EE331—EXAMPLE #5: TL VOLTAGE STANDING WAVE RATIO

The reflection coefficient Γ_L gives the ratio of the reflected voltage and incident voltage in terms of the load impedance Z_L and characteristic impedance of the line Z_0:

$$\Gamma_L = \frac{V_0^-}{V_0^+} = \frac{Z_L - Z_0}{Z_L + Z_0}.$$

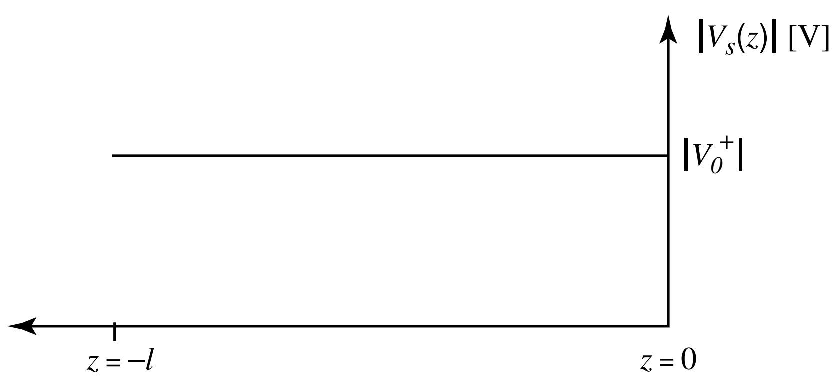
The ratio of the maximum voltage magnitude and the minimum voltage magnitude is called the standing wave ratio:

$$s = \frac{|V_s|_{\max}}{|V_s|_{\min}} = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|}.$$

This is also called the SWR or VSWR. Consider a lossless transmission line with a characteristic impedance of Z_0 Ω. (a) For a matched load (i.e., $Z_L = Z_0$), what is s and what are the values of $|V_s|_{\max}$ and $|V_s|_{\min}$? (b) Sketch $|V_s(z)|$ as a function of z for a matched load and explain why it looks the way it does. (c) What is s for an open-circuited line and what is it for a short-circuited line? (d) What are the values of $|V_s|_{\min}$ for open- and short-circuited lines? Note: $|V_s|_{\max} = |V_0^+|(1 + |\Gamma_L|)$ and $|V_s|_{\min} = |V_0^+|(1 - |\Gamma_L|)$.

(a) For a matched load, $\Gamma_L = 0$ (i.e., no reflection). Thus, $s = \dfrac{1+0}{1-0} = 1$.

(b) Since $\dfrac{|V_s|_{\max}}{|V_s|_{\min}} = s = 1$, $|V_s|_{\max} = |V_s|_{\min} = |V_0^+|$. $|V_s(z)| = |V_0^+|$ is constant because there's no reflected wave to interfere with the incident wave to cause a standing wave.



(c) For $Z_L \to \infty$, $\Gamma_L = 1$, and $|\Gamma_L| = 1$. Thus, $s \to \infty$. For $Z_L = 0$, $\Gamma_L = -1$, and $|\Gamma_L| = 1$. Thus, $s \to \infty$.

(d) We know $|V_s|_{\min} = |V_0^+|(1 - |\Gamma_L|)$. Since $|\Gamma_L| = 1$ for both an open-circuit load and a short-circuit load, $|V_s|_{\min} = 0$ for both.

Earlier we found that $0 \le |\Gamma_L| \le 1$. Now we find that $1 \le s \le \infty$.