

### 3.3: Transmission Lines as Two-Port Devices

Figure 3.3.1 shows common ways to represent transmission lines in circuit diagrams. In each case, the source is represented using a Thévenin equivalent circuit consisting of a voltage source  $V_S$  in series with an impedance  $Z_S$ .<sup>1</sup> In transmission line analysis, the source may also be referred to as the *generator*. The termination on the receiving end of the transmission line is represented, without loss of generality, as an impedance  $Z_L$ . This termination is often referred to as the *load*, although in practice it can be any circuit that exhibits an input impedance of  $Z_L$ .

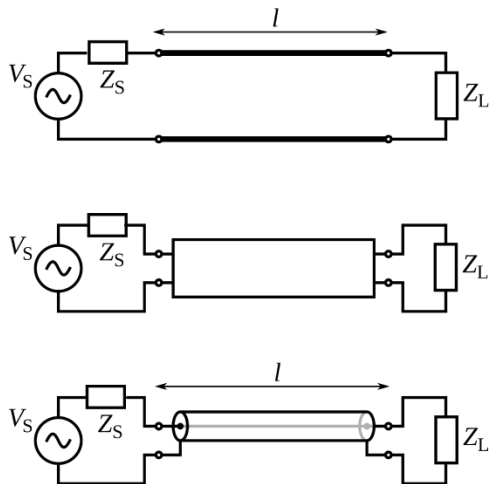


Figure 3.3.1: Symbols representing transmission lines: Top: As a generic two-conductor direct connection. Middle: As a generic two-port “black box.” Bottom: As a coaxial cable. © CC BY SA 3.0 Unported (modified)

The two-port representation of a transmission line is completely described by its length  $l$  along with some combination of the following parameters:

- Phase propagation constant  $\beta$ , having units of rad/m. This parameter also represents the wavelength in the line through the relationship  $\lambda = 2\pi/\beta$ . (See Sections 1.3 and 3.8 for details.)
- Attenuation constant  $\alpha$ , having units of 1/m. This parameter quantifies the effect of loss in the line. (See Section 3.8 for details.)
- Characteristic impedance  $Z_0$ , having units of  $\Omega$ . This is the ratio of potential (“voltage”) to current when the line is perfectly impedance-matched at both ends. (See Section 3.7 for details.)

These parameters depend on the materials and geometry of the line.

Note that a transmission line is typically not transparent to the source and load. In particular, the load impedance may be  $Z_L$ , but the impedance presented to the source may or may not be equal to  $Z_L$ . (See Section 3.15 for more on this concept.) Similarly, the source impedance may be  $Z_S$ , but the impedance presented to the load may or may not be equal to  $Z_S$ . The effect of the transmission line on the source and load impedances will depend on the parameters identified above.

1. For a refresher on this concept, see “Additional Reading” at the end of this section.↩

This page titled 3.3: Transmission Lines as Two-Port Devices is shared under a CC BY-SA 4.0 license and was authored, remixed, and/or curated by Steven W. Ellingson (Virginia Tech Libraries' Open Education Initiative) .

- **3.3: Transmission Lines as Two-Port Devices** by Steven W. Ellingson is licensed CC BY-SA 4.0. Original source: <https://doi.org/10.21061/electromagnetics-vol-1>.