

Rad pattern	Antenna ckt. model	dipole	patch
↳ beamwidth	↳ RLC series	↳ from time	↳ current distrib
↳ omnidirectional	↳ multi-resonant	↳ current distrib	
↳ dBi		↳ Rad approx.	

- Discussing propagation of fields → Friis transmission $P_{rx} = P_{tx} G_{tx} G_{rx} \left(\frac{\lambda}{4\pi r}\right)^2$

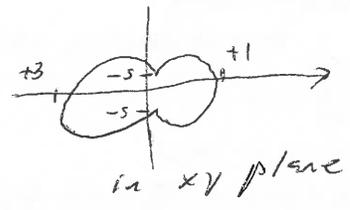
• Detail about polarization → rotating vector called circular polarization.

• Details about gain
 ↳ reported as dBi ~ decibels relative to isotropic

$$\sim 10 \log \frac{I(\theta, \phi)}{P_{tx}/4\pi r^2}$$

 ~ can add to logarithmic path loss

↳ reported as radiation pattern
 - polar plot of gain
 - logarithmic/dBi radius

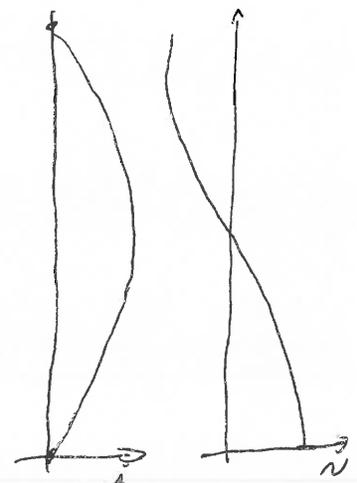
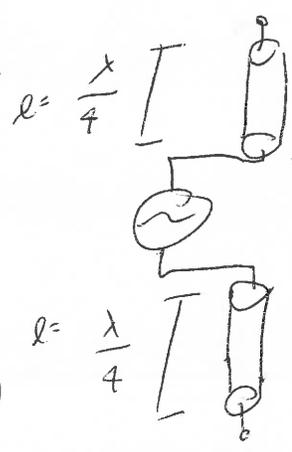


↳ summarized as beamwidth
 - half power angle of main lobe

↳ omnidirectional refers to uniform rad. pattern in one plane ≠ isotrop

Today = specific antennas & how to put them in circuits

- Need to start w/ the dipole
- "Bent" transmission line
- Assume sinusoidal current distrib.



driven @ $\lambda/2$ (zero current @ tips)

• Get same voltage for VSWR

- Z_{in} (feedpoint impedance) varies w/ feed location

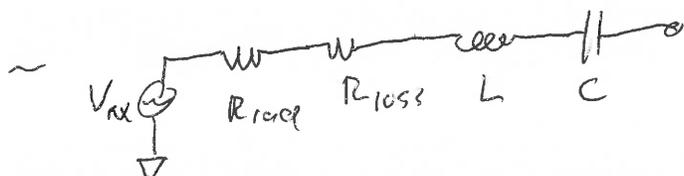
↳ Z_{in} varies @ different spots

↳ pick lowest Z_{in} as usual feed b/c 50Ω small

- Z_{in} varies w/ frequency

~ only $1/4$ @ cr frequency

~ model as reactive antenna behavior



~ measure power delivered to R_{rad} ... sometimes matching network but tend to be lossy

- Really care about R_{rad}

~ get from field theory

~ model differential element w/ pointing vector to find $\delta P \propto |I|^2$
Hertzian dipole

~ integrate over antenna & divide by $|I|^2$ $73 \Omega @ 1/2$

~ ($R_{rad} \equiv P_{tot} / |I|^2$, by the way)

• $R_{rad} \approx 20 \pi^2 \left(\frac{l}{\lambda}\right)^2$ if $l \ll \lambda$ • $R_{rad} = \frac{2\pi}{3} Z_0 \left(\frac{l}{\lambda}\right)^2$ for $1/2$

Effective length

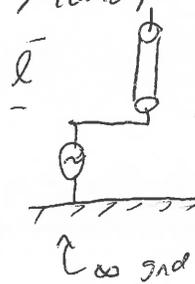
- fringing field @ end means $l \neq 0$

- treat as ~5% longer

- capacitance extends



Monopole:



- creates "image" charge antennas

- comes from Marconi

- $l_{eff} = 2 \times l \rightarrow 4 \times R_{rad}$ but only top $1/2$ radiates

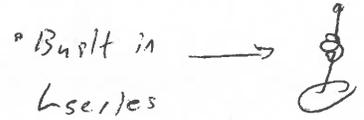
$R_{rad} = R_{rad, dipole} \times 2$

- short dipole is net capacitive reactance

↳ transform impedance up w/ series inductor

↳ $\sqrt{L/C} = \alpha$ higher α & l down so eventually re BW

- can approx. voltage as $\vec{E} \cdot l$

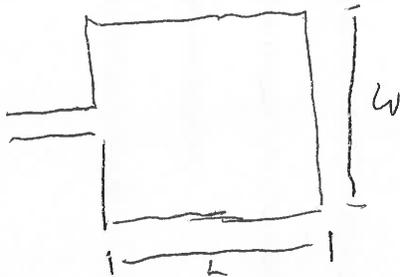


- Structures are multi-resonant - get $\vec{I} = 0$ @ $l = \lambda/2$ ~~($\lambda/4$)~~

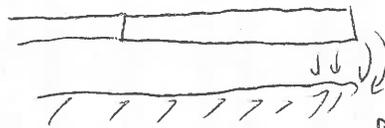
↳ but Rrad changes so less power delivered to modes w/ long l/λ

Patch antennas

Top view



side view



- can implement in microstrip

- High Q \rightarrow narrow BW

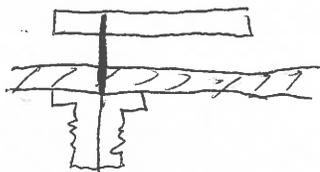
radiation caused by these fringing fields



very high Z
very low Z
 \approx short

- can adjust impedance by adjusting feed location

$$R_{rad} \approx \frac{90 \left(\epsilon_{r,eff} \frac{L+H}{L+H} \right)^2}{\epsilon_{r,eff} - 1}$$



↳ empirical

↳ longer width leaks more P

Large W gets weird

- How does it know which way to make standing wave?

↳ 2D resonant modes...