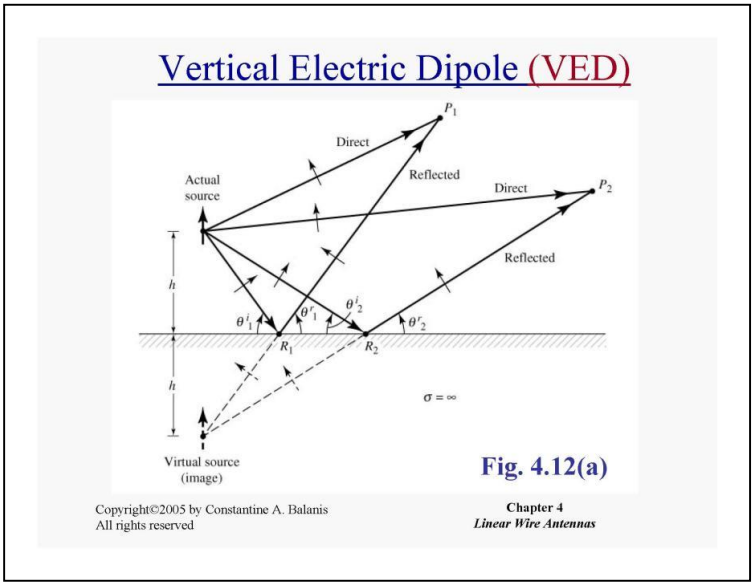
LINEAR ELEMENTS NEAR INFINITE PERFECT CONDUCTORS

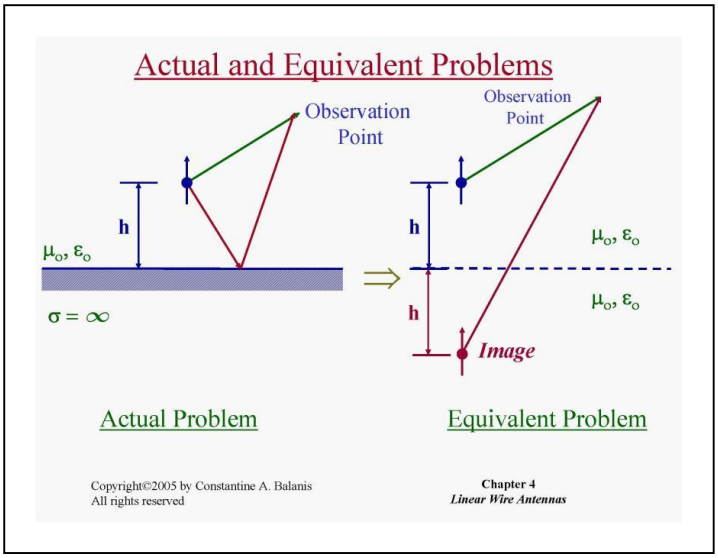
In general, ground is a lossy medium whose effective conductivity increases with conductivity.

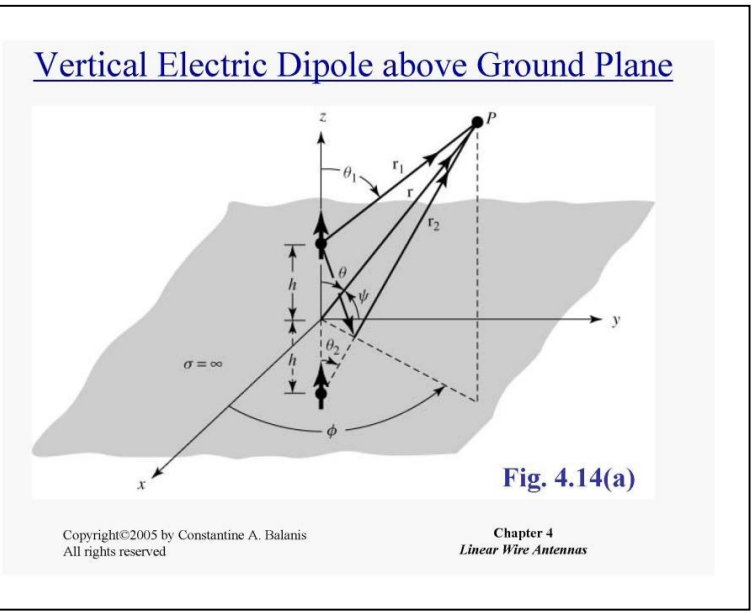
It can be considered as a good conductor.

Image Theory

To analyse the performance of an antenna near an infinite plane conductor, virtual sources (images) are introduced







The field above ground will be as if we have two dipoles, but below ground the field is zero.

The far zone component of the electric field of the infinitesimal dipole of a length ℓ and constant current I_o at observation point P is:

$$E_\theta^d = j\eta \frac{kI_o \ell e^{-jkr_1}}{4\pi r_1} \sin\theta_1$$

The reflected component can be accounted for by introducing the virtual source (image), and it can be written as since the reflection coefficient is equal to unity:

$$E_\theta^r = j\eta \frac{kI_o \ell e^{-jkr_2}}{4\pi r_2} \sin\theta_2$$

The total field above the interface $z \geq 0$ (the field inside the perfect electric conductor is zero, i.e. $z < 0$) is the addition of the direct and reflected

components. On the surface of the conductor, z=0, the tangential components of the electric field are zero.

We can write:

$$r_1 = \left[r^2 + h^2 - 2rh\cos\theta \right]^{1/2}$$

$$r_2 = \left[r^2 + h^2 - 2rh\cos(\pi - \theta) \right]^{1/2}$$

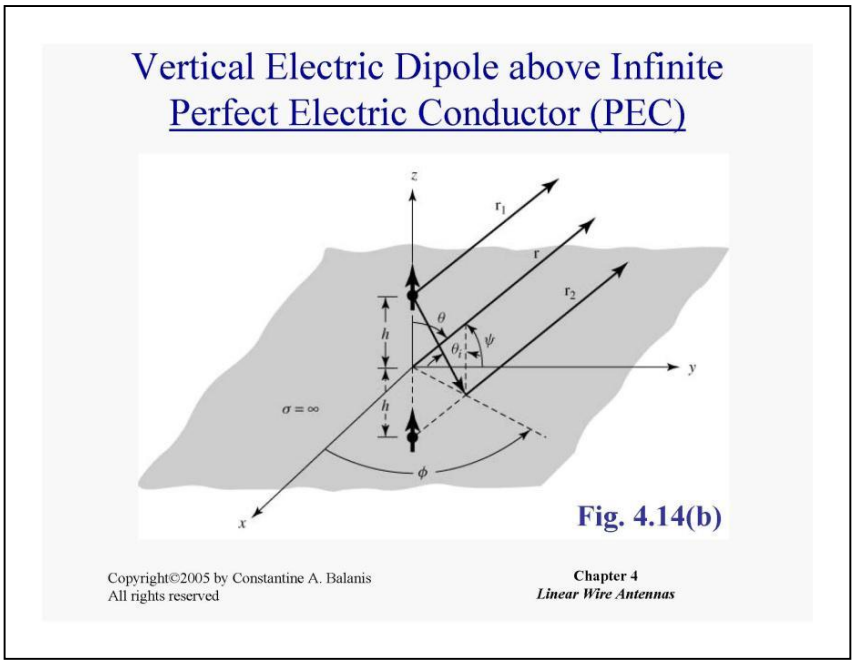
Far field observations $r \gg h$, we can use binomial expansions:

$$r_1 \approx r - h\cos\theta$$

$$r_2 \approx r + h\cos\theta$$

For amplitude variations:

$r_1 \simeq r_2 \simeq r$ (in the far field region r_1, r_2 and r become parallel.



So, the total fields:

$$E_\theta \simeq j\eta \frac{kI_o \ell e^{-jkr}}{4\pi r} \sin\theta \left[2\cos\left(kh\cos\theta\right)\right] \qquad z \geq 0$$

$$E_\theta \simeq 0 \qquad z < 0$$

This is equal to the product of the field of a single source positioned symmetrically about the origin and a factor (the term within the brackets) which is a function of the antenna height (h) and the observation angle θ. This is referred as pattern multiplication and the factor is the array factor which will be discussed later in details.

The shape and amplitude of the field is a function of the single element and as well the position above the ground. The following figure shows the normalized (to 0 dB) power patterns for different h values. Because of the symmetry, only half of each pattern is shown.

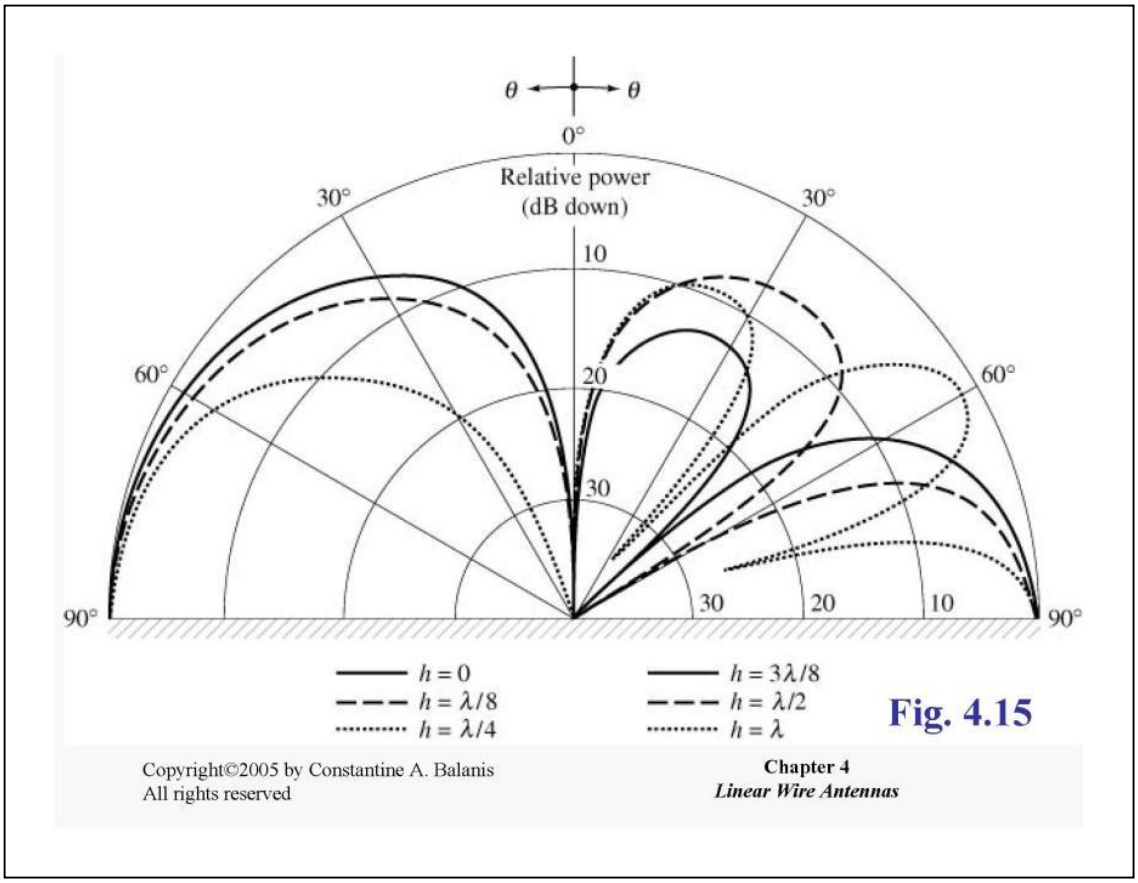


Fig. 4.15

For $h > \frac{\lambda}{4}$ more minor lobes are formed.

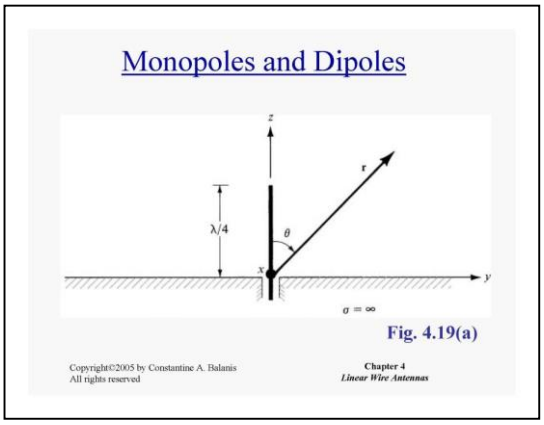
MONOPOLES AND DIPOLES

Monopole and dipole antennas are widely used in wireless communication systems.

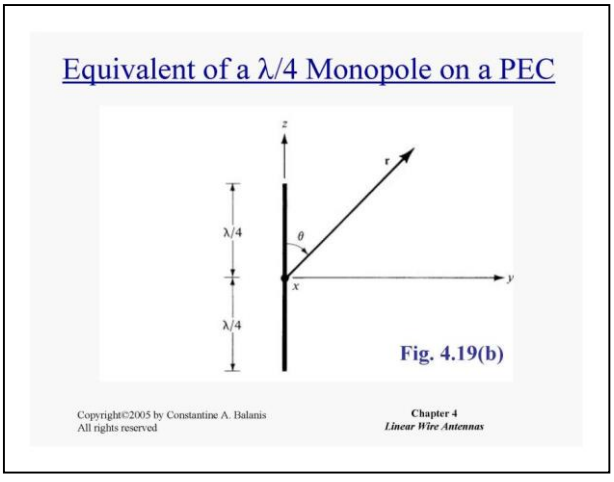
Monopole antennas are popular for portable units, automobiles and other vehicles.

In practice, quarter wave monopole antennas are widely used.

Monopole antenna is a wire antenna touching the ground at one end.

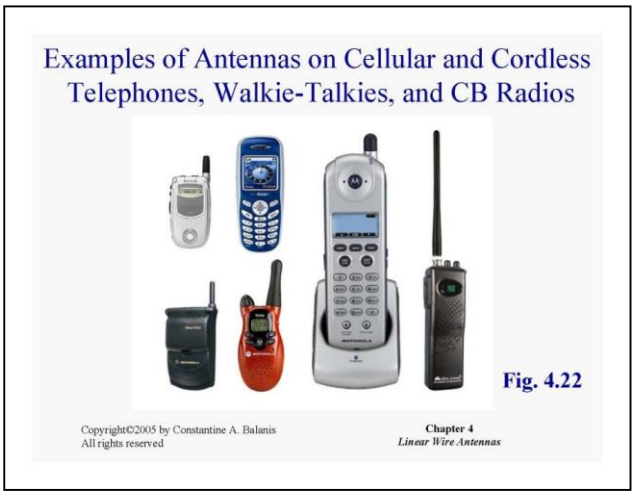


Monopolo of $\ell = \frac{\lambda}{4}$ above the ground is equivalent to the half-wave dipole for above the ground.

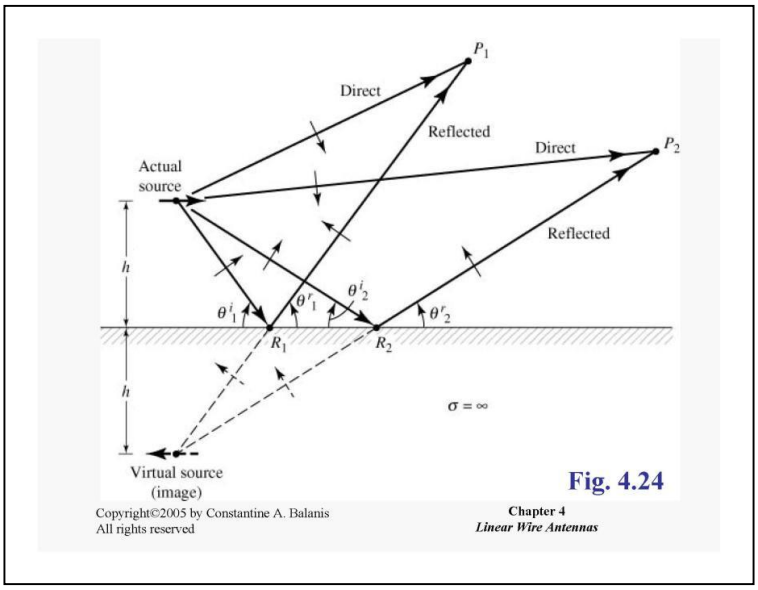


P_{rad} only above ground, half of the power of half-wave dipole.

$$R_r = \frac{73}{2} = 36.5\Omega$$



HORIZONTAL (Hertzian) Dipole



Horizontal Electric Dipole Above an Infinite Perfect Electric Conductor

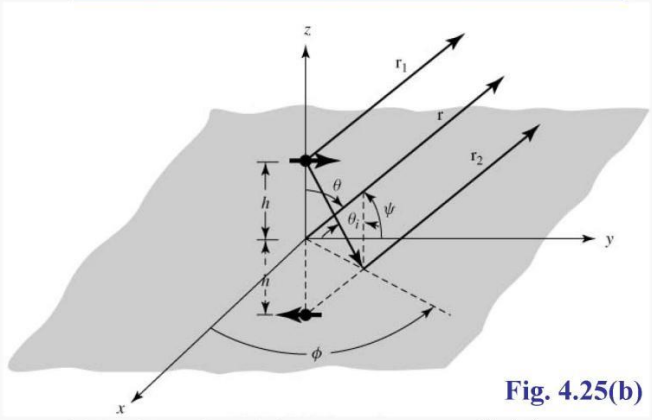


Fig. 4.25(b)