

Antenna Review

Patch Antennas

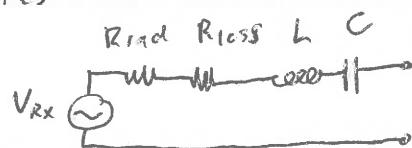
Noise Intro

Receiving Noise

- ↳ what is G_{eff}^2
- ↳ detⁿ including T \rightarrow LNA needs
- ↳ time & freq \rightarrow Noise vs signal spectrum

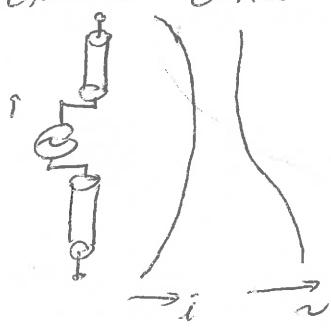
Talking about antennas

- ↳ circuit model



- ↳ R_{rad} represents loss to radiation \sim TX wants to dissipate power in it
- ↳ $L + C$ suggest antenna is resonant ... can only deliver P effectively @ one f

Resonance comes from geometry of wave on antenna



- special phase relationship when a wave fits exactly on an antenna \rightarrow real R_{rad}

- Out of phase if wave bigger or smaller than antenna $\rightarrow L + C$ model this

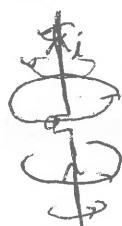
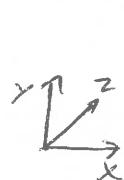
$$R_{\text{rad}} = 20 \pi^2 \left(\frac{l}{\lambda} \right)^2$$

- ↳ dipole \sim often use "short" dipole w/ λ not quite on it $\sim 73 \Omega @ \text{res}$
- ~ capacitive not resistance
- ~ series L makes more real, cap has "extends" length (^{as does}
_{monopole})

- 2 more topics: why directivity? patch antennas

often by accident
anything is near field leads

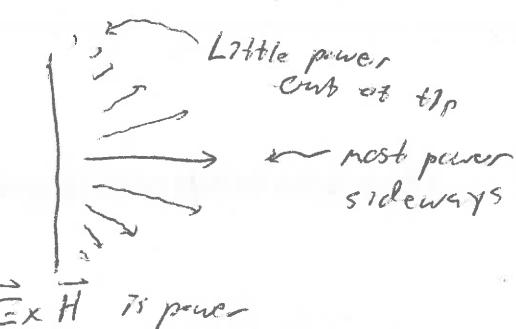
dipole directivity



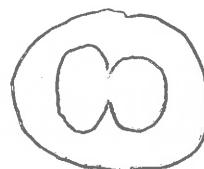
\vec{E} fields b_{top}
middle w/ b_{bottom}



\vec{E} fields



$\vec{E} \times \vec{H}$ is power



X Y rad pattern



In 3D rad pattern

• Max gain $\sim 1.79 \text{ dBi}$

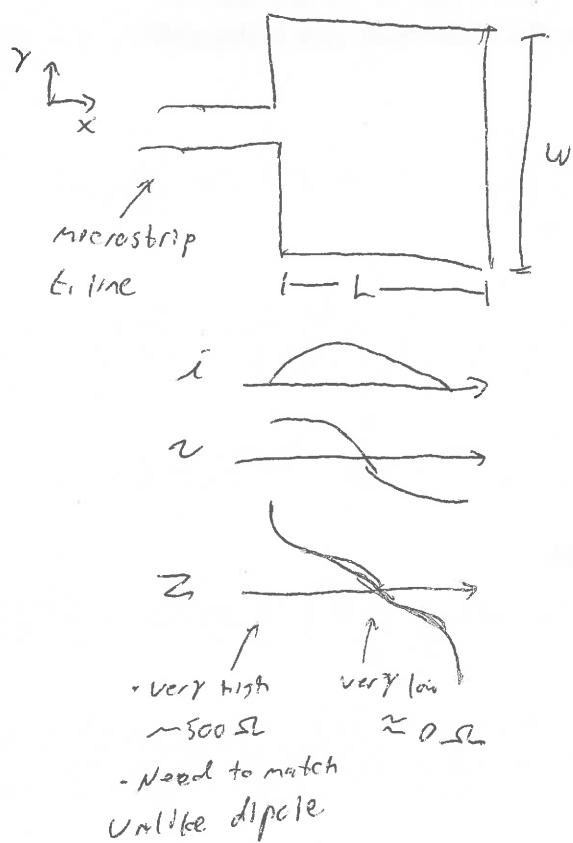
• Very low

• polarized along l

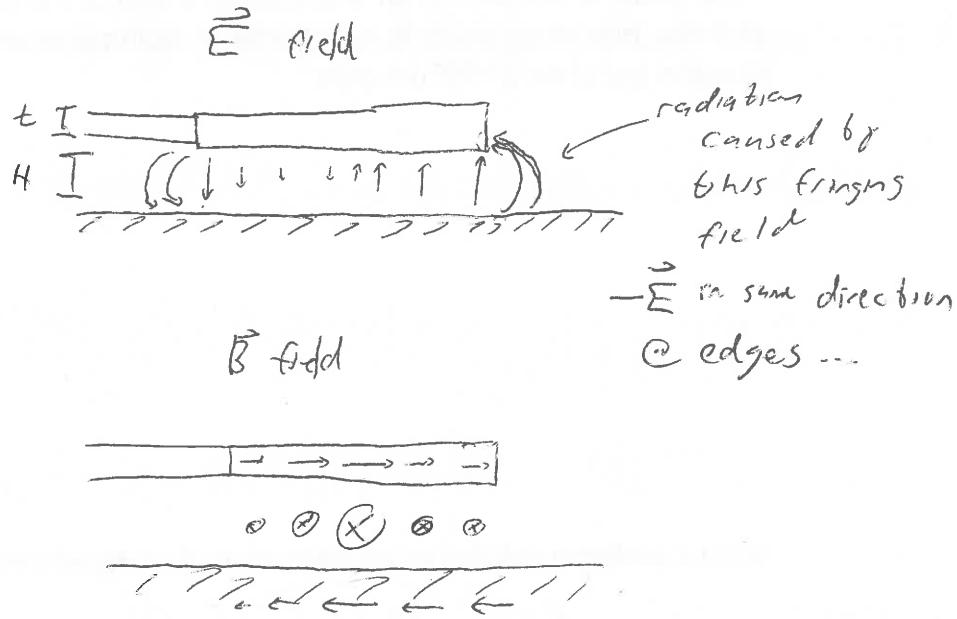
Patch Antenna

~ can be implemented in microstrip, but have high Q/narrow BW

Top View



Side View



~ picture leaking energy out of 1D box

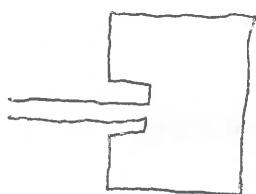
↳ why 1D? by design ... technically 2D resonant modes

↳ feed location seems to constrain

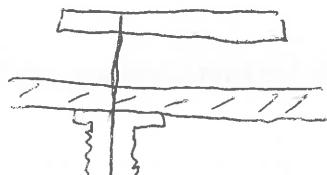
One of many empirical models

$$R_{\text{rad}} \approx \frac{90 (\epsilon_{r,\text{eff}} \cdot \frac{L+H}{W+H})}{\epsilon_{r,\text{eff}} - 1} \quad \begin{matrix} \text{more "leaking"} \\ \text{w/ longer W} \\ \text{Hard to lower Q} \end{matrix}$$

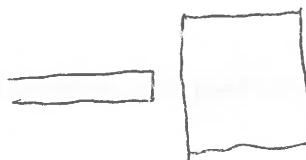
- Can adjust feed point impedance by tapping different location in current distribution



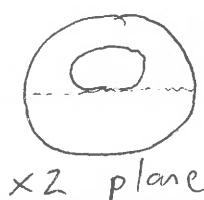
Inset microstrip feed



Thru feed



capacitively coupled feed



- ~ 5-7 dB directivity
- ~ 3 dB easiest to say ...

What is noise?

- Not f_{c} ... from 642 Hz
- Not hum
- Not pickup ... from antenna effects
- Not buzz ... from oscillation of unstable system
- Not coupling ... from moving power supplies

Noise is purely random: thermal excitation is a common example
 \hookrightarrow random motion of e^-

• quantization is other example \sim signal into ADC

4 units

• Qualitatively we see ^{thermal} noise as Gaussian RV on top of our signal



- Gaussian noise @ each "point" in time
- close to v_0 fast
- ensemble average leads to Gaussian

- mean is zero (generates power)
- want to know variance!

• Hard to predict noise variance in time domain ... usually think about in frequency

\hookrightarrow for thermodynamic reasons, equal noise power in **EVERY** Δf
 \hookrightarrow bandwidth of your system admits that noise power

• Describe w/ 4 variables (+ current equivalents)

V_n - noise voltage density - $nV/\sqrt{\text{Hz}}$ \leftarrow sometimes handy description

V_n^2 - noise power density - nW/Hz \leftarrow workhorse ... these add ... often white \rightarrow game@shif

N_n^2 - total noise power - nW \leftarrow integral over NPD, variance of voltage

\bar{V}_n - total noise voltage - nV \leftarrow std. dev. of noise

$\int E \propto V^2$, so same as power...
 doesn't add up if BW is non-

In RF it's common to represent NPD as noise temperature

↳ NPD is ~~available~~ some Energy/ΔS \sim if thermal, energy is kT

↳ ~~noise temperature~~ $T_n^2 \propto \int_{\text{freq}} \text{d}f \Delta S$ and $N_n^2 \propto kT \Delta S$

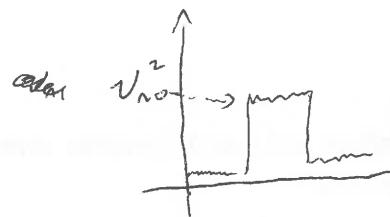
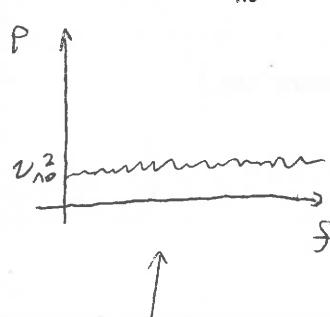
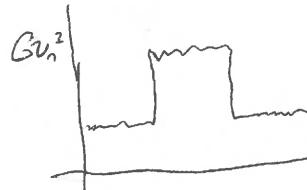
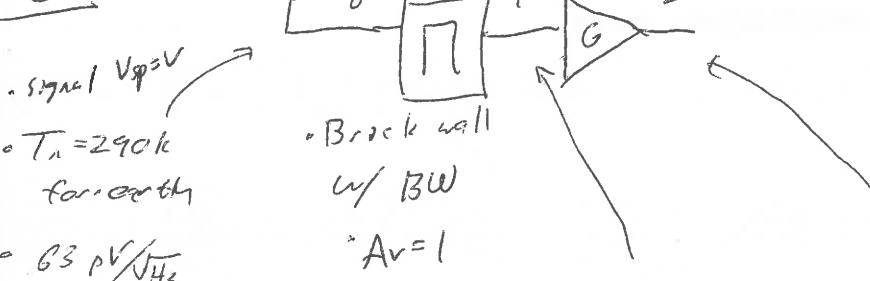
↳ $T_n = \frac{N_n^2}{k} \propto T \Delta S$ ← Noise temp is NPD/ k normalize to Boltzmann

... adds just the same

$$1.38e-23 \text{ J/K}$$

NPD affected by Xfer fn squared ... by dimensional analysis
... care about power gain

ex



Total noise is $N_n^2 \cdot \text{BW}$

Total signal $(GV)^2 / 2R$

- Noise amplified too

- $G^2 N_n^2 \cdot \text{BW} = P_{\text{noise}} = N_n^2 / 2R$

- $G^2 V^2 / 2R = P_{\text{signal}}$

$$\frac{P_{\text{signal}}}{P_{\text{noise}}} = \frac{G^2 V^2 / 2R}{N_n^2 / 2R}$$

$$= \frac{V^2}{N_n^2 \cdot \text{BW}}$$

↑
- Not a function of G !

- gain can't improve signal to noise!

- & noisyamps make SNR worse.

- No total noise defined because no bandwidth

- Signal power $V^2 P / 2R$

π
- kind of arbitrary
- whatever Z_0 is