MT360_UR7_2_8_1 Special Cases of The Lossless Line

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Title

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Description

The equivalent impedance of a transmission line ending in a short circuit can change depending on the length of the transmission line. A lossless 50 Ohm transmission line of length 2.25 wavelengths is terminated by a short circuit and attached to a generator with a source voltage of 2 V and a source impedance of 50 Ohms. Assume that the operating frequency is 300 MHz and that the phase velocity of the line is 0.75c, c refers to the speed of light. For the assignment assume that t = 0s;

Exercise

1. Calculate Zin at the source end of the line, Ohms.
2. Calculate the phasor voltage across Zin, V.
3. Calculate the amplitude of the forward and reverse propagating voltages, V.
4. Calculate the forward and reverse propagating voltages as a function of wavelength, lambda.
5. Find the total propagating voltage as a function of wavelength, lambda.
6. Calculate the forward, reverse, and total propagating currents as a function of wavelength.
7. Calculate the input impedance as a function of wavelength.
8. Plot the real parts of the forward, reverse, and total propagating voltages and currents as a function of wavelength.
9. The third plot is given to you. Notice how the total current, total voltage, and impedances are normalized. Using the third plot, estimate the shortest line length from the load when the equivalent reactance is 40 Ohms, 0.8 Ohms when normalized.

Questions

For the following questions d is the distance from the load.

1. From 0 λ < d < 1/4 λ is the equivalent impedance of the line inductive, capacitive, or neither?
2. At d = 1/4 λ, what is the equivalent impedance of the line?
3. From 1/4 λ < d < 1/2 λ is the equivalent impedance of the line inductive, capacitive, or neither?
4. At d = 1/2 λ, what is the equivalent impedance of the line?

Useful Information

The input impedance of a short-circuited line of length, l.

$$Z_{in}^{sc} = \frac{\tilde{V}_{sc}(l)}{\tilde{I}_{sc}(l)} = jZ_o \tan \beta l$$

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Note that the function tangent evaluated at 90 degrees is infinity.
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The phasor voltage across Zin (Zin is the input impedance at the source end of the line) is given by

$$\tilde{V}_i = \frac{\tilde{V}_g Z_{in}}{Z_g + Z_{in}}$$

The forward propagating voltage amplitude is related to the phasor voltage, Vi, by

$$V_o^+ = \frac{\tilde{V}_i}{e^{j\beta l} + \Gamma e^{-j\beta l}}$$

The reverse propagating voltage is related to the forward propagating wave by the reflection coefficient.

$$V_o^- = \Gamma V_o^+$$

The total phasor voltage anywhere on the line is related to the forward and reverse propagating voltages.

$$\tilde{V}(d) = V_o^+ + V_o^-$$

$$\tilde{V}(d) = V_o^+ + \Gamma V_o^+$$

$$\tilde{V}(d) = V_o^+[e^{j\beta l} + \Gamma e^{-j\beta l}]$$

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d represents the distance in meters from the load.
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- The total phasor current anywhere on the line is related to the forward and reverse propagating voltages by the characteristic impedances.*

$$\tilde{I}(d) = \frac{V_o^+}{Z_o} + \frac{V_o^-}{Z_o}$$

$$\tilde{I}(d) = \frac{V_o^+}{Z_o} + \Gamma\frac{V_o^-}{Z_o}$$

$$\tilde{I}(d) = \frac{V_o^+}{Z_o}[e^{j\beta l} + \Gamma e^{-j\beta l}]$$

d represents the distance in meters from the load.

Provided Code

```
param

% Parameters

length = 2.25;   % Length of transmission line, wavelength
l_array =...     % An array that represents different points on the T-
Line
  linspace(length,0,1000);
Vg = 2;          % Generator voltage, V
Zo = 50;         % Characteristic Impedance of the line, Ohms
Zg = 50;         % Impedance of generator, Ohms
gamma = -1;      % Reflection coefficient at the load
Up = 0.75*P.c;   % Phase velocity, m/s
f = 300e6;       % Frequency of signal, Hz
lambda = Up/f;   % Wavelength, m
X = 40;          % Desired reactance, Ohms
x = X/Zo;        % Normalized reactance, Ohms

% 1)
% The input impedance at the source end of the line. Hint, do not
 assign
% Zin a value, just mentally know what it is.
% Zin = % INSERT COMMENT HERE

% 2)

Vi = % INSERT CODE HERE    % The phasor voltage across Zin, V

% 3)
% Amplitude of the forward propagating wave, V
Vo_plus = % INSERT CODE HERE

% Amplitude of the reverse propagating wave, V
Vo_minus = % INSERT CODE HERE

% 4)
% Forward propagating voltage as a function of length, V
Vo_plus_array = Vo_plus*exp(1j*2*pi*l_array);

% Reverse propagating voltage as a function of length, V
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Vo_minus_array = % INSERT CODE HERE

% 5)
% Total voltage on the line as a function of length, V
Vsc_array = % INSERT CODE HERE

% 6)
% Forward propagating current as a function of length, A
Io_plus_array = % INSERT CODE HERE

% Reverse propagating current as a function of length, A
Io_minus_array = Vo_minus_array/Zo;

% Total current on the line as a function of length, A
Isc_array = Io_plus_array - Io_minus_array;

% 7)
% Input impedance as a function of distance from the load
Zsc = % INSERT CODE HERE

% 8)

figure(1),clf;
p1 =
 plot(l_array,real(Vo_plus_array),'*m',l_array,real(Vo_minus_array),'-
c',l_array,real(Vsc_array),'r');
set(p1(2), 'linewidth',2);
set(gca,'xdir','reverse')
axis([0 2.25 -2 2])
legend('Vo^+','Vo^-','Vsc');
title('Voltage Propagating Waves');
ylabel('V');
xlabel('Distance (\lambda)');

figure(2),clf;
p2 = % INSERT CODE HERE
set(p2(2), 'linewidth',2)
set(gca,'xdir','reverse')
xlim([0,length])
legend('Io^+','Io^-','Isc/j');
title('Current Propagating Waves');
ylabel('A');
xlabel('Distance (\lambda)');

figure(3),clf;
plot(l_array,Isc_array*Zo/(2*Vo_plus), l_array, Vsc_array/
(2j*Vo_plus), l_array, Zsc/(1j*Zo));
set(gca,'xdir','reverse')
axis([0 2.25 -11 11])
a=line([0,2.25],[0,0]);
set(a, 'color','k')
l=legend('$\frac{\tilde{I}sc(d)Zo}{2V_o^+}$','$\frac{\tilde{V}sc(d)}
{2jV_o^+}$','$\frac{Z_{in}^{sc}}{jZo}$','location','NorthWest');
set(l,'Interpreter','Latex','fontsize',15);
title('SC Voltage, Current, and Impedance');
ylabel('V,A,\Omega');
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xlabel('Distance (\lambda)');
```
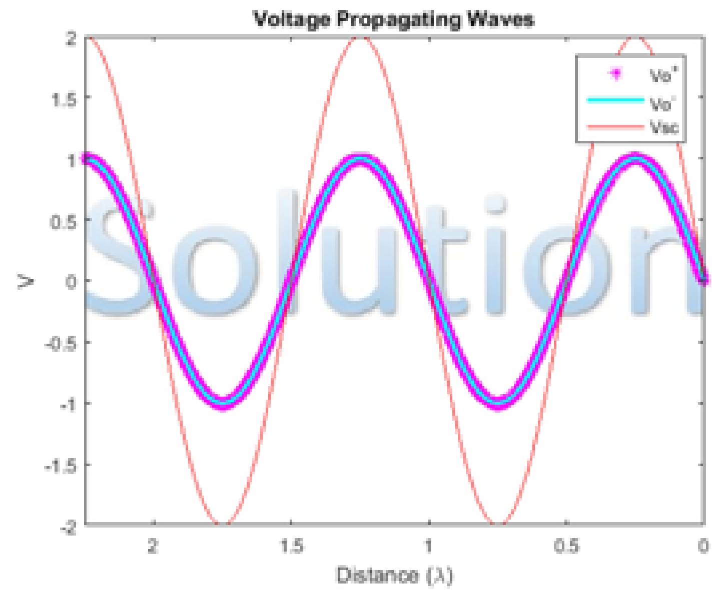
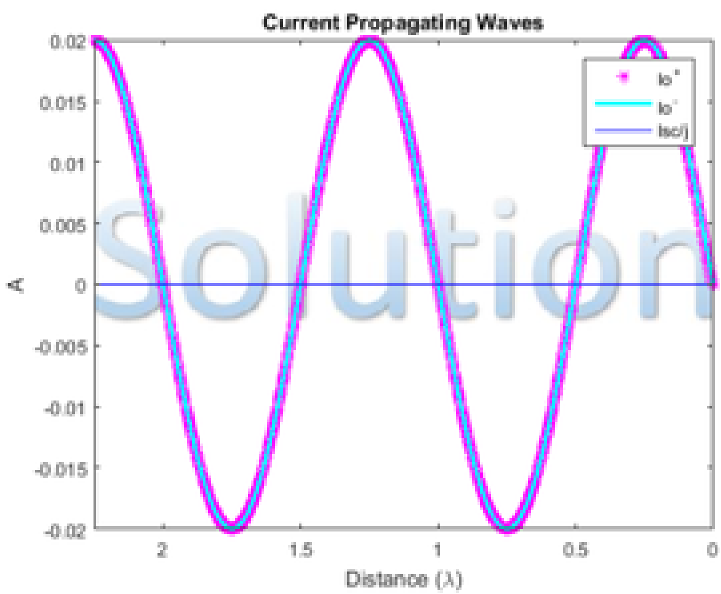
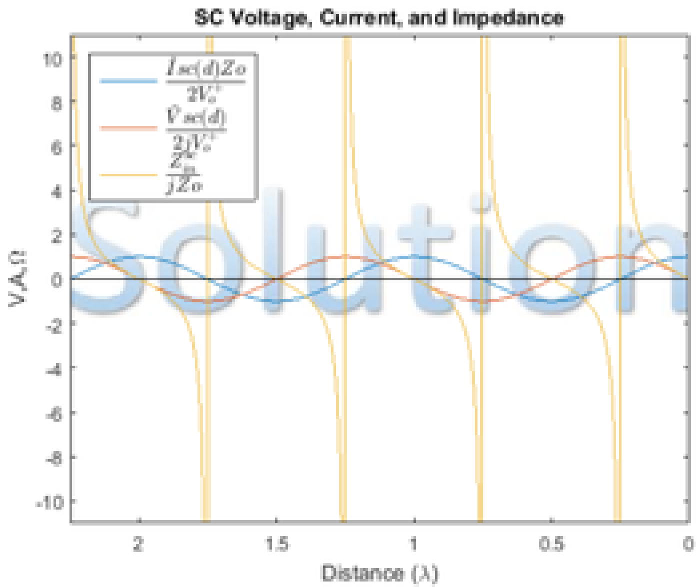

Solution

Approximated distance from the load that produces an equivalent reactance of 40 Ohms, m
0.0818







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