EE4108 Antenna Design

Zhaoxin HU

1 General Relations

rad intensity	U	$=$	$r^2 S$
		$=$	$\dfrac{\lvert\vec{E}\rvert^2 r^2}{2\eta}$

2 Hertzian Dipole

rad pwr	P	$=$	$\frac{1}{2} I^2 R_r$
		$=$	$\eta_0 \dfrac{(Idlk_0)^2}{12\pi}$
		$=$	$\eta_0 \dfrac{\pi}{3}\left(\dfrac{Idl}{\lambda}\right)^2$
rad res	R_r	$=$	$80\pi^2 \left(\dfrac{dl}{\lambda}\right)^2$
directivity	D	$=$	1.5

3 Finite Length Dipole

current distro	$I(z')$	$=$	$I_m \sin k\left(\dfrac{L}{2} - \lvert z'\rvert\right)$
feed pt current	$I(0)$	$=$	$I_m \sin \dfrac{kL}{2}$
rad res of short dipole	R_r	$=$	$20\pi^2\left(\dfrac{L}{\lambda}\right)^2$
rad res of short monopole	R_r	$=$	$40\pi^2\left(\dfrac{h}{\lambda}\right)^2$
rad imp of $\frac{\lambda}{2}$ dipole	$Z_a\left(\dfrac{\lambda}{2}\right)$	$=$	$73 + j42.5\ \Omega$
rad res of $\frac{\lambda}{4}$ monopole	$R_r\left(\dfrac{\lambda}{2}\right)$	$=$	$36.5\ \Omega$
directivity of $\frac{\lambda}{2}$ dipole	D	$=$	1.64
directivity of $\frac{\lambda}{4}$ monopole	D	$=$	3.28

4 Receiving Antenna

eff area	A_e	$=$	$\dfrac{P_a}{S}$
		$=$	$\dfrac{\eta}{4R_a}\lvert h_e(\theta)\rvert^2$
eff area & pwr gain	$\dfrac{A_e}{G}$	$=$	$\dfrac{\lambda^2}{4\pi}$
Friss formula	P_a	$=$	$\dfrac{P_t}{4\pi r^2} G_1(\theta_1) A_e 2(\theta_2)$
		$=$	$\dfrac{P_t \lambda^2}{(4\pi r)^2} G_1(\theta_1) G_2(\theta_2)$

5 Reflector

5.1 Corner Reflector

i/p imp	Z_{in}	$=$	

5.2 Parasitic Element

E-field in the xy-plane	E_θ	$=$	$C(I_1 + I_2 e^{jkd\cos\phi})$
		$=$	$CI_1\left(1 + \left\lvert\dfrac{Z_{12}}{Z_{22}}\right\rvert e^{j(\gamma + kd\cos\phi)}\right)$
const C	C	$=$	$\dfrac{j\eta}{2\pi r} e^{-jkr} \dfrac{1 - \cos\frac{1}{2}kL_1}{\sin\frac{1}{2}kL_1}$
cond for dir	γ	$=$	$-kd$
cond for refl	γ	$=$	kd

6 Array

E-field expr	$\vec{E}$	$=$	$\hat{\theta}\dfrac{j\eta k e^{-jkr}}{4\pi r} h_e(\theta) f(\cos\chi)$
array factor	$f(\cos\chi)$	$=$	$\displaystyle\sum_{n=0}^{N-1} I_n e^{jnkd\cos\chi}$

6.1 Progressive Phase Shift Array

current	I_n	$=$	$a_n e^{j\alpha_n}$
phase	α_n	$=$	$n\alpha$
array factor	$f(\cos\chi)$	$=$	$\displaystyle\sum_{n=0}^{N-1} a_n e^{jn(\alpha + kd\cos\chi)}$
mainbeam dir	$\cos\chi$	$=$	$-\dfrac{\alpha}{kd}$

6.2 Uniform Array

current	I_n	$=$	$a e^{j\alpha_n}$
phase	α_n	$=$	$n\alpha$
array factor	$f(u)$	$=$	$a\left\lvert\dfrac{\sin\frac{Nu}{2}}{\sin\frac{u}{2}}\right\rvert$
angle var	u	$=$	$\alpha + kd\cos\chi$
null loc	u	$=$	$\pm\dfrac{2n\pi}{N}$

7 Aperture and Horn

7.1 Rectangular Uniform Aperture

modified directivity	D	$=$	$\dfrac{4\pi}{\lambda^2}\epsilon_{ap} A_P$
$\frac{1}{2}$ pwr beamwidth	$HPBW$	$=$	$49.6\dfrac{\lambda}{a/b}{}^\circ$

7.2 Circular Uniform Aperture

modified directivity	D	$=$	$\dfrac{4\pi}{\lambda^2}\epsilon_{ap} A_P$
$\frac{1}{2}$ pwr beamwidth	$HPBW$	$=$	$58.44\dfrac{\lambda}{D}{}^\circ$

7.3 Fresnel Integrals

E-plane sect arg $$v = \frac{B}{2}\sqrt{\frac{2}{\lambda R_1}} = 1$$

H-plane sect arg 1 $$P_1 = \frac{1}{\sqrt{2}}\left(\frac{A}{\sqrt{\lambda R_2}} + \frac{\sqrt{\lambda R_2}}{A}\right) = 1.63$$

H-plane sect arg 2 $$P_2 = \frac{1}{\sqrt{2}}\left(\frac{\sqrt{\lambda R_2}}{A} - \frac{A}{\sqrt{\lambda R_2}}\right) = -0.82$$

C integral $$C(-v) = -C(v)$$

S integral $$S(-v) = -S(v)$$

7.4 E-Plane Sectoral Horn

flare dim $$B = \sqrt{2\lambda R_1}$$

rad pwr $$P_{rad} = \frac{aB}{4\eta}E_0^2$$

directivity $$D_E = \frac{64aR_1}{\pi\lambda B}(C^2(v) + S^2(v))$$

aperture eff $$\epsilon_E = \frac{\lambda^2 D_E}{4\pi A_P}$$

7.5 H-Plane Sectoral Horn

flare dim $$A = \sqrt{3\lambda R_2}$$

rad pwr $$P_{rad} = \frac{Ab}{2\eta}E_0^2$$

directivity $$D_H = \frac{4\pi b R_2}{\lambda A}((C(P_1) - C(P_2))^2 + (S(P_1) - S(P_2))^2)$$

aperture eff $$\epsilon_H = \frac{\lambda^2 D_H}{4\pi A_P}$$

7.6 Pyramidal Horn

directivity $$D_P = \frac{\pi}{32}\frac{\lambda D_E}{a}\frac{\lambda D_H}{b}$$

aperture eff $$\epsilon_P = \frac{\lambda^2 D_P}{4\pi A_P}$$

8 Parabolic Reflector

$\frac{1}{2}$ pwr beamwidth $$HPBW = 73\frac{\lambda}{D}^{\circ}$$