

Java™ Applet for Teaching Transmission Lines in Steady State

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Abstract

Teaching electromagnetics often involves spatial visualisation of theory and problems. Traditional teaching methods are effective, but can be augmented with the use of animation.

One specific electromagnetic situation is considered, transmission lines carrying one frequency in steady state. An applet in javaTM was developed to demonstrate by animation the transmission line concepts. This applet is presented to the students in a junior course in electromagnetic fields and waves. This particular applet demonstrates forward and reverse travelling waves, partial reflections, total reflections, matched loads, and standing waves.

The transmission line applet alone is insufficient to demonstrate the theory. However, the theory presented in a lecture is reinforced by the applet.

One technical issue that arose is spatial and temporal aliasing. Since the applet displays the animated and travelling waves

within a limited resolution and display time, aliasing may occur. This situation is detected by the applet and the user is informed. Even though aliasing may occur, the applet displays the aliased waveform. One noticeable effect of aliasing that can occur is the forward and reverse travelling waves travelling in the wrong direction.

The time to design and develop the applet is relatively high. The time for one developer to learn java™ would only occur once. However, the development time for each engineering application is nevertheless relatively high. The relative productivity in terms of course development time is lower with the java™ applet than that based on traditional teaching methods, such as lectures, laboratories, and assignments. However, the cost may eventually be recovered by repeated use of the applet in augmenting traditional teaching methods.

Introduction

- Problems with demands for graphics and animation have the most potential for assistance from java™ applets
- Appropriate applets are relatively rare
- Development cost, learning java™ (once), applying java™ to the engineering application, is high and can only augment, not replace, traditional teaching methods
- One applet demonstrating transmission line concepts will be shown

Applet Overview - Top Half

Source

$$V = V_s + \phi$$

$$Z_s = R_s + jX_s$$



V_s Mantissa = 5.0

V_s Exponent = 1

ϕ Mantissa = 0.0

ϕ Exponent = 0

R_s Mantissa = 5.0

R_s Exponent = 1

X_s Mantissa = 0.0

X_s Exponent = 0

f Mantissa = 1.0

f Exponent = -3

Tx Line

$$Z_o = R_o + jX_o$$

$$\gamma = \alpha + j\beta$$



R_o Mantissa = 5.0

R_o Exponent = 1

X_o Mantissa = 0.0

X_o Exponent = 0

α Mantissa = 0.0

α Exponent = 0

β Mantissa = 6.28

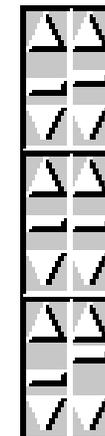
β Exponent = 0

L Mantissa = 4.0

L Exponent = 0

Load

$$Z_L = R_L + jX_L$$



R_L Mantissa = 1.67

R_L Exponent = 1

X_L Mantissa = 0.0

X_L Exponent = 0

Animation Delay =

200.0 milliseconds

example

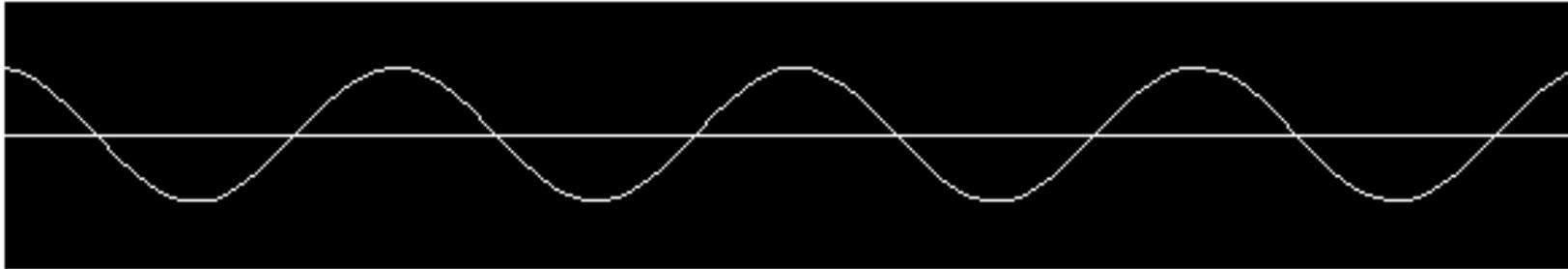
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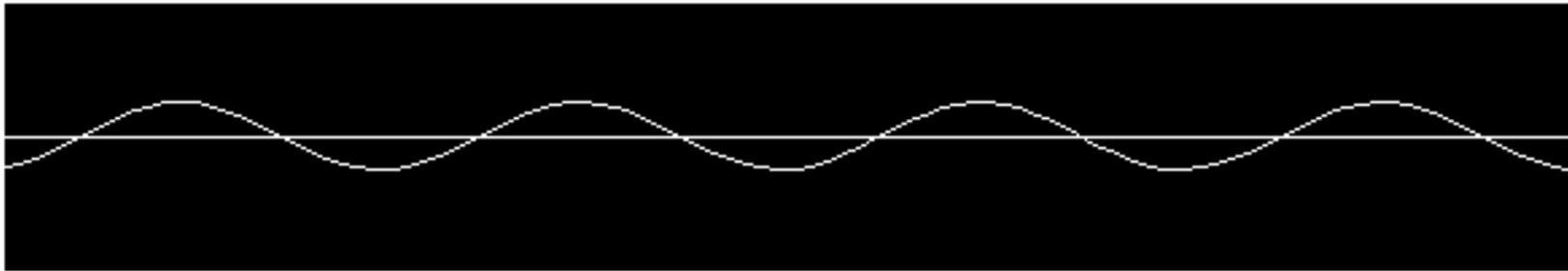
Applet Overview - Bottom Half

● Red Light = Aliasing.

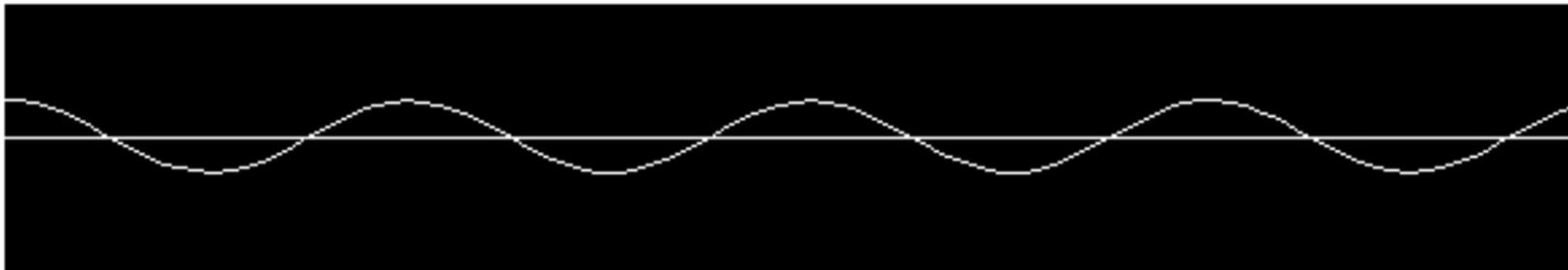
Forward Travelling Wave



Reverse Travelling Wave



Sum of Both Waves



Transmission Line Theory - Steady State

- Electromagnetics provides a basic science component of the computer engineering program
- Difficult concepts where animation assists learning
 - Travelling waves
 - Standing waves
 - Partial and full reflections
 - Distance between nodes in a standing wave pattern is half a wavelength
 - Voltage standing wave ratio

Teaching Methods

- Traditional advocated
 - Lectures
 - Labs
- For mathematically intensive courses, on-line and distance learning assist the traditional method
 - The Internet, the Web
 - JavaTM applets

Development of Applet - Construction

- Double learning curve
 - Java™ animation
 - Transmission line theory
- Construction time, on the order of two months, as seen in three senior undergraduate theses, while the students were involved in a regular undergraduate program
- To within an order of magnitude, 10^3 lines of java™, with classes for
 - Animation
 - Complex number calculations
- User interface, sliders versus typed input

Development of Applet - Resolution Problems

Aliasing in

- Space
 - 99 segments, 100 points, of the transmission line voltage along the length of the transmission line
 - The number of wavelengths attempted to be shown should be less than $99/2$.
- Time
 - Animations are redrawn every 1 (second) of transmission line simulation time (The actual animations are drawn much faster.)
 - The frequency of the wave should be less than 0.5 (Hertz).
- Applet detects aliasing and turns on a “red light”
- With aliasing, waves may travel backward and not be the proper frequency

Usage of Applet

- Applet alone is insufficient to teach the concepts
- Applet used in assignments where students have to enter specific values and describe what is observed
- Assignments may also describe an effect and ask the students to find the desired parameters, avoided due to potential trial and error solutions

Applet Demonstrations

Conclusions

- Appropriate applets are rare and require animation
- Development cost is high, and can only augment, not replace, traditional teaching methods
- One applet animating transmission line concepts was demonstrated
- Continuing search for useful applets
- Continuing search for useful development environments
 - Macromedia flash, www.macromedia.com
 - Shockwave, www.shockwave.com
 - MATLAB[®] animation, but with a required web interface