$$\text{wave length } \lambda = \frac{c \rightarrow 3\times10^8 \text{ m/sec speed of light}}{F \rightarrow \text{Frequency}}$$

5. Horn Antenna
6. Vivaldi Antenna
7. Telescopes.

Other Antennas:-

1. NFC Antenna
2. Fractal Antenna
3. Wearable Antenna.

4nec2
Numeric Electromagnetic Codes

19/1/2023

C EMA Ex. 1

1. Configure a linear wire antenna so as to operate at $f = 400\,MHz$,

$$\lambda = \frac{c}{f} = \cancel{\frac{3\times10^{8}}{4\times10^{8}}} \quad \frac{3\times10^8}{400\times10^6} = \frac{3}{4}$$

$$= \cancel{\frac{3}{4}} \quad \cancel{\frac{3\times10^2}{4}} \quad \lambda = 0.75\,m$$

1) Symbols

odd value greater than 9

lambda $= \lambda = 0.75$ m

Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius
Wire	1	27	0	0	$-\lambda/2$	0	0	$+\lambda/2$	0.0001m

2) Geometry

~~Vtg-src~~ 1

11

3) Source/load

Type	Tag	seg	(opt)	Real	Imag	Magn	Phase
voltag-src	1	14	00	1	0	1	0

~~22~~ Middle of previous seg.

4) Freq/Ground

Frequency → 400MHz From question

Environment → Free-space

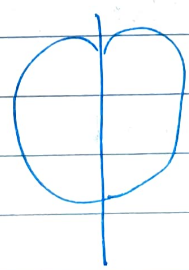
Run button Green color. upper right side.

Select. Far field
Resolution 5

Click generate.

Omni directional pattern.
E Non-directional pattern in given plane
& directional pattern in its orthogonal plane

Dipole Antenna



Mono pole →

Variable Name

1. It can be only one word.
2. It can use only letters, numbers and the underscore (_) character.
3. It can't begin with a number.

input() function → Store value in form of string.

len() function

In python, ~~one data~~ type can change one data type to another data type.

EMA Practical - 2 27/01/2023

Title:- Performance comparison of half wave dipole verses, quarterwave mono~~wave~~pole antenna.

$c = 3 \times 10^8$ m/s

$f = 500 MHz = 500 \times 10^6$

$\lambda = \frac{c}{f} = \frac{3}{5} = 0.6$

$\lambda = 0.6$ m

l = lambda/2

Geometry

Type	Tag	Segs	X_1	Y_1	Z_1	X_2	Y_2	Z_2	Radius
Wire	1	21	0	0	$-l/2$	0	0	$l/2$	0.0001

Source / load

Type	Tag	Seg	opt	Real	Imag	Magn	Phase
Vtg source	1	11	00	1	0	1	0

Environment - Free-space.

For halfwave dipole at f=500MHz.

1. Gain = 2.17 dB
2. HPBW = Half pwr beamwidth = 80 dg
3. Impedance = 80.5 + j46.4 Ω

For quarterwave monopole
l = lambda/4

Geometry.

	Z1		Z2	
— 11 —	0	— 11 —	l	— 11 —

Source / load

	Seg	
— 11 —	1	— 11 —

Freqn / Gnd

Environment - perfect ground

For quarterpole dipole at f= 500 MHz

1. Gain = 5.18 dB
2. HPBW = 40 dg
3. Impedance = 40.3 + j23.6 Ω

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Expt. 3

Study of effect of variation of length of linear wire antenna on radiation pattern and associated parameters.

Symbols

lambda = 1

L = lambda/4

$$\lambda = \frac{c}{f}$$

$$f = \frac{c}{\lambda} = \frac{3\times10^8}{1} = 300MHz$$

$\lambda = 1m$

Geometry

Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius.
wire	1	27	0	0	$-L/2$	0	0	$L/2$	0.0001

Serial no. of wire

Source / Load

Type	Tag	Segs	(opt)	Real	Imag	Magn	Phase ~~(...)~~
vtg-src	1	14	00	1	0	1	0

Freq/ Ground

Frequency = 300MHz

Environment = Freespace

Far-field ~~region~~. pattern

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$$

Observation Table:-

Sr. No	Length of Linear wire antenna	HPBW Theoretical	HPBW Practical	Gain (in dB)
1.	$\lambda/4$	87 dg	90 dg	1.85 dB
2.	$\lambda/2$	78 dg	80 dg	2.17 dB
3.	$3\lambda/4$	64 dg	60 dg	2.8 dB
4.	λ	47.8 dg	50 dg	3.91 dB
5.	1.25λ	---	30 dg	5.09 dB

$\downarrow$ HPBW = Directivity $\uparrow$

~~Gain~~ =

$G = e \cdot d$

Efficiency of antenna × Directivity of antenna

Restrict length of λ upto 1λ.
$\because$ there will not be any side lobes.

Q.6) Why log periodic antenna is so called?

In ~~as~~ case of log periodic antenna, the electric properties of the antenna are varying periodically with respect to logarithm of freqn ($\log f$). Hence it is so called.

Q.7) The normalised field pattern of a certain antenna is given by $E(\theta) = \sin\theta$ for $0 \leq \theta \leq \pi$, where θ is in radians. Compute 3dB beamwidth for this antenna.

EMA

EXPT 4

Date 10 / 2 / 2023

Title:- Principle of pattern multiplication.

Aim:- To understand & verify principle of pattern multiplication for a given antenna array configuration.

Software used:-

~~use~~ Scilab.

Theory:-

Statement of principle of patter multiplication

Case 1 : An array of 4 isotropic point sources fed with equal amplitude & equal phase seperated by $d = \lambda/2$.

Step 1 to 5.

Case 2:- An —— " —— equal amplitude & opposite phase seperated by $d = \lambda/2$

step 1 to 5.

o/p :- Program print. Case 1 & Case 2

o/p print (Plot). both.

Conclusion:- Take batch 3.

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for case 1:-

```
// Principle of Pattern Multiplication.
clear;
clc ;
lambda = 1;
d= lambda / 2;
beta = (2 * %pi)/ lambda ;
delta = 0; // defining delta as a phase of
              difference between dipoles.
phi = 0: 0.01 : 2* %pi ; // Variation of the
              theta from 0 to 360 degrees.
subplot (2, 2, 1);
EP= cos (%pi /2 * (cos (phi) ));
polarplot (phi ,abs( EP)); // plot of single
              element pattern.
title ('~~Element~~ ELEMENT PATTERN');
AF = cos(%pi * (cos( phi) + delta)) // Expression
              for an Array Factor
subplot (2, 2, 2);
polarplot ( phi , abs (AF)); // plot of Array
              pattern.
title ('ARRAY FACTOR PATTERN);
subplot ( 2, 2, 3.5) ;
polarplot ( phi, abs ( EP) .* abs (AF));
   // Plot of Total Field Pattern of Array.
title ('TOTAL ARRAY PATTERN');
```

for case 2
just change

```
EP=sin (%pi /2 * ( cos(phi)));
```

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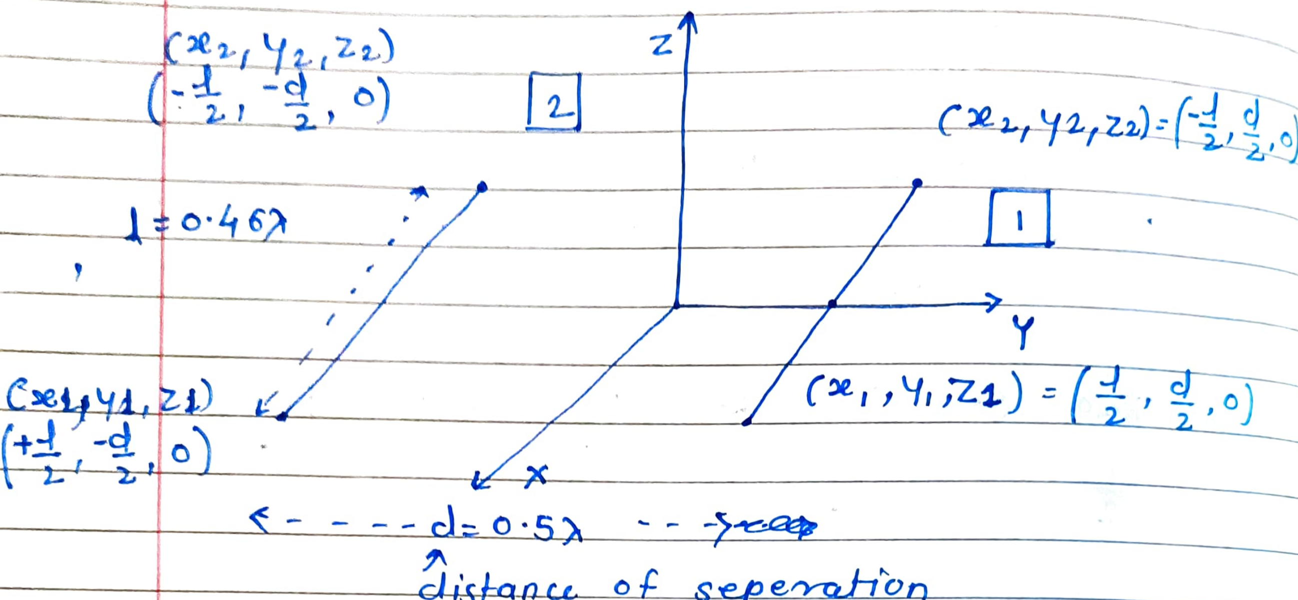
EMA EXPT 5

Title:- Performance comparison of broadside array and endfire array.

Two element antenna array.



Broad Real		Real End fire		Imag	
1	1	1	-1	0	0

*End fire *

Symbols:- Jambda = 1

L = ~~0.5~~ 0.46 x Jambda

d = 0.5 x Jambda

Geometry:

Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius
Wire	1	27	L/2	d/2	0	-L/2	d/2	0	0.001
Wire	2	27	L/2	-d/2	0	-L/2	-d/2	0	0.001

Source / Load

Type	Tag	Seg.	(opt)	Real	Imag	Magn	Phase
vtg.-src	1	14	00	1	0	1	0
vtg-src	2	14	00	-1	0	1	0

Time varying excitation

Freq / Ground

$f = 300$ MHz

Environment

Free space.

---

* For Broadside *

Remain all settings are same only change in Source / Load :-

Type	Tag	Seg	(opt)	Real	Imag	Magn	Phase
Vtg-Src	1	14	00	1	0	1	0
Vtg-Src	2	14	00	1	0	1	0

10/3/2023

Expt 7

Study of circular loop antenna.

Types of Loop antenna.

Electrically small

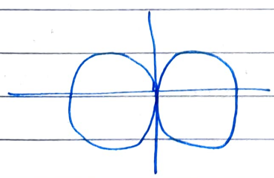
$D < \frac{\lambda}{10}$

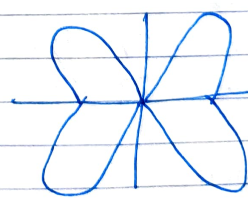
$C_\lambda = \frac{C}{\lambda} = \frac{\pi D}{\lambda} < 0.314$

Electrically large.

$D \geq \lambda$

$C_\lambda = \frac{C}{\lambda} = \frac{\pi D}{\lambda} \geq 3.14$





For single turn small loop antenna.

$$R_r = 20\pi^2\left(\frac{C}{\lambda}\right)^4$$

where $C = 2\pi a$ is circumference of Loop antenna

For N turns

$$R_r = 20\pi^2 N^2\left(\frac{C}{\lambda}\right)^4$$

for large loop ($C \geq 314\lambda$) Anteenna

$$R_r = 60\pi^2\left(\frac{C}{\lambda}\right)$$

Symbols:-

lambda = 1 f = 300 MHz.

D = lambda/10

Geometry

Type	Tag	Segs	Arc-rad	Angl-1	Angl-2	Wire-rad
Arc	1	50	D/2	0	360	0.0001

Source/load

Type	Tag	Seg	(opt)	Real	Imag	Magn	Phase
Vtg.src	1	1	00	1	0	1	0

Freq/Gnd

F = 300 MHz

Free-space.

Far-field pattern.

Observation Table

Sr.No.	Loop Diameter (D)	Max. Gain (in dBi).
1.	$\lambda/10$	1.55
2.	$\lambda/8$	1.47
3.	$\lambda/4$	2.53
4.	$\lambda/2$	3.85
5.	λ	4.14

Caparison of different circular loop antenna.

Case i) - LoD (D) = $\lambda/10$

Structure (Hide pattern) 3D pattern (Multicolor)

fig. Loop antenna structure and 3d radiation pattern.

Vertical plane Horizontal plane.

fig. 2D vertical & hori field patterns of loop antenna.

Very Very Important

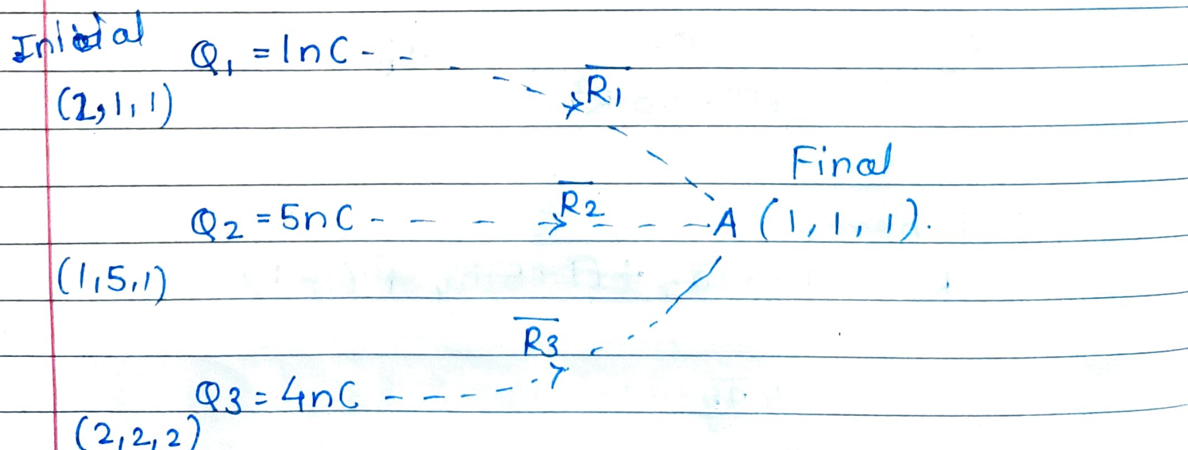
Cartesian	Cylindrical	Spherical.
Differential in length	— " —	— " —
$dL = dx\,a_x + dy\,a_y + dz\,a_z$	$dL = d\rho\,a_\rho + \rho\,d\phi\,a_\phi + dz\,a_z$	$dL = dr\,a_r + r\,d\theta\,a_\theta + r\sin\theta\,d\phi\,a_\phi$
Differential surface.	— " —	— " —
$dS_x = dy\,dz\,a_x$ $dS_y = dx\,dz\,a_y$ $dS_z = dx\,dy\,a_z$	$dS_\rho = \rho\,d\phi\,dz\,a_\rho$ $dS_\phi = d\rho\cdot dz\,a_\phi$ $dS_z = \rho\,d\phi\,d\rho\,a_z$	$dS_r = r^2\sin\theta\,d\theta\,d\phi\,a_r$ $dS_\theta = r\sin\theta\,dr\,d\phi\,a_\theta$ $dS_\phi = r\,dr\,d\theta\,a_\phi$
Differential Volume	— " —	— " —
$dV = dx\,dy\,dz$	$dv = \rho\,d\rho\,d\phi\,dz$	$dV = r^2\sin\theta\,dr\,d\theta\,d\phi$

17/3/2023

Expt. 8

Study of Principle of superposition for calculation of Electric Field Intensity due to 'N' poinch charges

EQ.1) Calculate the electric field intensity at point A(1,1,1) due to three point charges each of magnitude 1nC, 5nC, 4nC located at (2,1,1); (1,5,1) and (2,2,2) respectively.



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$$\bar{E}_1 = \frac{Q_1}{4\pi \cdot \varepsilon_0 R_1^2} \cdot \bar{a}_{R_1}$$

But here.

$$\bar{R}_1 = (1-2)\bar{a}_x + (1-1)\bar{a}_y + (1-1)\bar{a}_z$$

$$|\bar{R}_1| = \sqrt{(-1)^2} = 1$$

$$\bar{a}_{R_1} = \frac{\bar{R}_1}{|\bar{R}_1|} = \frac{-\bar{a}_x}{1} = -\bar{a}_x$$

~~Now, $\bar{E}_1 = 8.98(-\bar{a}_x)$ V/m~~

$$\bar{E}_1 = \frac{1 \times 10^{-9}}{4\pi \times (8.854 \times 10^{-12}) \times 1} \bar{a}_x$$

$$\boxed{\bar{E}_1 = 8.98(-\bar{a}_x) \text{ V/m}}$$

$$* \boxed{\bar{E}_1 = -8.98\, \bar{a}_x \text{ V/m}}$$

$$\bar{E}_2 = \frac{Q_2}{4\pi \cdot \varepsilon_0 R_2^2} \cdot \bar{a}_{R_2}$$

But here,

$$\bar{R}_2 = (1-1)\bar{a}_x + (1-5)\bar{a}_y + (1-1)\bar{a}_z$$

$$= -4\bar{a}_y$$

$$|\bar{R}_2| = \sqrt{(-4)^2} = 4$$

$\cancel{\bar{a}_{R_2} = 4}$ $\bar{a}_{R_2} = \frac{\bar{R}_2}{|\bar{R}_2|} = \frac{-4\bar{a}_y}{4} = \cancel{-\frac{1}{4}\bar{a}_y}$ $-\bar{a}_y$

$$\bar{E}_2 = \frac{5\times10^{-9}}{4\pi\times(8.854\times10^{-12})\times(4)^2}(-\bar{a}_y)$$

$$\boxed{\bar{E}_2 = -2.808\bar{a}_y \ V/m}$$

$$\bar{E}_3 = \frac{Q_3}{4\pi\varepsilon_0 R^2}\bar{a}_{R_3}$$

But here,

$$\bar{R}_3 = (1-2)\bar{a}_x + (1-2)\bar{a}_y + (1-2)\bar{a}_z$$

$$= -\bar{a}_x - \bar{a}_y - \bar{a}_z$$

$$|\bar{R}_3| = \sqrt{(-1)^2+(-1)^2+(-1)^2} = \sqrt{3}$$

$$\bar{a}_{R_3} = \frac{\bar{R}_3}{|\bar{R}_3|} = \frac{-\bar{a}_x - \bar{a}_y - \bar{a}_z}{\sqrt{3}} =$$

$$\bar{E}_3 = \frac{4\times10^{-9}}{4\pi\times(8.854\times10^{-12})\cdot(\sqrt{3})^2} \cdot \frac{-\bar{a}_x-\bar{a}_y-\bar{a}_z}{\sqrt{3}}$$

$$= 11.983 \cdot \frac{-\bar{a}_x-\bar{a}_y-\bar{a}_z}{\sqrt{3}}$$

$$\boxed{\cancel{\bar{E}_3 = -6\cdot(\bar{a}_x+\bar{a}_y+\bar{a}_z) \ V/m}}$$

$$\boxed{\bar{E}_3 = -6.9187(\bar{a}_x+\bar{a}_y+\bar{a}_z) \ V/m}$$

$$\cancel{= -6.9187\bar{a}_x - 6.9187\bar{a}_y - 6.9187\bar{a}_z} \ V/m$$

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$$|\bar{E_1}| = \sqrt{(8.98)^2} = 8.98 \text{ V/m}$$

$$|\bar{E_2}| = \sqrt{(-2.808)^2} = 2.808 \text{ V/m}$$

$$|\bar{E_3}| = \sqrt{(-6.9187)^2+(-6.9187)^2+(-6.9187)^2} = 11.983 \text{ V/m}$$

By principle of Superposition.

$$\bar{E} = \bar{E_1} + \bar{E_2} + \bar{E_3}$$

$$\bar{E} = (8.98 + 2.808 + 11.983) \text{ V/m}$$

$$\boxed{\bar{E} = 23.771 \text{ V/m}}$$

//Program for Electric Field Intensity due to N point charges

```
clc; clear all;
N=input('Enter the number of point charges:');
p=input('Enter the coordinates of a point at which
        E is to be calculated in the form [x, y z]:');
epso = input('Enter the value of permittivity of
        the medium:');
E=0;
for M=1:N
    Q=input('Enter the magnitude of a point charge:');
    T=input('Enter the point at which charge is
        located as [x y z]:');
    R=norm(P-T);
    EN=Q/(4*%pi*epso*R*R);
    E=E+EN
end
disp('The Resultant Electric Field Intensity:',E,'V/m');
```

EMA Expt. 6

5 element Yagi Uda antenna:-

Symbols:- where lambda = 0·75. for f = 400 MHz

Act = 0·48 × lambda
Ref = 0·525 × lambda
Dir1 = 0·42 × lambda
Dir2 = 0·4 × lambda
Dir3 = 0·37 × lambda
S1 = 0·2 × lambda
S2 = 0·3 × lambda
S3 = 0·55 × lambda
S4 = 0·8 × lambda
H = lambda.

Geometry

Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius
Wire	1	21	0	-Act/2	H	0	Act/2	H	0·0001
"	2	21	+S1	-Ref/2	H	S1	Ref/2	H	"
"	3	21	-S2	-Dir1/2	H	S2	Dir1/2	H	"
"	4	21	-S3	-Dir2/2	H	S3	Dir2/2	H	"
"	5	21	-S4	-Dir3/2	H	S4	Dir3/2	H	"

Source / load

Type	Tag	Seg	(opt)	Real	Img	Magn	Phase
Vtg-src	1	11	00	1	0	1	0

Freq / Gnd
F = 400 MHz,

Environment
→ Free space.

Far field pattern.

3 element Yagi-Uda antenna:-

Symbols:-

Jambda = 0.75

Act = 0.48 x Jambda

Ref = 0.525 x Jambda

Dir = 0.42 x Jambda

S1 = 0.2 x Jambda

S2 = 0.3 x Jambda

H = Jambda

Geometry

Type	Tag	Seg	X_1	Y_1	Z_1	X_2	Y_2	Z_2	Radius
Wire	1	21	0	-Act/2	Z	0	Act/2	H	0.0001
—"—	2	21	S1	-Ref/2	Z	S1	Ref/2	H	0.0001
—"—	3	21	-S2	-Dir/2	Z	-S2	-Dir/2	H	0.0001

Source / Load

Type	Tag	Seg	(opt)	Real	Img	Mag	Phase
Vtg-Src	1	11	00	1	0	1	0

Freq / Gnd

F = 400 MHz

Environment

Free space

Far field pattern.