Antenna Parameters

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1 Radiation Fields

The radiation fields are actually just the E-field and H-field of the antenna.

For example, $E_{Hertzian} = \frac{\eta jkI\Delta ze^{-jkr}}{4\pi r}\left[1 + \frac{1}{jkr} + \frac{1}{(jkr)^2}\right]\sin\theta\hat{\theta}$, expand it

$$E_{Hertzian} = \left[\underbrace{\frac{\eta jkI\Delta ze^{-jkr}}{4\pi r}}_{\text{Radiation term}} + \underbrace{\frac{\eta I\Delta ze^{-jkr}}{4\pi r^2}}_{\text{Induction term}} + \underbrace{\frac{\eta I\Delta ze^{-jkr}}{4j\pi kr^3}}_{\text{Electrostatic term}}\right]\sin\theta\hat{\theta}$$

Certain apporixmation is needed to handle the complicated field

When r is large, the radiation term dominant.

When r is large, the electrostatic term dominant.

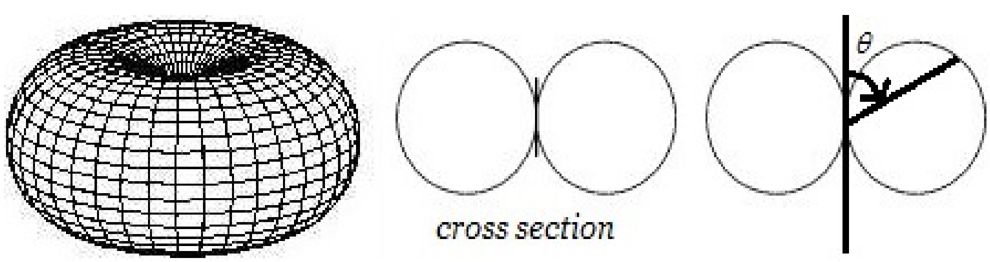
Thus , for $Far\ Field$ ($kr \gg 1$) , $E_{Hertzian} \approx E_{Rad}$

$$E_{FarField} = \frac{\eta jkI\Delta ze^{-jkr}}{4\pi r}\sin\theta\cdot\hat{\theta} \qquad H_{FarField} = \frac{jkI\Delta ze^{-jkr}}{4\pi r}\sin\theta\cdot\hat{\phi}$$

The fields $E \perp H$, and

$$|E_{FarField}| = \frac{\eta k|I|\Delta ze^{-jkr}}{4\pi r}|\sin\theta| \qquad |H_{FarField}| = \frac{k|I|\Delta ze^{-jkr}}{4\pi r}|\sin\theta|$$

It looks like



For the above diagram, notice that when $\theta = 90$ (sin achieve its maximum)

2 Power Terms

The Poynting Vector $\bar{S} = \bar{E} \times \bar{H}$ can be used for power manipulation.

The time-dependent Poynting Vector $\bar{S}(r,t) = \bar{E}(r,t) \times \bar{H}(r,t)$

The time-average Poynting Vector $\left\langle \bar{S}(r) \right\rangle = \frac{1}{2}\mathrm{Re}\left[\bar{E}(r) \times \bar{H}(r)*\right]$

The Total radiated power $P_{Rad} = \iint_S \left\langle \bar{S}(r) \right\rangle \cdot d\mathbf{S} = \int_{\phi=0}^{\phi=2\pi} \int_{\theta=0}^{\theta=\pi} \left\langle \bar{S}(r) \right\rangle \cdot \hat{r} r^2 \sin\theta d\theta d\phi$

Average radiated power $P^{Avg} = \frac{P_{Rad}}{\iint_S dS} = \frac{P^{Tot}}{4\pi r^2}$

3 Antenna Gain and Directivity

$$G = \frac{\left\langle \bar{S}(r) \right\rangle}{P^{Avg}} = \frac{\left\langle \bar{S}(r) \right\rangle}{P_{Rad}/4\pi r^2}$$

Directivity $D = \max G$

4 Antenna Circuit Equivalent

Radiation Resistance $R_{Rad} = \frac{P_{Rad}}{I_{Rms}^2}$

Radiation Efficiency $Eff_{Rad} = \frac{R_{Rad}}{R_{Rad} + R_{OhmicLoss}}$

Input Impedance $Z_{In(Rad)} = R_{Rad} + \chi_{Circuit} + R_{Ohimc}$

Effective Length $l_{Eff} = \underbrace{\int_{-\frac{l}{2}}^{+\frac{l}{2}} I(z)dz}_{Tx} = \underbrace{\frac{V_{OC}}{|E_{Receiving}|}}_{Rx}$

Power deliver to matched load for lossless antenna $P_L = \frac{1}{2}\left(\frac{V_{OC}^2}{4R_{Rad}}\right)$

Effective Area for Rx $A_{Eff} = \frac{P_L}{P_{\textbf{incident EM}}} = \frac{\lambda^2}{4\pi}G$

Friis Transmission Formula $\frac{P_L}{P_{Rad(Tx)}} = \frac{A_{EffTx}A_{EffRx}}{r^2\lambda^2} = \frac{D_{Tx}D_{Rx}\lambda^2}{(4\pi r)^2}$

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