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

<u>THT3</u> : Open- and Short-Circuit Loads

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

Prerequisite Skills

Prerequisites / Requirements:
THT2 Sinusoids on Transmission Lines

Competencies

Competency THT.3: **Analyze the time-harmonic voltage and current on transmission lines terminated with open and short circuits**

Competency Builders:
THT.3.1 Define voltage standing wave ratio
THT.3.2 Calculate the impedance transformation effects of lines terminated in open- or short-circuits
THT.3.3 Sketch the voltage and current distribution as a function of space on an open- or short-circuited transmission line

Supplemental Reading and Resources

Supplemental Reading Materials:

Prof. Peterson's online lecture notes 14

Assessments

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

Question: THT.3.1 *Competency:* THT.3.1

What is the VSWR of a transmission line terminated with a short or open circuit?

Answer:

Infinite

Question: THT.3.2 *Competency:* THT.3.2

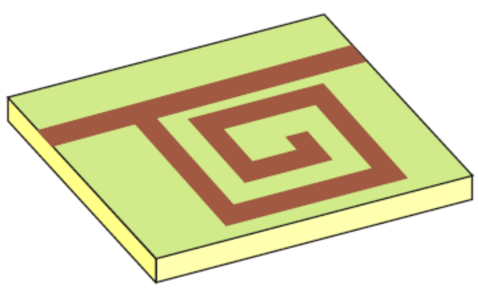
A short circuit load appears to be a [*Answer*] from the source side of a $\lambda/4$-length transmission line under sinusoidal excitation.

Answer:

open circuit

Question: THT.3.3 *Competency:* THT.3.2

You are asked to reverse engineering a competitor's RF board. When you open the enclosure to look at the board, you notice a strange squiggly structure (see below) protruding from the side of a microstrip line. The squiggle is somewhere between 0.25λ and 0.5λ in length. What equivalent circuit element is the RF designer trying to recreate here? Why not use a ceramic circuit component instead?

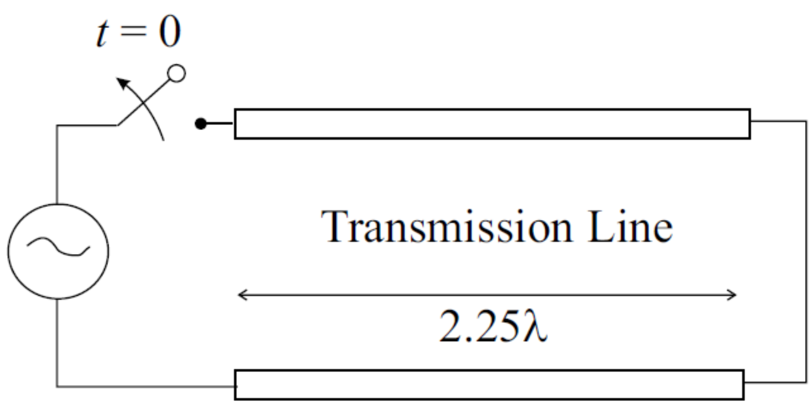


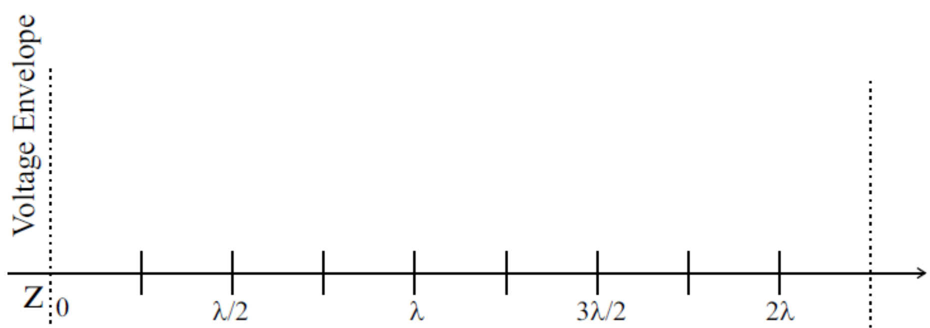
Answer:

This is an inductor (check the Smith chart: an open-circuited stub transforms to a positive imaginary impedance for lengths between 0.25λ and 0.5λ). Anyone who even brushed up against the following benefits in their description was given credit: 1) the squiggle is cheaper than a discrete inductor, 2) less lossy, 3) higher Q, 4) requires less packaging/assembly, 5) more stable/predictable inductor value.

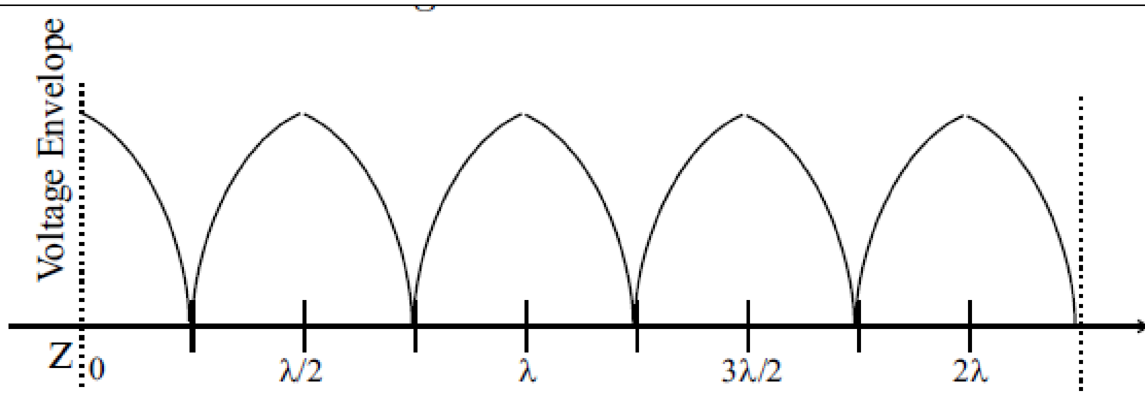
Question: THT.3.4 *Competency:* THT.3.3

Superconductors for Power Storage: Some engineers have proposed that s
perconductor transmission lines can be used for storing AC power for a very lo
time. Since there are no ohmic losses ($R = 0$) on a superconductive transmissi
line, the attenuation constant is equal to 0. Below is an example of a steady-st
transmission line that is suddenly switched off of the AC power supply at $t = 0$.
the graphs below, sketch the envelope of the total current and the total voltage th
continues to oscillate on the line. (Hint: for this particular example, the volta
and currents on the line remain the same after the switch is opened $t = 0$.)





Answer:



Question: THT.3.5 *Competency:* THT.3.3

Waves on a Transmission Line: *A true story.* Some Motorola engineers were taking power amplifier measurements on the roof of a building, hooking a UHF amplifier to an antenna with some heavy-duty coaxial cable. The load of the antenna was matched to the coaxial line so that, under normal operation, there are no reflections. Several thousand Watts were sent down the line to the antenna for each test ($\beta \approx \frac{2\pi}{1 \text{ meter}}$ for this example). During one test, the engineers accidentally kinked part of the coaxial cable. For this test, no power was radiated by the antenna, the power amplifier blew up, and there were actually periodic places on the cable (before the kink) that bulged where high voltages had melted and burned the dielectric of the expensive coaxial cable. Explain, electromagnetically, what happened and how far apart the bulges were in the ruined cable. (10 points)

Answer:

The kind caused a perfect reflection midway down the line. The peaks of the bulge occur every $\lambda/2$ or 0.5m.