1) **The Broadside array of an 4 -element uniform linear array of element spacing d =$\lambda/2$ and successive phase shift δ . plot the radiation pattern and Find the mainlobe maximum and the sidelobe maxima and all of nulls?**

① Broadside Antenna Array

Condition $\longrightarrow$ δ must be equal zero

$$\boxed{\delta = 0}$$

$$\psi = K d \cos\theta + \delta$$

$$\psi = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \cos\theta + 0$$

$$\psi = \pi \cos\theta$$

To find Af_{max} assume $\psi = 0$ at main lobe maximum

$$\therefore \pi \cos\theta = 0$$

$$\theta_{max} = \cos^{-1}(0) = 90^\circ , 270^\circ$$

Two major lobes are seen because The broadside array is symmetric about $\theta = \pm\pi/2$

At all of nulls

$$\frac{N\psi}{2} = \pm K\pi \quad ; where \ K = 1, 2, 3, \dots$$

$$\frac{4\pi\cos\theta}{2} = \pm K\pi$$

$$2\pi\cos\theta = \pm K\pi$$

$$\cos\theta_{null} = \pm K/2$$

at 1^{st} null $\rightarrow K = 1$, $\theta = \cos^{-1}(1/2) = 60^\circ$

$\theta = \cos^{-1}\left(\frac{-1}{2}\right) = 120^\circ$

at 2^{nd} null $\rightarrow K = 2$, $\theta = \cos^{-1}\left(\frac{2}{2}\right) = 0^\circ$

$\theta = \cos^{-1}(-2/2) = 180^\circ$

3^{rd} null at $k=3 \longrightarrow \cos\theta_{null} = \pm 3/2$ $\boxed{X}$ math error

max of $\cos \rightarrow 1$

side lobes

$$\frac{N\psi}{2} = \pm \frac{(2K+1)\pi}{2} \quad ; K = 1, 2, 3 \ldots$$

$$\frac{4\pi\cos\theta}{2} = \pm \frac{(2K+1)\pi}{2}$$

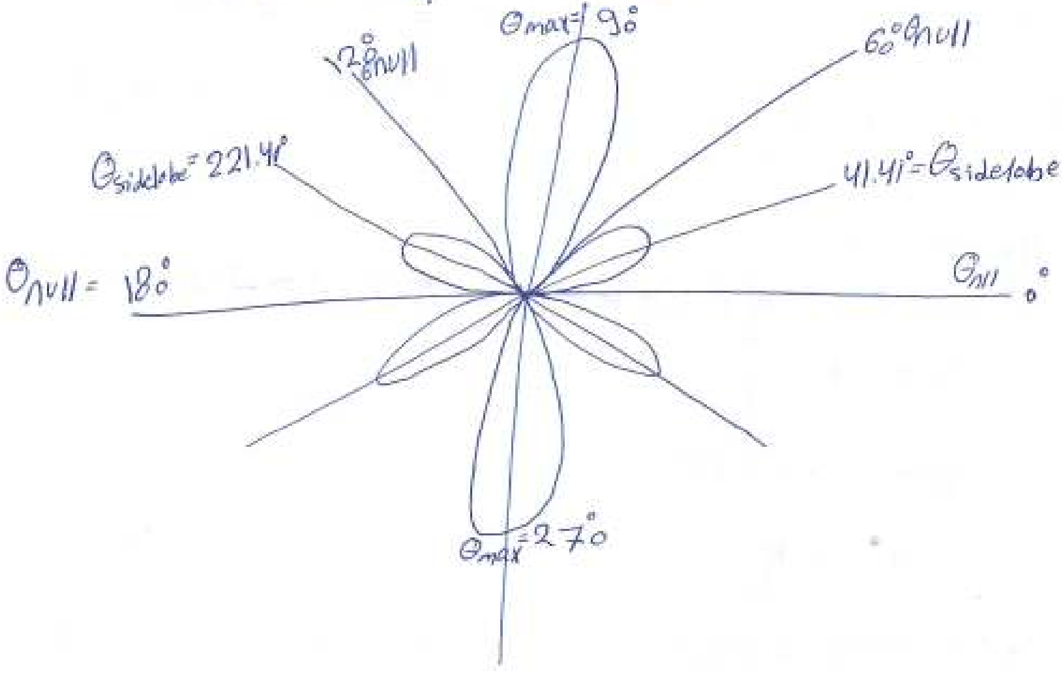
$$\cos\theta = \pm\frac{(2K+1)}{4}$$

1^{st} sideloop $\longrightarrow$ at $K=1 \longrightarrow \theta = \cos^{-1}\left(\frac{3}{4}\right) = 41°.41$

$\theta = \cos^{-1}\left(\frac{-3}{4}\right) = 221.41°$

2^{nd} sidloop $\longrightarrow$ at $K=2$

$\cos\theta = \pm\frac{5}{4}$ $\rightsquigarrow$ $\boxed{X}$ math error max of cos function $= 1$



2) The End Fire array of an 4 -element uniform linear array of element spacing d =$\lambda/2$ and successive phase shift δ . plot the radiation pattern and Find the mainlobe maximum and the sidelobe maxima and all of nulls?

② End fire Array

$N = 4 \quad , d = \lambda/2$

Condition $\delta = -kd$

$\psi = kd\cos\theta + \delta$

$= kd\cos\theta - kd$

$= \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \cos\theta - \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2}$

$\therefore \psi = \pi\cos\theta - \pi$

AT main lobe

Find θ_{max}

$\psi = \pi\cos\theta - \pi = 0$

$\pi\cos\theta = \pi$

$\theta = \cos^{-1}(1) = 0° , 180°$

To find nulls

$N\frac{\psi}{2} = \pm k\pi$

$\frac{4(\pi\cos\theta - \pi)}{2} = \pm k\pi$

$\pi\cos\theta - \pi = \pm\frac{k\pi}{2}$

$\pi(\cos\theta - 1) = \pm\frac{k\pi}{2}$

$\therefore \cos\theta = \pm\frac{(k+1)}{2}$

At 1^{st} null $\rightarrow k = 0 \Rightarrow \theta = \cos^{-1}(1/2) = 60°$

$\theta = \cos^{-1}(-1/2) = 120°$

Side lobes

$\frac{N\psi}{2} = \pm\frac{(2k+1)\pi}{2}$

$2(\pi\cos\theta - \pi) = \pm\frac{(2k+1)\pi}{2}$

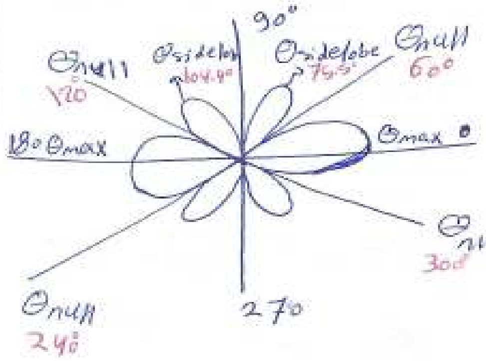
$\cos\theta - 1 = \pm\frac{(2k+1)}{4}$

$\cos\theta = \pm\frac{(2k+1)}{4} + 1$

$\cos\theta = \pm\frac{(2k+5)}{4}$

1^{st} sidelobe at $\theta = \pm 75.52°$

2^{nd} sidelobe $\theta = \pm 104.47°$



3) The Phased array with a maximum at an angle of 60 from the array line, of an 4 -element uniform linear array of element spacing d =$\lambda/2$ and successive phase shift δ . plot the radiation pattern and Find the mainlobe maximum and the sidelobe maxima and all of nulls?

③ Phased Array

$N=4 \quad , d = \lambda/2 \quad , \theta = 60^\circ$

$\psi = kd\cos\theta + \delta$

At mainlobe $\psi = 0$

$\frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \cos 60 + \delta = 0$

$\therefore \delta = -\pi \cos 60$

$\delta = -\frac{\pi}{2}$

$\therefore \psi = \pi \cos\theta - \pi/2$

$0 = \pi\cos\theta - \pi/2$

$\cos\theta = 1/2 \quad , \theta_{mainlobe} = 60^\circ, 300^\circ$

Nulls

$\frac{N\psi}{2} = \pm k\pi$

$2(\pi\cos\theta - \pi/2) = \pm k\pi$

$2\pi\cos\theta - \pi = \pm k\pi$

$2\cos\theta - 1 = \pm k$

$\cos\theta = \frac{\pm(k+1)}{2}$

at $k=1$

$\theta = \cos^{-1}(1) = 0^\circ ; 180^\circ$

at $k = \cancel{1}$

$\theta = \cos^{-1}(0) = 90^\circ, 270^\circ$

at $k=-2$, $\theta = \cos^{-1}(\frac{-1}{2})$

$= 120^\circ, 240^\circ$

sidelobe

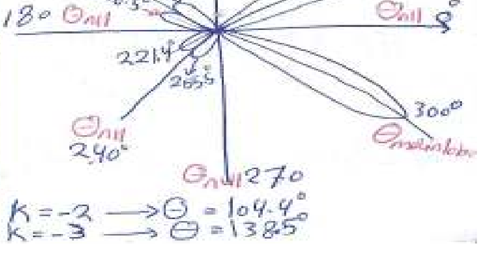
$\frac{N\psi}{2} = \frac{\pm(2k+1)}{2}\pi$

$2(\pi\cos\theta - \pi/2) = \frac{\pm(2k+1)\pi}{2}$

$2\cos\theta - 1 = \pm\frac{(2k+1)}{2}$

$2\cos\theta = \pm\frac{2k+1}{2} + 1$

$\cos\theta = \frac{\pm(2k+1)+2}{4} = \pm\frac{(2k+3)}{4}$



$k=-2 \longrightarrow \theta = 104.4^\circ$

$k=-3 \longrightarrow \theta = 138.5^\circ$