Ain Shams University
Faculty of Engineering
Electronics & Communication Engineering Dept.

3rd Year Communication
Microwaves II

Microwave.2 – Assignment.2

Microstrip & Striplines Analysis

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Striplines

1. TX Line Results:

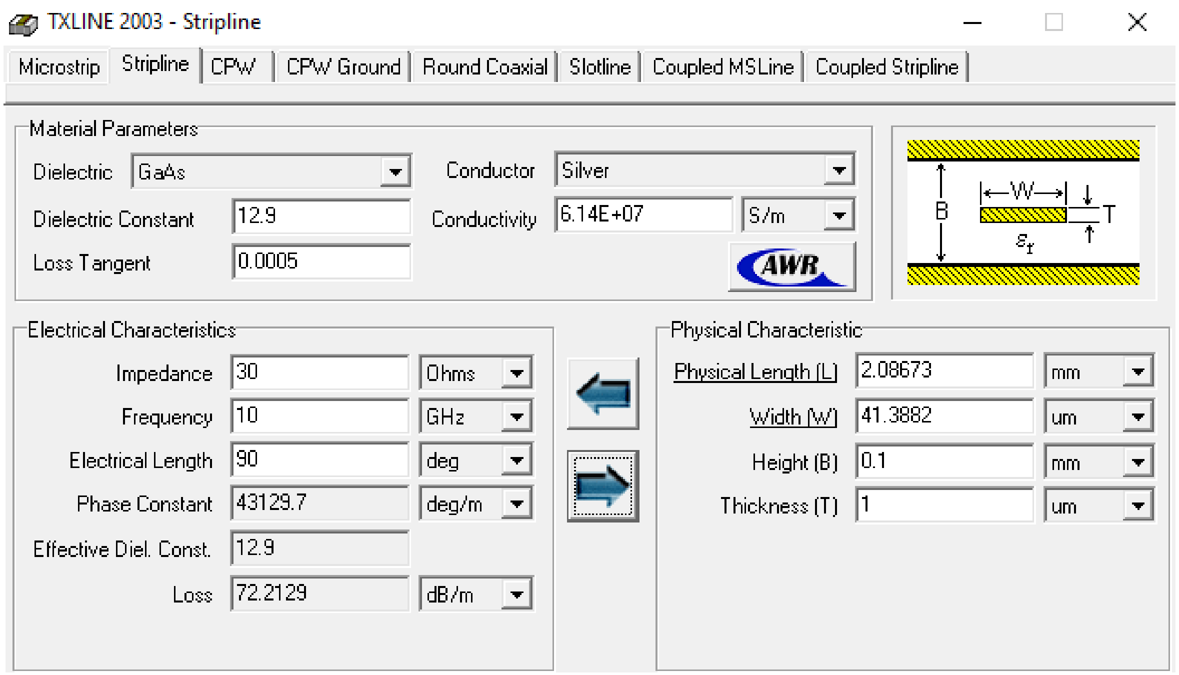

Fig.1 TX line window results of impedance assumption

We assume that we use GaAs dielectric material with permittivity $\varepsilon_r = 12.9$, and assume the characteristic impedance and operating frequency will be as following: $Z_o = 30\ ohms, f_o = 10\ GHz$.

And as shown from above figure that these assumptions give us the following dimensions: a=2.09673 mm, b=0.1 mm, W= 41.3882 um and T=1 um.

2. Theoretical Analysis (MATLAB):

Using theoretical equations of capacitance by summation and impedance in slides as following: $C = \frac{W}{\sum_n \frac{2a \sin\frac{n\pi W}{2a} \sinh\frac{n\pi b}{2a}}{\varepsilon (n\pi)^2 \cosh\frac{n\pi b}{2a}}}, Z_o = \sqrt{\frac{L}{C}}, V_p = \frac{1}{\sqrt{LC}} = \frac{c}{\sqrt{\varepsilon_r}}, k = \frac{\omega}{V_p}$.

- **Code:**

```
clear all
a= 2.08673*10^-3;
b= 0.1016*10^-3;
w= 42.084*10^-6;
```

```
T= 10^-6;
Er= 12.9;Eo= 8.85*10^-12; V= 3*10^8;
Vp = V/sqrt(Er);
Sum =0;
for n= 1:2:1000;
    y= floor(1+(n/2));
    Sum= Sum +
2*a*sin(n*pi*w/(2*a))*sinh(n*pi*b/(2*a))/(Er*Eo*(n*pi)^2*cosh(n*pi*b/(2*a)));
    Den(y)= Sum;
end
C = w./ Den;
Z = 1./(Vp.*C);
plot (Z)
title('(Stripline)')
xlabel('Iterations(n)')
ylabel('Zo(OHMs)')
```

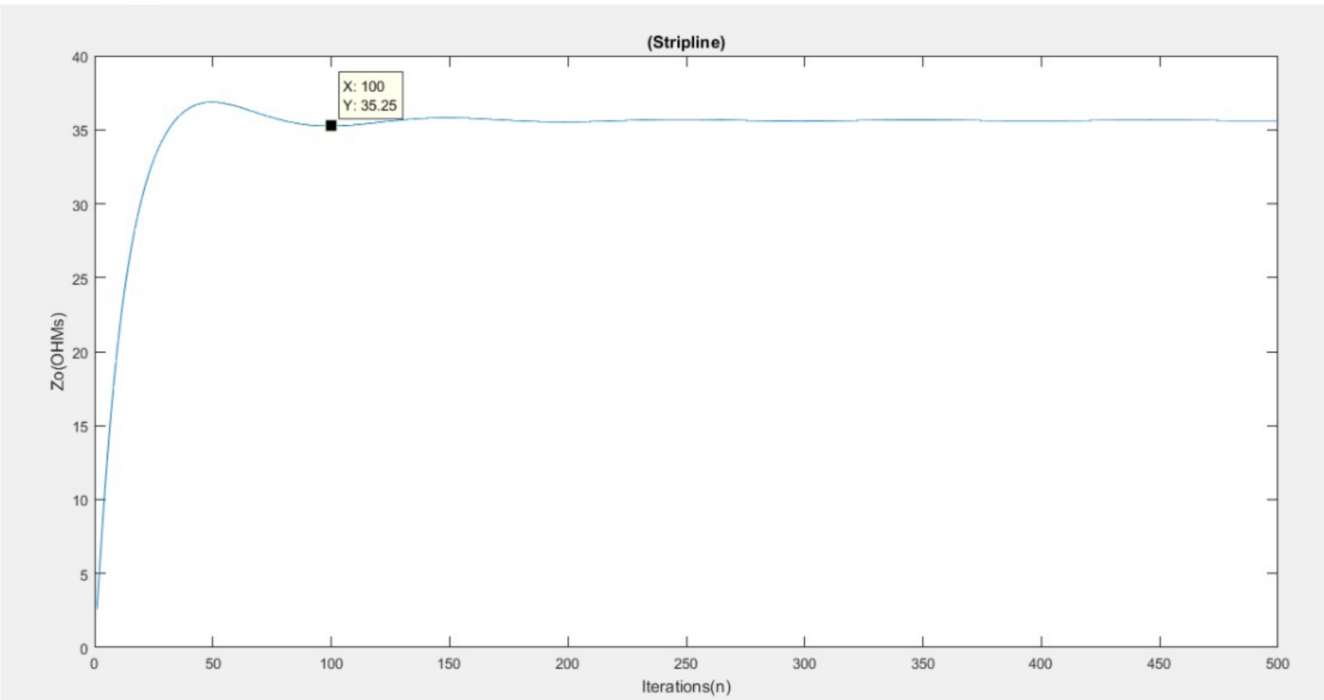

Fig.2 Zo versus n (no.of iterations)

As shown in above figure that impedance saturates after 100 iterations and at value equal 35.25 ohms, and capacitance value at this impedance will be 3.34*10^(-10), so we get following results: $V_p = \frac{1}{\sqrt{LC}} = \frac{c}{\sqrt{\varepsilon_r}} = \frac{3*10^8}{\sqrt{12.9}} = 83.53 * 10^6 \frac{m}{sec}, L = Z_o^2 * C = 35.25^2 * 3.34 * 10^{-10} = 420\ nH, k = \frac{2\pi f}{V_p} = \frac{2\pi*10*10^9}{83.53*10^6} = 752.2\ m^{-1}$.

3. Empirical Equations (MATLAB):

Using empirical formula given in slides and calculate it by MATLAB and we find that characteristic impedance will be: $Z_o = 50\ ohms$.

And code will be:

- **Code:**

```
 clear all
a= 2.08673*10^-3;
h= 0.1016*10^-3;
w= 42.084*10^-6;
t= 10^-6;
Z=376.8;
n=100;
Er= 12.9;Eo= 8.85*10^-12; c= 3*10^8;
Vp = c/sqrt(Er);
b=2*h+t;
x=(1/pi)*log(c/sqrt(((1/(2*(b-t))/(t+1))^2)+(((1/4*pi)/((w/t)+1.1))^n)));
W=w+x*t;
v=((8*(b-t))/(pi*W))+sqrt(((8*(b-t)/(pi*W))^2+6.27));
y=log(1+((4*(b-t))/(pi*W))*v);
d=Z/(2*pi*sqrt(Er));
zo=d*y;
zo
```

Microstrip

1. TX Line Results:

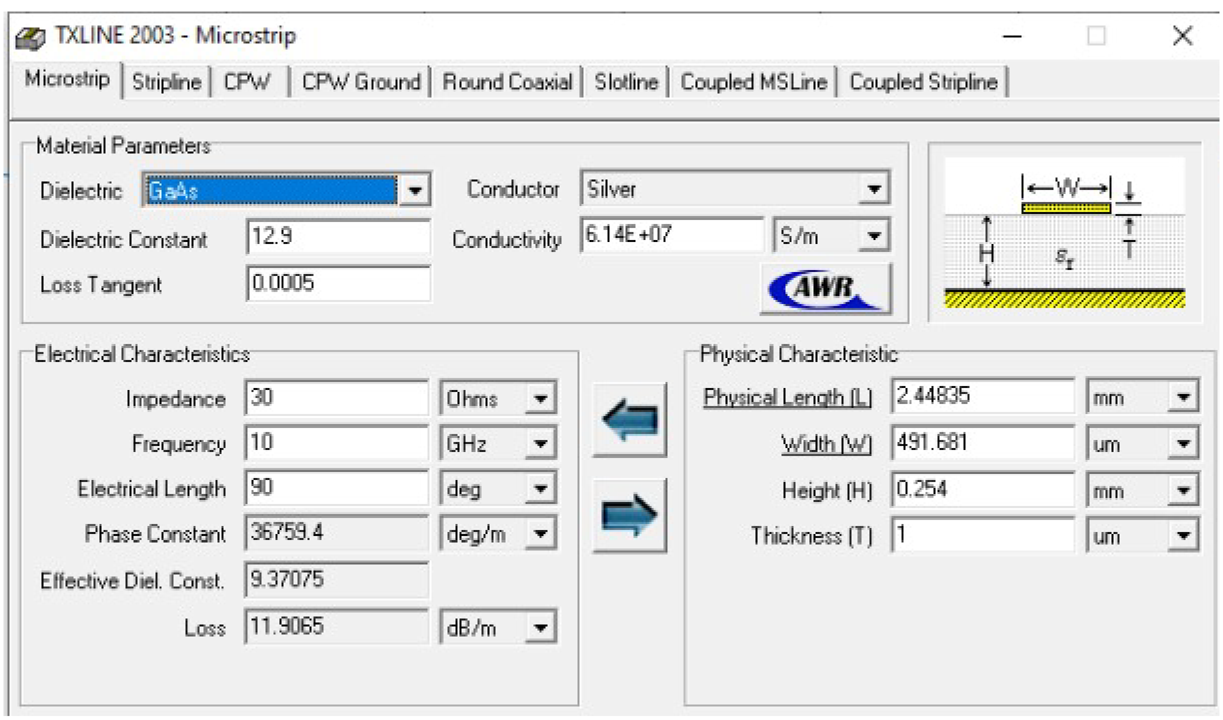

Fig.3 TX line window results of impedance assumption

We assume that we use GaAs dielectric material with permittivity $\varepsilon_r = 12.9$, and assume the characteristic impedance and operating frequency will be as following: $Z_o = 30\ ohms, f_o = 10\ GHz$.

And as shown from above figure that these assumptions give us the following dimensions: a=2.44835 mm, b=0.254 mm, W= 491.681 um, T=1 um and $\varepsilon_{eff} = 9.37075$.

2. Theoretical Analysis (MATLAB):

Using theoretical equations of capacitance by summation and impedance in slides as following: $C = \frac{W}{\sum_n \frac{4a\sin\frac{n\pi W}{2a}\sinh\frac{n\pi d}{a}}{(n\pi)^2\varepsilon_o(\sinh\frac{n\pi d}{a}+\varepsilon_r\cosh\frac{n\pi d}{a})}}$, $Z_o = \sqrt{\frac{L}{C}}, V_p = \frac{1}{\sqrt{LC}} = \frac{c}{\sqrt{\varepsilon_r}}$, $k = \frac{\omega}{V_p}$.

- **Code:**

```
 clear all
a= 2.44835*10^-3;
d= 0.254*10^-3;
w= 491.681*10^-6;
T= 10^-6;
Er= 12.9; Ere= 9.37075; Eo= 8.85*10^-12; V= 3*10^8;
Vp = V/sqrt(Ere);
Sum =0;
for n= 1:2:100;
    y= floor(1+(n/2));
    Sum= Sum +
4*a*sin(n*pi*w/(2*a))*sinh(n*pi*d/(a))/(Eo*(n*pi)^2*(sinh(n*pi*d/(a))+Er*cosh(n*pi*d/(a))
));
    Den(y)= Sum;
end
C = w./ Den;
Z = 1./(Vp.*C);
plot (Z)
title('(Microstrip)')
xlabel('Iterations(n)')
ylabel('Zo(OHMs)')
```

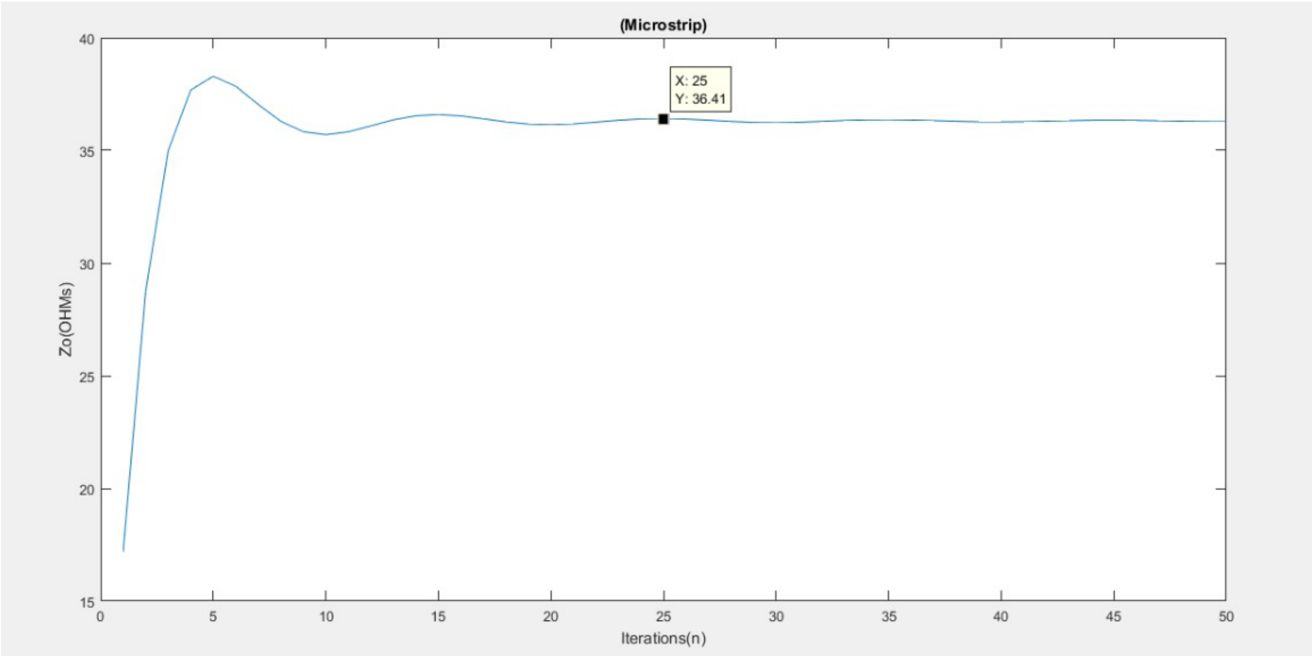

Fig.4 Zo versus n (no.of iterations)

As shown in above figure that impedance saturates after 100 iterations and at value equal 36.41 ohms, and capacitance value at this impedance will be 2.8*10^(-10), so we get following results: $V_p = \frac{1}{\sqrt{LC}} = \frac{c}{\sqrt{\varepsilon_{eff}}} = \frac{3*10^8}{\sqrt{9.37}} = 98 * 10^6 \frac{m}{sec}, L = Z_o^2 * C = 36.41^2 * 2.8 * 10^{-10} = 371.8\, nH, k = \frac{2\pi f}{V_p} = \frac{2\pi*10*10^9}{83.53*10^6} = 641.14\, m^{-1}$.

3. Empirical Equations (MATLAB):

Using empirical formula given in slides and calculate it by MATLAB and we find that characteristic impedance will be: $Z_o = 25\ ohms$.

And code will be:

- **Code:**

```
 clear all
a= 2.44835*10^-3;
h= 0.254*10^-3;
w= 491.681*10^-6;
T= 10^-6;
Er= 12.9; Ere= 9.37075; Eo= 8.85*10^-12; V= 3*10^8;
Vp = V/sqrt(Ere);
ere=((Er+1)/2)+((Er-1)/2)*(1+(12*h/w))^(-0.5);
we= w + (1+(1/ere))/2;
v=sqrt(((14+(8/ere))/2)^2 *(4*h/we)^2 + we*pi^2);
Zo= 377/(2*pi*sqrt(2*(ere+1)))*log(1+(4*h/we)*(((14+(8/ere))*4*h)/(11*we))+v);
```

Final Results

Striplines	Theoretical	Empirical	TX Line
Chara. Impedance Zo	35.25 ohms	50 ohms	30 ohms
Propagation Velocity V_p	83.53*10^6 m/sec	83.53*10^6 m/sec	83.53*10^6 m/sec
Propagation Const. K	752.2 m^{-1}	752.2 m^{-1}	752.2 m^{-1}
Capacitance per Length C	334 pf/m	239.4 pf/m	399 pf/m
Inductance per Length L	420 nH/m	598.6 nH/m	359.15 nH/m

Microstrip	Theoretical	Empirical	TX Line
Chara. Impedance Zo	36.41 ohms	25 ohms	30 ohms
Propagation Velocity V_p	98*10^6 m/sec	98*10^6 m/sec	98*10^6 m/sec
Propagation Const. K	641.14 m^{-1}	641.14 m^{-1}	641.14 m^{-1}
Capacitance per Length C	280 pf/m	408 pf/m	340 pf/m
Inductance per Length L	371.9 mH/m	255.2 nH/m	306 nH/m