EE2703 : Applied Programming Lab

Endsem

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Aim

The current in the wires of a dipole antenna is given by:

$$I = I_m sin(k(l - |z|))$$

according to standard analysis. We have to find out if it is a good assumption.

Pseudo-code

- Initialize location array going from 0 to 2N (where N=4).
- using boundary conditions and find the value of current using the formula.
- Finding the M matrix.
- Distance vectors R_z, R_u and R_iN are used to find the value of P and P_B.
- Further Q and Q_B values are found out.
- Using the M matrix and the Q matrix to find out the value of the current J. Values of current through the two methods are plotted versus 'z'
- The above processes are repeated for N=100 and the observations are compared.

Assignment

Q1:Defining Vectors and Current Using Formula

The wire of the dipole is considered to be of length 2l (-l to l). We determine the vector z at each point from 0 to 2N considering the element dz.

$$dz = \frac{l}{N}$$

We use the boundary conditions appropriately and find the value of current using the formula.

$$I = I_m sin(k(l - |z|))$$

```
# Q1
i = np.linspace(-N, N, 2*N+1)  # i ranges from -N to N
z = i*dz                       # Defining the vector z
I = np.array
Im = 1.0
Iupper = Im*np.sin(k*(l - z[N:]))
Ilower = Im*np.sin(k*(l + z[:-(N+1)]))
I = np.append(Ilower, Iupper)            # I calculated from
    formula
u = np.delete(z, 0)
u = np.delete(u, -1)
u = np.delete(u, N-1)
j = np.delete(I, 0)
j = np.delete(j, -1)
j = np.delete(j, N-1)
```

Q2:Ampere's Circuital Law

$$2\pi a H_\phi(z_i) = I_i$$

Here We use these matrix equations to get the unknown current values. We determine the matrix M.

$$\begin{bmatrix} H_\phi[z_1] \\ \dots \\ H_\phi[z_{N-1}] \\ H_\phi[z_{N+1}] \\ \dots \\ H_\phi[z_{2N-1}] \end{bmatrix} = \frac{I_{2N-2}}{2\pi a} \begin{bmatrix} J_1 \\ \dots \\ J_{N-1} \\ J_{N+1} \\ \dots \\ J_{2N-1} \end{bmatrix}$$

$$H_\phi = M * J$$

I_{2N-2} is an identity matrix of order 2N-2.

```
Id = np.identity(2*N-2)
M = 1/(2*np.pi*a)*Id
```

Q3 & Q4:Determine the Vector Potential Equation

Here, we firstly find the values of Rz, Ru, and RiN (different distances). There are 2N-2 observers.

$$\vec{A}(r,z) = \frac{\mu_0}{4\pi}\int \frac{I(z')\hat{z}e^{-jkR_{ij}}dz'}{R}$$

Simplified Equation:

$$\sum_j P_{ij}I_j + P_B I_N$$

We further find the values of P and P_B

After finding the Values of P and P_B we use the euqtion:

$$H_\phi(r,z_i) = -\sum_j P_{ij}\frac{r}{\mu_0}(\frac{-jk}{R_{ij}} - \frac{1}{R_{ij}^2})I_j + P_B\frac{r}{\mu_0}(\frac{-jk}{R_{iN}} - \frac{1}{R_{iN}^2})I_m$$

Which simplifies to:

$$\sum_j Q_{ij}J_j + Q_{Bi}I_m$$

Hence we can find the value of Q and Q_B

```
# Q3
Rz = np.sqrt(np.add(a*a, np.square(np.subtract.outer(z, z))))
Ru = np.sqrt(np.add(a*a, np.square(np.subtract.outer(u, u))))
list = np.delete(np.arange(1, 2*N), N-1)
RiN = Rz[list, N]
Pb = (mu0/(4*np.pi))*((np.exp(-1j*k*RiN))*dz)/RiN
P = (mu0/(4*np.pi))*((np.exp(-1j*Ru*k))/Ru)*dz

# Q4:
Qb = -(Pb*a/mu0*(-1j*k/RiN-1/RiN**2))
Q = -(P*a/mu0*(-1j*k/Ru-1/Ru**2))
```

Q5:Finding Computed Value of Current

Now, we use the final equation:

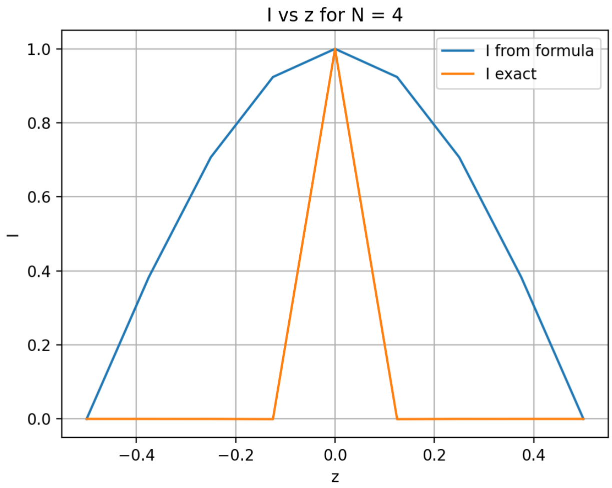
$$(M - Q)J = Q_B I_m \tag{1}$$

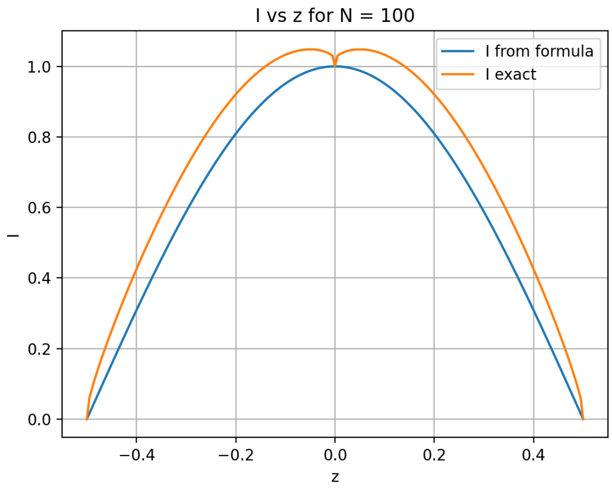
$$J = (M - Q)^{-1} Q_B I_m$$

and find the value of current. The plot of both the values of current found out by different methods as a function of z is made.

```
# Q5
J = np.dot(np.linalg.inv(M-Q), (Qb*Im))
list = J.tolist()                                    # Considering
    Boundary conditions
list.insert(0, 0)
list.insert(N, Im)
list.insert(2*N, 0)
J = np.array(list)

# Plotting
plt.figure()
plt.title("I vs z")
plt.xlabel("z")
plt.ylabel("I")
plt.plot(z, I, label="I from formula")
plt.plot(z, J, label="I exact")
plt.grid()
plt.legend()
plt.show()
```





Output Values

```
z =
 [-0.5  -0.38  -0.25  -0.12   0.   0.12   0.25   0.38   0.5 ]

############################################################

Ru=
 [0.01    0.13   0.25   0.5    0.63   0.75]
 [0.13    0.01   0.13   0.38   0.5    0.63]
 [0.25    0.13   0.01   0.25   0.38   0.5 ]
 [0.5     0.38   0.25   0.01   0.13   0.25]
 [0.63    0.5    0.38   0.13   0.01   0.13]
 [0.75    0.63   0.5    0.25   0.13   0.01]

############################################################

Rz=
 [0.01   0.13  0.25  0.38  0.5   0.63  0.75  0.88   1.  ]
 [0.13   0.01  0.13  0.25  0.38  0.5   0.63  0.75   0.88]
 [0.25   0.13  0.01  0.13  0.25  0.38  0.5   0.63   0.75]
 [0.38   0.25  0.13  0.01  0.13  0.25  0.38  0.5    0.63]
 [0.5    0.38  0.25  0.13  0.01  0.13  0.25  0.38   0.5 ]
 [0.63   0.5   0.38  0.25  0.13  0.01  0.13  0.25   0.38]
 [0.75   0.63  0.5   0.38  0.25  0.13  0.01  0.13   0.25]
 [0.88   0.75  0.63  0.5   0.38  0.25  0.13  0.01   0.13]
```

```
 [1.     0.88  0.75  0.63  0.5   0.38  0.25  0.13   0.01]

##########################################################

RiN =
 [0.5  0.38  0.25  0.13  0.01  0.13  0.25  0.38  0.5 ]

##########################################################

Pb=
 [1.27-3.08j 3.53-3.53j 9.2 -3.83j 9.2 -3.83j 3.53-3.53j 1.27-3.08j]

##########################################################

P=
 [[124.94-3.93j   9.2 -3.83j   3.53-3.53j  -0.  -2.5j   -0.77-1.85j
   -1.18-1.18j]

 [  9.2 -3.83j 124.94-3.93j   9.2 -3.83j   1.27-3.08j  -0.  -2.5j
   -0.77-1.85j]

 [  3.53-3.53j   9.2 -3.83j 124.94-3.93j   3.53-3.53j   1.27-3.08j
   -0.  -2.5j ]

 [ -0.  -2.5j    1.27-3.08j   3.53-3.53j 124.94-3.93j   9.2 -3.83j
    3.53-3.53j]

 [ -0.77-1.85j  -0.  -2.5j    1.27-3.08j   9.2 -3.83j 124.94-3.93j
    9.2 -3.83j]

 [ -1.18-1.18j  -0.77-1.85j  -0.  -2.5j    3.53-3.53j   9.2 -3.83j
  124.94-3.93j]]

##########################################################

Qb =
 [0.-0.j   0.01-0.j  0.05-0.j  0.05-0.j  0.01-0.j  0.-0.j]

##########################################################
```

```
I =
 [0.   0.38  0.71  0.92  1.   0.92  0.71  0.38  0.  ]

###########################################################

J =
 [ 0.0000e+00+0.000e+00j -3.3030e-05+1.065e-05j -9.5460e-05+1.152e-05j
 -6.4825e-04+1.208e-05j  1.0000e+00+0.000e+00j -6.4825e-04+1.208e-05j
 -9.5460e-05+1.152e-05j -3.3030e-05+1.065e-05j  0.0000e+00+0.000e+00j]
###########################################################
```

Conclusion:

- We observe that as the value of N increases, the error in the current value decreases (The curve fits better).
- The error becomes more as n is lowered because summation has to be used in the situation but as the number of points are indefinitely increased the summation turns into an integral resulting in precise values of current. Given by the equation:

$$I = I_m sin(k(l - |z|))$$