ANTENNA THEORY
ANALYSIS AND DESIGN

THIRD EDITION

Constantine A. Balanis

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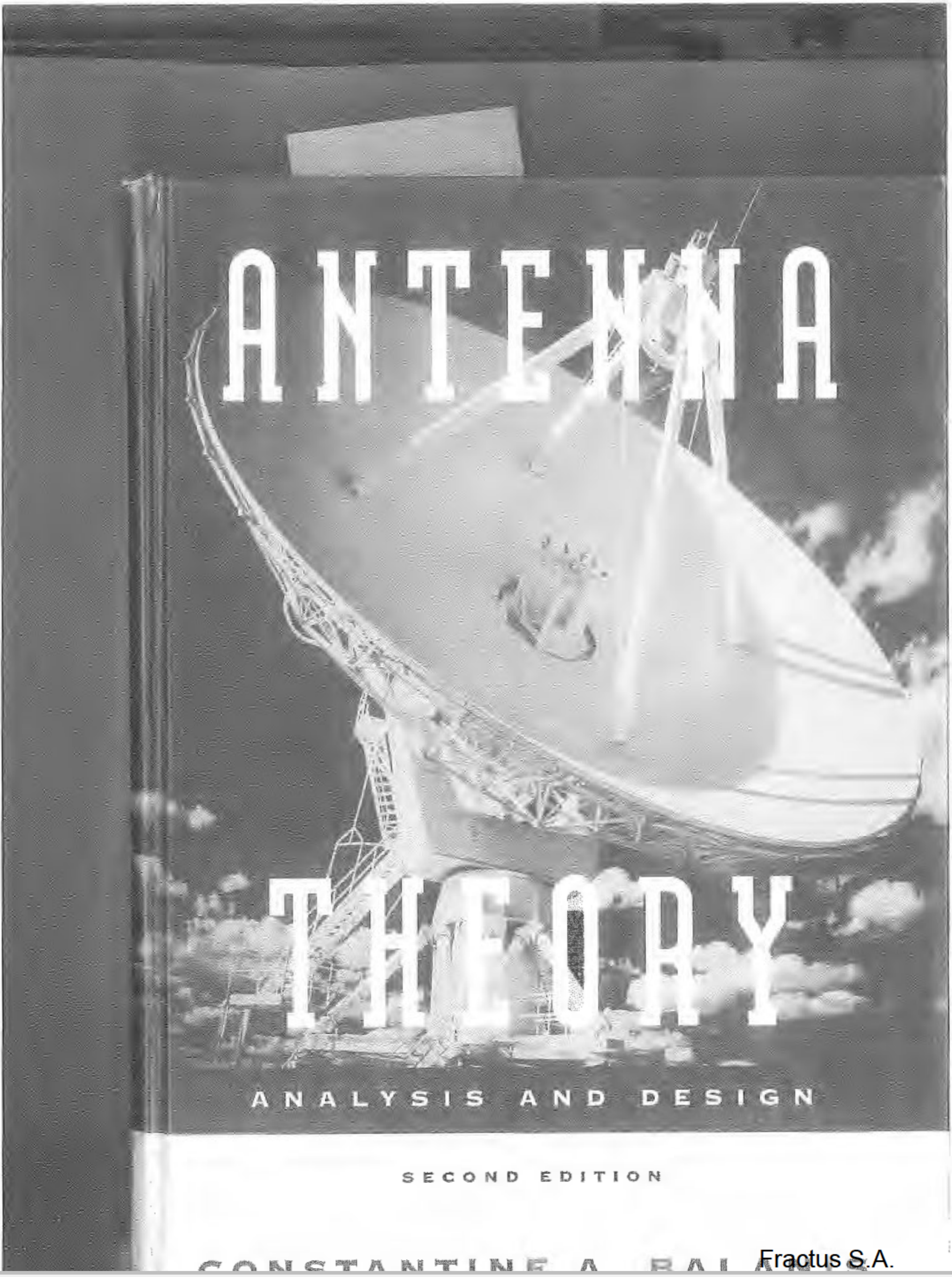

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CONSTANTINE A. BALA

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$$\beta = \pm k \tag{4-61b}$$

$$\gamma = kl/2 \tag{4-61c}$$

After some mathematical manipulations, (4-60) takes the form of

$$\boxed{E_\theta \simeq j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]} \tag{4-62a}$$

In a similar manner, or by using the established relationship between the E_θ and H_ϕ in the far-field as given by (3-58b) or (4-27), the total H_ϕ component can be written as

$$\boxed{H_\phi \simeq \frac{E_\theta}{\eta} \simeq j\frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]} \tag{4-62b}$$

4.5.3 Power Density, Radiation Intensity, and Radiation Resistance

For the dipole, the average Poynting vector can be written as

$$\mathbf{W}_{av} = \frac{1}{2}\mathrm{Re}[\mathbf{E} \times \mathbf{H}^*] = \frac{1}{2}\mathrm{Re}[\hat{\mathbf{a}}_\theta E_\theta \times \hat{\mathbf{a}}_\phi H_\phi^*] = \frac{1}{2}\mathrm{Re}\left[\hat{\mathbf{a}}_\theta E_\theta \times \hat{\mathbf{a}}_\phi \frac{E_\theta^*}{\eta}\right]$$

$$\mathbf{W}_{av} = \hat{\mathbf{a}}_r W_{av} = \hat{\mathbf{a}}_r \frac{1}{2\eta}|E_\theta|^2 = \eta\frac{|I_0|^2}{8\pi^2 r^2}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]^2 \tag{4-63}$$

and the radiation intensity as

$$U = r^2 W_{av} = \eta\frac{|I_0|^2}{8\pi^2}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]^2 \tag{4-64}$$

The normalized (to 0 dB) elevation power patterns, as given by (4-64) for $l = \lambda/4$, $\lambda/2$, $3\lambda/4$, and λ are shown plotted in Figure 4.6. The current distribution of each is given by (4-56). The power patterns for an infinitesimal dipole $l \ll \lambda$ ($U \sim \sin^2\theta$) is also included for comparison. As the length of the antenna increases, the beam becomes narrower. Because of that, the directivity should also increase with length. It is found that the 3-dB beamwidth of each is equal to

$l \ll \lambda$ 3-db beamwidth = 90°
$l = \lambda/4$ 3-dB beamwidth = 87°
$l = \lambda/2$ 3-dB beamwidth = 78° (4-65)
$l = 3\lambda/4$ 3-dB beamwidth = 64°
$l = \lambda$ 3-dB beamwidth = 47.8°

[redacted]

[redacted]

Elevation plane amplitude patterns for a thin dipole w

ribution ($l = \lambda/4, \lambda/2, 3\lambda/4, \lambda$).

As the length of the dipole increases beyond one wavelength ($l > \lambda$), the number of lobes begin to increase. The normalized power pattern for a dipole with $l = 1.25\lambda$ is shown in Figure 4.7. In Figure 4.7(a) the three-dimensional pattern is illustrated using the software from [5], while in Figure 4.7(b) the two-dimensional (elevation pattern) is depicted. For the three-dimensional illustration a 90° angular section of the pattern has been omitted to illustrate the elevation plane directional pattern variations.

[redacted]

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