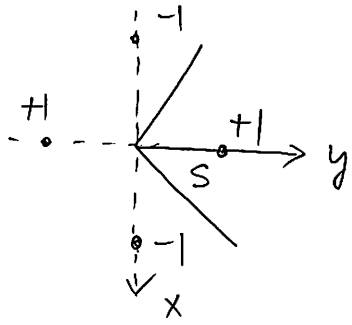
1. a) $EF = \sin\theta$ $\quad s = \frac{\lambda}{2}$ $\quad ks = \pi$



$$AF = e^{+jk\frac{\lambda}{2}\sin\theta\sin\phi} + e^{-jk\frac{\lambda}{2}\sin\theta\sin\phi} - e^{+jk\frac{\lambda}{2}\sin\theta\cos\phi} - e^{-jk\frac{\lambda}{2}\sin\theta\cos\phi}$$

$$AF \propto \cos(\pi\sin\theta\sin\phi) - \cos(\pi\sin\theta\cos\phi)$$

↑ y direction ↑ x direction

$$\text{Pattern} = (\sin\theta \cdot AF)^2$$

E-plane y-z plane $\phi = 90^\circ$ $\quad \text{Pattern} = \sin^2\theta\left[\cos(\pi\sin\theta) - 1\right]^2$

H-plane x-y plane $\theta = 90^\circ$ $\quad \text{pattern} = \left[\cos(\pi\sin\phi) - \cos(\pi\cos\phi)\right]^2$

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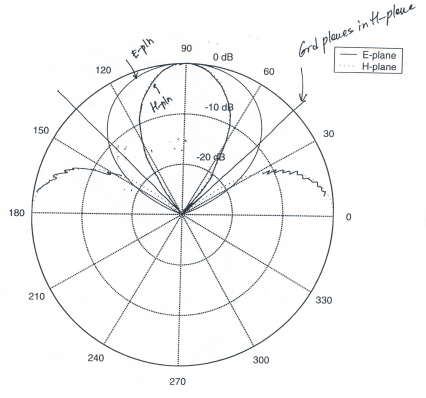
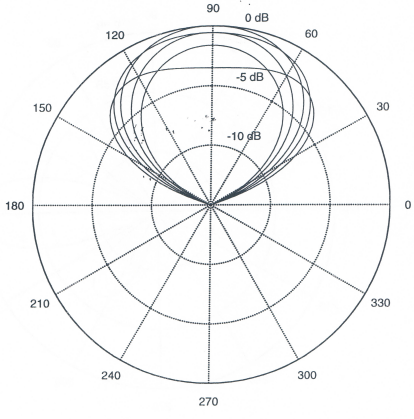




b) $s = \lambda$ $\quad AF \propto \cos(2\pi\sin\theta\sin\phi) - \cos(2\pi\sin\theta\cos\phi)$

y-axis means $\phi = \frac{\pi}{2}$, $\theta = \frac{\pi}{2}$ $\quad AF = 0$ on y axis

the image (-1) travels 1λ and canels the field by antenna with (+1)

c) $\text{pattern} = \sin^2\theta\left[\cos\left[\frac{2\pi}{\lambda}\cdot s\sin\theta\right] - 1\right]^2$

$\phi = 90^\circ$ $\quad$ fix $s = \frac{\lambda_0}{2}$ $\quad$ See plot.

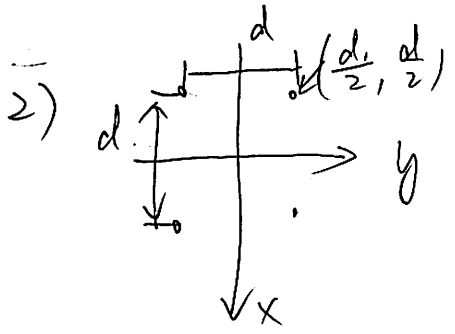
E plane.

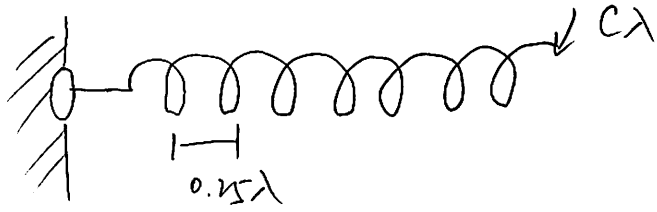
2. 1) $C_\lambda = 1.1$ $n = 8-9$ $S_\lambda = 0.25$ $\alpha = 12.6^\circ$ Gain $\approx$ 13 dB

$D \approx 20 - 30$ sidelobe level ≈ -13 dB $R = 154\,\Omega$

HPBW = 32°

2)





$$AF = \cos\left(k \cdot \frac{d}{2} \sin\theta \sin\phi\right) \cos\left(k \cdot \frac{d}{2} \sin\theta \cos\phi\right)$$

↑ y axis ↑ x axis

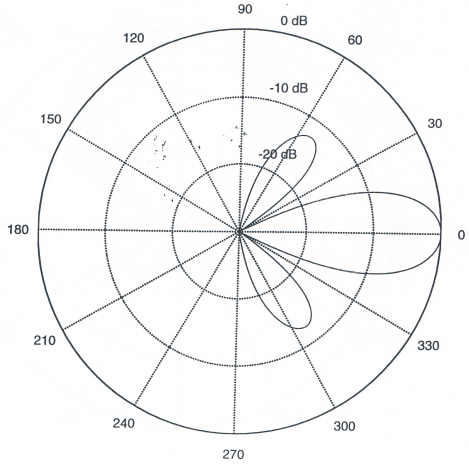
Choose $d = 0.8 - 1.0\,\lambda$ (max) Do not choose $D = 1.2\lambda$

$D \approx 50 - 60$ due to grating lobes and increased sidelobe levels.

$$f(\theta) = \cos(\pi \sin\theta)^2 \left[\sin\left(\frac{\pi}{n}\right) \cdot \frac{\sin\left(n\frac{\psi}{2}\right)}{\sin\left(\frac{\psi}{2}\right)} \cos\theta \right]^2$$

$$\psi = 2\pi \left[S_\lambda (1 - \cos\theta) + \frac{1}{2n} \right]$$

$S_\lambda = 0.25$ $n = 8$.



3. $\alpha = -kd_1 = -\frac{2\pi}{\lambda} \times 0.3\lambda = -0.6\pi$

$\beta = -kd_2 = -\frac{2\pi}{\lambda} \times 0.5\lambda = -\pi$

$\gamma = +kd_3 = +0.4\pi$

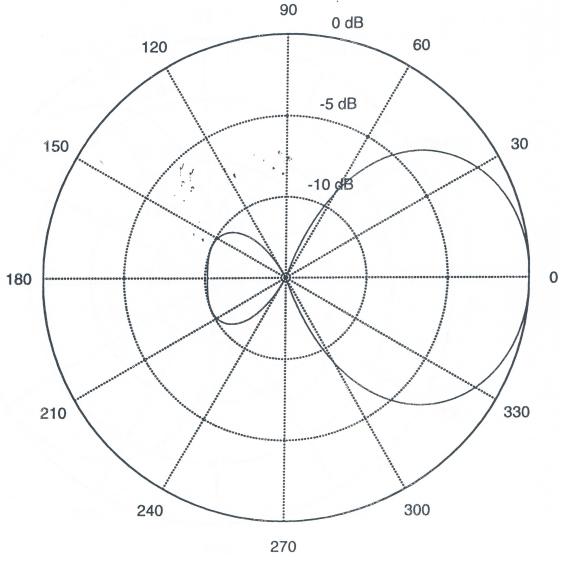
$$AF = 0.9\, e^{-jk(0.2\lambda)\cos\theta + 0.4\pi} + 1 + 0.7\, e^{jk(0.3\lambda)\cos\theta - 0.6\pi} + 0.5\, e^{+jk(0.5\lambda)\cos\theta - \pi}$$

$EF = \sqrt{1 - \sin^2\theta \sin^2\phi}$ $\hat{y}$ oriented dipole.

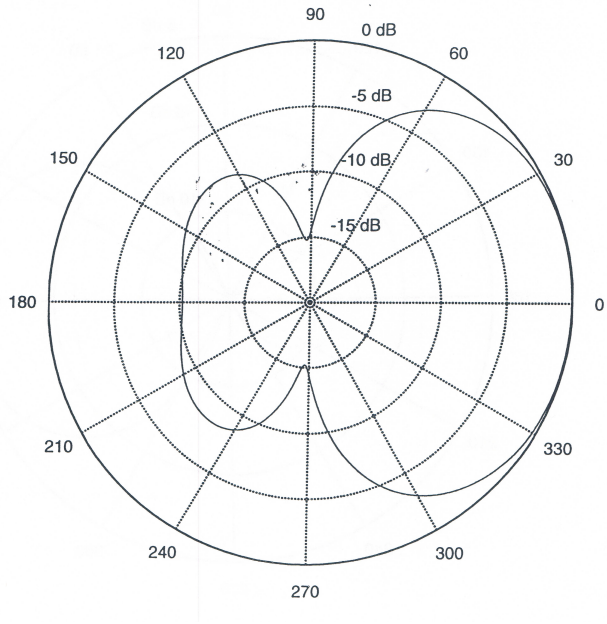
E-plane Y-Z plane $\phi = 90^\circ$ $EF = \sqrt{1-\sin^2\theta} = \cos\theta$

H-plane X-Y plane $\phi = 0^\circ$ $EF = 1$

$D \approx 6.3$ dB Forward/back ratio ≈ 10 dB.



E Plane



H plane