Antenna Axial Ratio Measurements

1. Planewave Polarization

2. Circularly Polarized Antennas

3. Antenna Axial Ratio Measurements

1. Planewave Polarization

- Planewave Polarization

$$\widetilde{\mathbf{E}}(z) = \hat{\mathbf{x}}\widetilde{E}_x(z) + \hat{\mathbf{y}}\widetilde{E}_y(z),$$

$$\widetilde{E}_x(z) = E_{x0}e^{-jkz},$$

$$\widetilde{E}_y(z) = E_{y0}e^{-jkz},$$

$$E_{x0} = a_x,$$

$$E_{y0} = a_y e^{j\delta},$$

$$\widetilde{\mathbf{E}}(z) = (\hat{\mathbf{x}}a_x + \hat{\mathbf{y}}a_y e^{j\delta})e^{-jkz}$$

$$\begin{aligned}\mathbf{E}(z,t) &= \Re\mathfrak{e}\left[\widetilde{\mathbf{E}}(z)\, e^{j\omega t}\right] \\ &= \hat{\mathbf{x}}a_x \cos(\omega t - kz) \\ &\quad + \hat{\mathbf{y}}a_y \cos(\omega t - kz + \delta)\end{aligned}$$

$$\begin{aligned}|\mathbf{E}(z,t)| &= [E_x^2(z,t) + E_y^2(z,t)]^{1/2} \\ &= [a_x^2 \cos^2(\omega t - kz) \\ &\quad + a_y^2 \cos^2(\omega t - kz + \delta)]^{1/2}\end{aligned}$$

$$\psi(z,t) = \tan^{-1}\left(\frac{E_y(z,t)}{E_x(z,t)}\right)$$

- LP(Linear Polarization)

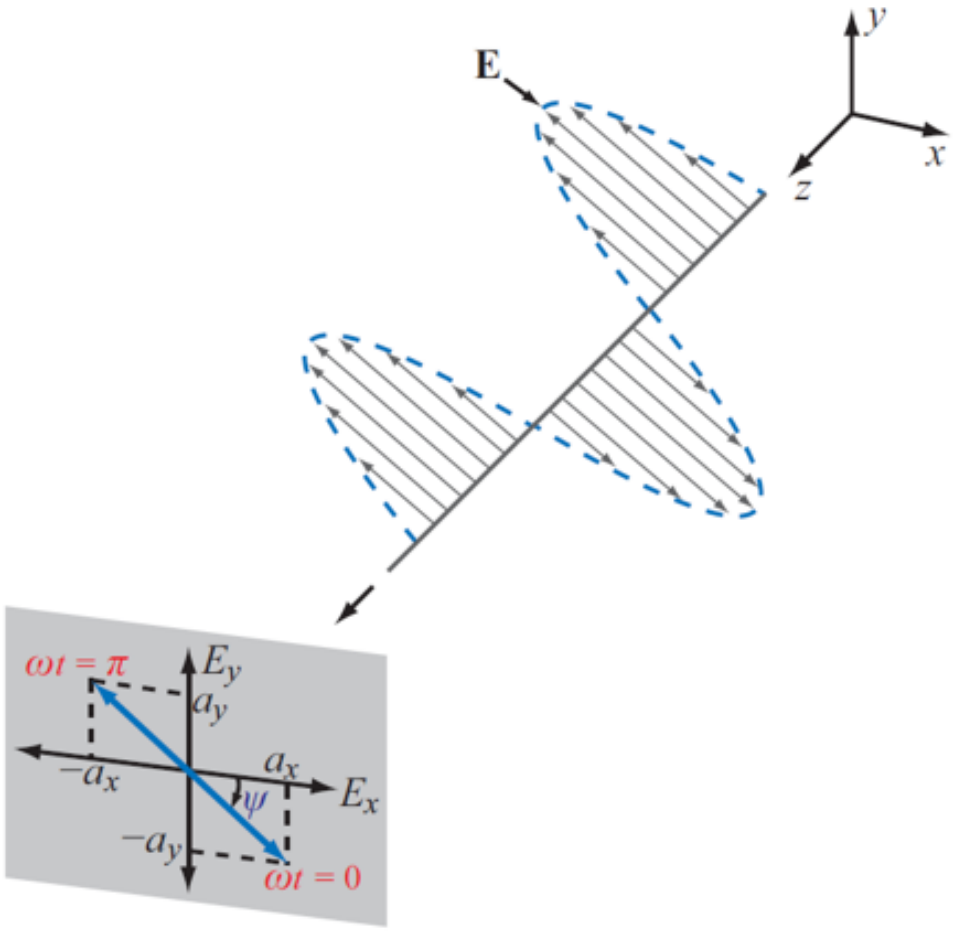
$$E_{x0} = a_x,$$

$$E_{y0} = a_y e^{j\delta},$$

$\delta = 0$ or $\delta = \pi$

$$E_x = a_x \cos(\omega t - kz)$$

$$E_y = a_y \cos(\omega t - kz)$$



- LHCP(Left-hand Circular Polarization)

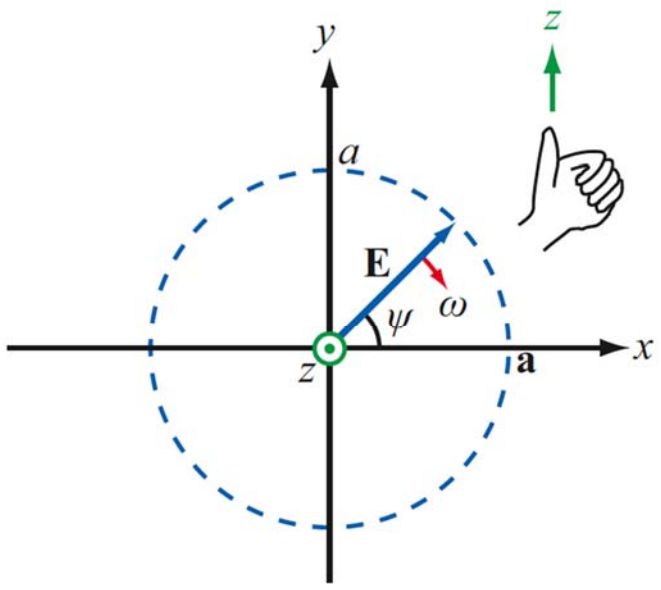
$$E_{x0} = a_x,$$

$$E_{y0} = a_y e^{j\delta},$$

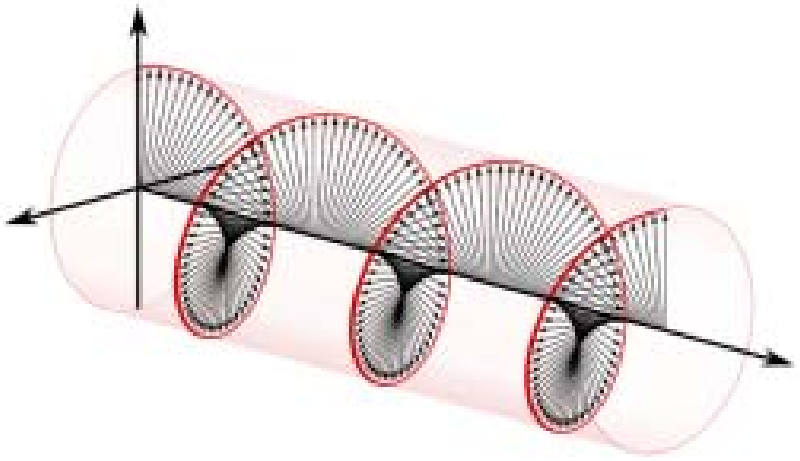
$$a_x = a_y = a \text{ and } \delta = \pi/2$$

$$E_x = a\cos(\omega t - kz)$$

$$E_y = a\cos(\omega t - kz + \pi/2) = -a\sin(\omega t - kz)$$



(a) LHC polarization



- RHCP(Right-hand Circular Polarization)

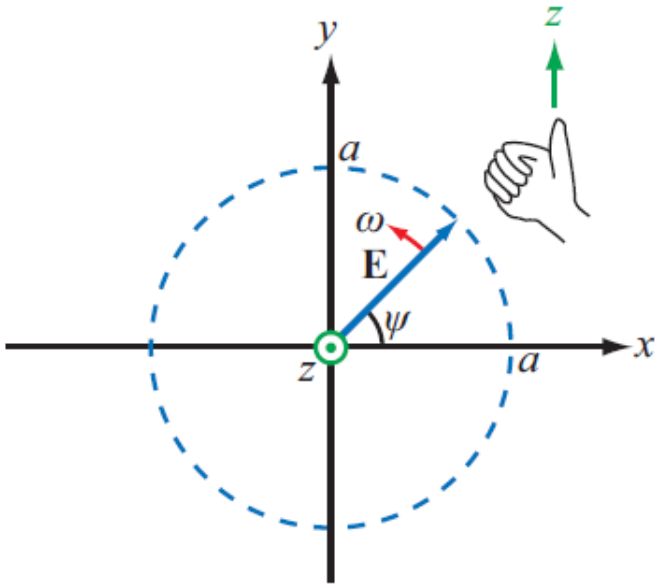
$$E_{x0} = a_x,$$

$$E_{y0} = a_y e^{j\delta},$$

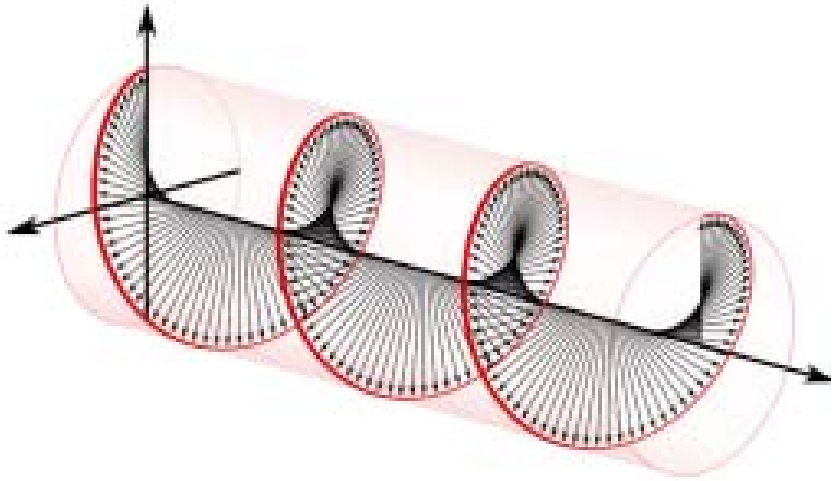
$$a_x = a_y = a \text{ and } \delta = -\pi/2,$$

$$E_x = a\cos(\omega t - kz)$$

$$E_y = a\cos(\omega t - kz - \pi/2) = a\sin(\omega t - kz)$$



(b) RHC polarization



- EP(Elliptic Polarization)

$$E_{x0} = a_x,$$

$$E_{y0} = a_y e^{j\delta},$$

$$\tan 2\gamma = (\tan 2\psi_0)\cos\delta \quad (-\pi/2 \le \gamma \le \pi/2),$$

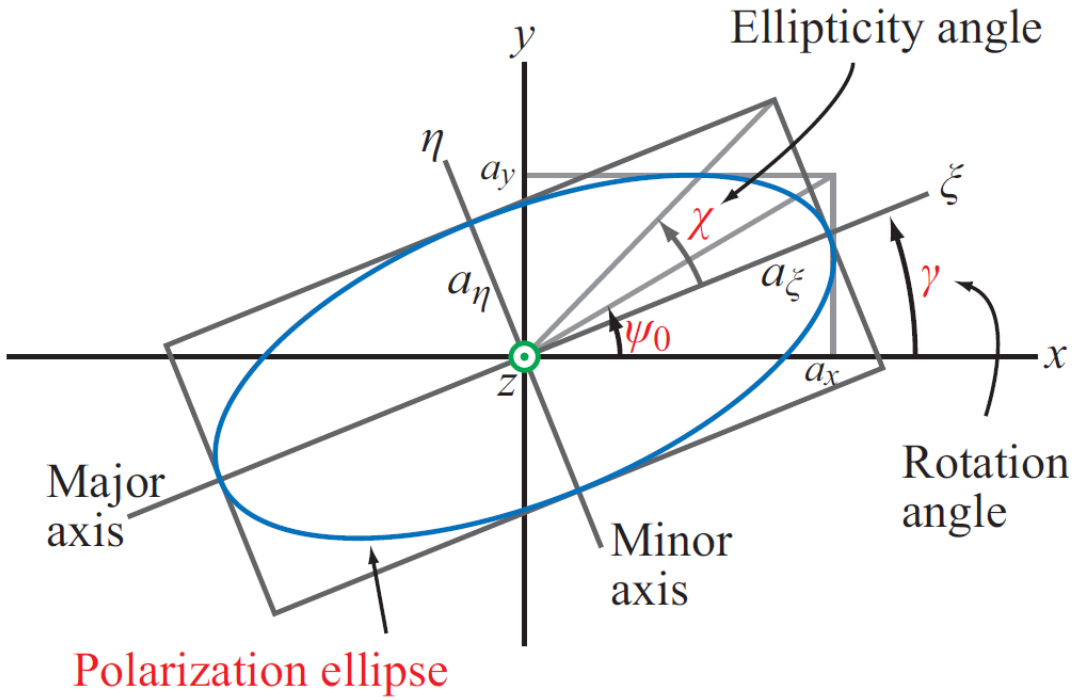
$$\sin 2\chi = (\sin 2\psi_0)\sin\delta \quad (-\pi/4 \le \chi \le \pi/4),$$

where ψ_0 is an ***auxiliary angle*** defined by

$$\tan\psi_0 = \frac{a_y}{a_x} \qquad \left(0 \le \psi_0 \le \frac{\pi}{2}\right.$$

$\gamma > 0$ if $\cos\delta > 0$,

$\gamma < 0$ if $\cos\delta < 0$.



- EP(Elliptic Polarization)

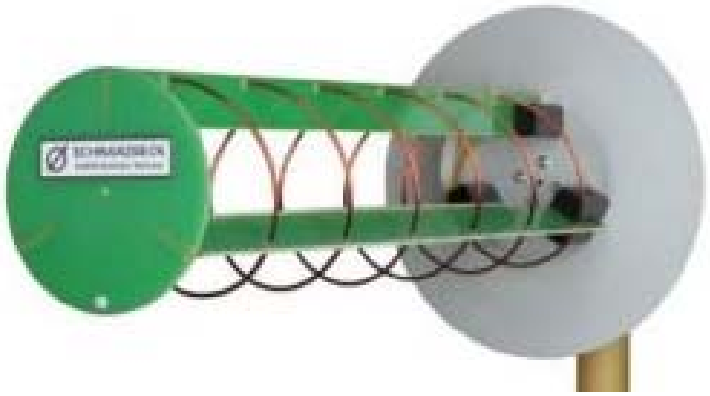
$$a_{\xi}^2 = (a_x^2 + a_y^2)\frac{1+\sqrt{1-\sin^2(2\gamma)\sin^2\delta}}{2}$$

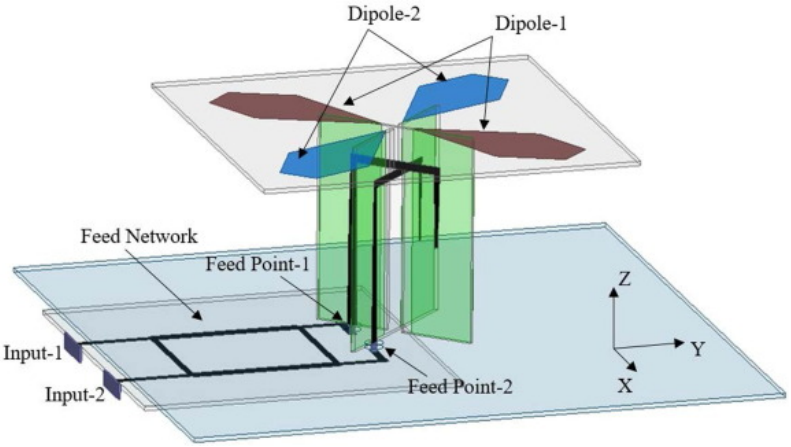
$$a_{\eta}^2 = (a_x^2 + a_y^2)\frac{1-\sqrt{1-\sin^2(2\gamma)\sin^2\delta}}{2}$$

$$\text{AR} = \frac{\text{Major axis}}{\text{Minor axis}} \geq 1$$

$$\text{AR (dB)} = 20\log_{10}\text{AR}$$

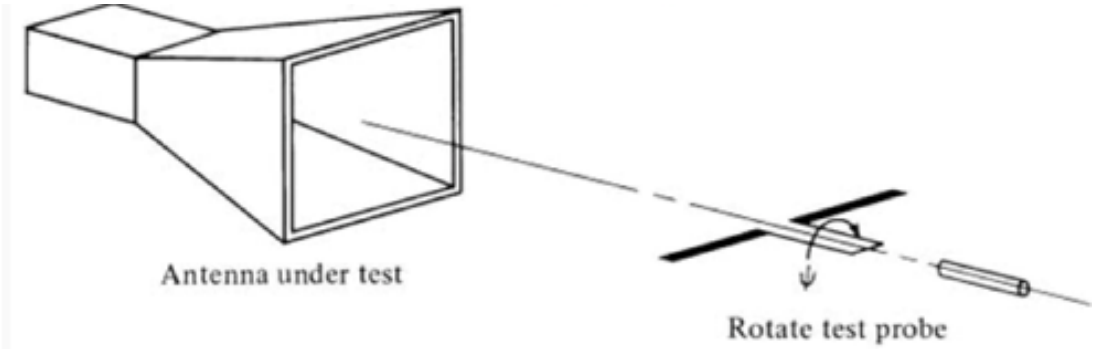
2. Circularly Polarized Antennas

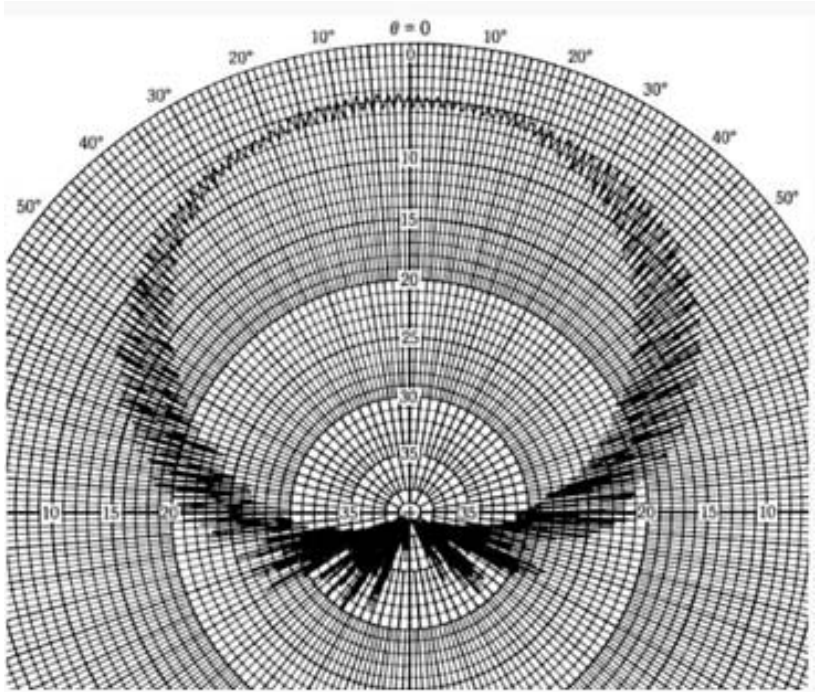




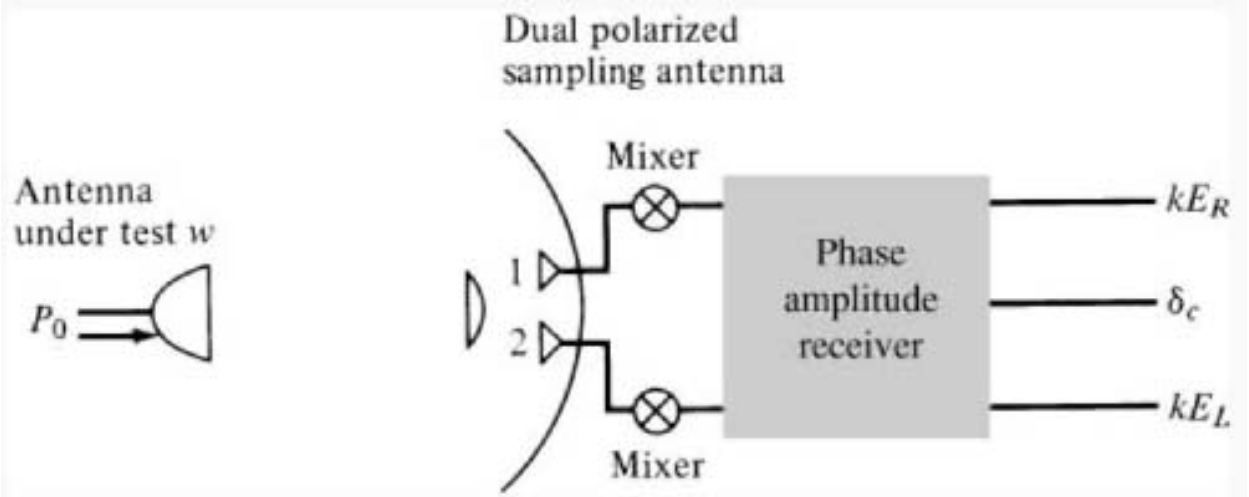
3. Antenna Polarization Measurements

- Rotating Dipole Method

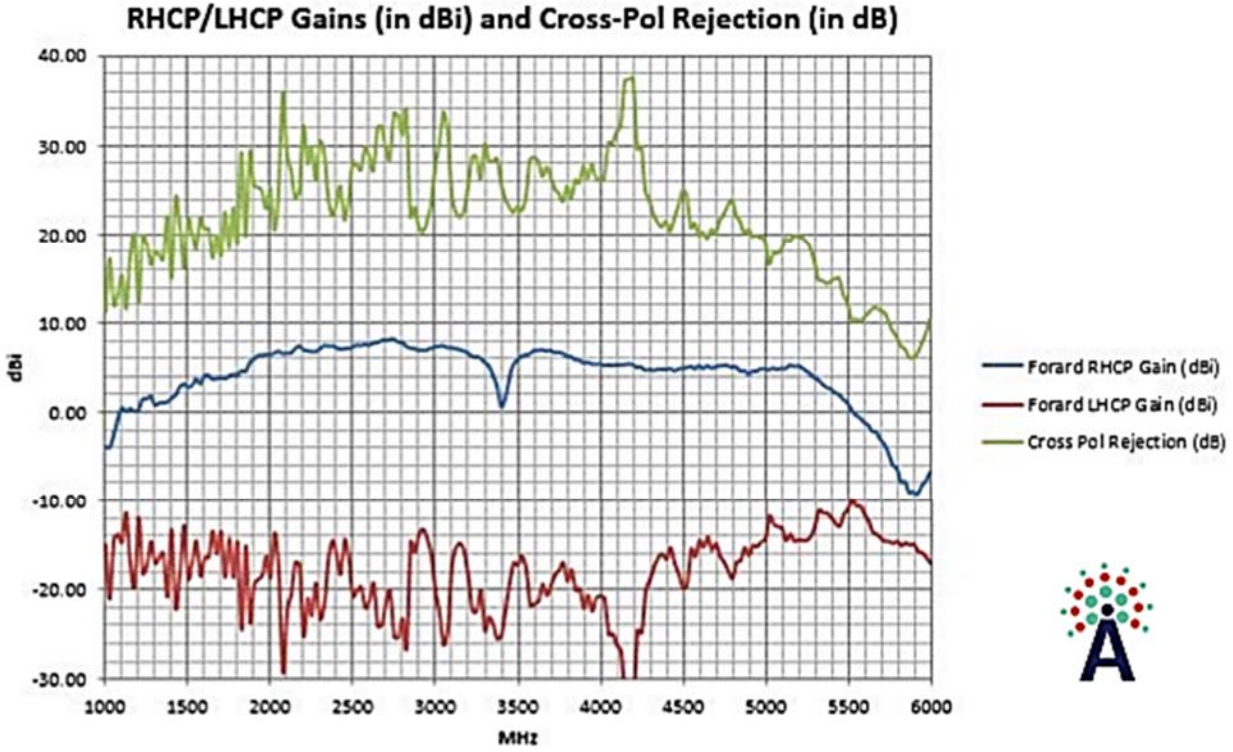


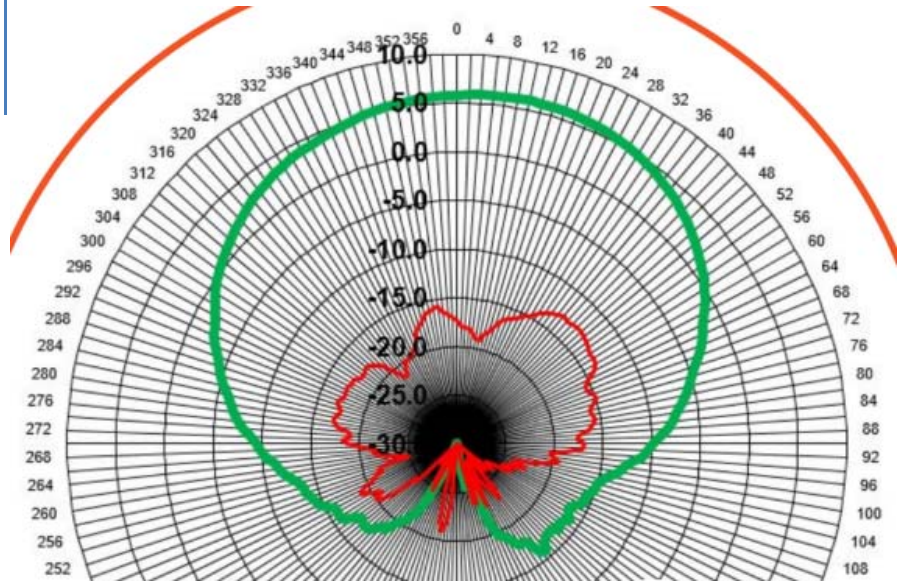


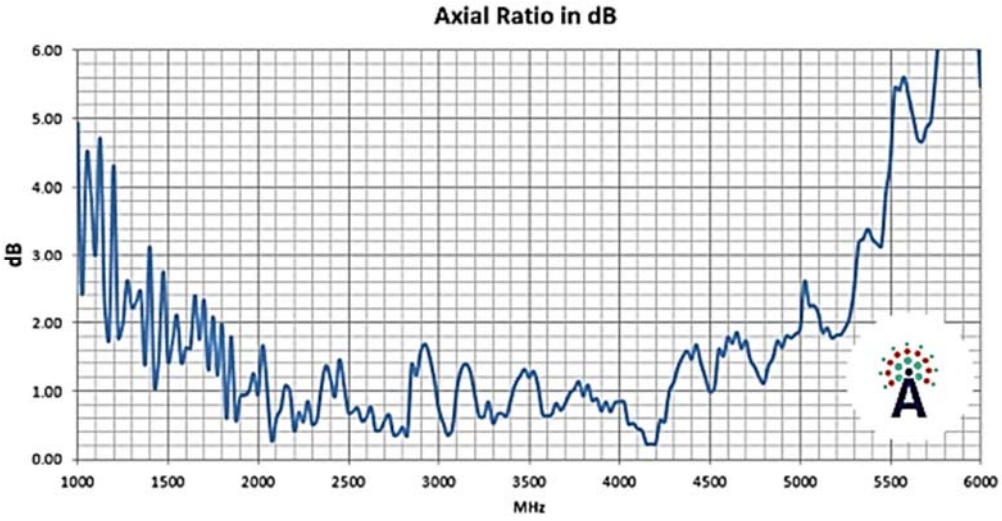
- Dual-polarization Measurement Method



- Example: cavity-backed planar Archimedian spiral antenna [antennatestlab.com]







Fin

(End)