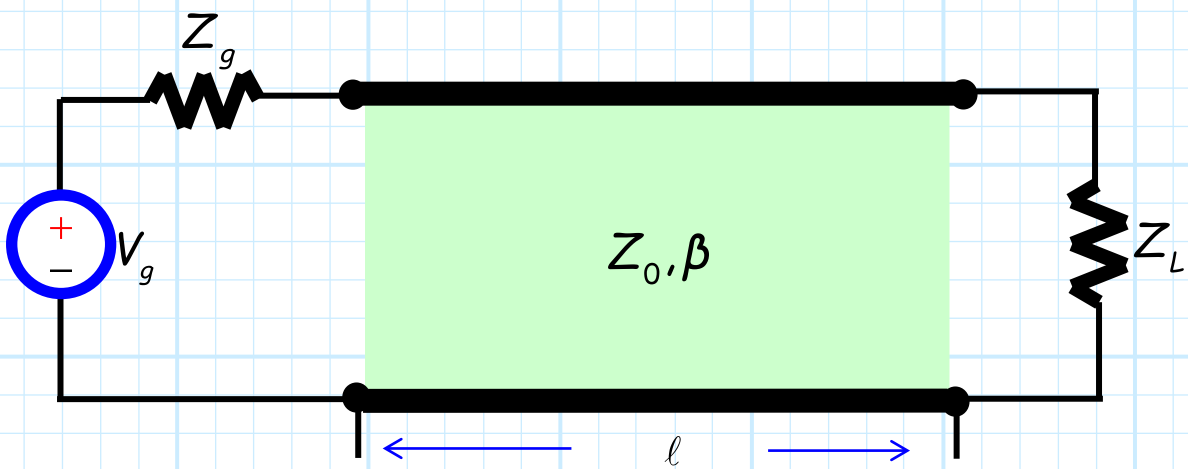
Matching Networks and Transmission Lines



Q: *But let's deal with the reality of a cold, **cruel**, non-ideal world.*

*If we directly connect an **arbitrary** source to an **arbitrary** load via a length of transmission line, don't we just have to **accept** the hard truth that the power absorbed by the load will be **less** than that available from the source?*

You're just not that lucky!

A: 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 indeed **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.

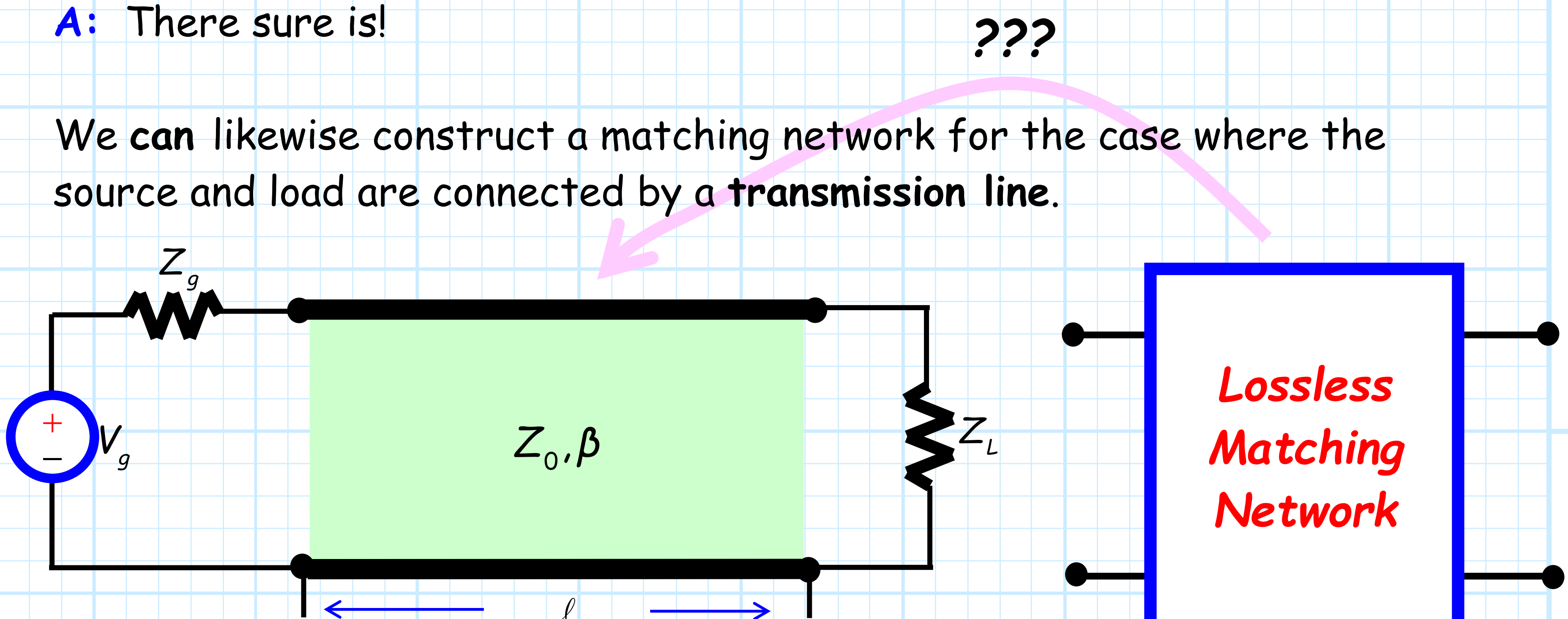
What about a matching network?

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, even if there is a transmission line connecting them?*

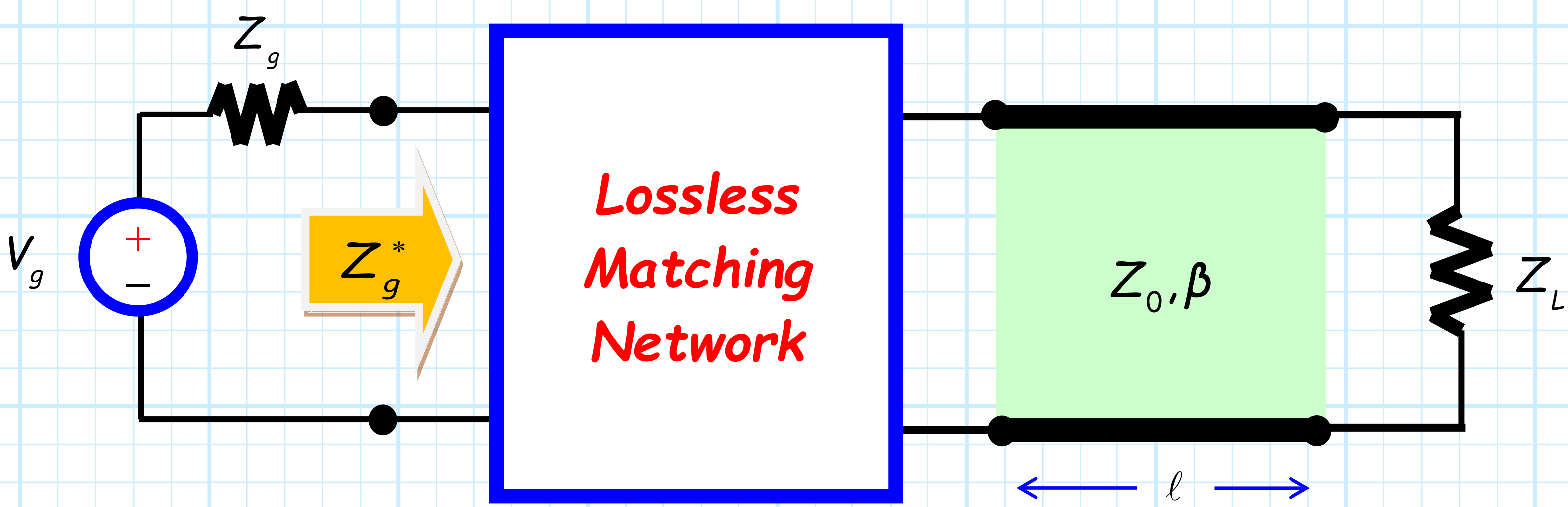
A: There sure is!

We **can** likewise construct a matching network for the case where the source and load are connected by a **transmission line**.



Matching network to the rescue!

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

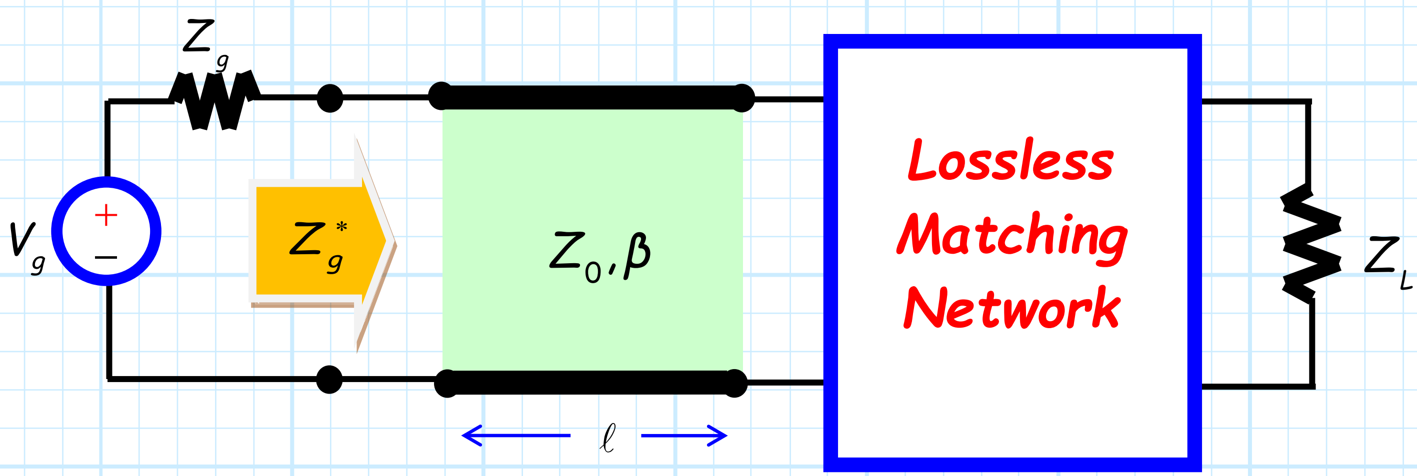


But, where to put it?

Q: *But, do we absolutely* ***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.

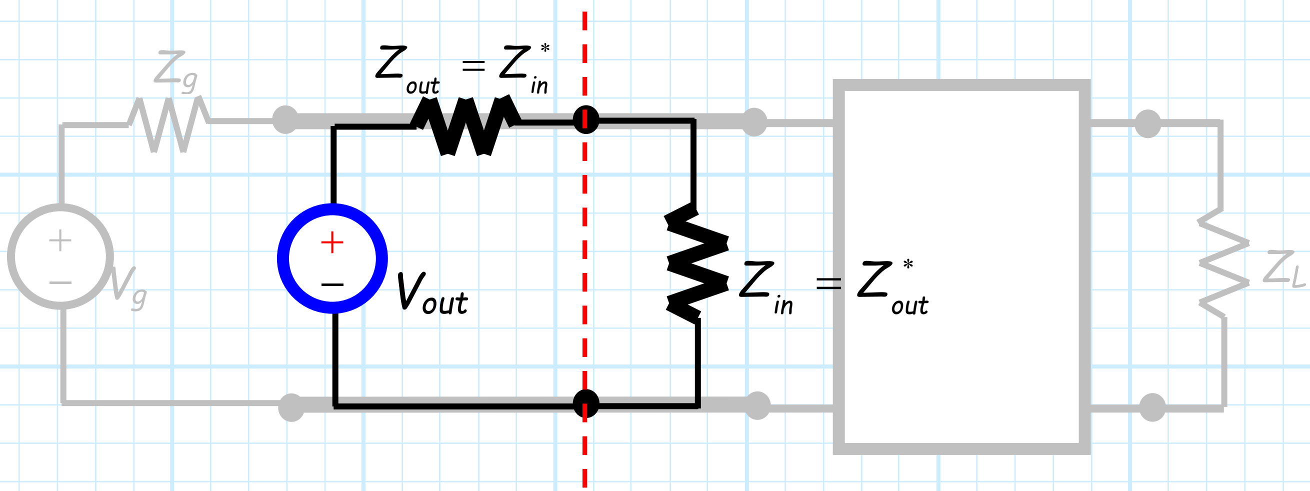


A conjugate match at *one* location means a conjugate match at *all* locations!

In either case, we find at **any** and **all** points along this matched circuit that:

a) the output impedance of the equivalent **source** (i.e., looking left), will be

b) **equal** to the **complex conjugate** of the **input** impedance (i.e., looking right)!



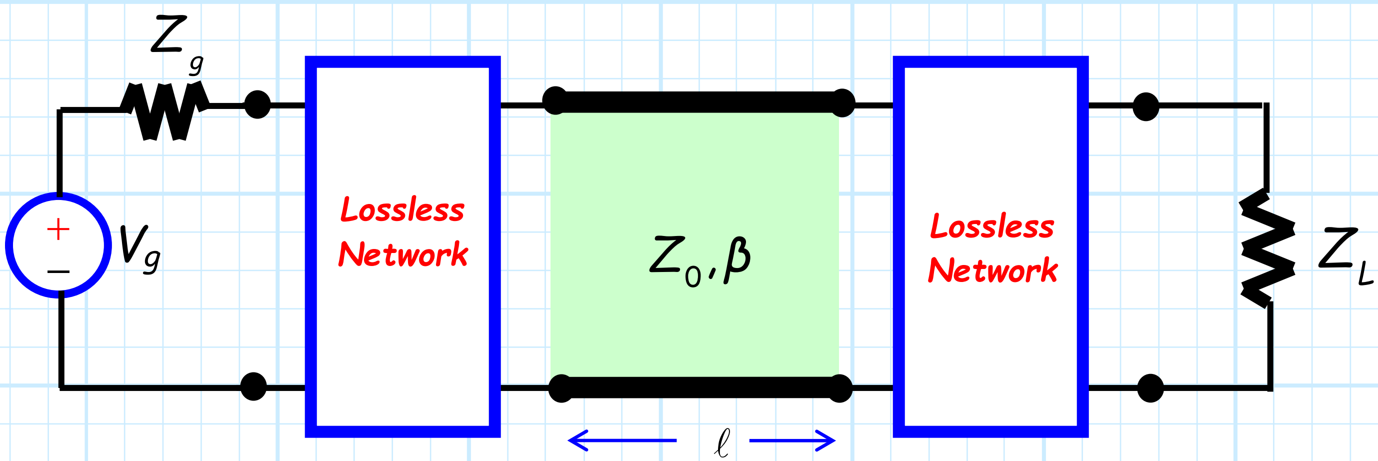
Two networks are the solution!

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?*

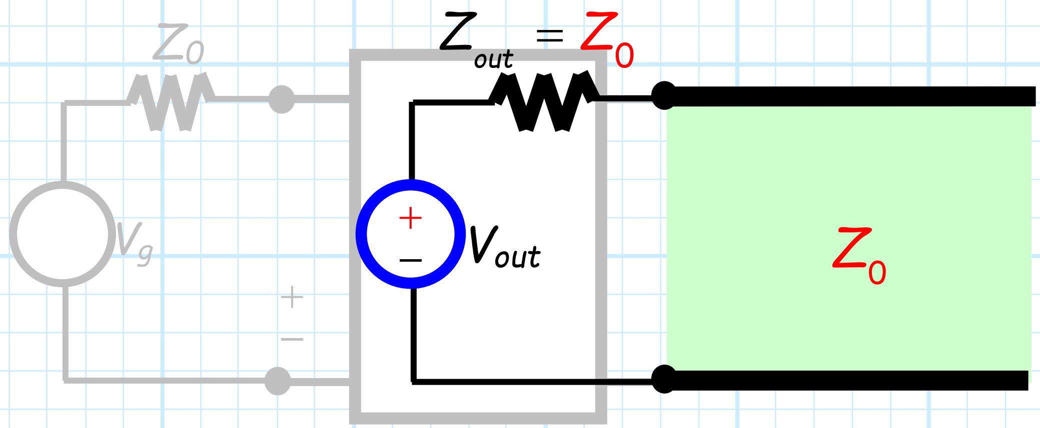
A: Actually, the typical solution is to **do both**!

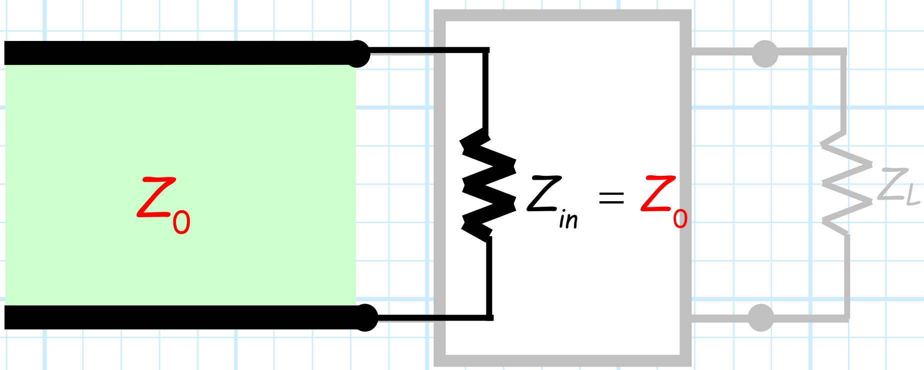
We find that often there is a **lossless network** between the source and the transmission line, **and** between the line and the load.



We put it at both ends!

The **first** lossless network transforms the **source**, such that the resulting **output** impedance is numerically equal to the **transmission line characteristic impedance** Z_0 .





The **second** lossless network transforms the **load**, such that the resulting **input impeadance** is numerically equal to the **transmission line characteristic impedance** Z_0:

Why do we need two networks?

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

A: By using two **separate** lossless 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.

The line length does not matter!!!!

Alternatively, the design of the lossless network **transforming the source impedance to a value** Z_0 depends on **only**:

1. the source impedance Z_g.
2. the transmission line characteristic impedance Z_0.

Whereas, the design of the lossless network transforming the **load impedance to a value** Z_0 depends on **only**:

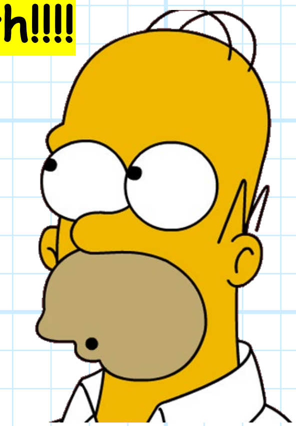
1. the load impedance Z_L.
2. the transmission line characteristic impedance Z_0.

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

Devices are typically matched to 50Ω

Thus, by **transforming the source** to characteristic impedance Z_0 **and** likewise **transforming the load** to the line impedance, a **conjugate match** is **assured**.

And this is true regardless of the transmission line **length!!!!**



In fact, the typically **problem** for microwave engineers is to:

a) transform a **load** (e.g., device **input** impedance) to a **standard** transmission line impedance (typically $Z_0 = 50\Omega$); **or** to

b) independently transform a **source** (e.g., device **output** impedance) to a **standard** line impedance.

The ideal case: line lengths no longer matter!

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