EECS 723-Microwave Engineering

Teacher: *"Bart, do you even **know** your multiplication tables?"*

Bart: *" Well, I know **of** them".*

Like Bart and his multiplication tables, many electrical engineers know **of** the concepts of microwave engineering.

Concepts such as characteristic impedance, scattering parameters, Smith Charts and the like are familiar, but often we find that a **complete**, **thorough** and **unambiguous** understanding of these concepts can be somewhat lacking.

Thus, the goals of this class are for **you** to:

1. Obtain a complete, thorough, and unambiguous understanding of the fundamental concepts on microwave engineering.

2. Apply these concepts to the **design** and **analysis** of useful microwave devices.

2.1 -The Lumped Element Circuit Model for Transmission Lines

Reading Assignment: *pp. 1-5, 48-51*

The most important fact about microwave devices is that they are connected together using transmission lines.

Q: *So just what is a **transmission line**?*

A: A passive, linear, two port device that allows bounded E. M. energy to flow from one device to another.

→ Sort of an "electromagnetic pipe" !

Q: *Oh, so it's simply a conducting **wire**, right?*

A: NO! At high frequencies, things get much more complicated!

HO: THE TELEGRAPHERS EQUATIONS

HO: TIME-HARMONIC SOLUTIONS FOR TRANSMISSION LINES

Q: *So, what complex functions I(z) and V(z) **do** satisfy both telegrapher equations?*

A: The solutions to the transmission line **wave equations**!

HO: The Transmission Line Wave Equations

Q: *Are the solutions for I(z) and V(z) completely **independent**, or are they **related** in any way ?*

A: The two solutions are related by the transmission line **characteristic impedance**.

HO: The Transmission Line Characteristic Impedance

Q: *So what is the significance of the complex constant γ? What does it tell us?*

A: It describes the **propagation** of each **wave** along the transmission line.

HO: The Complex Propagation Constant

Q: *Now, **you** said earlier that **characteristic** impedance Z_0 is a **complex** value. But I recall engineers referring to a transmission line as simply a "50 Ohm line", or a "300 Ohm line". But these are **real** values; are they **not** referring to characteristic impedance Z_0 ??*

A: These real values are in fact some **standard** Z_0 values. They are **real** values because the transmission line is **lossless** (or nearly so!).

HO: The Lossless Transmission Line

Q: *Is **characteristic** impedance Z_0 the same as the concept of impedance I learned about in **circuits** class?*

A: **NO!** The Z_0 is a **wave** impedance. However, we can also define **line impedance**, which **is** the same as that used in circuits.

HO: LINE IMPEDANCE

Q: *These **wave** functions $V^+(z)$ and $V^-(z)$ seem to be important. How are **they** related?*

A: They are in fact **very** important! They are related by a function called the **reflection coefficient**.

HO: THE REFLECTION COEFFICIENT

Q: *Does this mean I can describe transmission line activity in terms of (complex) voltage, current, and impedance, **or alternatively** in terms of an incident wave, reflected wave, and reflection coefficient?*

A: Absolutely! A microwave engineer has a **choice** to make when describing transmission line activity.

HO: V, I, Z OR V^+, V^-, Γ ?