NIKHIL.V
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30/30

SRM INSTITUTE OF SCIENCE & TECHNOLOGY

SRM Institute of Science and Technology
College of Engineering and Technology

DEPARTMENT OF ECE

SRM Nagar, Kattankulathur – 603203, Chengalpattu District, Tamilnadu

Academic Year: 2024-2025 (ODD)

Test: LLT-1 (Simulation Study)
Course Code / Title: 21ECC205T Electromagnetic Theory and Interference
Year & Sem: II & III

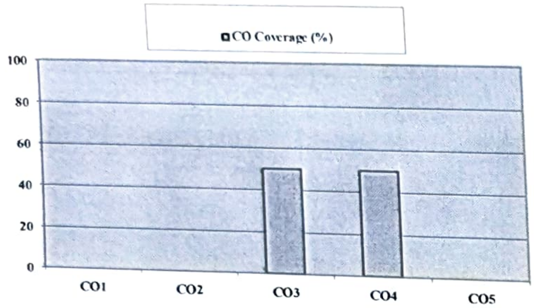
Due Date: 04.11.2024
Max. Marks: 30

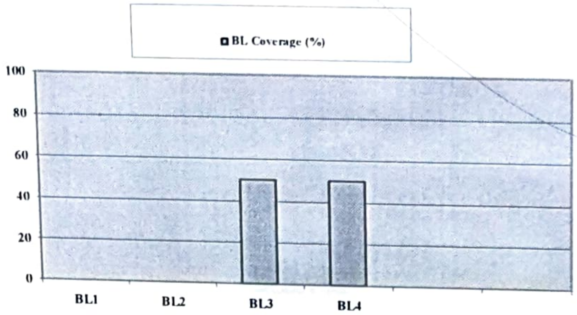
Course Articulation Matrix :

	21ECC205T - ELECTROMAGNETIC THEORY AND INTERFERENCE	Program Learning Outcomes (PLO)												PSO		
S.NO	Course Learning Outcomes (CLO)	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	Apply the concepts and knowledge to solve problems related to electric field.	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
2	Analyze the concepts of Magnetic field and Maxwell's equations in the real-world application.	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
3	Translate the phenomenon of guided wave propagation and its mode of propagation.	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
4	Describe the importance of transmission line theory applicable to low frequency transmission lines.	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
5	Solve transmission line parameter and impedance matching through analytical and graphical methods.	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-

	Part – A (5×4 = 20 Marks) Answer any FIVE questions				
Q. No	Question	Marks	BL	CO	PO
1.	(a) Write a MATLAB code to find the cut-off frequency and the modal field distribution (both electric and magnetic fields) of TE_{10} and TE_{01} mode in a rectangular waveguide having dimensions on longer and shorter sides as 2 cm and 1 cm, respectively. Consider the operating wavelength to be 1550 nm.	7.5	3	CO3	2
	(b) Now vary the dimensions and operating wavelength in the problem and, analyze and discuss the effect of these variations on the cut-off frequency and modal field distribution. Compare your observations with the theoretical observations obtained in class using analytical formulas.	7.5	4	CO3	3
2.	(a) Consider a transmission line with characteristic impedance $Z_0 = 50\ \Omega$ and various load impedances $Z_L = 25\ \Omega$, $75\ \Omega$ and $1000\ \Omega$. Write a MATLAB code and estimate the reflection coefficient and VSWR for each load. Assuming the operating frequency to be 1 GHz and Transmission line length to be 50 cm, plot the Voltage standing wave pattern for each case and estimate VSWR from the plots. Compare the VSWR obtained analytically and from the graphs.	7.5	4	CO4	3
	(b) Estimate the power transfer efficiency for each case and show that the power transfer is maximum when the characteristic impedance matches with the load impedance.	7.5	3	CO4	2

Course Outcome (CO) and Bloom's level (BL) Coverage in Questions





Evaluation Sheet

Name of the Student: NIKHIL.V

Register No.: RA2311004010387

Q. No	CO	PO	Maximum Marks	Marks Obtained	Total
1(a)	3	3	7.5	7.5	30
1(b)	3	2	7.5	7.5	
2(a)	4	3	7.5	7.5	
2(b)	4	3	7.5	7.5	

Consolidated Marks:

CO	Maximum Marks	Marks Obtained
3	15	15
4	15	15
Total	30	30

PO	Maximum Marks	Marks Obtained
2	15	15
3	15	15
Total	30	30

Signature of Course Teacher

CUTOFF FREQUENCY:

The cutoff frequency for a mode in a rectangular waveguide depends on the waveguide's dimensions a and b (longer and shorter sides) and the mode numbers (TE_{10} and TE_{01})

For TE_{10} : $f_c = \frac{c}{2a}$.

For TE_{01} = $f_c = \frac{c}{2b}$

FIELD DISTRIBUTION:

For TE_{10}, the magnetic field H_z and electric field E_x and E_y are calculated based on sine and cosine functions over x and y.

(b). CUTOFF FREQUENCY:

*Increases in waveguide dimensions a or b decrease the cutoff frequency, allowing lower frequencies to propagate.

FIELD DISTRIBUTION:

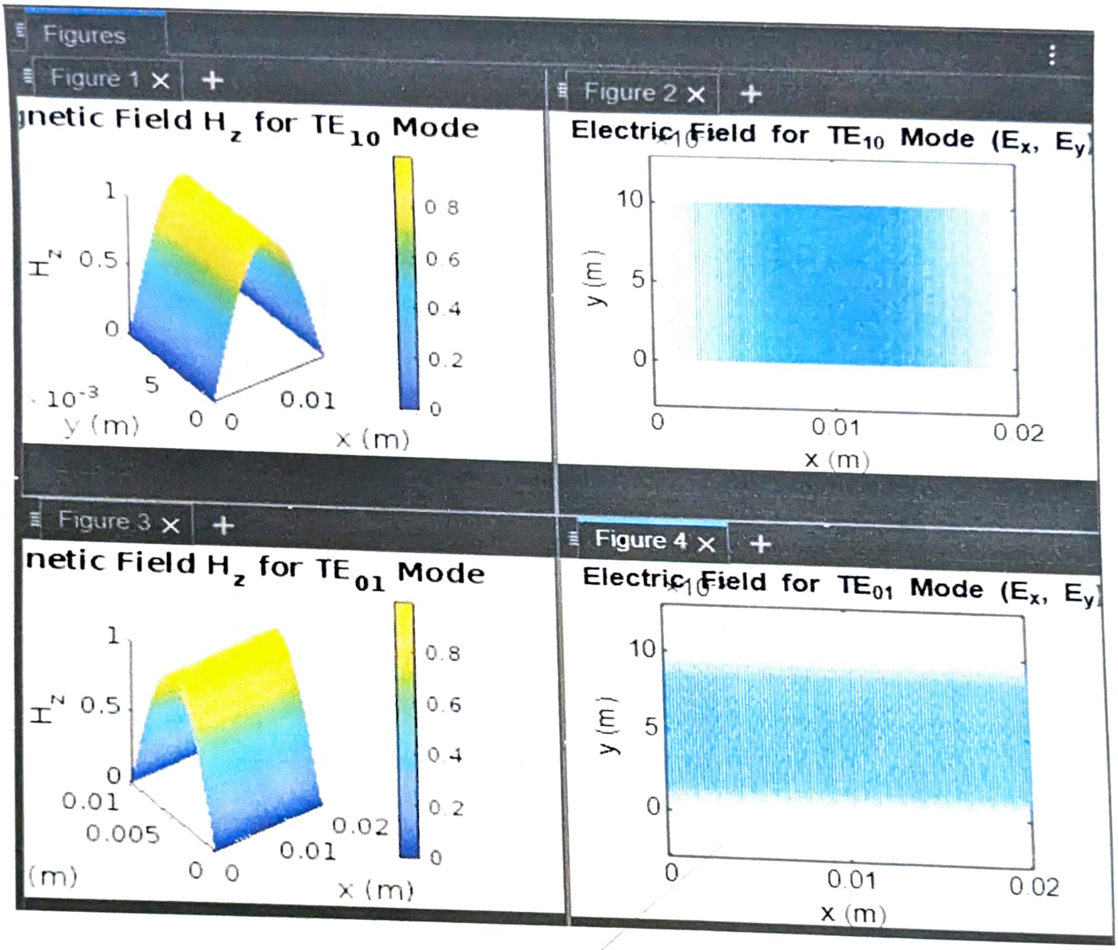
* Changes in a, affect TE_{10} mode more, while changes in b affect TE_{01}.

*When comparing, MATLAB plots show how field distributions and cutoff frequencies shift with varying dimensions, matching analytical results.

1. MATLAB Code for Question 1(a) and 1(b)

```
% Parameters
a = 0.02; % Waveguide width in meters
b = 0.01; % Waveguide height in meters
lambda = 1.55e-6; % Operating wavelength in meters
c = 3e8; % Speed of light in vacuum (m/s)

% Calculate the cut-off frequencies for TE10 and TE01 modes
m_TE10 = 1; n_TE10 = 0;
m_TE01 = 0; n_TE01 = 1;

% Cutoff frequencies (in Hz) for TE modes
fc_TE10 = c / (2 * sqrt((m_TE10/a)^2 + (n_TE10/b)^2));
fc_TE01 = c / (2 * sqrt((m_TE01/a)^2 + (n_TE01/b)^2));

% Display cutoff frequencies
disp(['Cutoff frequency for TE10 mode: ', num2str(fc_TE10), ' Hz']);
disp(['Cutoff frequency for TE01 mode: ', num2str(fc_TE01), ' Hz']);

% Define the spatial grid for field plotting
x = linspace(0, a, 100); % x-direction grid
y = linspace(0, b, 100); % y-direction grid
[X, Y] = meshgrid(x, y); % Create the 2D grid

% Magnetic field (H_z) and electric field (E_x, E_y) for TE10 mode
Hz_TE10 = sin(pi * X / a); % H_z for TE10
Ex_TE10 = -(pi / b) * sin(pi * X / a); % E_x for TE10
Ey_TE10 = zeros(size(X)); % E_y for TE10 is zero


% Magnetic field (H_z) and electric field (E_x, E_y) for TE01 mode
Hz_TE01 = sin(pi * Y / b); % H_z for TE01
Ex_TE01 = zeros(size(X)); % E_x for TE01 is zero
Ey_TE01 = -(pi / a) * sin(pi * Y / b); % E_y for TE01

% Plot H_z for TE10 mode
figure;
surf(X, Y, Hz_TE10);
title('Magnetic Field H_z for TE_{10} Mode');
xlabel('x (m)');
ylabel('y (m)');
zlabel('H_z');
shading interp;
colorbar;


% Plot electric field for TE10 mode
figure;
quiver(X, Y, Ex_TE10, Ey_TE10);
title('Electric Field for TE_{10} Mode (E_x, E_y)');
xlabel('x (m)');
ylabel('y (m)');
axis equal;

% Plot H_z for TE01 mode
figure;
surf(X, Y, Hz_TE01);
title('Magnetic Field H_z for TE_{01} Mode');
xlabel('x (m)');
ylabel('y (m)');
zlabel('H_z');
```

```
shading interp;
colorbar;

% Plot electric field for TE01 mode
figure;
quiver(X, Y, Ex_TE01, Ey_TE01);
title('Electric Field for TE_{01} Mode (E_x, E_y)');
xlabel('x (m)');
ylabel('y (m)');
axis equal;
```



REFLECTION CO-EFFICIENT (Γ):

Calculated as $\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$, where Z_L is load impedance & Z_0 is characteristic impedance.

VOLTAGE STANDING WAVE RATIO (VSWR):

Given by $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$

STANDING WAVE PATTERN:

The voltage pattern along the line varies with position z and depends on the reflection coefficient, indicating points of min & max voltages.

POWER TRANSFER EFFICIENCY:

Calculated as $\eta = 1 - |\Gamma|^2$, showing max. efficiency when $Z_L = Z_0$.

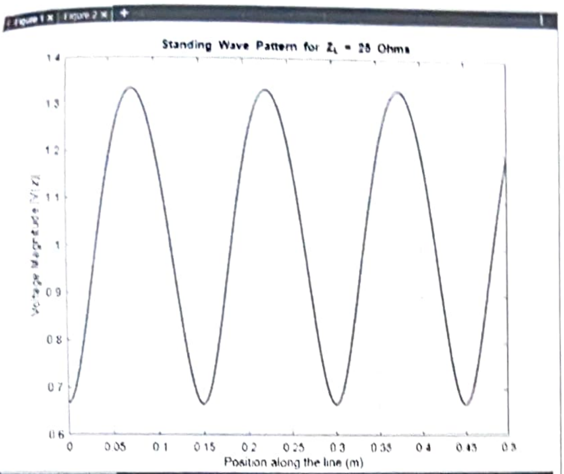
(b). * The power transfer efficiency (η) is highest when $Z_L = Z_0$, meaning no reflection.

* Impedance mismatch: For mismatched Z_L values (eg., 25, 50, 1000 ohms) efficiency drops due to reflection.

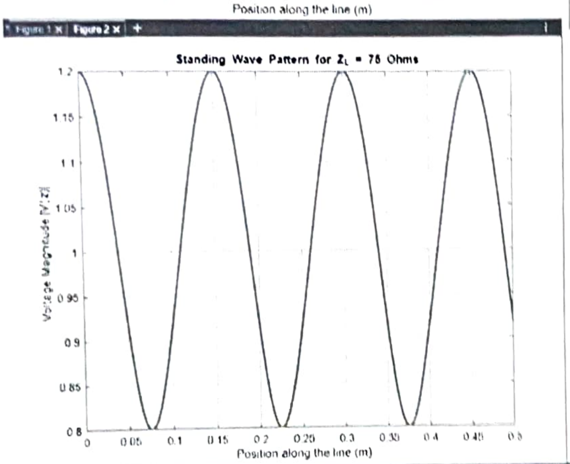
* Here, efficiency peaks when $Z_0 = Z_L$, verified by MATLAB.

```
% Given values
Z0 = 50; % Characteristic impedance in Ohms
ZL_values = [25,75,1000]; % Load impedances
frequency = 1e9; % Operating frequency (1 GHz)
c = 3e8; % Speed of light (m/s)
lambda = c / frequency; % Wavelength
line_length = 0.5; % Transmission line length (in m)
z = linspace(0, line_length, 500); % Points along the line
% Initialize arrays to store results
reflection_coefficients = zeros(1, length(ZL_values));
VSWR_values = zeros(1, length(ZL_values));
efficiency_values = zeros(1, length(ZL_values));
% Calculation for each load impedance
for i = 1:length(ZL_values)
  ZL = ZL_values(i);
  % Reflection Coefficient
  Gamma = (ZL - Z0) / (ZL + Z0);
  reflection_coefficients(i) = Gamma;
  % VSWR
  VSWR = (1 + abs(Gamma)) / (1 - abs(Gamma));
  VSWR_values(i) = VSWR;
  % Power Transfer Efficiency
  efficiency = 1 - abs(Gamma)^2;
  efficiency_values(i) = efficiency;
  % Display results
  fprintf('For Z_L = %d Ohms:\n', ZL);
  fprintf('Reflection Coefficient (Gamma) = %.3f\n', Gamma);
  fprintf('VSWR = %.3f\n', VSWR);
  fprintf('Power Transfer Efficiency = %.3f%%\n\n', efficiency * 100);
end
% Plot Standing Wave Pattern for ZL = 25 Ohms
ZL = 1000; % Set load impedance for plot
Gamma = (ZL - Z0) / (ZL + Z0); % Reflection coefficient
beta = 2 * pi / lambda; % Phase constant
V_in = 1; % Incident voltage magnitude
V_ref = Gamma * V_in; % Reflected voltage magnitude
% Voltage along the line: V(z) = V_in * exp(-j*beta*z) + V_ref * exp(j*beta*z)
V_z = V_in * exp(-1i * beta * z) + V_ref * exp(1i * beta * z);
V_magnitude = abs(V_z); % Magnitude of voltage along the line
% Plot
figure;
plot(z, V_magnitude, 'LineWidth', 2);
xlabel('Position along the line (m)');
ylabel('Voltage Magnitude |V(z)|');
title('Standing Wave Pattern for Z_L = 1000 Ohms');
grid on;
```

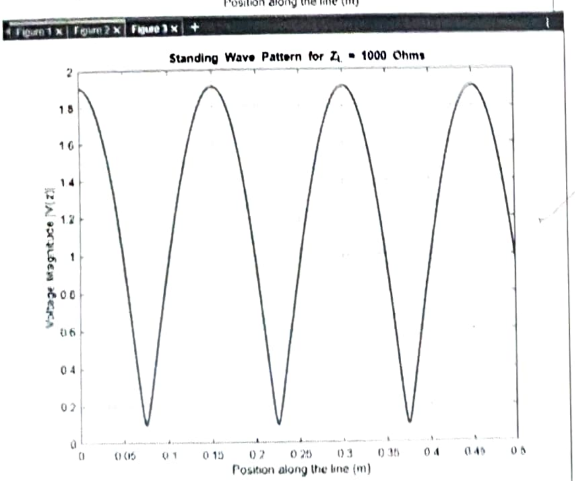
2 (a) (b)




```
For Z_L = 25 Ohms:
Reflection Coefficient (Gamma) = -0.333
VSWR = 2.000
Power Transfer Efficiency = 88.889%
```




```
For Z_L = 75 Ohms:
Reflection Coefficient (Gamma) = 0.200
VSWR = 1.500
Power Transfer Efficiency = 96.000%
```




```
For Z_L = 1000 Ohms:
Reflection Coefficient (Gamma) = 0.905
VSWR = 20.000
Power Transfer Efficiency = 18.141%
```

```
>> Qn2
For Z_L = 25 Ohms:
Reflection Coefficient (Gamma) = -0.333
VSWR = 2.000
Power Transfer Efficiency = 88.889%

For Z_L = 50 Ohms:
Reflection Coefficient (Gamma) = 0.000
VSWR = 1.000
Power Transfer Efficiency = 100.000%

For Z_L = 75 Ohms:
Reflection Coefficient (Gamma) = 0.200
VSWR = 1.500
Power Transfer Efficiency = 96.000%

For Z_L = 1000 Ohms:
Reflection Coefficient (Gamma) = 0.905
VSWR = 20.000
Power Transfer Efficiency = 18.141%
```