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

3rd Communication Year
Microwaves II

Assignment.3
Network Theory
Sheet.2-Problem.9

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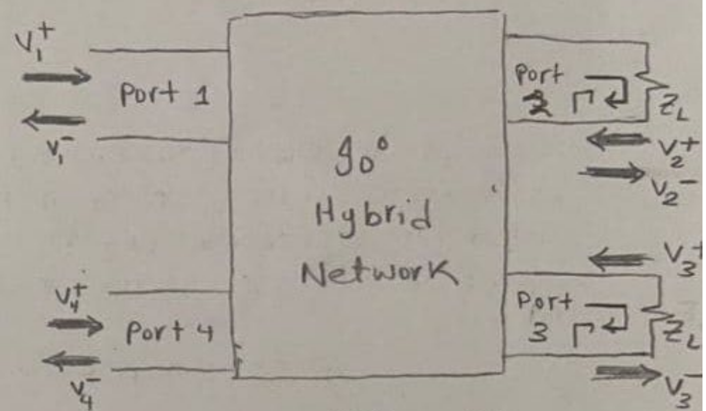
Section: 1

- **Analytical Solution:**

4-Port Network S-parameters

$$\begin{bmatrix} V_1^- \\ V_2^- \\ V_3^- \\ V_4^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix} \begin{bmatrix} V_1^+ \\ V_2^+ \\ V_3^+ \\ V_4^+ \end{bmatrix}$$



① To Get $T = \dfrac{V_4^-}{V_1^+}$?? we have $\Rightarrow \Gamma = \dfrac{V_2^+}{V_2^-} = \dfrac{V_3^+}{V_3^-}$ #

$$V_4^- = S_{41}V_1^+ + S_{42}V_2^+ + S_{43}V_3^+ + \cancel{S_{44}V_4^+} \quad (a)$$

(Port 4 matched load $V_4^+ = 0$

From [S] of Hybrid network $\Rightarrow$ $\left(\begin{aligned} V_2^- &= S_{21}V_1^+ = \frac{-j}{\sqrt{2}}V_1^+ \\ V_3^- &= S_{31}V_1^+ = \frac{-1}{\sqrt{2}}V_1^+ \end{aligned} \right)$

So we have the following :

$$\left(V_2^+ = \frac{-j}{\sqrt{2}}\Gamma V_1^+ \qquad V_3^+ = \frac{-1}{\sqrt{2}}\Gamma V_1^+ \right) \Rightarrow \text{Sub. in (a)}$$

$$\therefore V_4^- = -\frac{1}{\sqrt{2}}\cdot\frac{-j}{\sqrt{2}}\Gamma V_1^+ + \frac{-j}{\sqrt{2}}\cdot\frac{-1}{\sqrt{2}}\Gamma V_1^+ = j\Gamma V_1^+$$

$$\therefore \boxed{T = \frac{V_4^-}{V_1^+} = j\Gamma} \ \#$$

② To Show matching at port 1 ?? prove $(V_1^- = 0)$

$$V_1^- = \overset{0}{S_{11}}V_1^+ + S_{12}V_2^+ + S_{13}V_3^+ + \overset{0}{S_{14}}V_4^+$$

$$V_1^- = 0 + \frac{-j}{\sqrt{2}}\cdot\frac{-j}{\sqrt{2}}\Gamma V_1^+ + \frac{-1}{\sqrt{2}}\cdot\frac{-1}{\sqrt{2}}\Gamma V_1^+ + 0$$

$\boxed{V_1^- = 0}$ # matched for all Γ values

Fig.1 hand analysis analytical solution for hybrid network

• Simulation Circuit Schematic & Results:

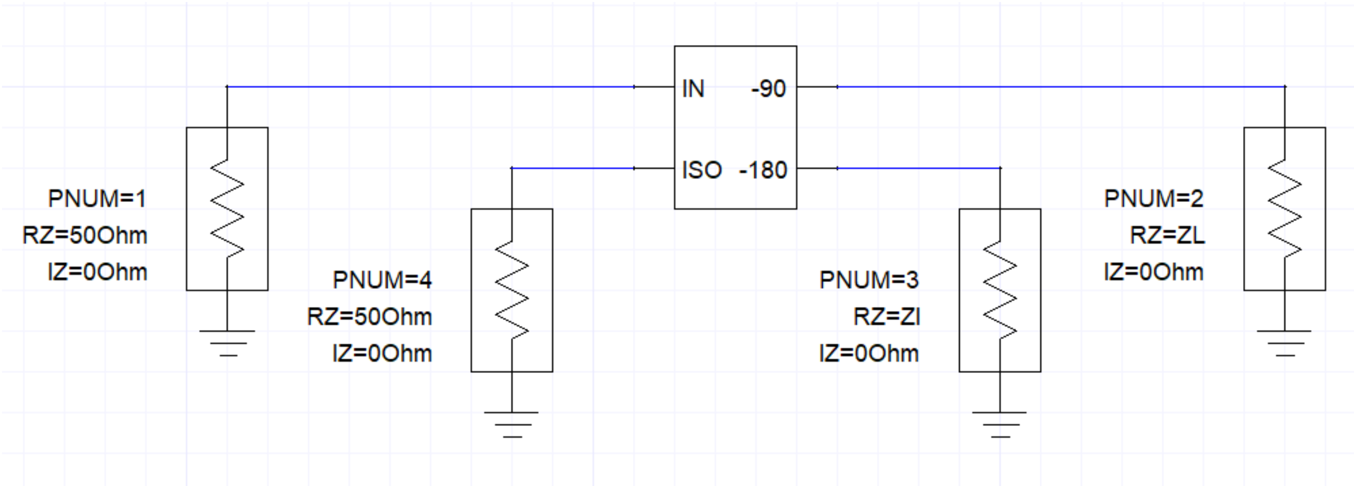


Fig.2 Circuit schematic from ANSOFT designer simulator

Now we will select the value for $Z_l/Z_o = 5$, so load impedance will be $Z_l = 250\ ohms$.

So $T = S_{41} = J\Gamma = \frac{Z_l - Z_o}{Z_l + Z_o} = J\frac{250-50}{250+50} = J0.667 = \frac{2}{3}\angle 90°$.

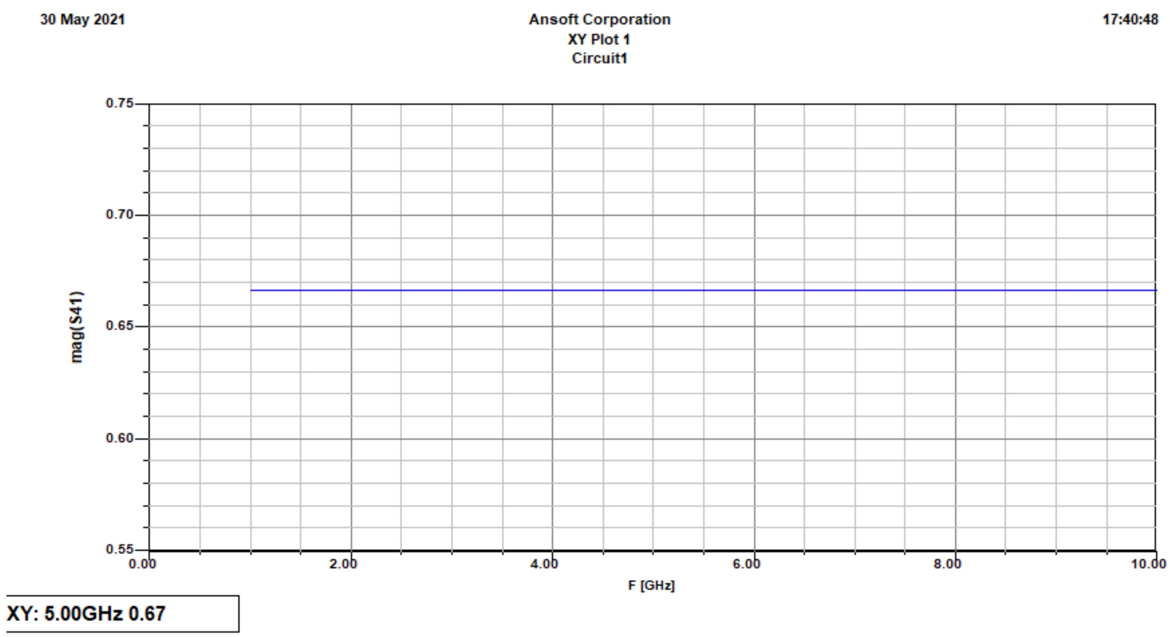


Fig.3 transmission coefficient. S41 from ANSOFT designer

Comment: so as it shown from the previous figure that $T = J\Gamma = |S_{41}| = 0.67$.

• Attenuation Coefficient Vs Normalized Impedance:

Hint: I cannot draw the variation of attenuation coefficient versus normalized impedance on ANSOFT designer simulator so I do it analytically on MATLAB.

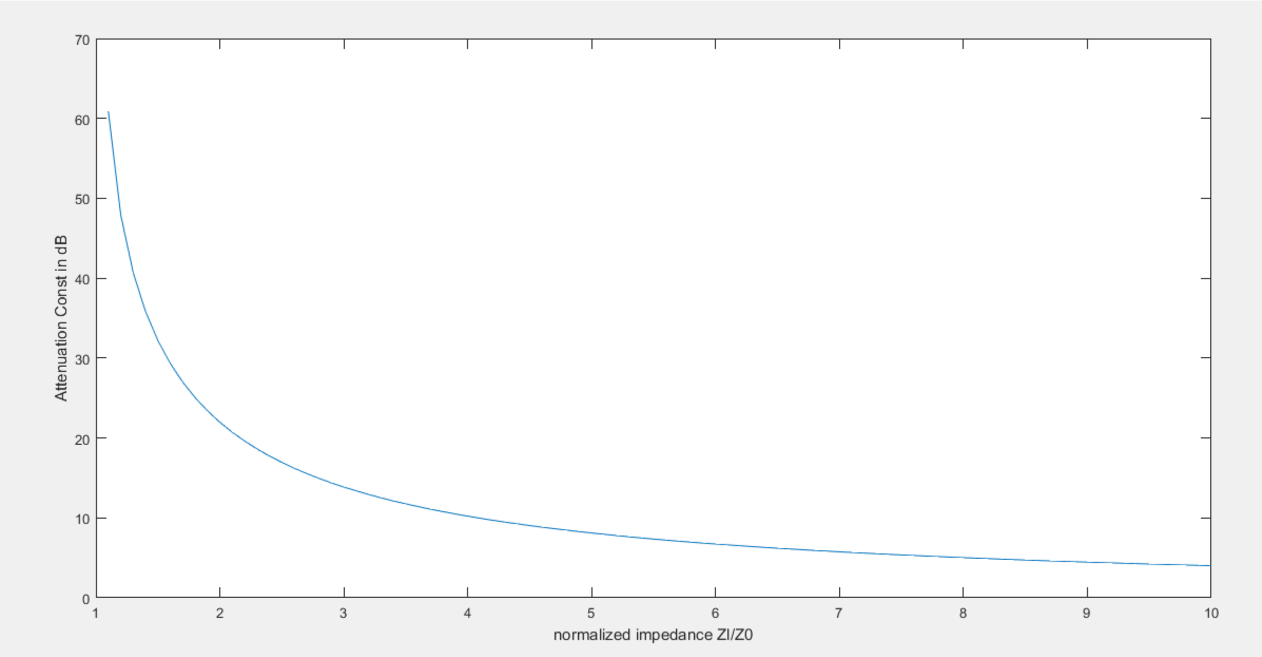


Fig.4 attenuation coefficient (S41) versus normalized impedance

MATLAB Code:

```
clear all:
close all;

x = 1:0.1:10;          % x = Zl / Zo
Gamma = (x-1)./(x+1);  % Gamma = S41
y = -20*log(Gamma);    % y = attenuation coff.

figure(1);
plot(x,y)
xlabel('normalized impedance Zl/Z0');
ylabel('Attenuation Const in dB');
```