Measuring Impedance in a double-voltage divider

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Introduction

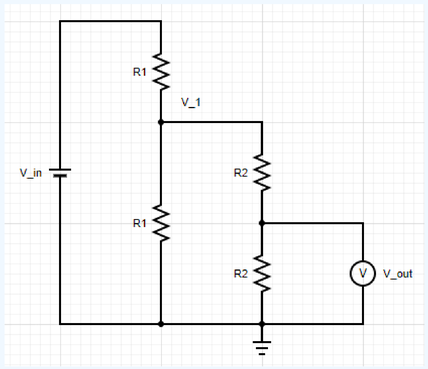
Output impedance - corresponds to internal resistance of device creating voltage

Input impedance - corresponds to internal resistance of device measuring voltage

To show internal resistances, replace real device with its ideal version

Single vs Double voltage divider

Double Voltage divider:



Expected Values

break circuit into two parts

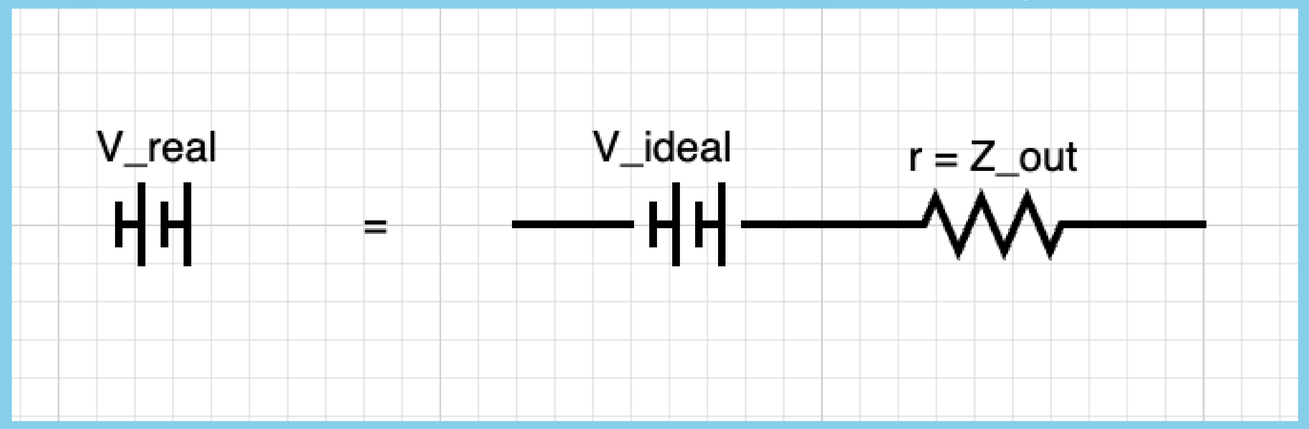
To find output - resistors in parallel; expect our impedance to be $Z_{out} = \frac{R_1}{2}$

To find input - resistors are in series; expect our impedance to be $Z_{in} = 2R_2$

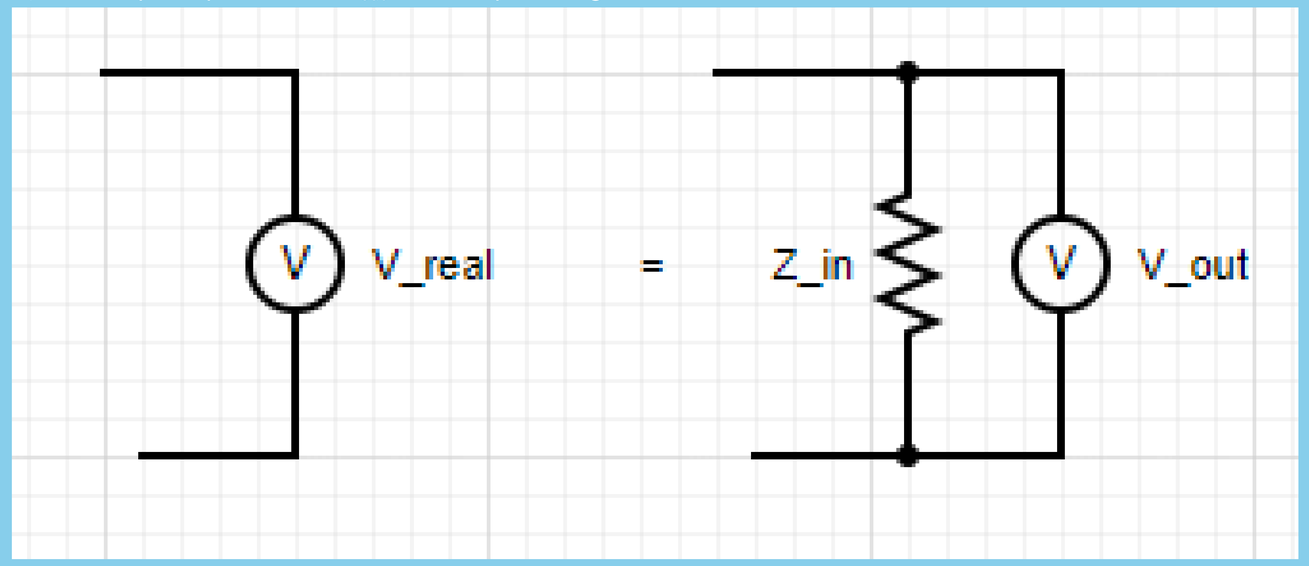
To measure the impedance, we will treat the left hand side as a voltage source with a Z_{out} and the right most voltage divider as the voltage measuring device with a Z_{in}

Differences between input and output impedance and their affect on a circuit

An example of output impedance. V_{real} is the regular battery and the diagram on the right shows it's ideal version where $r = Z_{out}$ is the output impedance (internal resistance of the battery) and V_{ideal} is the input voltage



An example of input impedance. V_{real} is the regular voltmeter and the diagram on the right shows it's ideal version where Z_in is the input impedance and V_{out} is the output voltage



Impedance Equations

Impedance is denoted by a Z

Output Impedance:

Where R_L is the load resistance and V_{nL} is the voltage the device produces with only the voltmeter connected

$$Z_{out} = \frac{\Delta V_{nL} - \Delta V_L}{\Delta V_L} R_L \quad (1)$$

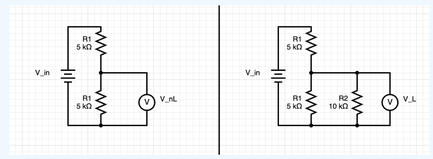
Input Impedance:

$$Z_{in} = \frac{\Delta V_L}{\Delta V_{nL} - \Delta V_L} Z_{out} \quad (2)$$

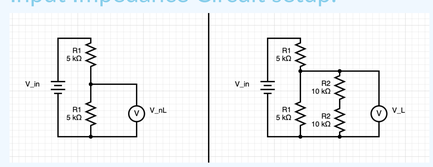
Procedure

Steps to find input impedance in a circuit

Output Impedance Circuit setup:



Input Impedance Circuit setup:



- Measure V_{NL} and V_L
- Calculate output impedance using equation 1
- measure new V_L with second circuit diagram
- Calculate input impedance using equation 2

Results and Conclusion

Expected output: 5000 ohms

Actual output: 4940 ohms

Expected input: 10000 ohms

Actual input: 9980 ohms

Our actual input was very similar to our expected input, thus we sucessfully measured the impedance in a double-voltage divider.