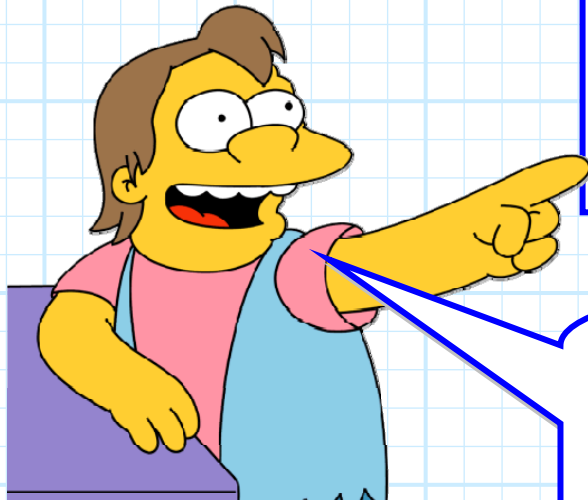


# Line Impedance

Now let's define **line impedance**  $Z(z)$ , a **complex** function which is simply the ratio of the complex line **voltage** and complex line **current**:



$$Z(z) = \frac{V(z)}{I(z)}$$

**Q:** *Hey! I know what this is!*

*The ratio of the voltage to current is simply the characteristic impedance  $Z_0$ , right ???*

**A:** **NO!** The line impedance  $Z(z)$  is (generally speaking) **NOT** the transmission line **characteristic impedance**  $Z_0$ !!!

→ It is **unfathomably important** that you understand this!!!! ←

## Why Line Impedance is not $Z_0$

To see why line impedance  $Z(z)$  is different than characteristic impedance  $Z_0$ , recall that:

$$V(z) = V^+(z) + V^-(z) \quad \text{and that} \quad I(z) = \frac{V^+(z) - V^-(z)}{Z_0}$$

Therefore, line impedance is:

$$Z(z) = \frac{V(z)}{I(z)} = Z_0 \left( \frac{V^+(z) + V^-(z)}{V^+(z) - V^-(z)} \right) \neq Z_0$$

Or, more specifically, we can write:

$$Z(z) = Z_0 \left( \frac{V_0^+ e^{-j\beta z} + V_0^- e^{+j\beta z}}{V_0^+ e^{-j\beta z} - V_0^- e^{+j\beta z}} \right)$$

## What then is $Z_0$ ?

**Q:** *I'm confused! Isn't:*

$$V^+(z)/I^+(z) = Z_0 ???$$



**A:** Yes! That is true! The ratio of the voltage to current for **each** of the two propagating waves is  $\pm Z_0$ .

However, the ratio of the **sum** of the two voltages, to the **sum** of the two currents, is **not** equal to  $Z_0$  (generally speaking)!

→ This is actually confirmed by the expression of  $Z(z)$  above.

Say that  $V^-(z) = 0$ , so that only **one** wave ( $V^+(z)$ ) is propagating on the line.

In this case, the ratio of the **total** voltage to the total current is simply the ratio of the voltage and current of the **one** remaining wave—the **characteristic impedance**  $Z_0$ !

$$Z(z) = \frac{V(z)}{I(z)} = Z_0 \left( \frac{V^+(z)}{I^+(z)} \right) = \frac{V^+(z)}{I^+(z)} = Z_0 \quad (\text{when } V^-(z) = 0)$$

## Let's Summarize!!

**Q:** *So, it appears to me that characteristic impedance  $Z_0$  is a transmission line parameter, depending **only** on the transmission line values  $L$  and  $C$ .*

*Whereas line impedance is  $Z(z)$  depends the magnitude and phase of the two propagating waves  $V^+(z)$  and  $V^-(z)$  —values that depend **not only** on the transmission line, but also on the two things **attached** to either **end** of the transmission line!*

*Right !?*



**A:** Exactly!

Moreover, note that characteristic impedance  $Z_0$  is simply a **number**, whereas line impedance  $Z(z)$  is a **function** of position ( $z$ ) on the transmission line.