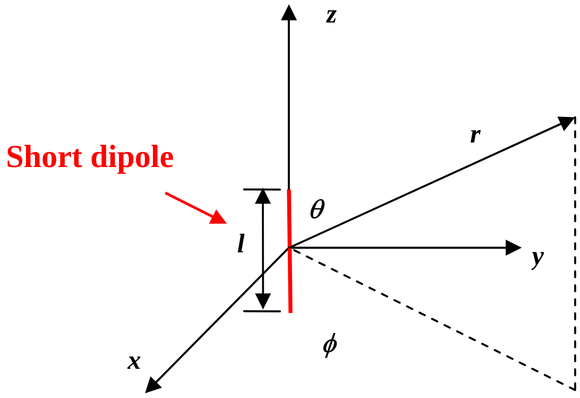
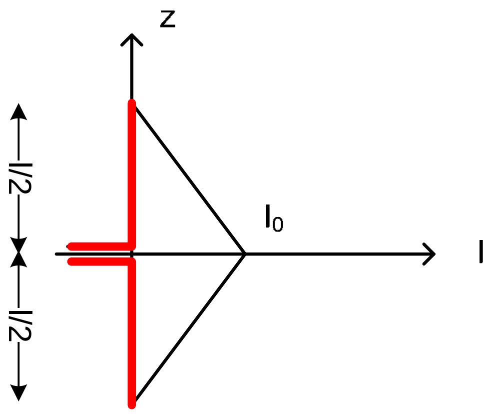
The Small Dipole (Short Dipole)





The Current Distribution

The current distribution for a short dipole ($\frac{\lambda}{50} \le l \le \frac{\lambda}{10}$) is linear and given by:

$$I_e(x',y',z') = \begin{cases} \hat{a}_z \, I_0 (1 - \frac{2}{l} z') & 0 \le z' \le l/2 \\ \hat{a}_z \, I_0 (1 + \frac{2}{l} z') & -l/2 \le z' \le 0 \end{cases}$$

Radiated fields of the short dipole

For the short dipole, → $\frac{\lambda}{50} \le l \le \frac{\lambda}{10}$

Current is assumed linear →

To find the radiated fields, find ***A*** due to $I_e(z')$

The assumptions are:

$$\therefore R = \sqrt{(x-x')^2 + (y-y')^2 + (z-z')^2}$$
$$= \sqrt{x^2 + y^2 + z^2} = r$$

and $dl' = dz'$

$$\therefore A(x,y,z) = \frac{\mu}{4\pi}\left[\hat{a}_z \int_{-l/2}^{0} I_o(1+\frac{2}{l}z')\frac{e^{-jkr}}{R}dz' + \hat{a}_z \int_{0}^{l/2} I_o(1-\frac{2}{l}z')\frac{e^{-jkr}}{R}dz'\right]$$

or $A_z = \frac{1}{2}\frac{\mu I_o l}{4\pi r}e^{-jkr}$

This is one half the value of the infinitesimal dipole.

It follows that the fields (in the far field region) of the short dipole are half those of the infinitesimal dipole.

In the far field region $(kr \succ\succ 1)$, they are given by:

$$E_\theta = j\eta \frac{kI_o l\, e^{-jkr}}{4\pi r}\sin\theta$$

$$\therefore H_\phi = j\frac{kI_o l\, e^{-jkr}}{4\pi r}\sin\theta$$

& $E_r = E_\phi = H_r = H_\theta = 0$

Directivity of the short dipole

Directivity is controlled by the relative shape of the radiation pattern. It follows that the directivity of the short dipole is the same as the infinitesimal dipole (= 1.5)

Radiation resistance of the short dipole

The radiation resistance depends on the total radiated power, which is a function of the current distribution. It can be shown that the radiated power of the short dipole is one-fourth of the infinitesimal dipole

$\therefore P_{rad} = \frac{1}{4}\eta\frac{\pi}{3}\left|\frac{I_o l}{\lambda}\right|^2$ and it follows that the radiation resistance is given by:

$$\therefore R_r = \frac{1}{4}\eta\frac{2\pi}{3}\left(\frac{l}{\lambda}\right)^2 = 20\pi^2\left(\frac{l}{\lambda}\right)^2$$

$$where\ \eta\ for\ free\ space = 120\pi\ \Omega$$

Finite Length Dipole Current Distribution

For a very thin dipole (ideally zero diameter), the current distribution, to a very good approximation, is:

$$I_e(x'=0, y'=0, z') = \begin{cases} \hat{a}_z\, I_0 \sin\left[k\left(\frac{l}{2} - z'\right)\right] & 0 \le z' \le l/2 \\ \hat{a}_z\, I_0 \sin\left[k\left(\frac{l}{2} + z'\right)\right] & -l/2 \le z' \le 0 \end{cases}$$

This assumes the antenna is center fed.