EE533-12

note: no class - Lecture 11

example: $f = 1\,MHz \Rightarrow \lambda = 300\,m$

Let $L = 1m$ (old style car ant)

$$R_r = 80\pi^2 \left|\frac{1}{300}\right|^2 = 0.00876\,\Omega \quad \text{(for uniform I)}$$

$$R_r = 20\pi^2 \left|\frac{1m}{300m}\right|^2 = 0.00219\,\Omega \quad \text{(for Linear I)}$$

$$R_s = \sqrt{\frac{\omega\mu}{2\sigma}} = 2.63\times10^{-4}$$

$R_\Omega = 0.103\,\Omega$ (uniform) $\qquad R_\Omega = 0.0344\,\Omega$ (linear)

$\eta = 7.8\%$ $\qquad \eta = 6\%$

$\Rightarrow$ We loose more than 90% of the power to heat! (even if we could match a T Line to the antenna!)

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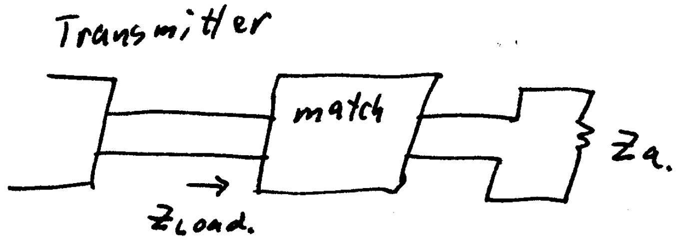


when Z_a is very small it is very difficult to design a Low loss matching network, ⇒ AM car antennas use a partial match + live with the very low effeciency!

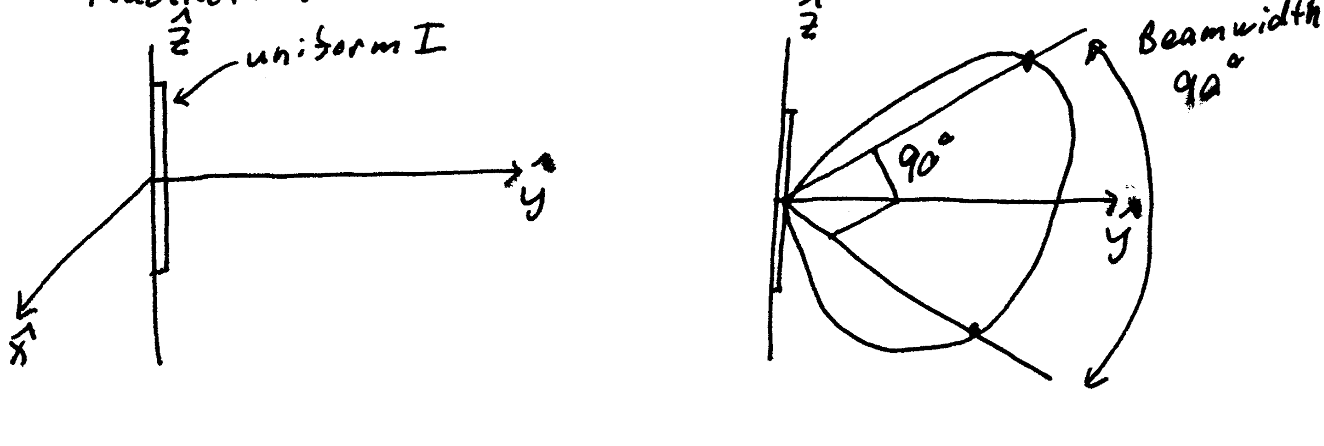
To increase η we must increase the antenna size ⇒ $\approx \lambda/2$ if possible.

example:

Cell phone Antenna $f \cong 1GHz$

$\lambda = .3cm = 30cm \Rightarrow \eta \approx 99\%$ are possible.

Radiation Pattern of a short dipole - far-field.



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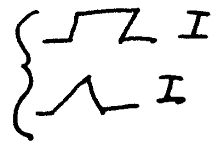
$\hat{x}$ - $\hat{y}$ plane : omnidirectional radiation

$\hat{y}$ - $\hat{z}$, $\hat{x}$ - $\hat{z}$ } plane: Beamwidth = 90°

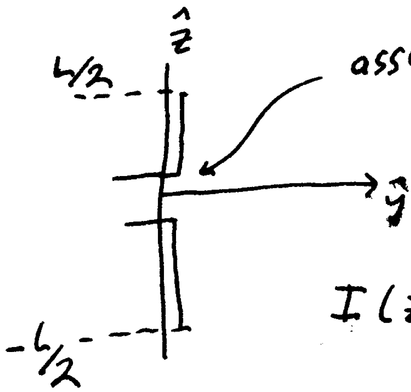
note: for Both



the directivity $D = \frac{3}{2} = 1.76\ dBi$ (see text for details)

$\frac{\lambda}{2}$ dipole $\rightarrow L = \frac{\lambda}{2}$.

assume gap feedpoint distance ≈ 0



$$I(z) = I_o \cos\left(\frac{2\pi z}{\lambda}\right)$$ $\Rightarrow$ current distribution.

$$E_\phi = 0$$

$$E_\theta = j\omega\mu \frac{2I_o}{k} \frac{e^{-jkr}}{4\pi r} \frac{\cos\left[\frac{\pi}{2}\cos\theta\right]}{\sin\theta}$$

The normalized field $F(\theta) = \dfrac{\cos\left[\frac{\pi}{2}\cos\theta\right]}{\sin\theta}$

$D = 1.64 = 2.15\,dBi$

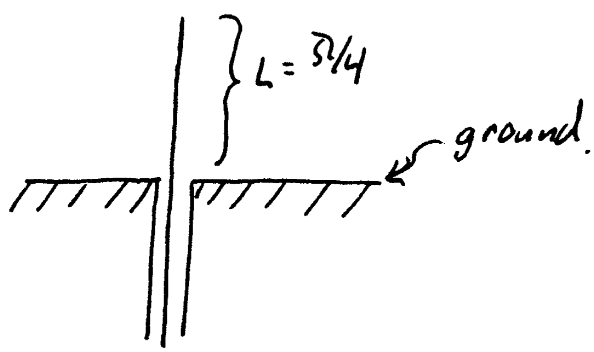
$R_r = 73\Omega$ fixed value.

$R_\Omega = 7.7\Omega$ for copper.

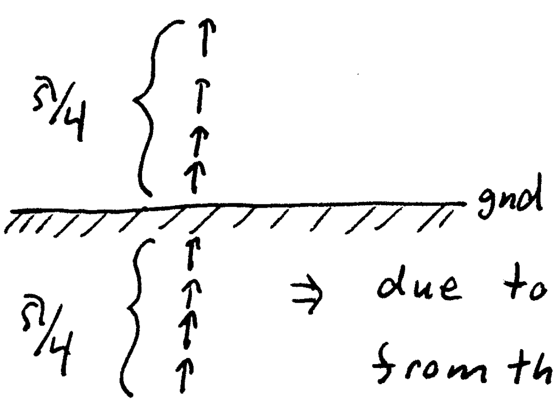
then $\eta = 90\%$!

Lecture 13 10/1/08

the monopole ⇒ special case of dipole.



Radiation is from the current on the wire and the induced current on the ground plane.



by image theory (see section 4.71 txt)

⇒ due to the image (≈ the contribution from the induced current on the ground plane)

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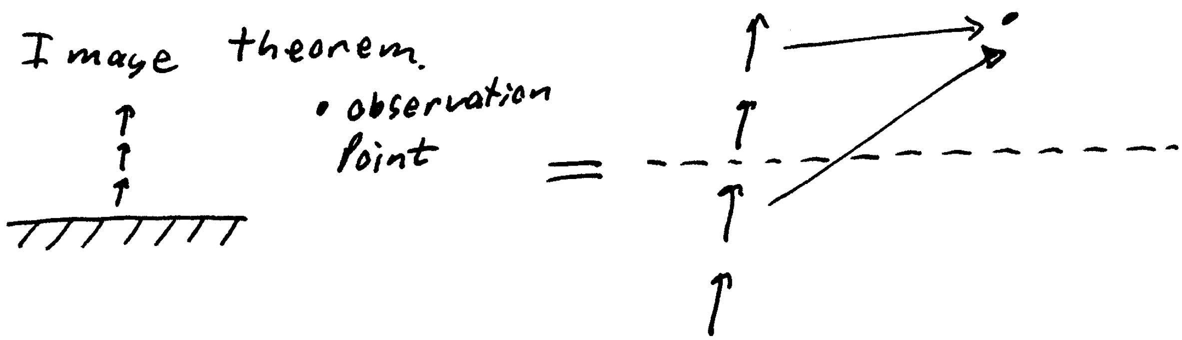
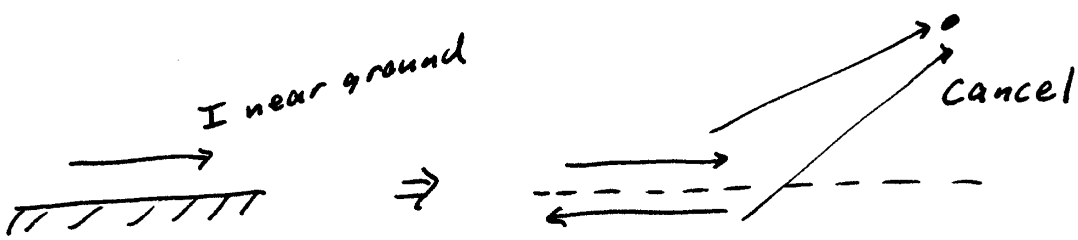
$\frac{\lambda}{4}$ + gnd plane $\approx$ a $\frac{\lambda}{2}$ dipole.

Image theorem.



note for current distributions near the ground, this only works when I is $\perp$ to the ground.



this is an example of microstrip line on a PCB. the line is not radiating. but is transporting E+M power along the transmission line.

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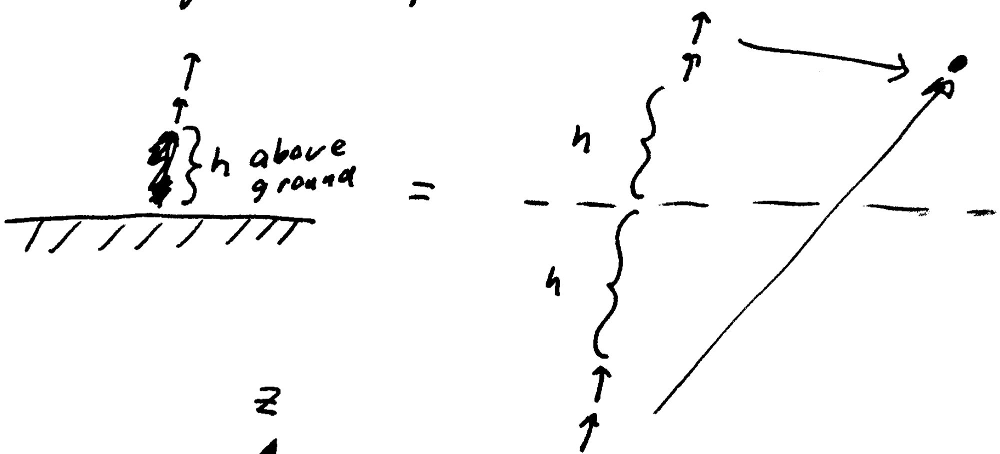
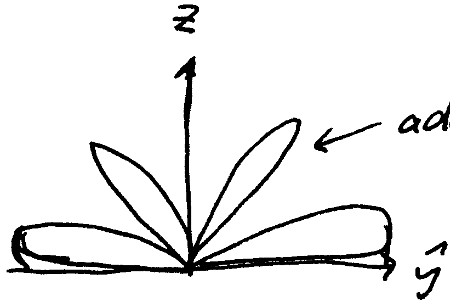
as the antenna is placed <u>higher</u> above the ground, additional lobes appear and the gain drops.

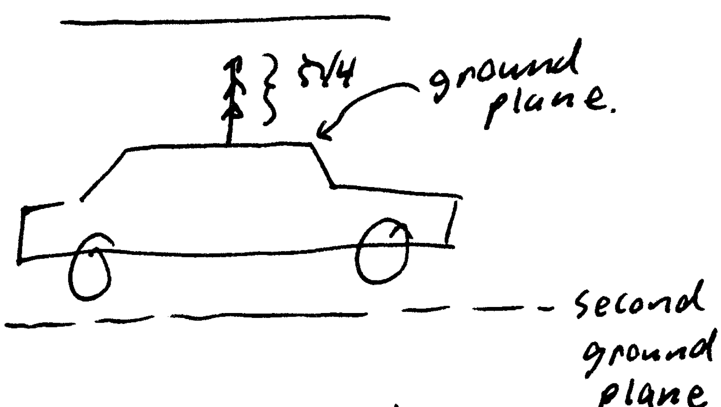




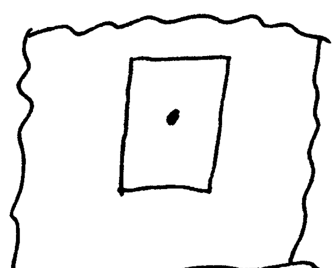
additional lobes as h increases.

see fig 4.15 in text.

number of lobes $\cong \frac{2h}{\lambda} + 1$



Top view.



so some side lobes are possible depending on λ.

example of steped gnd plane.

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Directivity of $\lambda/4$ on ground:

$D_{\lambda/4} = \frac{\lambda}{4} + \text{gnd directivity} = 2 D_{\lambda/2}$

this is because the power is radiated only 180° in elevation plane. ↳ D_{of} $\frac{\lambda}{2}$ antenna.

from before, $D_{\lambda/2} = 1.64 = 2.15\,dBi$

$D_{\lambda/4} = 2 D_{\lambda/2} = 3.28 = 5.16\,dBi$! this is substantial

from Text: $Z_a|_{\lambda/2} = 73 + j\,42.5$ (4-93 txt)

$Z_a|_{\frac{\lambda}{4}} = \frac{Z_a|_{\lambda/2}}{2} \Rightarrow 36.5 + j\,21.25$ (4-106 txt)

See Table 4.2 in Text for Summary of dipole in Far Field.

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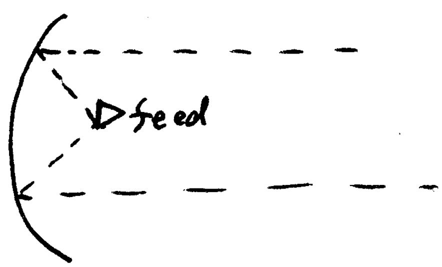
Gain $\Rightarrow$ $G = D \cdot \eta_e$ where $\eta_e < 1$ is the antenna efficiency

for a dipole antenna: $\eta_e < 10\%$ short dipole

$\eta_e > 90\%$ $\frac{\lambda}{2}$ dipole.

High gain antennas are usually a <u>reflector</u> type:

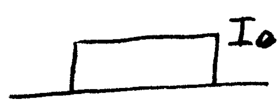


Directivity

$D_o(\text{maximum}) = \frac{4\pi}{\lambda^2} A_p$

A_p: physical aperature Area.

D_o is only achieved with uniform field distribution.



$G = \frac{4\pi}{\lambda^2} A_e$

A_e is the "effective" area. this corrects for the non uniform field dist over the physical aperature.

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$A_e < A_p$

$A_e = \varepsilon_e A_p$ ε_e = Aperture effeciency

so $G = \left(\frac{4\pi}{\lambda^2} A_p\right) \varepsilon_e$ for dish antennas. $\varepsilon_e \approx 55\%$ including feed point coupling.

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gain increase using pattern multiplication.

the gain of a simple antenna is usually small. this is ok for some applications, but what about where we want higher gain? (ex: point to point fixed Link.)

One method is to use an array of simple antennas to increase $A_e \Rightarrow$ which will increase G.