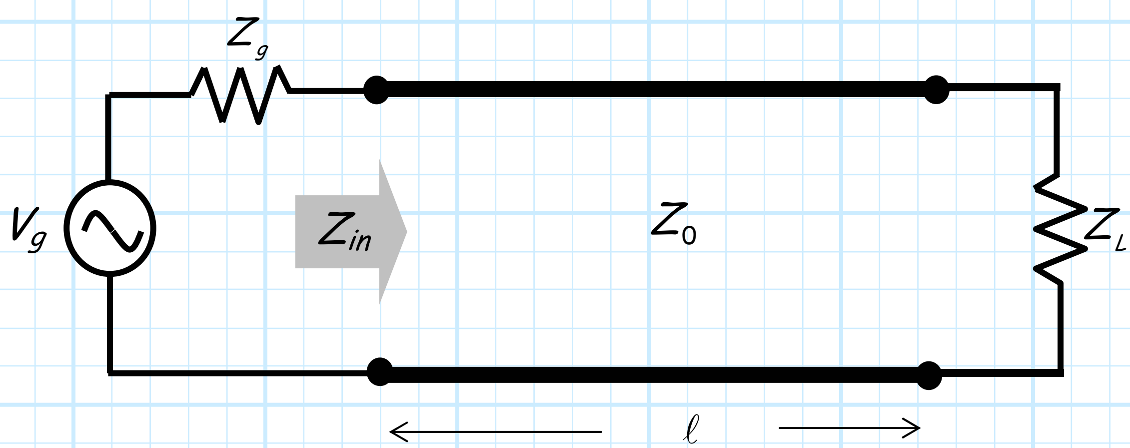
Matching Networks and Transmission Lines

Recall that a primary purpose of a transmission line is to allow the transfer of **power** from a source to a load.



Q: *So, say we directly connect an **arbitrary** source to an **arbitrary** load via a length of transmission line. Will the power delivered to the load be equal to the **available power** of the source?*

A: Not likely! Remember we determined earlier that the efficacy of power transfer depends on:

1. the source impedance Z_g.

2. load impedance Z_L.

3. the transmission line characteristic impedance Z_0.

4. the transmission line length ℓ.

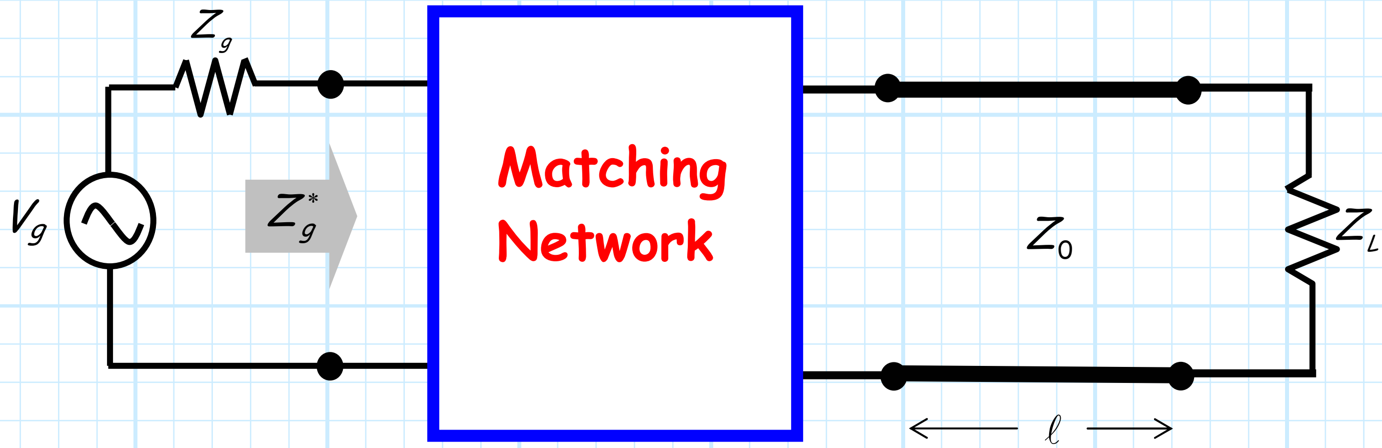
Recall that **maximum** power transfer occurred only when these four parameters resulted in the **input impedance** of the transmission line being equal to the **complex conjugate** of the **source impedance** (i.e., $Z_{in}^{*} = Z_{g}$).

It is of course **unlikely** that the very **specific** conditions of a **conjugate match** will occur if we simply connect a length of transmission line between an **arbitrary** source and load, and thus the power delivered to the load will generally be **less** than the **available power** of the source.

Q: *Is there any way to use a **matching network** to fix this problem? Can the power delivered to the load be increased to **equal** the available power of the source if there is a transmission line connecting them?*

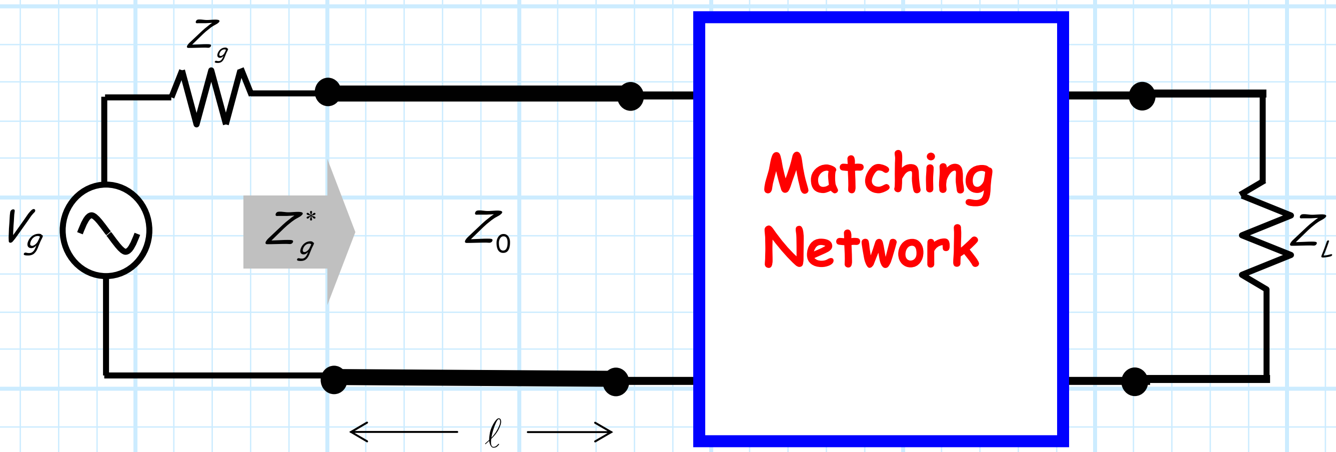
A: There sure is! We **can** likewise construct a matching network for the case where the source and load are connected by a **transmission line**.

For example, we can construct a network to transform the **input impedance** of the transmission line into the complex conjugate of **the source impedance**:

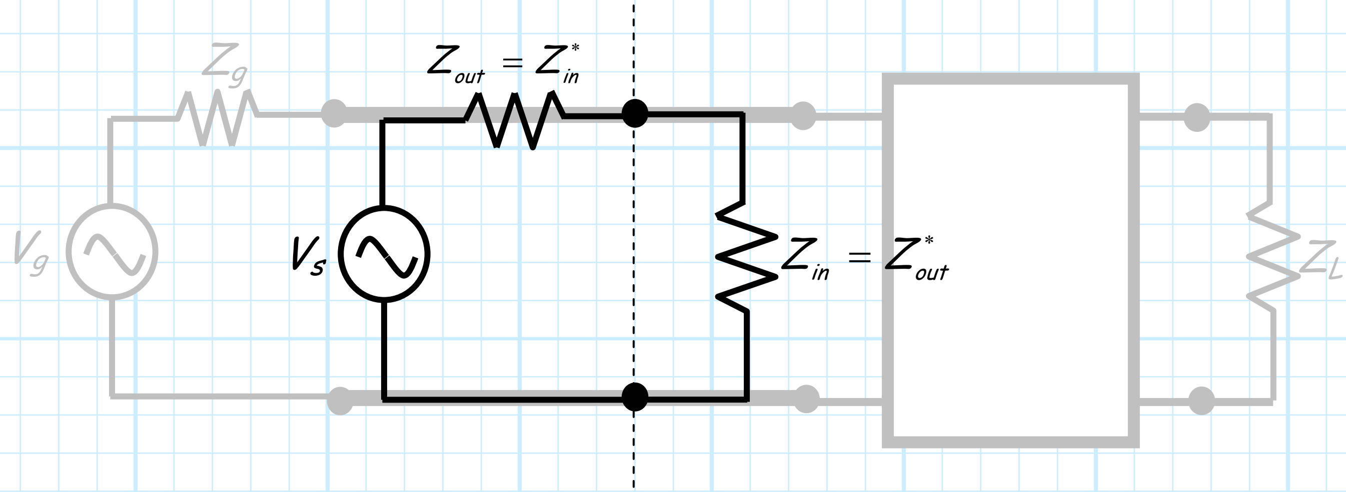


Q: *But, do we **have** to place the matching network between the source and the transmission line?*

A: Nope! We could **also** place a (different) matching network between the transmission line and the load.



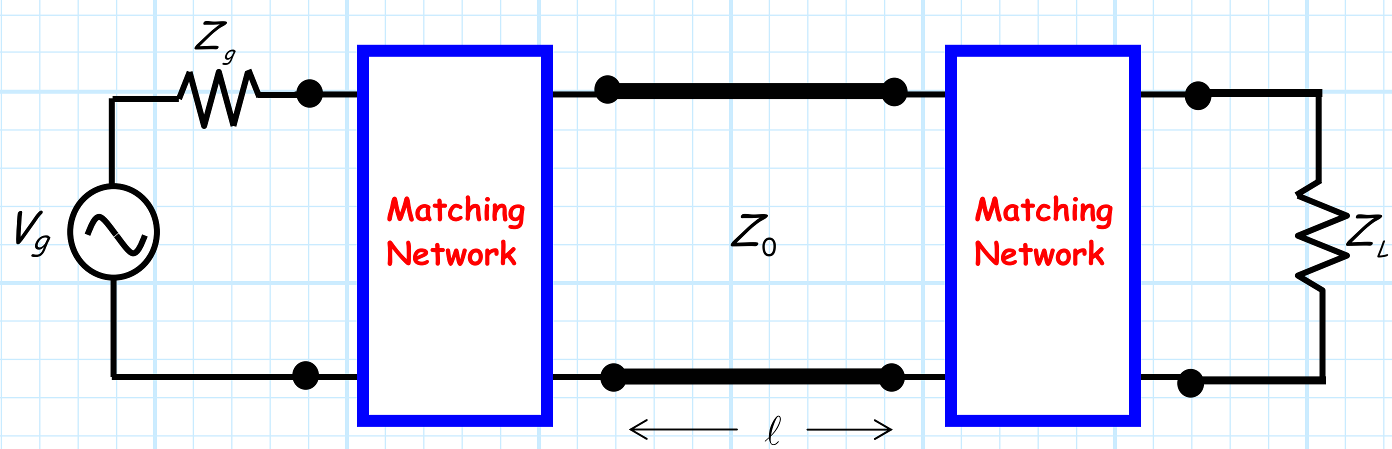
In either case, we find that at **any** and **all** points along this matched circuit, the output impedance of the equivalent **source** (i.e., looking left) will be equal to the **complex conjugate** of the **input** impedance (i.e., looking right).



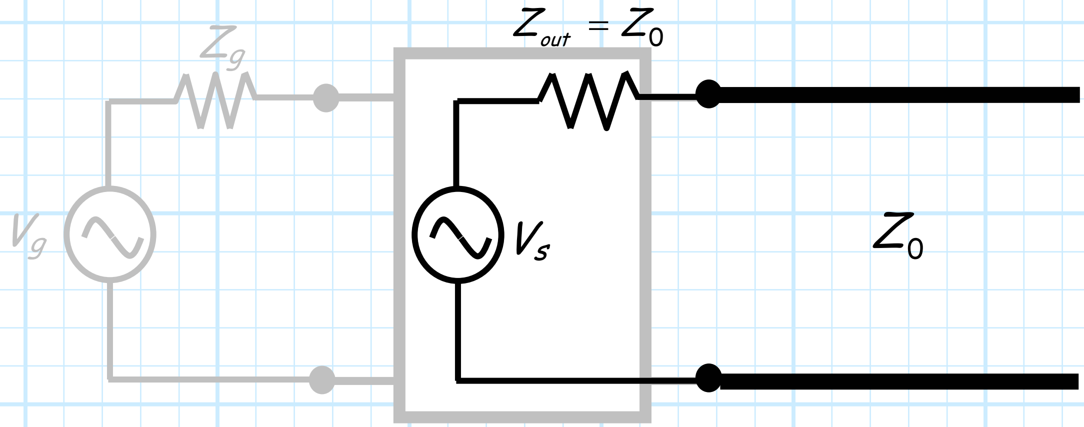
Q: *So **which** method should we chose? Do engineers typically place the matching network between the source and the transmission line, **or** place it between the transmission line and the load?*

A: Actually, the typical solution is to do **both**!

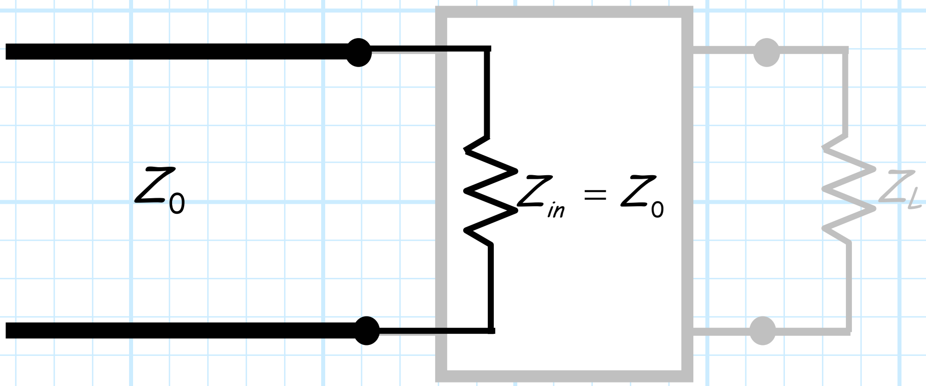
We find that often there is a matching network between the a source and the transmission line, **and** between the line and the load.



The first network matches the **source** to the **transmission line**—in other words, it transforms the **output impedance** of the equivalent source to a value numerically equal to **characteristic impedance** Z_0:



The second network matches the **load** to the **transmission line**—in other words it transforms the **load impedance** to a value numerically equal to **characteristic impedance** Z_0:



Q: *Yikes! Why would we want to build **two** separate matching networks, instead of just **one**?*

A: By using two separate matching networks, we can **decouple** the design problem. Recall again that the design of a **single** matching network solution would depend on four separate parameters:

1. the source impedance Z_g.

2. load impedance Z_L.

3. the transmission line characteristic impedance Z_0.

4. the transmission line length ℓ.

Alternatively, the design of the network matching the **source** and **transmission line** depends on **only**:

1. the source impedance Z_g.

2. the transmission line characteristic impedance Z_0.

Whereas, the design of the network matching the **load** and **transmission line** depends on **only**:

1. the source impedance Z_L.

2. the transmission line characteristic impedance Z_0.

Note that **neither** design depends on the transmission line **length** ℓ!

Q: *How is that possible?*

A: Remember the case where $Z_g = Z_0 = Z_L$. For that **special** case, we found that a conjugate match was the result—**regardless** of the transmission line length.

Thus, by matching the source to line impedance Z_0 **and** likewise matching the load to the line impedance, a conjugate match is **assured**—but the **length** of the transmission line does **not** matter!

In fact, the typically problem for microwave engineers is to match a load (e.g., device input impedance) to a **standard** transmission line impedance (typically $Z_0 = 50\Omega$); **or** to independently match a source (e.g., device output impedance) to a **standard** line impedance.

A **conjugate match** is thus obtained by connecting the two with a transmission line of **any length**!