SAVEETHA SCHOOL OF ENGINEERIING,

SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES

TRANSMISSION LINES & WAVEGUIDES

ECA15

NAME:

REG.NO:

LAB MANUEL

SAVEETHA SCHOOL OF ENGINEERING
SAVEETHA INSTITUTE OF TECHNICAL AND MEDICAL SCIENCES

Engineer to Excel

INDEX

S. No.	Experiment	CO	BTL	Date	Signature
1.	Investigating the significance of Characteristic Impedance (Zo), and Propagation Constant (γ) of a Transmission Line using the following parameters a) Resistance b) Capacitance c) Inductance d) Conductance	CO1	3		
2.	Estimation of Primary Constants (R,L,G &C) from Secondary Constants (Zo & γ)of an open wire transmission line	CO1	3		
3.	Examining the impact of open and short circuited loads on a)Characteristic Impedance b) Propagation Constant	CO1	3		
4.	Evaluation of current and voltage of a short circuited Lossless transmission line at the receiving end	CO2	3		
5.	Analysis of SWR (Standing Wave Ratio) pattern in High Frequency Transmission Lines by varying a) load impedance b) characteristic impedance	CO2	4		
6.	Exploration of the relationship between SWR (Standing Wave Ratio) and the position of Voltage minima nearest to the load by varying magnitude of reflection coefficient K	CO2	4		
7.	Designing a Quarter wave transformer for impedance matching for the following parameters a) frequency b) input impedance c) characteristic impedance	CO3	3		

8.	**Strategize impedance matching with Short Circuited Stub for a given characteristic impedance and load impedance through the measurement of** **a) Location of the stub** **b) Length of the stub**	**CO3**	**4**		
9.	**Analysis of Electromagnetic Waves across the two parallel plates by estimating the following** **a) Critical Wavelength** **b) Guide Wavelength**	**CO4**	**3**		
10.	**Determination of Dominant mode of Rectangular waveguides by examining the TE and TM modes**	**CO4**	**3**		
11.	**Calculation of Group velocity, Phase velocity and phase constant of EM waves in rectangular waveguides**	**CO4**	**3**		
12.	**Examining the propagation characteristics of circular waveguide in terms of a)Cutoff wavelength** **b) Guide wavelength** **c) characteristic impedance**	**CO5**	**4**		
13.	**Inference of Q Factor of Rectangular Cavity Resonator for TE101 mode with the following inputs** **a) Dimension a in x axis** **b) Dimension b in y axis** **c) Dimension p in z axis**	**CO5**	**4**		
14.	**Computation of Resonant Frequency of Rectangular Cavity Resonator for** **a)Transverse Electric mode** **b)Transverse Magnetic mode**	**CO5**	**4**		
15.	**Estimation of Resonant Frequency in a Cylindrical Cavity Resonator for** **a)Transverse Electric mode** **b)Transverse Magnetic mode**	**CO5**	**3**		

Investigating the significance of Characteristic Impedance (Zo), and Propagation Constant (γ) of a Transmission Line using the following parameters

a) **Resistance**
b) **Capacitance**
c) **Inductance**
d) **Conductance**

Experiment Number:1

AIM: Finding Characteristic Impedance, and Propagation Constant of a Transmission Line for the given values of R,L,G and C

SOFTWARE REQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
R=10;L=.0037;f=1000;G=.4*(10^-6);C=.0083*(10^-6);
w=2*%pi*
f;
Z=R+(%i*
w*L);
Y=G+(%i*
w*C);
Zo=sqrt(Z/
Y);
C=round(re
```

```
al(Zo));
D=round(i
mag(Zo));
printf('-Zo = %f + j(%f)
ohms\n',C,D);
P=sqrt(Z*Y); a=real(P);
a1=round(a*1000
0)/10000;
printf('-Attenuation constant a = %f
neper/km\n',a1); b=imag(P);
b1=round(b*10000)/10000;
printf('-Phase constant b = %f radians/km',b1);
```

OUTPUT:

Variable R
Constants L=.0037; f=1000; G=.4*(10^-6); C=.0083*(10^-6).

S. No.	Inputs (R)	Outputs		
		Z0(ohms)	α(neper/km)	β(radians/km)
1				
2				
3				
4				
5				

Variable L
Constants R=20; f=1000; G=.4*(10^-6); C=.0083*(10^-6);

S. No.	Inputs (L)	Outputs		
		Z0(ohms)	α (neper/km)	β (radians/km)
1				
2				
3				
4				
5				

Variable f
Constants R=20; L=.009; G=.4*(10^-6); C=.0083*(10^-6);

S. No.	Inputs (f)	Outputs		
		Z0(ohms)	α (neper/km)	β (radians/km)
1				
2				
3				
4				
5				

Variable C
Constants R=20; L=.009; f=2500; G=.4*(10^-6);

S. No.	Inputs (C)	Outputs		
		Z0(ohms)	α (neper/km)	β (radians/km)
1				
2				
3				
4				
5				

RESULT:

The characteristic impedance and propagation constant of a transmission line is calculated using SCILAB and the impact of primary constants on secondary constants are investigated.

Estimation of Primary Constants (R,L,G &C) from Secondary Constants (Zo & γ)of an open wire transmission line

Experiment Number:2

AIM: To estimate the primary constants of a transmission line from Secondary Constants (Zo & γ)of an open wire transmission line

SOFTWARE REQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
Zo=2039.6;f=800; //value of Zo as taken in solution
P=0.054* exp(%i*(%pi/(180/87.9)));
w=2*%pi*f;
Z=Zo*P;
R=real(Z);
printf('-Resistance R = %f ohms/km\n',R);
L=(imag(Z))/w;
printf('-Inductance L = %f mH/km\n',L*(10^3));
Y=P/Zo;
G=real(Y);
printf('-Conductance G = %f micromhos/km\n',G*(10^6));
C=((imag(Y))/w)*(10^6);c=round(C*10000)/10000
printf('-Capacitance C = %f microfarads/km\n',c);
```

OUTPUT:

Variable Zo; Constant
F= 800 Hz;

S. No	Input (Zo) ohms	Outputs			
		R(ohms/km)	L(mH/km)	G(microohms/km)	C(microfarads/km)
1					
2					
3					
4					
5					

Variable f;
Constant Zo=3000 Ω;

S. No	Input(f) MHz	Outputs			
		R(ohms/km)	L(mH/km)	G(microohms/km)	C(microfarads/km)
1					
2					
3					
4					
5					

RESULT:

The primary constants of a transmission line are estimated using SCILAB and the impact of frequency and characteristic impedance on the output is studied.

Examining the impact of open and short circuited loads on
a)Characteristic Impedance
b) Propagation Constant

Experiment Number:3

AIM: To examine the impact of open and short circuited loads on Characteristic Impedance and Propagation Constant

SOFTWAREREQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
Zoc=2000*exp(%i*(-%pi/(180/80)));Zsc=20*exp(%i*(%pi/(180/20)));l=0.5;w=10000;
//value of length of cable as taken in solution
Zo=sqrt(Zoc*Zsc);
C=real(Zo);
  D=imag(Zo);
  printf("-Zo = %f /_ %f ohms\n",abs(Zo),atan(D,C)*180/%pi);
  A=atanh(sqrt(Zsc/Zoc));
  P=A/l;
  a=real(P);
  printf("-a = %f neper/km\n",fix(a*10000)/10000);
  b=imag(P);
  printf("-b = %f henry/km",round(b*10000)/10000);
```

OUTPUT:

Zoc=ConstantVariable-Zsc

Zsc	Zo	γ

Zsc = Constant

Variable - Zoc

Zoc	Zo	γ

RESULT:

The impact of open and short circuited loads on Characteristic Impedance and Propagation Constant is investigated over various values of Zsc and Zoc.

Evaluation of current and voltage of short circuited Lossless transmission line at the receiving end

Experiment Number:4

AIM: To evaluate the value of current and voltage of short circuited Lossless transmission line at the receiving end

SOFTWAREREQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
Zo=600;a=0.1;b=0.05;x=10;Is=20*(10^-3);
Vr=0;
printf("-Receiving end voltage Vr=0 because the receiving end has been short ciruited\n");
P=a+(%i*b);
Ir=Is/(cosh(10*P));
A=real(Ir);
B=imag(Ir);
printf("-Received current is Ir = %f /_ %f mA
",round(abs(Ir)*(10^3)*100)/100,fix(atan(B,A)*180*10/%pi)/10);
```

OUTPUT:

α	Current $I_{R\ (mA)}$

β	Current $I_{R\ (mA)}$

RESULT: The value of current and voltage of short circuited Lossless transmission line at the receiving end are determined using SCILAB for various values of short circuited load impedance.

Analysis of SWR (Standing Wave Ratio) Transmission Lines by varying
a) load impedance
b)characteristic impedance

Experiment Number:5

AIM: To analyze the impact of load impedance and characteristic impedance on SWR

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clc;
clear;
close;
Zo=200;ZR=650-(%i*475);
K=(ZR-Zo)/(ZR+Zo);
ampK=sqrt((real(K)^2)+(imag(K)^2));
S=(1+ampK)/(1-ampK);
printf("(c)Standing wave ratio = %f",round(S*1000)/1000);
```

OUTPUT:

Z_o=50 ohms
Variable: Z_R

Z_R Ohms	SWR

Z_R=50/_40^o ohms
Variable: Z_o

Zo Ohms	SWR

RESULT:

The impact of load impedance and characteristic impedance on SWR is estimated using SCILAB by varying the of the load impedance and characteristic impedance

Exploration of the relationship between position of Voltage minima nearest to the load by varying magnitude of reflection coefficient K

Experiment Number:6

AIM: To explore the relationship between position of Voltage minima nearest to the load by varying magnitude of reflection coefficient K

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
Zo=50;f=300*(10^6);ZR=50+(%i*50);
lo=300/(f*(10^-6)); //where f is in megahertz ,lo=wavelength of wave in air
K=(ZR-Zo)/(ZR+Zo);
ampK=sqrt((real(K)^2)+(imag(K)^2));
S=(1+ampK)/(1-ampK);

printf("-VSWR = %f\n",round(S*100)/100);
phi=atan(imag(K)/real(K));
ymax=phi*lo/(2*2*%pi);
ymin=ymax+(lo/4);
printf("-Position of voltage minimum nearest load = %f metres",round(ymin*10000)/10000);
```

OUTPUT:

Z_o=50 ohms Variable: Z_R

Z_R Ohms	**SWR**

Z_R=50/_40º ohms
Variable: Z_o

Z_o Ohms	**SWR**

RESULT: The relationship between position of Voltage minima nearest to the load is studied by varying magnitude of reflection coefficient K using Scilab.

.

Designing a Quarter wave transformer by varying following parameters
a) frequency
b) input impedance
c) characteristic impedance

Experiment Number:7

AIM: To Design a Quarter wave transformer by varying following parameters
a) frequency
b) input impedance
c) characteristic impedance

SOFTWAREREQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
Zr=100;s=9;d=0.1;
Zs=50;
Ro=sqrt(Zs*Zr);f=100*(10^6);
r=d/2;
Zof=276*log10(s/r);
Zoq=sqrt(Zr*Zof);
L=300/(f*(10^-6));
printf("length of lambda/4 transformer = %f lambda\n",L);
printf("characteristic impedance of quarter wave line = %f ",fix(Ro*10000)/10000);
```

OUTPUT:

Z_R=50 ohms
Variable: Z_S

Z_S	Ro

Z_S=50 ohms
Variable: Z_R

Z_R	Ro

Frequency	Length of $\lambda/4$ transformer

RESULT: Quarter wave transformer by varying frequency, input impedance and characteristic impedance

Strategize impedance matching with characteristic impedance and load impedance through the measurement of
a) Location of the stub
b) Length of the stub

Experiment Number:8

AIM: To calculate the location and length of single stub for varying characteristic impedance and load impedance

SOFTWAREREQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clear;
clc;
ZR=100;Zo=600;f=100*(10^6);
lo=300/(f*(10^-6)); //lo=wavelength
Ls=(lo/(2*%pi))*(atan(sqrt(ZR/Zo)));
printf("-Point of attachment = %f cms\n",round(Ls*(10^2)*10)/10)
Lt=(lo/(2*%pi))*(%pi+(atan((sqrt(ZR*Zo))/(ZR-Zo))));
printf("-Length of the short circuited stub = %f cms",round(Lt*(10^2)));
```

OUTPUT:

Variables Z_R;
Constants Zo = 600; f=100*(10^6);

Input	Output	
ZR Ohms	**Point of attachment**	**Length of short-circuited stub**
100		
150		
200		
250		
350		

Variable Zo;
Constants ZR =100; f=100*(10^6);

Input	Output	
Zo Ohms	**Point of attachment**	**Length of short-circuited stub**
600		
900		
1200		
1500		
1800		

RESULT:

The location and length of single stub are calculated using SCILAB.

Analysis of Electromagnetic Waves across the two parallel plates estimating the following
a) Critical Wavelength
b) Guide
Wavelength
Experiment Number:9

AIM: To analyze the critical and guide wavelength of Electromagnetic waves between parallel plates

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
c=3*(10^8);
f=3000*(10^8);
lo=c/f;
l=lo*(10^4);
m=1;n=0;a=7.62;
lc=2*a;
printf("-Critical wavelength = %f cm\n",lc);
lg=sqrt((l*l*lc*lc)/((lc*lc)-(l*l)));
printf("-Guide wavelength = %f cm",round(lg*10)/10);
```

OUTPUT:

Spacing a(cm)	Critical wavelength	Guide wavelength

RESULT:

The critical wavelength and guide wavelength of Electromagnetic waves between two parallel plates are calculated using SCILAB

Determination of Dominant mode of Rectangular waveguides by examining the TE and TM modes

Experiment Number:10

AIM: To determine the dominant mode in a waveguide by examining the TE and TM modes

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clc;
clear;
close;
//TE10 Mode
a=8.636*10^-2;
b=4.318*10^-2;
f=4*10^9;
V=3*10^8;
m=input("enter the value of m= ");
n=input("enter the value of n= ");
fc=(V/(2*3.14))*sqrt((m*3.14/a)^2+(n*3.14/b)^2);
disp("Cut off frquency=",fc*10^-9);
```

OUTPUT:

Variable: a , Constant: Zs = 600; N=477; C=3*(10^8),b=5 cm;

TE Mode (m,n)	Cutoff frequency GHz
$TE_{1,0}$	
$TE_{1,1}$	
$TE_{1,2}$	
$TE_{2,1}$	
$TE_{2,2}$	

TM Mode (m,n)	Cutoff frequency GHz
$TM_{3,1}$	
$TM_{1,1}$	
$TM_{2,1}$	
$TM_{1,2}$	
$TM_{1,3}$	

RESULT:

The dominant mode in a waveguide is estimated using SCILAB.

Calculation of Group velocity, Phase velocity and phase constant of EM waves in rectangular waveguides

Experiment Number:11

AIM: To find the group velocity, phase velocity and phase constant of Electromagnetic waves in Rectangular Waveguides

SOFTWARE REQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clc;
clear;
close;
//TE10 Mode
a=8.636*10^-2;
b=4.318*10^-2;
f=4*10^9;
V=3*10^8;
m=input("enter the value of m= ");
n=input("enter the value of n= ");
fc=(V/(2*3.14))*sqrt((m*3.14/a)^2+(n*3.14/b)^2);
disp("Cut off frquency=",fc*10^-9);
//let phase velocity = A
A=V/sqrt(1-(fc/f)^2);
disp("Phase velocity in Mm/sec=",A*10^-6);
//let group velocity = B
B=V*V/A;
disp("Group velocity in Mm/sec =", B*10^-6);
```

OUTPUT:

variable a;
constant b=4; f=9*(10^9); c=3*(10^8); n=377;

Input a (cm)	Output	
	Phase velocity(m/sec)	Group Velocity(m/sec)

Variable f requency
Constants a=4; b=4; c=3*(10^8); n=377;

Frequency (Hz)	Output	
	Phase velocity(m/sec)	Group Velocity(m/sec)

RESULT:

The group velocity, phase velocity and phase constant of waves in a rectangular waveguide are estimated using SCILAB.

. **Examining the propagation characteristics of circular waveguide in terms of**
a)Cutoff wavelength
b) Guide wavelength
c) characteristic impedance

Experiment Number:12

AIM: To determine the propagation characteristics of circular waveguide in terms of Cutoff wavelength. Guide wavelength and characteristic impedance

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
c=3*(10^8);f=8*(10^9);r=2.5;h=1.84;n=377;
l=c/f;
lo=l*(10^2);
lc=2*%pi*r/h;
printf("-Cutoff wavelength = %f cm\n",round(lc*100)/100);
lp=lo/(sqrt(1-((lo/lc)^2)));
printf("-Guide wavelength = %f cm\n",round(lp*100)/100);
Zo=n/(sqrt(1-((lo/lc)^2)));
printf("-Characteristic wave impedance = %f ohm",fix(Zo*10)/10);
```

OUTPUT:

a (cm)	λg m	λc m	Zo Ohms

RESULT: The propagation characteristics of circular waveguide in terms of Cutoff wavelength Guide wavelength and characteristic impedance

Inference of Q Factor of Rectangular Cavity Resonator for TE101 mode with the following inputs
a) Dimension a in x axis
b) Dimension b in y axis
c) Dimension p in z axis

Experiment Number:13

AIM: To determine the Q Factor of Rectangular Cavity Resonator for TE101 mode by varying three dimensions

SOFTWAREREQUIRED:

SCILAB

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clear;
clc;
a=5*10^-2,b=4*10^-2,c=10*10^-2,C=5.8*10^7,Uo=4*%pi*10^-7;
f101=3.335*10^9;
d=sqrt(1/(%pi*f101*Uo*C));
Q=(a*a+c*c)*a*b*c/(d*(2*b*(a^3 + c^3)+a*c*(a*a+c*c)));
disp(Q,'Quality factor of TE101 = ');
```

OUTPUT:

Constant: b, d
Variable :a

a (cm)	Q factor

Constant: a, d
Variable :b

b (cm)	Q factor

Constant: a, b
Variable :d

d(cm)	Q factor

RESULT: The Q Factor of Rectangular Cavity Resonator for TE101 mode by varying three dimensions is determined using Scilab

Computation of Resonant Frequency of Rectangular Cavity Resonator for
a)Transverse Electric mode
b) Transverse Magnetic mode

Experiment Number:14

AIM: To find the Resonant Frequency of Rectangular Cavity Resonator for TE and TM mode

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

```
clc;
clear;
format('e',11);
a=0.05;
b=0.04;
c=0.03;
v=3*10^8;
p=1;
//for m=0,n=1.
m=0;
n=1;
fr011=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr011,"fr011(in Hz)=");
//for m=1,n=0.
```

```
m=1;
n=0;
fr101=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr101,"fr101(in Hz)=");
```

OUTPUT:

a (cm)	**fr (TE101) MHz**	**b (cm)**	**fr (TE011) MHz**

RESULT:

The Resonant Frequency of Rectangular Cavity Resonator for TE mode is determined using SCILAB

Estimation of Resonant Frequency in a Cylindrical Cavity Resonator for
a)Transverse Electric mode
b) Transverse Magnetic mode

Experiment Number:15

AIM: To determine the resonant frequency of a Cylindrical Cavity Resonator for TE and TM mode

SOFTWAREREQUIRED:

SCILAB Version 6.1.1

PROCEDURE:

- Open SCILAB software
- Open file-new
- Put the input values
- Type the program
- Execute the program
- End the program

PROGRAM:

TE Mode

```
clc;
clear;
a=0.0274;
v=3*10^8;
Xnm=3.832
;
d=2*a;
TE011=v/2*%pi*sqrt((Xnm/a)^2+(%pi/d)^2)*10^-9;
printf("TE011(in Hz)=%f GHZ",TE011);
```

TM Mode

```
clc;
clear;
a=0.0274;
v=3*10^8;
Xnm=2.405
;
d=2*a;
TM011=v/2*%pi*sqrt((Xnm/a)^2+(%pi/d)^2)*10^-9;
printf("TM011(in Hz)=%f GHZ",TM011);
```

OUTPUT:

a (cm)	fr (TE101) MHz	fr (TM011) MHz

RESULT: The resonant frequency of a Cylindrical Cavity Resonator for TE and TM mode are determined using Scilab