POLARIZATION

Polarization of an antenna in a given direction is defined as the ***polarization*** of the wave transmitted (radiated) by the antenna.

When the direction is not stated, the polarization is taken to be the polarization of the maximum gain.

Polarization of a radiated wave is defined as that property of an electromagnetic wave describing the time varying direction and relative magnitude of an electric field vector, specially, the figure traced as a function of time at a constant location in time.

Generally, the polarization of an antenna is **direction dependent**, thus we can define a polarization pattern, i.e. polarization as a function of (θ,ϕ).

Rotation of Wave

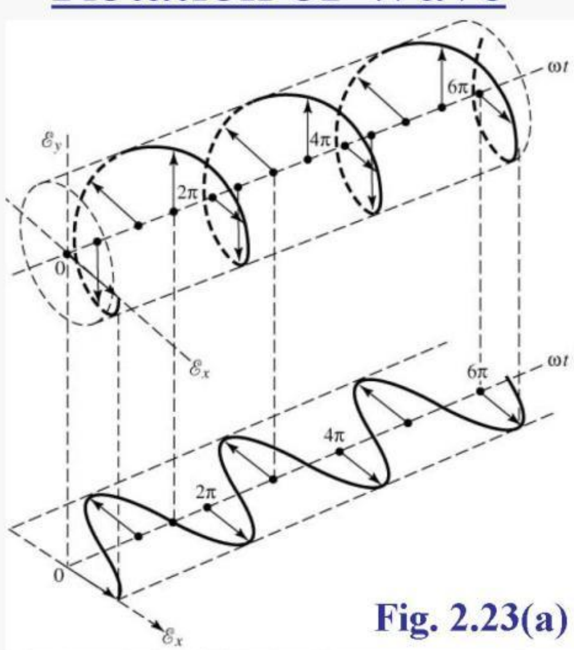
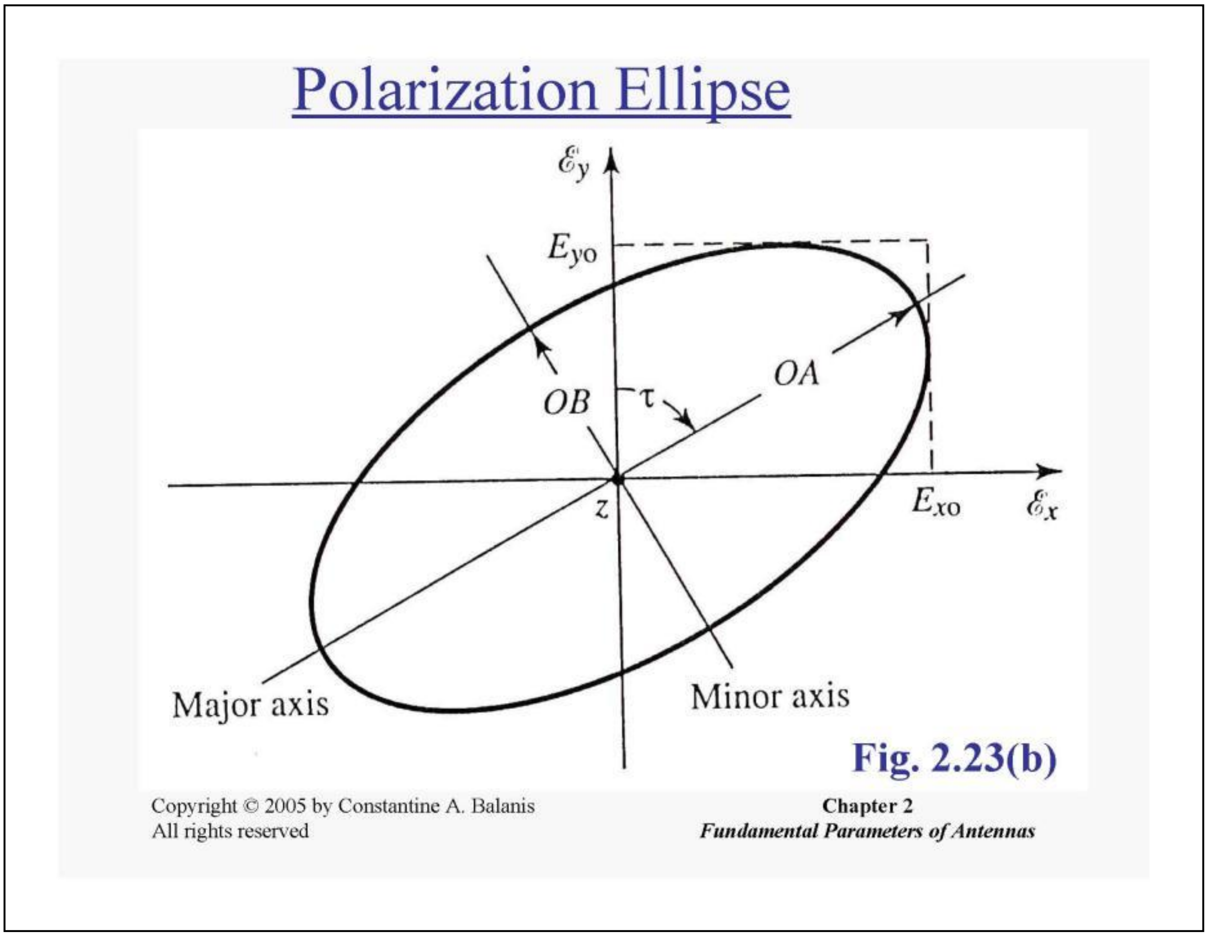


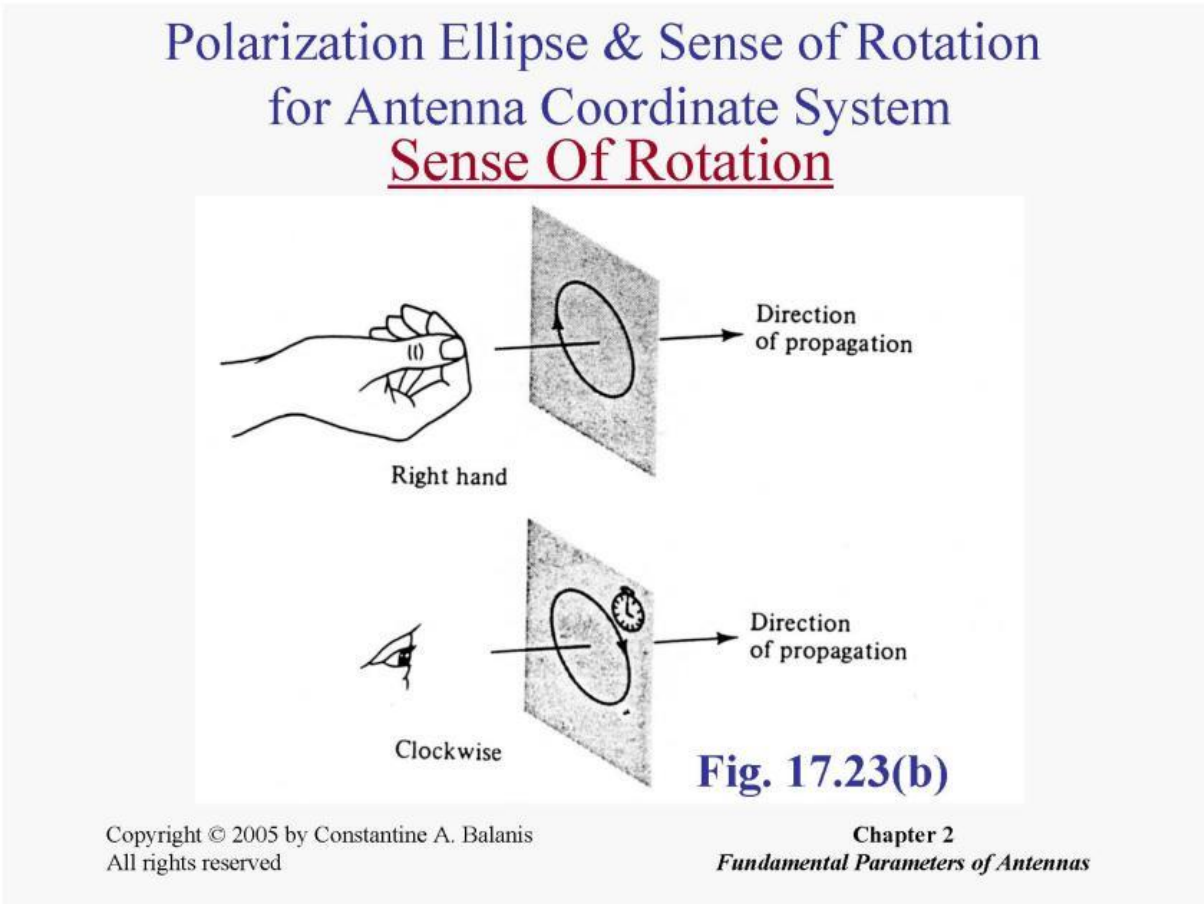
Fig. 2.23(a)

Chapter 2
Fundamental Parameters of Antennas

We have, in general **elliptic polarization**. **Linear** and **circular** polarizations are special cases.



The figure of the electric field is traced in a clockwise (CW) or counter-clockwise (CCW) sense. Clockwise rotation of the electric field vector is designated as *right-hand polarization* and counter-clockwise as left hand polarization.



Since the polarization is information of the time-varying field, we can convert the phasor field by using the following formula:

$$\bar{E}(x,y,z,t) = \mathrm{Re}\left\{\bar{E}(x,y,z)e^{j\omega t}\right\}$$

Example:

If the phasor electric field is $\bar{E}(z) = \hat{a}_x E_{x_o} e^{jkz}$, the time-domain expression:

$$\bar{E}(z,t) = \text{Re}\left[\hat{a}_x E_{x_o} e^{j(\omega t + kz)}\right] = \text{Re}\left[\hat{a}_x E_{x_o} e^{j(\omega t + kz)}\right]$$

$$\bar{E}(z,t) = \hat{a}_x \cos(\omega t + zt)$$

LINEAR POLARIZATION:

The plane wave is always oriented along the same straight line at every instant of time. This is accomplished if the field (electric or magnetic) possesses:

a) Only one component, or
b) Two orthogonal linear components that are in time phase or 180^o (or multiples of 180^o) out of phase.

CIRCULAR POLARIZATION:

The plane wave traces a circle at given point as a function of time.

The necessary and sufficient conditions to accomplish this are if the field vector possesses all the following:

1) The field must have two orthogonal linear components, and
2) The two components must have the same magnitude, and
3) The two components must have a time-phase difference of odd multiples of 90^o.

ELLIPTICAL POLARIZATION:

A harmonic wave is elliptically polarized if the tip of the field vector traces an elliptical locus in space. The necessary and sufficient conditions are:

a) The field must have two orthogonal linear components,
b) The two components can be of the same or different magnitude.

Example: What is the polarization of a wave propagating in the radial direction (along $\hat{a}_r$) if its electric field vector at any fixed point in space given by:

a) $\bar{E}_a = \hat{a}_\theta + j\hat{a}_\phi$

b) $\bar{E}_a = j\hat{a}_\theta + \hat{a}_\phi$

Solution:

$\bar{E}_a = \hat{a}_\theta \cos \omega t - \hat{a}_\phi \sin \omega t$ LHCP

$\bar{E}_a = -\hat{a}_\theta \sin s \omega t + \hat{a}_\phi \cos \omega t$ RHCP

POLARIZATION LOSS FACTOR

(Polarization Mismatch)

If the incoming wave can be expressed as:

$\bar{E}^i = E^i \hat{a}_i$

and antenna field can be expressed as:

$\bar{E}_a = E_a \hat{a}_a$

where $\hat{a}_{\hat{i}}$ and $\hat{a}_a$ can be complex, then the Polarization Loss Factor,

PLF=$\left|\hat{a}_i \cdot \hat{a}_a^*\right|^2 = \left|\cos \varphi\right|^2$

The value of the PLF $0 \le PLF \le 1$

If PLF=1, then antenna is polarization matched and there is no polarization power loss. If PLF=0, the antenna is incapable of receiving the signal.