المحاضرة السابعة

Chapter (4)

4.1. Antenna and Radiation الاشعاع والهوائيات

Antenna: The region of transition between a guided wave and a free space Wave may be defined as the Antenna.

الهوائي : محطة نقل بين الموجة الموجهة وموجة الفضاء الحر

4.2 مقاومة الاشعاع الثنائي قطب قصير

Radiation Resistance of a Short dipole by taking the surface integral of the average poynating vector over any Surface enclosing an antenna. The total power radiated by the antenna is obtained. Thus

وبالتالي تحسب قدرة الاشعاع الكلية من تكامل معدل متجه بوينتك حول سطح مرفق بالهوائي , وبالتالي

P = $\int_s S_{av} \ .ds$ ------------------ (1)

Where P= power radiated. (W) القدرة المشمه بالواط

S_{av} = average poynting vector, (wm^{-2}) معدل متجه بوينتك بـ واط / متر^2

But the average poynting vector glue by the relation

لكن معدل متجه بوينتك يعطى بالعلاقة

$S_{av} = \frac{1}{2}\ Re\ (\ E \times H^{*})$ ------------ (2) Sub (2) in (1) wegetl the power radiated 15

P = $\int_s S_{av} \ .ds$ = $\frac{1}{2}\ \int_s \ Re\ (\ E \times H^{*}).ds$ __________ (3)

In the for field only E_0 and $H_{\emptyset}$ are not Zero » Se that equation (3) reduce to لا تساوي, $H_{\emptyset}$, E_Θ للمجالات البعيدة فقط

يمكن استبدال صفر H^*,E بدلالة E_Θ , $H^{*}_{\emptyset}$) إلى 3لتؤول المعادلة)

P = $\frac{1}{2}\ \int_s \ Re\ E_\theta\ H_\varphi^{*}\ \hat{r}\ .ds$ --------- (4)

Where $\hat{r}$ is the unit vector in the radial direction.

But $\hat{r} . ds = ds$ حيث $\hat{r}$ متجه وحدة بالاتجاه الشعاعي

The eq. (4) becomes

∴ P = $\frac{1}{2} \int_s Re\ E_\theta\ H_\varphi^* \ . ds$ --------- (5)

Where E_θ , H_φ^* are complex, H_φ^* being the complex conjugate of H_φ

Now E_θ= H_φ Z ⟶ so eq^n (5) becomes

P = $\frac{1}{2} \int_s Re\ \ H_\varphi\ H_\varphi^*\ Z\ \ ds$

P = $\frac{1}{2} \int_s \ \ |\ H_\varphi|^2\ Re\ \ Z\ \ ds$ ------------ (6)

Since Re Z = $\sqrt{\mu_0/\epsilon_0}$ and ds = r^2 sin Ɵ dƟ dϕ ----------- (7)

Sub (7) in (6) we get

$$p = \frac{1}{2} \sqrt{\mu_0/\epsilon_0} \ \int_0^{2\pi} \int_0^{\pi} |H_\emptyset|^{\ 2}\ \ r^2 \ \ \sin\theta d\theta\ d\emptyset \quad \text{------------ (8)}$$

Where $|H_\emptyset|$ is the absolute value of the H field given by

$$|H_\emptyset| = \frac{\omega\ I_0\ l\ \sin\theta}{4\ \pi\ cr} \rightarrow \ |H_\emptyset|^2 = \frac{\omega^2 I_0^2 l^2 \sin^2\theta}{16\ \pi^2 c^2 r^2} \quad \text{------------ (9)}$$

Where

I_0 = amplitude of Current , A

l = length of dipole, m

ω = radian frequency = (2 π f = frequency, Hz)

Ɵ = angle between dipole and radius vector of length r

C = velocity of Light = 300 Mms^{-1}

r = distance from center of point P, m

But

$\beta = \frac{\omega}{c} \rightarrow \beta^2 = \frac{\omega^2}{c^2}$ ------------- (10)

Sub (10) in (9) we get

$|H_\emptyset|^2 = \frac{\beta^2 I_0^2 l^2 sin^2\theta}{16 \pi^2 r^2}$ ------------ (11) → $\beta =$ phase constant rad

"$\beta = 2\pi/\lambda$" ثابت الطور

Sub (11) in (8) we get

$p = \frac{1}{32} \sqrt{\mu_0/\epsilon_0} \, (\frac{\beta^2 I_0^2 l^2}{\pi^2}) \int_0^{2\pi} \int_0^{\pi} \sin^3 \theta d\theta \, d\emptyset$ ---------- (12)

Upon integration (12) becomes وبناءاً على تكامل المعادلة (12) تصبح

$p = \sqrt{\mu_0/\epsilon_0} \, (\frac{\beta^2 I_0^2 l^2}{12\pi})$ (w) --------------- (13)

This is the power radiated by

Assuming no losses, the power radiated by the antenna equal

P = $\frac{1}{2} I_0^2 R_r \rightarrow 2p = I_0^2 R_r$ and the radiation resistance is

$R_r = \frac{2p}{I_0^2}$ ------------ (14)

Substituting the power (P) from (13) into (14) yield for the radiation resistance of the short dipole

$R_r = \sqrt{\mu_0/\epsilon_0} \, \frac{(\beta l)^2}{6\pi}$ (Ω) ------------ (15)

Since $\sqrt{\mu_0/\epsilon_0} = 376.7 \approx 120 \, \pi \rightarrow eq^n(15)$

Reduce to $R_r = 20 \, (20\beta l)^2$ ------------ (16)

But $\beta = \frac{2\pi}{\lambda}$ --------------- (17)

Sub (17) in (16) we get

$R = 80 \ \pi^2 (\frac{l}{\lambda})^2$ (Ω) ---------- (18)

Ex / find the radiation resistance of a dipole antenna $\lambda/_{10}$ long.

Sol. / $R_r = 80 \, \pi^2 (\frac{l}{\lambda})^2$

$R_r = 80 \, \pi^2 (\frac{1}{10})^2$ = 7.9 Ω

$R = R_{loss} + R_r \quad \rightarrow \quad R_{loss} = 1 \ \ for \ the \ \frac{\lambda}{10} \ dipole$

R = 1 + 7.9 = 8.9 Ω

The antenna efficiency K is

$K = \frac{\boldsymbol{power\ radiated}}{\boldsymbol{power\ input}} = \frac{\boldsymbol{R_r}}{\boldsymbol{R_r + R_{loss}}} = \frac{\mathbf{7.9}}{\mathbf{8.9}}$ = 89 percent