

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Department of Electrical Engineering and Computer Science

Problem Set No. 7  
Spring Term 2008

6.632 Electromagnetic Wave Theory

Issued: 04/08/2008 T  
Due: 04/17/2008 R

-----  
**Reading assignment:** Section 4.4 ; J. A. Kong, “*Electromagnetic Wave Theory*,” EMW Publishing, 2005.

**Problem P7.1**

Consider a broadside Dolph-Chebyshev array of five elements separated with equal distance  $d$ .

- (a) For symmetric excitations and with  $d = \lambda/2$ , if the sidelobe level  $1/R = 0.03$ , show that  $b = 1.6036$ . The first zero of  $T_4(x_1)$  is  $x_1 = 0.9239$ , from  $u_1 = kd \cos(\psi_1) = 2 \cos^{-1} x_0/b$ , show that  $\psi_0 = 52.47^\circ$ . What is the beamwidth between the first nulls?
- (b) Find the excitation amplitudes of the Dolph-Chebyshev array.
- (c) For  $d = \lambda/3$ , what is the beamwidth for the Dolph-Chebyshev array if  $1/R = 0.03$ ?
- (d) For  $d = \lambda/3$  and  $1/R = 0.03$ , consider an array generated by the polynomial  $P_4(x) = 14.2x^4 - 19.3x^2 + 5.56$  under the Dolph transformation. Show that the first sidelobe peak generated by  $P_4(x)$  occurs at  $x = 0.8244$ ,  $P_4(0.8244) = -0.9979$ , and  $b = 1.4943$ . The first null of  $P_4(x)$  occurs at  $x_1 \doteq 0.9719$ , calculate the first-null beam width. Show that no other higher sidelobes than the first one occur within the visible region. Compare the beamwidth with that of the Dolph-Chebyshev array and explain. What are the excitation coefficients for  $P_4$  array?
- (e) For case (c), use Riblet transformation  $x = b \cos u + c$  and redesign the Dolph-Chebyshev array. Find the excitation coefficients. Summarize and compare the results with those of cases (c) and (d).

**Problem P7.2**

Consider a seven-element, equally spaced array with separation  $d$ .

- (a) If the current distribution is

$$\bar{J}(\vec{r}') = I\ell \sum_{n=0}^{n=6} \delta(x' - nd)\delta(y')\delta(z')$$

and set  $d = \lambda/2$ ,  $\alpha = 0$ , find the maximum sidelobe level and the first-null beamwidth.

- (b) If the current distribution is

$$\bar{J}(\vec{r}') = I\ell \sum_{n=-3}^{n=3} (4 - |x'|/d)\delta(x' - nd)\delta(y')\delta(z')$$

and set  $d = \lambda/2$ ,  $\alpha = 0$ , find the maximum sidelobe level and the first-null beamwidth.

- (c) If the current distribution is

$$\bar{J}(\vec{r}') = I\ell \sum_{n=0}^{n=6} \sin(kax')\delta(x' - nd)\delta(y')\delta(z')$$

and  $6kad = \pi$  as well as  $d = \lambda/2$ ,  $\alpha = 0$ , find the maximum sidelobe level and the first-null beamwidth.

- (d) Synthesize a seven-element, equally spaced, broadside Dolph-Chebyshev array with  $d = \lambda/2$ , which has the same sidelobe level with (a). Determine the excitation coefficients. Find the first-null beamwidth and compare it with the result in (a).
- (e) Synthesize a seven-element, equally spaced, broadside Dolph-Chebyshev array with  $d = \lambda/2$ , which has the same sidelobe level with (b). Determine the excitation coefficients. Find the first-null beamwidth and compare it with the result in (b).