Mixed Impedance Matching

The real part of the load impedance is rarely equal to the transmission-line impedance. In most cases, we have to transform the real part of the impedance as well.

For example, load impedance $Z_L = 25 + j50\Omega$ represents a series connection of a 25Ω resistor and a $7.96\,\text{nH}$ inductor at $1\,\text{GHz}$. To match $Z_L = 25 + j50\Omega$ impedance to the transmission-line impedance $Z_0 = 50\Omega$, we first normalize the load impedance to transmission-line impedance.

$$\overline{Z}_L = \frac{Z_L}{Z_0} = 0.5 + j1 \tag{1}$$

This impedance is shown in Figure 1.

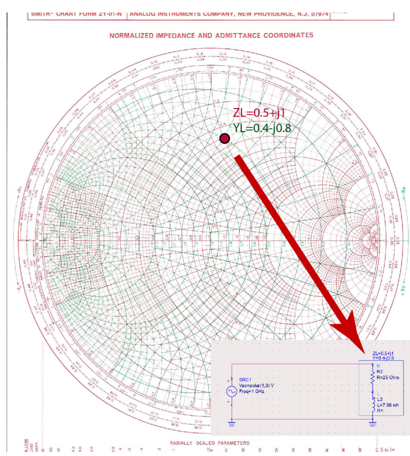

Figure 1: Load impedance $Z_L = 0.5 + j1$ on Smith Chart.

SWR circle

Then, we identify an SWR circle that this impedance is on, as shown in Figure 2. The point where the SWR circle intersects the green circle is of interest because the real part of the input admittance is equal to one $Y_1 = 1$. This second point,

Learning outcomes: Design a mixed impedance matching network for any load impedance and discuss pros and cons of various designs.

Author(s): Milica Markovic

where $Y = 1 + j1.6$, will give us the length of the line that we have to add to the load impedance.

Example 1. *Explain how the position of the load impedance on the Smith Chart changes the SWR circle.*

Explanation. *To see how SWR circle changes depending on where the load impedance is use the following simulation. Click on point A, to change its position. Observe how SWR circle changes.*

Geogebra link: `https://tube.geogebra.org/m/ugy2wcxc`

Length of the line that will transform the real part of load impedance

To find the length of the line that will transform the real part of z_L to $y_1 = 1$, we identify the position of the load impedance $Z_L = 0.5 + j1$, and the input impedance $Z_1 = 0.3 - j0.45$ at the *Wavelengths Towards Generator* (WTG) scale. The reason we picked impedance $Z_1 = 0.3 - j0.45$ is because the real part of the admittance $y_1 = 1/z_1$ is equal to one $\Re(y_1) = 1$. Load impedance Z_L is at 0.135λ, and the input impedance Z_1 is at 0.425λ. The difference between these two positions gives us the length of the line 0.29λ. In electrical degrees, this length is approximately 105^0. The input admittance to the line is now $Y_L = 1 + 1.6$.

Adding a lumped-element to remove the susceptance

The final step is to add a susceptance that will remove the imaginary part of the input admittance $Y_1 = 1 + j1.6$. We see that to get the final admittance of $Y_M = 1$, numerically, we have to add an admittance of $Y_{add} = -j1.6$. This represents an inductance. Since we are adding the two admittances $Y_1 + Y_{add}$, they have to be in parallel (as we know that when elements are in parallel, we add their admittances).

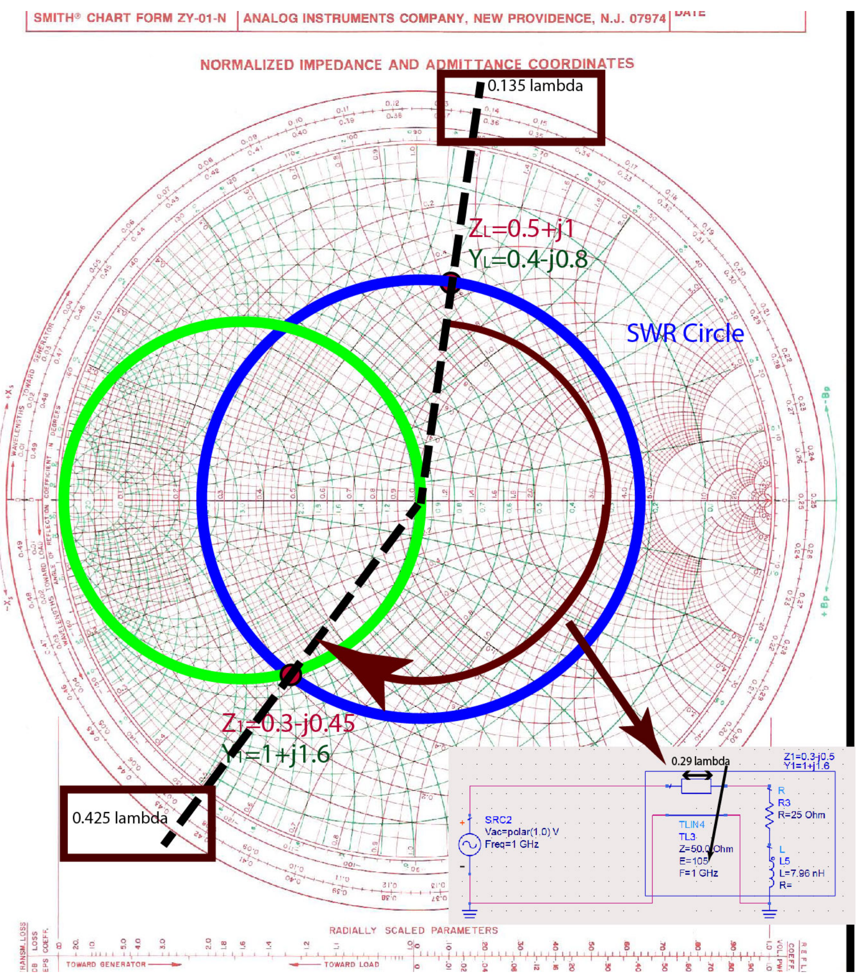

Figure 2: SWR circle for impedance $Z_L = 0.5 + j1$.

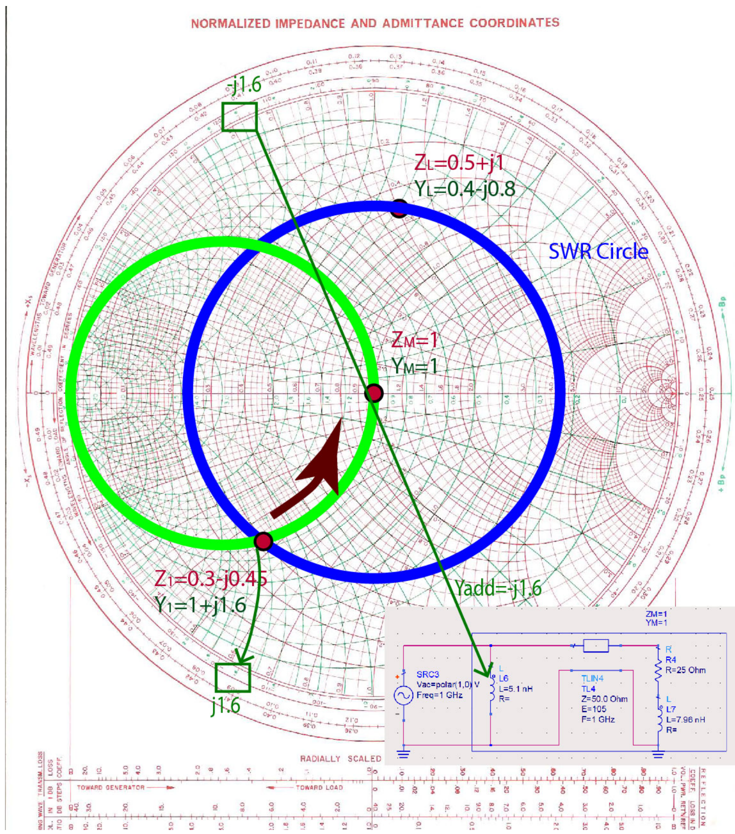

Figure 3: The result of impedance matching.

Other possible solutions

Graphically, there are several different mixed or transmission-line impedance matching circuits that we can make for a specific impedance. For example, for impedance $Z_L = 25 + j50\Omega$, $z_L = 0.5 + j1$, there are four different circuits that we can make, as shown in Figure 4. In this paragraph, we used the green path on the Smith Chart, with intermediate admittance Y_2.

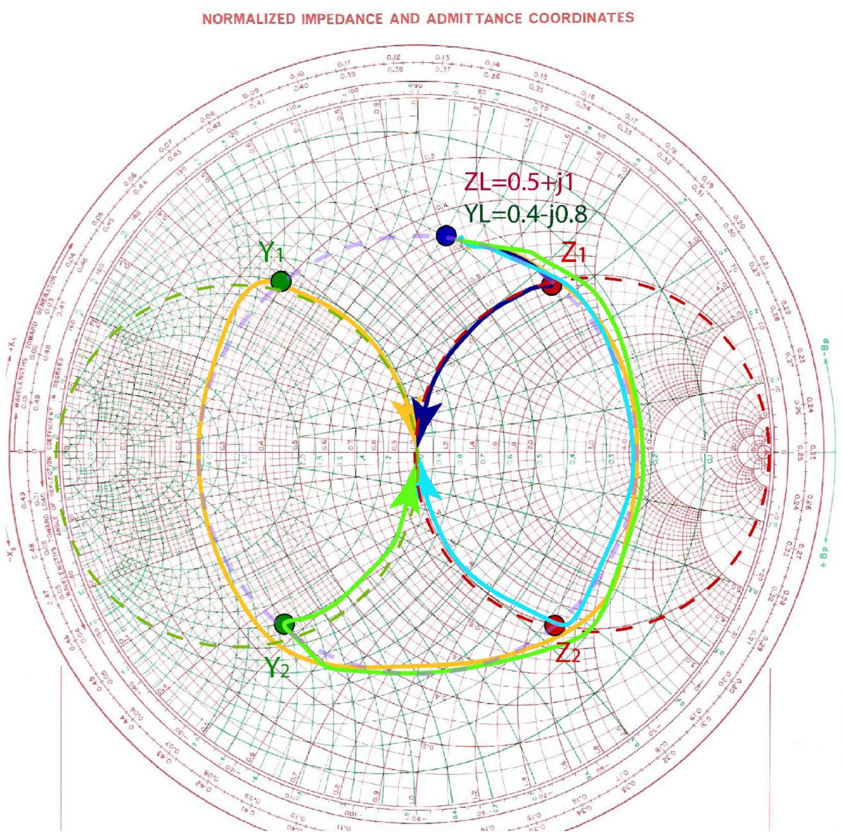

Figure 4: A variety of possible impedance matching circuits for impedance $Z_L = 25 + j50\Omega$.