Antenas

Análisis de antenas básicas

Jesús Sanz Marcos

e-mail: jesus.sanz@upcnet.es

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Dipolo elemental básico

$\vec{J} = Id(x)d(y)\hat{z} \qquad \vec{N} = Il\hat{z}$

$\vec{A} = \frac{mIl}{4p}\frac{e^{-jkr}}{r}\hat{z} \qquad r >> l \text{ y } l >> l$

$\vec{E}_{rad} = E_q\hat{q} = -jwA_q\hat{q} = jwm\frac{Il}{4p}\frac{e^{-jkr}}{r}\text{sen}q\hat{q}$

$\vec{H}_{rad} = H_f\hat{f} = \frac{E_q}{h}\hat{f}$

$\vec{\wp} = \text{Re}\{\vec{E}\times\vec{H}^*\} = \hat{r}\frac{(Il)^2}{16p^2}\frac{kwm}{r^2}\text{sen}^2 q$

$P_r = \iint_S \vec{\wp}\, d\vec{s} = I^2 p\frac{h}{2}\frac{l^2}{l^2}\frac{4}{3}$

$R_r = \frac{P_r}{I^2} = 80p^2\frac{l^2}{l^2}$

$D = \frac{P_{max}}{P_{rad}/4pr^2} = \frac{\wp_{máx}}{\wp_{med}} = \frac{3}{2}$

$t = \text{sen}^2 q \Rightarrow \Delta q_{-3dB} = 90°$

Espira circular elemental

$\vec{N} = j2paIJ_1(k\,\text{sen}q)\hat{f}$

$N_f = jkpa^2 I\,\text{sen}q, a << l$

$K = \frac{h}{4l^2}|N_f|^2 = \frac{h}{4l^2}k^2p^2a^4I^2\text{sen}^2 q$

$t(q,f) = \text{sen}^2 q$

$P_r = \frac{ph}{6}(ka^4)I^2 \quad R_r = 20p^2(ka^2) \quad D = \frac{3}{2}$

$R_\Omega = \frac{1}{s}\frac{2pa}{2pbd} \qquad L = ma\left(\ln\left(\frac{8a}{b}\right) - 2\right)$

$d_s = \sqrt{pfms} \qquad X_e = Lw$

Espira cargada con ferrita

$V = \oint_{C'} E\cdot d\vec{l} = \frac{-d}{dt}\iint_{S'}\vec{B}\cdot d\vec{s} = -jwm_0 m_e HA$

$m_e = \frac{m_f}{1 + D(m_f - 1)} \qquad \frac{R_{r\,\text{ferrita}N\,\text{vueltas}}}{R_{r\,\text{espira}}} = N^2 m_e^2$

Expresiones generales de $\vec{N}$

Dipolo elemental eléctrico

$\vec{N} = jw\vec{p} \qquad \vec{p} = \int_{V'} r(\vec{r}')\vec{r}'\,dv'$

Dipolo elemental magnético

$\vec{N} = jk\vec{m}\times\hat{r} \qquad \vec{m} = \iint_{S'} I\hat{n}'\,ds'$

Antenas cilíndricas

$\vec{J}(\vec{r}') = \hat{z}I(z')d(x')d(y')$

$I(z') = I_m \,\text{sen}\, k(H - |z'|)$ $\quad H$: altura de un hilo

$\vec{N} = \hat{z}2I_m\frac{\cos(kH\cos q) - \cos kH}{k\,\text{sen}^2 q}$

$D = \frac{\wp_{max}4pr^2}{P_r} \qquad R_r = \frac{P_r}{I_m^2}$

Dipolo en λ/2 (o dipolo de media onda)

$H = l/4$

$$\vec{N} = \hat{z}I_m 2\frac{\cos\left(\frac{p}{2}\cos q\right)}{k\,\text{sen}^2 q}$$

$$\wp = \frac{30I_m^2}{pr^2}\left(\frac{\cos(\frac{p}{2}\cos q)}{\text{sen}q}\right)^2$$

$R_r = 73\Omega \qquad D = 1.64$

Dipolo corto

$H < 0.1l \qquad I(z') = I_0\left(1 - \frac{|z'|}{H}\right)$

$P_{rad} = \frac{1}{4}P_{rad_{UNIF}} \Rightarrow R_{rad} = \frac{1}{4}R_{rad_{UNIF}}$

Uniforme

$I(z)$ 

D=1.5

$t = \text{sen}^2 q$

$R = 80p^2\left(\frac{l}{l}\right)^2$

Corto

$I(z)$ 

D=1.5

$t = \text{sen}^2 q$

$R = \frac{1}{4}R_{uniforme}$

Monopolos

$E_M = E_D(z \geq 0) \qquad I_M = I_D$

$P_M = P_D u(z) \qquad D_M = 2D_D$

$P_{rad_M} = \frac{1}{2}P_{rad_D} \qquad R_{rad_M} = \frac{1}{2}R_{r_D}$

$A_{ef_M} = \frac{1}{2}A_{ef_D} \qquad l_{ef_M} = \frac{1}{2}l_{ef_D}$

Teorema reciprocidad

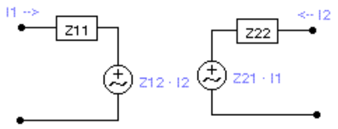
$$\int_V \vec{E}^a \vec{J}^b dv = \int_V \vec{E}^b \vec{J}^a dv$$

$$I_1^a V_1^b \left(I_1^b = 0\right) = I_2^b V_2^a \left(I_2^a = 0\right)$$

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \Rightarrow Z_{21} = Z_{12}$$

Igualdad impedancias en Tx y Rx



$$Z_1^{Rx} = Z_1^{Tx} \qquad Z_1^{Rx} = \frac{V_{ca}}{I_{cc}} = Z_1^{Tx}$$

$$Z_1^{Tx} = \frac{V_1}{I_1} = Z_{11} - \frac{Z_{12} Z_{21}}{Z_{22} + Z_L}$$

Potencia entregada a la carga

$$Z_L = Z_{22}^* \qquad V_2 = Z_{22} I_2 + Z_{21} I_1$$

$$P_{R_2} = \left| \frac{Z_{21} I_1}{Z_{22} + Z_{LL}} \right|^2 \operatorname{Re}\{Z_L\} = \frac{|Z_{21}|^2}{4R_{22}} |I_1|^2$$

$$\frac{P_{R_2}}{P_{T_1}} = \frac{|Z_{21}|^2}{4R_{22} R_{11}} = \frac{P_{R_1}}{P_{T_2}}$$

$$\frac{P_{R_2}}{P_{T_1}} = \frac{D_1 A_{ef\,2}}{4pr^2} \qquad \frac{P_{R_1}}{P_{T_2}} = \frac{D_2 A_{ef\,1}}{4pr^2}$$

$$\frac{D_1}{A_{ef\,1}} = \frac{D_2}{A_{ef\,2}}$$

Igualdad de diagramas

$$I_{CC} = \frac{1}{V} \int_{ant} E_z^i \cdot I(z) dz$$

$$V_{ca} = -\frac{1}{I(0)} \int_{ant} E_z^i I_1(z) dz = -E_i l_{ef}$$

Área y longitud efectiva

$$A_{ef} = \frac{P_L}{\wp} = \frac{|V_{ca}|^2}{4R_r \wp} = \frac{|V_{ca}|^2 h}{|E|^2 4R_r} = \frac{l_{ef}^2 h}{4R_r}$$

$$l_{ef} = \frac{|V_{ca}|}{|E|}$$

Adaptación

$$P_{L_{máx}} = \frac{|V_{ca}|^2}{4R_a} \qquad P_L = P_{L_{max}} C_a$$

Coeficiente de desadaptación:

$$C_a = \frac{4R_a R_L}{(R_a + R_L)^2 + (X_a + X_L)^2}$$

$$C_a = 1 \Leftrightarrow Z_L = Z_a^*$$

Ecuación de transmisión

$$\wp = \frac{P_R}{4pr^2}$$

$$\wp(q, f) = \frac{P_R}{4pr^2} D(q, f) = \frac{P_e}{4pr^2} G(q, f)$$

$$PIRE = P_{Radiada} D = P_{entregada} G$$

$$P_L = \frac{P_r}{4pr^2} D_T A_{efR}$$

Coeficiente de desacoplo de polarización:

$$c_p = |\hat{e}_t \hat{e}_r|^2$$

$$\frac{P_L}{P_r} = \left(\frac{l}{4pr} \right)^2 D_T D_R$$

$$G: \text{ganancia} = Dh_{óhmica}$$

$$h_\Omega = \frac{R_{rad}}{R_{rad} + R_\Omega}$$

Impedancia y autoimpedancias

Cuanto más grueso sea el dipolo, más baja es la resistencia de radiación. Los dipolos gruesos tienen mayor ancho de banda pero una resistencia de radiación pequeña.

Dipolo doblado

$$Z_{DD} = 4Z_D$$

$$D_{DD} = D_D$$