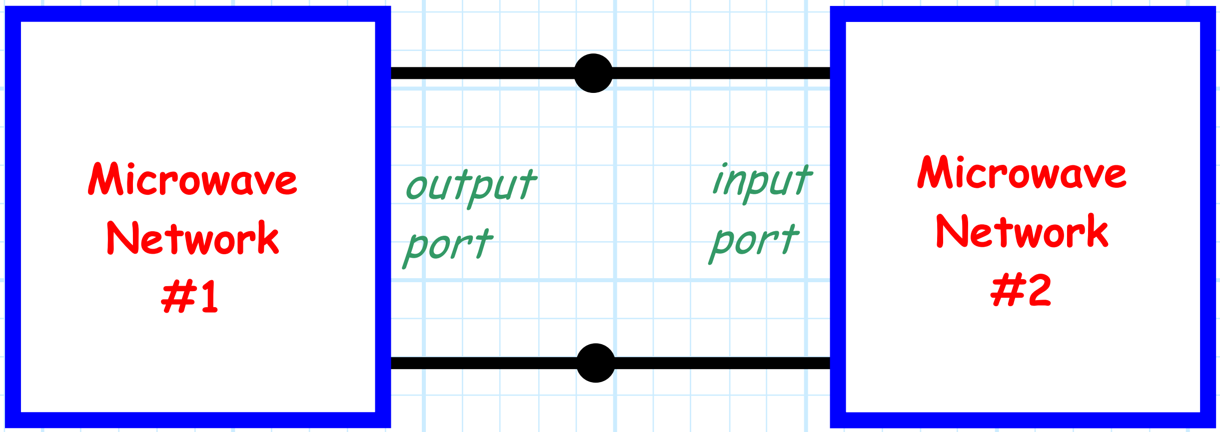
Connecting a Source and Load

Say we wish to connect the **output** of one microwave network/component to the **input** of another microwave network/component.

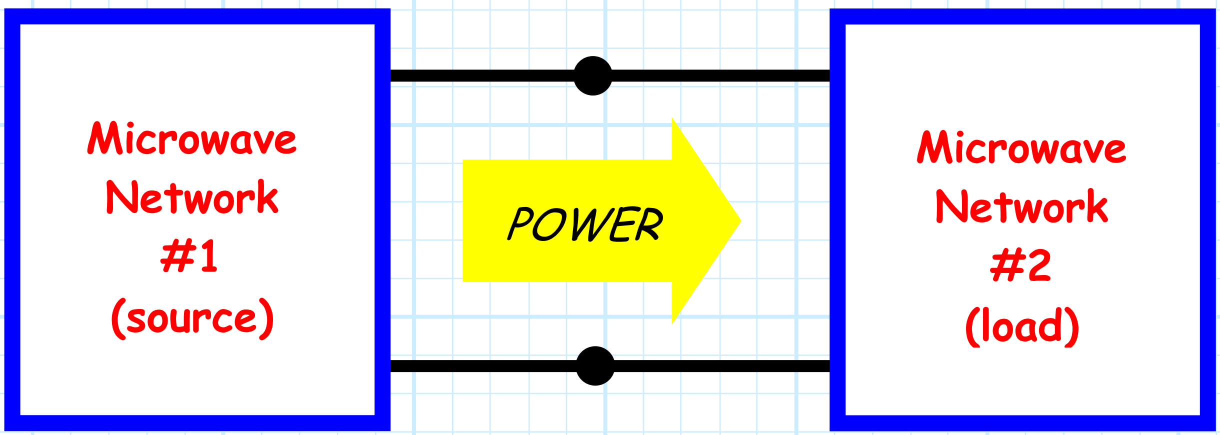


The terms "input" and "output" tells us that we wish for signal energy to flow **from** the output network **to** the input network.

Source Delivers; Load Absorbs

We can say that the **output delivers** signal power to the input, or equivalently, that the **input absorbs** power from the output.

In this case, the first network is the **source**, and the second network is the **load**—the **source delivers** power to the load, or equivalently, the **load absorbs** power from the source.

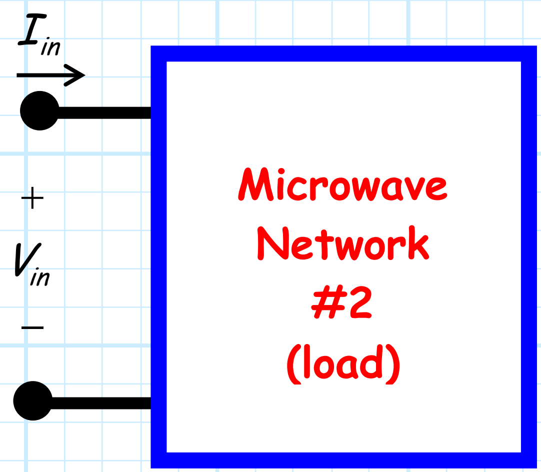


Each of these two networks may be quite complex, but we can always simply this problem by using **equivalent circuits**.

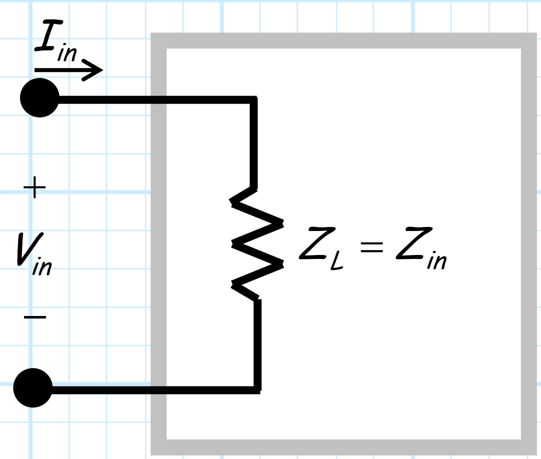
Input Impedance: The Equivalent Load

For example, if we assume time-harmonic signals (i.e., eigen functions!), the load can be modeled as a simple lumped **impedance** , with a **complex** value equal to the **input impedance** of the network.

$$Z_{in} = \frac{V_{in}}{I_{in}}$$



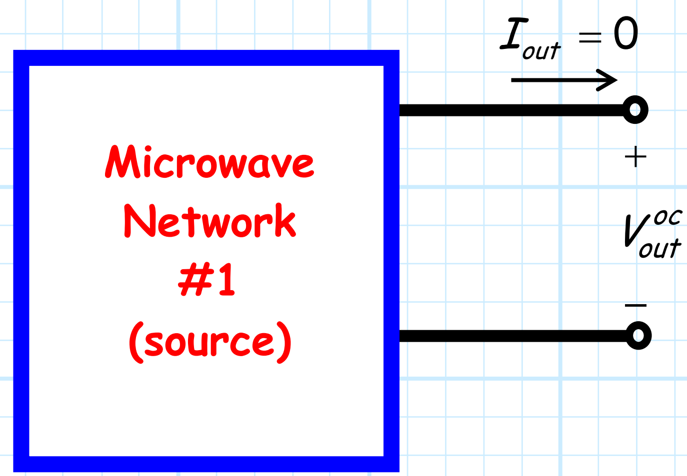
$$V_{in} = Z_{in} I_{in}$$



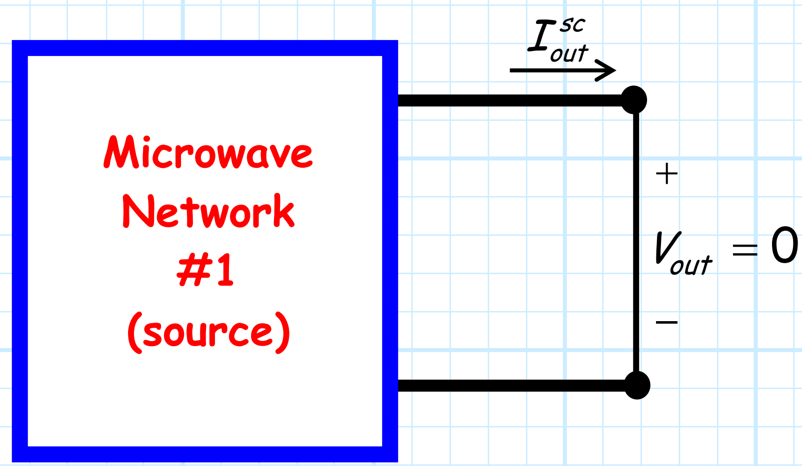
The Equivalent Source

The source network can likewise be modeled using either a Thevenin's or Norton's equivalent.

This equivalent circuit can be determined by first evaluating (or measuring) the **open-circuit** output **voltage** V_{out}^{oc}:



And likewise evaluating (or measuring) the **short-circuit** output **current** I_{out}^{sc}:

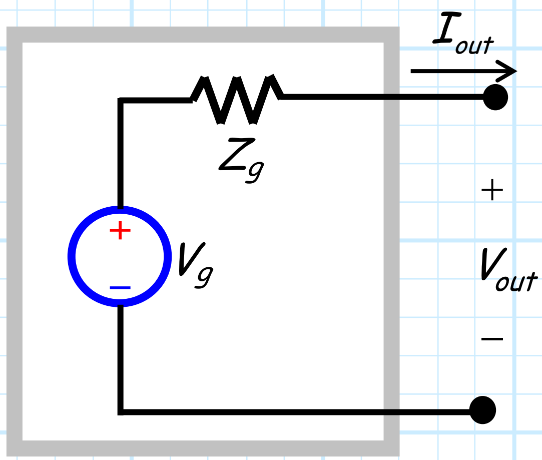


Thevenin's and Norton's Equivalent Source

From these two values (V_{out}^{oc} and I_{out}^{sc}) we can determine the **Thevenin's equivalent source**:

$$V_g = V_{out}^{oc}$$

$$Z_g = \frac{V_{out}^{oc}}{I_{out}^{sc}}$$



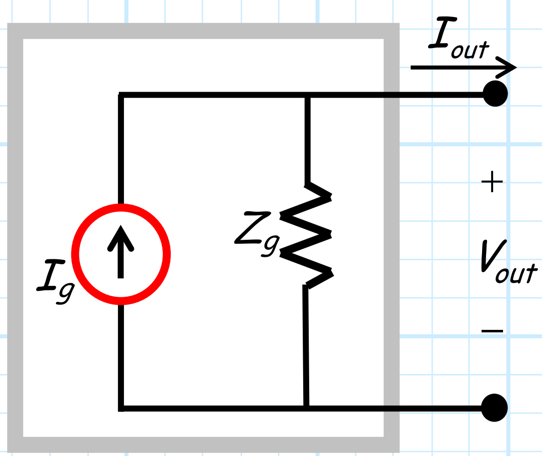
$$V_{out} = V_g - Z_g I_{out}$$

$$I_{out} = \frac{V_g - V_{out}}{Z_g}$$

Or, we could use a **Norton's equivalent** circuit:

$$I_g = I_{out}^{sc}$$

$$Z_g = \frac{V_{out}^{oc}}{I_{out}^{sc}}$$

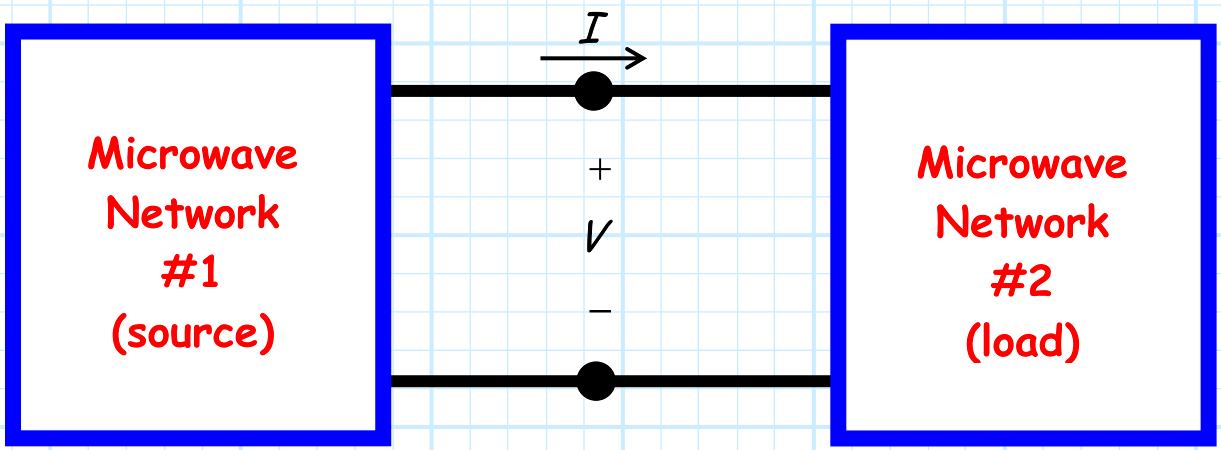


$$I_{out} = I_g - V_{out}/Z_g$$

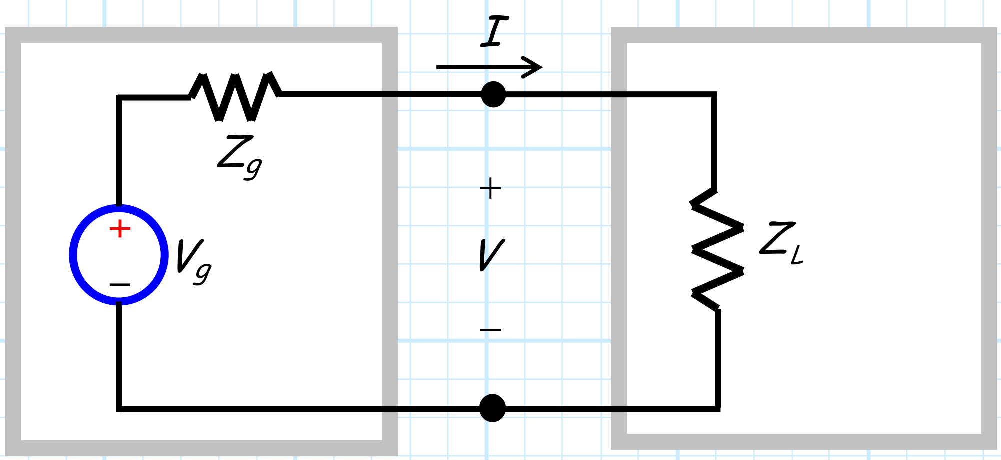
$$V_{out} = \left(I_g - I_{out}\right) Z_g$$

A Source and Load Equivalent

Thus, the **entire circuit**:



can be modeled with **equivalent circuits** as:



Power Absorbed by the Load…

Please note that we have assumed a **time harmonic** source, such that all the values in the circuit above (V_g, Z_g, I, V, Z_L) are **complex** (i.e., they have a **magnitude** and **phase**).

The **time-averaged power** absorbed (a **real** value!) by the **complex** load impedance is (remember??):

$$P_{abs} = \frac{1}{2}\text{Re}\{V\, I^*\}$$

Where * denotes the complex **conjugate** operator.

Analyzing the equivalent circuit, we find that the power **absorbed by the load** is:

$$P_{abs} = \frac{1}{2}\text{Re}\{V\, I^*\} = \frac{|V_g|^2}{2}\frac{R_L}{|Z_g + Z_L|^2}$$

where R_L is the real (i.e., resistive) part of the load impedance:

$$\text{Re}\{Z_L\} = \text{Re}\{R_L + jX_L\} = R_L$$

…Equals Power Delivered by the Source

From **conservation of energy**, this absorbed power is likewise that of the power P_{del} **delivered by the source** (i.e., $P_{abs} = P_{del}$):