<u>Curriculum Topic</u> :
Time-Harmonic Transmission Lines

<u>THT5</u> : Lossy Transmission Lines

Module Outline:	
Prerequisite Skills	Competencies
Supplemental Reading and Resources	Assessments
Power Point Slides and Notes	

Prerequisite Skills

Prerequisites / Requirements:
THT4 Arbitrary Loads on Transmission Lines

Competencies

Competency THT.5: Compute physical quantities on a transmission line with loss

Competency Builders:
THT.5.1 Understand the physical origins of loss on a transmission line
THT.5.2 Estimate the loss in dB on a line given an attenuation coefficient
THT.5.3 Apply low-loss approximations to solve for voltage and current on a realistic transmission line
THT.5.4 Compute loss on a coaxial cable given its electrical properties and dimensions

Supplemental Reading and Resources

Supplemental Reading Materials:

Prof. Peterson's online lecture notes 16

Assessments

The following questions and exercises may serve as either pre-assessment or post-assessment tests to evaluate student knowledge.

Question: THT.5.1 *Competency:* THT.5.1

What are two physical mechanisms of loss on a transmission line?

Answer:

Conductor losses and dielectric losses

Question: THT.5.2 *Competency:* THT.5.1

__________ (1) __________ (2)

In addition to per-unit-length series inductance, L, and shunt capacitance, C, what two circuit elements are added to our model for lossy transmission lines? Write words, not symbols.

Answer:

series resistance, shunt conductance

Question: THT.5.3 *Competency:* THT.5.2

You measure the attenuation coefficient of a twisted-pair of wires to be 0.020 Np/m. How much loss in dB would result in a signal traveling 50m of this wire length.

Answer:

Loss is 0.020 Np/m x 8.7 dB/Np x 50 m = 8.7 dB

Question: THT.5.4 *Competency:* THT.5.1

__________ (1) __________ (2)

Loss-per-meter on a transmission line tends to increase when the frequency of the excitation [*Answer 1*] due to the [*Answer 2*] effect.

Answer:

increases, skin

Question: THT.5.5 *Competency:* THT.5.1

True or False: Lossy transmission lines distort transmitted signals with frequency content since their velocity of propagation and attenuation are frequency dependent.

Answer:

True

Question: THT.5.6 *Competency:* THT.5.4

Industry sells two types of leaky feeder cables. The first type radiates a constant power along the length of the line, providing uniform radio coverage along the entire length. The second type radiates an exponentially decreasing amount of power along the length of the line to provide non-uniform radio coverage. Both are manufactured in a similar manner, taking regular coaxial cable and puncturing the outer conductor in places along the length so that some of the wired power escapes through radiation. The line loss due to radiation is proportional to the spatial density of puncturing. Which type of leaky feeder cable can be manufactured with uniform puncturing along the length and why?

Answer:

Although it may sound counter-intuitive, a uniformly punctured line will produce leaky-feeder lines with non-uniform coverage. Why? Because constant loss in a transmission line introduces an exponential taper on the signal as it travels down the line. In order to make a leaky-feeder line with uniform radiation loss, we must increase the loss as a function of line length, to compensate for the fact that the signal is losing power and cannot shed as much power with the same attenuation constant.

Question: THT.5.7 *Competency:* THT.5.3

Power Storage: Technologists have speculated that sinusoidal electric power could be generated at night (when public usage is low) and placed in storage for time T; after that period, it could be dumped back into the power grid during peak hours when the generation capacity is strained. Batteries are too expensive and inefficient to store such large amounts of power. Instead, engineers have discussed the possibility of using large circulating transmission lines buried in the earth (think of these as giant coaxial cables that loop around and connect back on themselves). The rings would have to be made out of special super-conductive material and cooled to eliminate the conductive losses ($\alpha_c = 0$). If the velocity of propagation was v_p (m/s), how low would any residual dielectric shunt losses have to be in order for a waveform to loose no more than half its power (-3 dB) over a time period T (s). Your answer should be a value for α_d measured in dB/km, simplified but obviously not evaluated. (**10 points**)

Answer:

The total distance that the wave on the transmission line travels is obviously Tv_p. Therefore, the total attenuation would be $\alpha_d T v_p$ if α_d were measured in dB/m. This total attenuation must be less than 3 dB. Thus, the following condition must hold:

$$\alpha_d < \frac{3000}{Tv_p}\,\text{dB/km}$$

where the extra factor of 1000 is to convert from dB/m to dB/km.