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6-1. a. $E_{\Sigma} = E_1 + E_2 + E_3 = 2E_0 \frac{e^{jkr}}{r} + E_0 \frac{e^{jkr_1}}{r_1} + E_0 \frac{e^{jkr_2}}{r_2}$

where the center element is placed at the origin. For far-field observations

$$\begin{aligned} r_1 &\approx r - d \cos \theta \\ r_2 &\approx r + d \cos \theta \end{aligned} \quad \left. \begin{array}{l} \text{for phase variations} \\ r_1 \approx r_2 \approx r \end{array} \right\} \text{for amplitude variations}$$

and $E_{\Sigma} \approx E_0 \frac{e^{jkr}}{r} \{ 2 + e^{jkd \cos \theta} + e^{-jkd \cos \theta} \}$
 $\approx E_0 \frac{e^{jkr}}{r} \{ 2 [1 + \frac{1}{2} (e^{jkd \cos \theta} + e^{-jkd \cos \theta})] \}$
 $= E_0 \frac{e^{jkr}}{r} \{ 2 [1 + \cos(kd \cos \theta)] \}$

Computer Program

Directivity

$$U = \cos^4\left(\frac{\pi}{4} \cos \theta\right)$$

$$\text{A+ } d = \lambda/4$$

$$\text{Prad} = 8.7119$$

$$D_0 = 1.44244$$

$$= 1.5910 \text{ dB}$$

$$kd = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \frac{\pi}{2}$$

$$AF(\theta) = 4 \cos^2\left(\frac{\pi}{4} \cos \theta\right)$$

Thus the array factor is equal to

$$AF(\theta) = 2 [1 + \cos(kd \cos \theta)] = 4 \cos^2\left(\frac{kd}{2} \cos \theta\right)$$

which in normalized form can also be written as

$$AF(\theta)_n = 1 + \cos(kd \cos \theta) = 2 \cos^2\left(\frac{kd}{2} \cos \theta\right)$$

b. The nulls of the pattern can be found using either of the above forms for the array factor. For example

One Form

the other Form

$$AF(\theta) = 1 + \cos(kd \cos \theta_n) = 0$$

$$2 \cos^2\left(\frac{kd}{2} \cos \theta_n\right) = 0$$

$$\cos(kd \cos \theta_n) = -1$$

$$\frac{kd}{2} \cos \theta_n = \cos^{-1}(0) = \frac{n\pi}{2}, \quad n = \pm 1, \pm 3, \dots$$

$$kd \cos \theta_n = \cos^{-1}(-1) = n\pi, \quad n = \pm 1, \pm 3, \dots$$

$$\theta_n = \cos^{-1}(n\lambda/2d), \quad n = \pm 1, \pm 3, \dots$$

$$\theta_n = \cos^{-1}(n\lambda/2d), \quad n = \pm 1, \pm 3, \pm 5, \dots$$

which are of identical form. Therefore both forms yield the same results. Thus for $d = \lambda/4$

$$\theta_n = \cos^{-1}\left(\frac{n\lambda}{2d}\right)_{d=\lambda/4} = \cos^{-1}(2n), \quad n = \pm 1, \pm 3, \dots \Rightarrow \text{No nulls exist.}$$

c. Similarly the maxima of the pattern can be found using either of the two forms for the array factor. For example

(Continued)



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