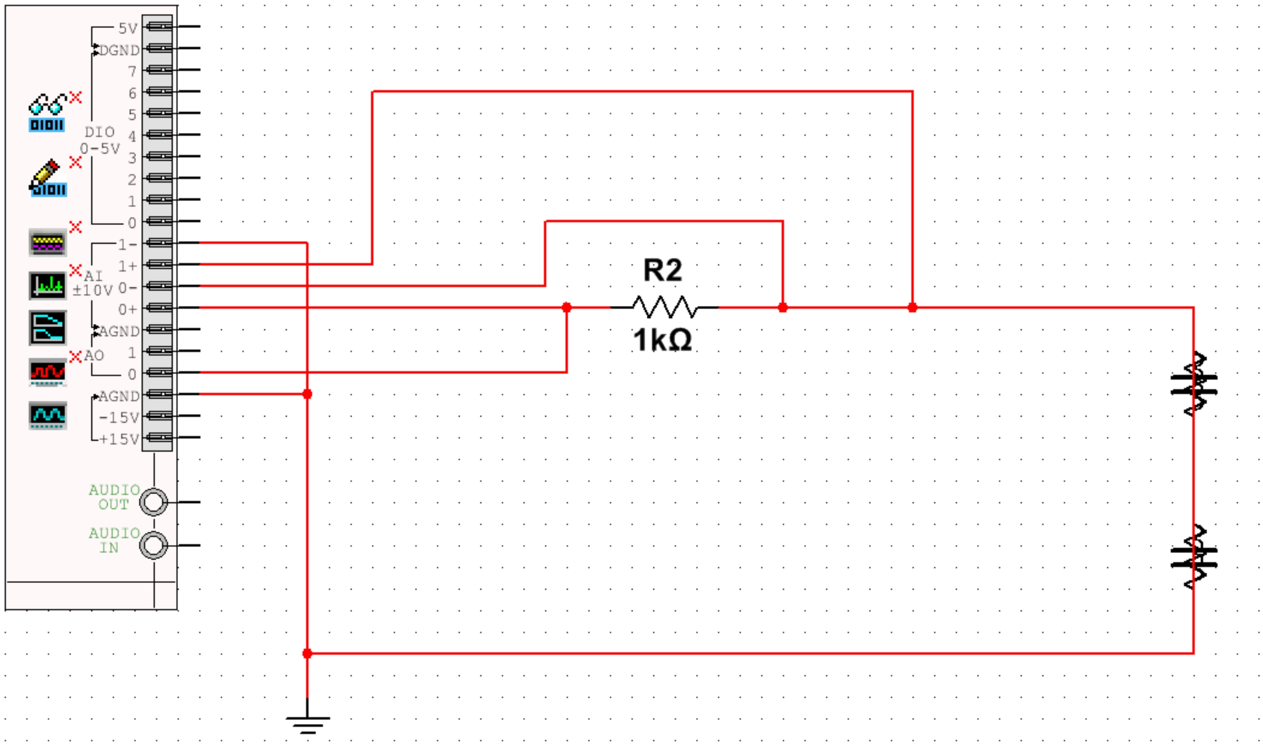


Figure 1: Multisim schematic with two unknown components.

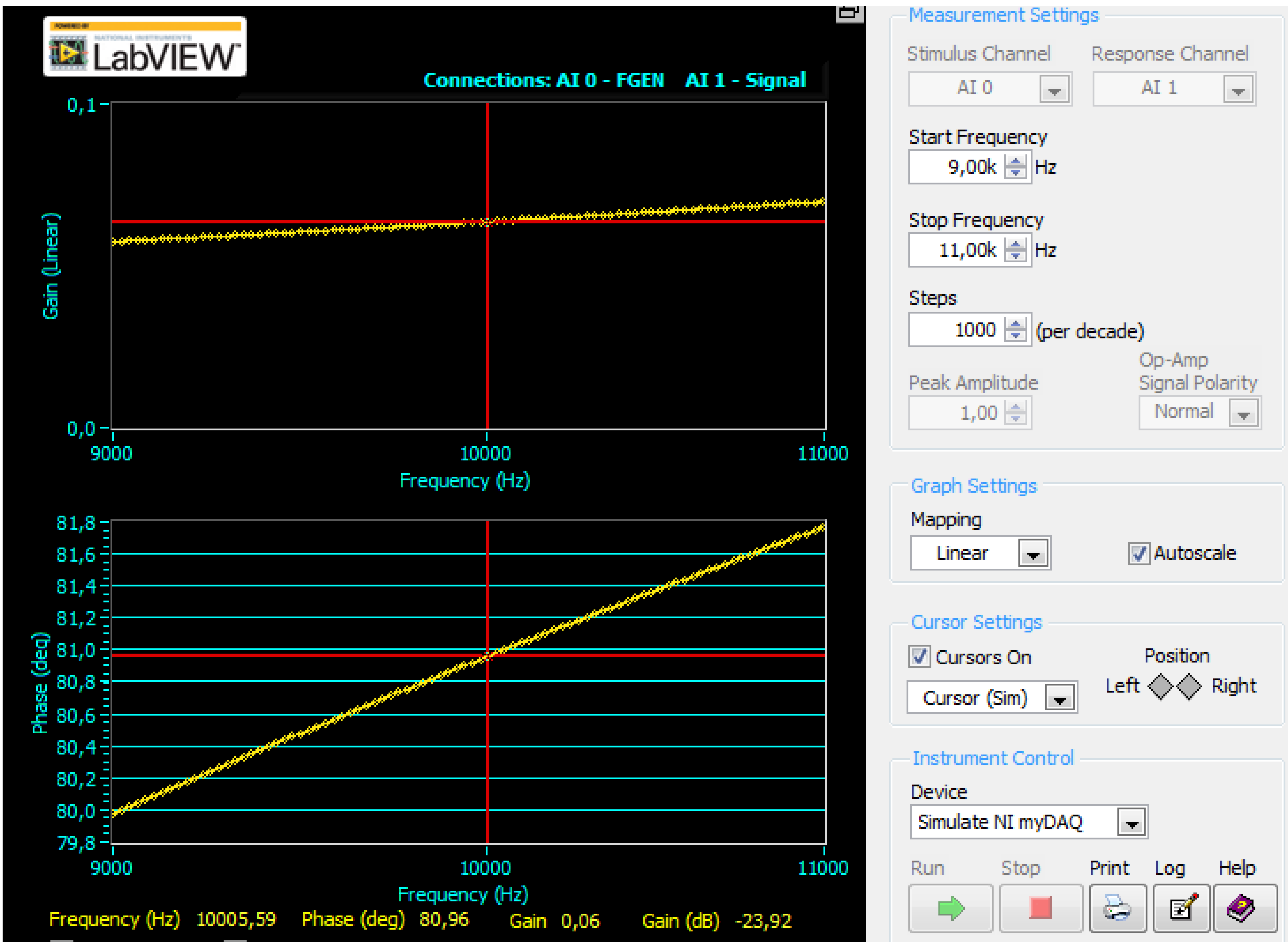


Figure 2: Multisim simulation results.