Antenna Theory and Design

Homework 10

1B)

a) Given $L = 0.4781\lambda$

and $\frac{d}{\lambda} = 0.45$

we know that $\psi_x = \beta d_x \sin(\theta)\cos(\phi) + \alpha_x$

$$AF = \frac{\sin\left(\frac{N\psi_x}{2}\right)}{\sin\left(\frac{\psi_x}{2}\right)}$$

$$I_3 = I_1 e^{j36^\circ}$$

and $I_2 = I_1 e^{-j144^\circ}$

$\Rightarrow Z_{11} = Z_{22} = Z_{33} = 48 + j25.4\,\Omega$

$\Rightarrow Z_{12} = Z_{21} = Z_{23} = Z_{32}$ which is equal to $4 - j45\,\Omega$

$\Rightarrow Z_{13} = Z_{31} = -22 + j8\,\Omega$

$\Rightarrow$ Value of V_1 is given by following equation

$$V_1 = Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3 \quad -(1)$$

$$Z_1 = \frac{V_1}{I_1}$$

$$= \frac{Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3}{I_1} \quad (\text{from eq } ⑥)$$

$$= Z_{11} + Z_{12}\frac{I_2}{I_1} + Z_{13}\frac{I_3}{I_1}$$

$$= Z_{11} + Z_{12}\, e^{-j140} + Z_{13} e^{j36}$$

$$= (48 + j^{\circ}25.4) + (4 - j^{\circ}45)\, e^{-j140} + (22 + j^{\circ}8)\, e^{j36}$$

$$Z_1 = 43.25 + j^{\circ}39.97\,\Omega$$

Similarly $V_2 = Z_{21}I_1 + Z_{22}I_2 + Z_{23}I_3$

$$Z_2 = \frac{V_2}{I_2}$$

$$= \frac{Z_{21}I_1}{I_2} + \frac{Z_{22}I_2}{I_2} + \frac{Z_{23}I_3}{I_2}$$

$$Z_2 = 54.25 + j^{\circ}31.2\,\Omega$$

Similarly $V_3 = Z_{31}I_1 + Z_{32}I_2 + Z_{33}I_3$

$$Z_3 = \frac{V_3}{I_3}$$

$$= \frac{Z_{31}I_1 + Z_{32}I_2 + Z_{33}I_3}{I_3}$$

$$Z_3 = 56.2 + j^{\circ}24.2\,\Omega$$

b) Since all antennas are fed in phase, I_1, I_2 and I_3 are given as

$$I_1 = I_2 = I_3$$

and

$$Z_{11} = Z_{22} = Z_{33} = 48 + j25.4\ \Omega$$

$$Z_{12} = Z_{21} = Z_{23} = Z_{32} = 4 - j3\ \Omega$$

and

$$Z_{13} = Z_{31} \text{ which is } 2 + j\ \Omega$$

So $V_1 = Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3$

$$Z_1 = \frac{V_1}{I_1}$$

$$= \frac{Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3}{I_1}$$

$$Z_1 = 48 + j35\ \Omega$$

So $V_2 = Z_{21}I_1 + Z_{22}I_2 + Z_{23}I_2$

$$Z_2 = \frac{V_2}{I_2}$$

$$= \frac{Z_{21}I_1 + Z_{22}I_2 + Z_{23}I_2}{I_2}$$

$$Z_2 = 44 + j9.2\ \Omega$$

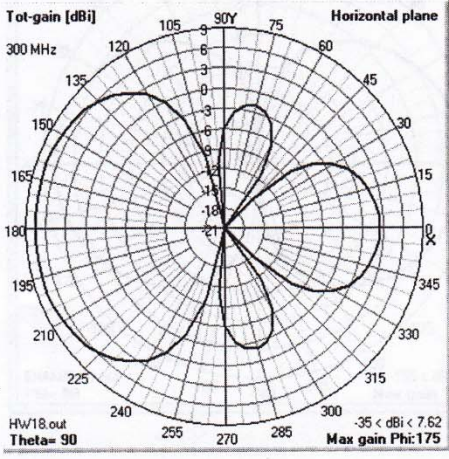
$$V_3 = Z_{11} I_1 + Z_{12} I_2 + Z_{13} I_3$$

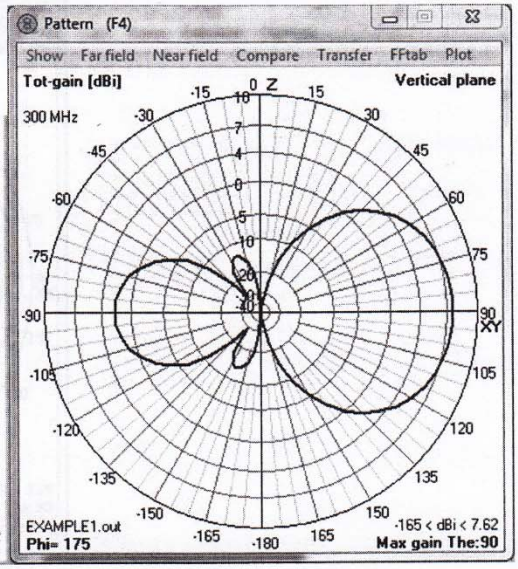
$$Z_3 = \frac{V_3}{I_3}$$

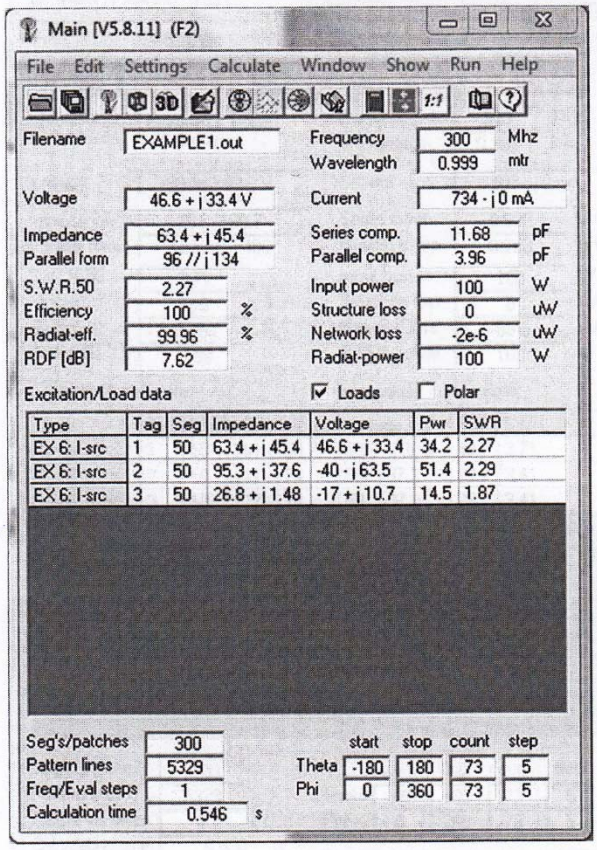
$$= \frac{Z_{11} I_1 + Z_{12} I_2 + Z_{13} I_3}{I_3}$$

$$Z_3 = 4 - j35\ \Omega$$

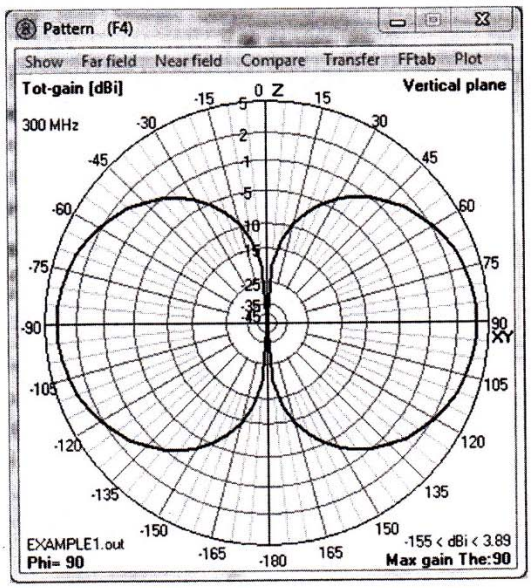
$$1.7 \angle 36^\circ$$

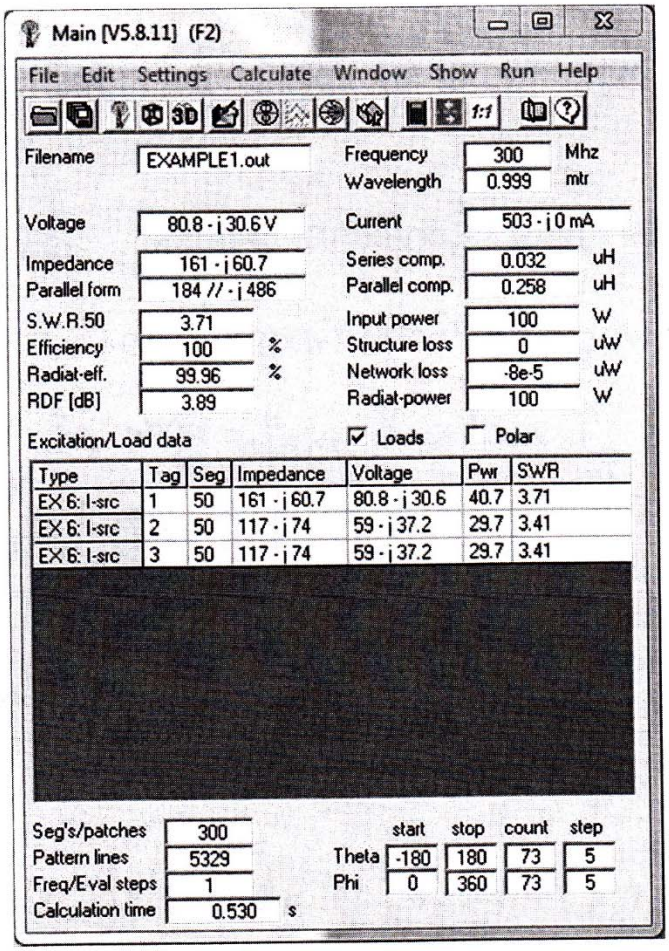

Tot-gain [dBi]
300 MHz
Horizontal plane
90Y
0X
HW18.out
Theta= 90
-35 < dBi < 7.62
Max gain Phi:175


Pattern (F4)
Show Far field Near field Compare Transfer FFtab Plot
Tot-gain [dBi]
Vertical plane
300 MHz
0 Z
90 XY
EXAMPLE1.out
Phi= 175
-165 < dBi < 7.62
Max gain The:90


Main [V5.8.11] (F2)
File Edit Settings Calculate Window Show Run Help
Filename EXAMPLE1.out
Frequency 300 Mhz
Wavelength 0.999 mtr
Voltage 46.6 + j 33.4 V
Current 734 - j 0 mA
Impedance 63.4 + j 45.4
Parallel form 96 // j 134
Series comp. 11.68 pF
Parallel comp. 3.96 pF
S.W.R.50 2.27
Efficiency 100 %
Radiat-eff. 99.96 %
RDF [dB] 7.62
Input power 100 W
Structure loss 0 uW
Network loss -2e-6 uW
Radiat-power 100 W
Excitation/Load data
Loads
Polar
Type Tag Seg Impedance Voltage Pwr SWR
EX 6: I-src 1 50 63.4 + j 45.4 46.6 + j 33.4 34.2 2.27
EX 6: I-src 2 50 95.3 + j 37.6 -40 - j 63.5 51.4 2.29
EX 6: I-src 3 50 26.8 + j 1.48 -17 + j 10.7 14.5 1.87
Seg's/patches 300
Pattern lines 5329
Freq/Eval steps 1
Calculation time 0.546 s
start stop count step
Theta -180 180 73 5
Phi 0 360 73 5

19) a)


Pattern (F4)
Show Far field Near field Compare Transfer FFtab Plot
Tot-gain [dBi]
Vertical plane
300 MHz
0 Z
15
30
45
60
75
90
XY
105
120
135
150
165
-180
-165
-150
-135
-120
-105
-90
-75
-60
-45
-30
-15
5
2
1
-5
-10
-15
-25
-35
-45
EXAMPLE1.out
Phi= 90
-155 < dBi < 3.89
Max gain The:90


Main [V5.8.11] (F2)
File Edit Settings Calculate Window Show Run Help
Filename EXAMPLE1.out
Frequency 300 Mhz
Wavelength 0.999 mtr
Voltage 80.8 - j 30.6 V
Current 503 - j 0 mA
Impedance 161 - j 60.7
Parallel form 184 // - j 486
Series comp. 0.032 uH
Parallel comp. 0.258 uH
S.W.R.50 3.71
Efficiency 100 %
Radiat-eff. 99.96 %
RDF [dB] 3.89
Input power 100 W
Structure loss 0 uW
Network loss -8e-5 uW
Radiat-power 100 W
Excitation/Load data
Loads
Polar
Type Tag Seg Impedance Voltage Pwr SWR
EX 6: I-src 1 50 161 - j 60.7 80.8 - j 30.6 40.7 3.71
EX 6: I-src 2 50 117 - j 74 59 - j 37.2 29.7 3.41
EX 6: I-src 3 50 117 - j 74 59 - j 37.2 29.7 3.41
Seg's/patches 300
Pattern lines 5329
Freq/Eval steps 1
Calculation time 0.530 s
start stop count step
Theta -180 180 73 5
Phi 0 360 73 5

19) b)