Antenna Briefs #2 -- Power, Range, and Licensing

Slides downloaded from: https://ecefiles.org/rf-design/

Companion video at: https://www.youtube.com/watch?v=UcGXtjOQZv0

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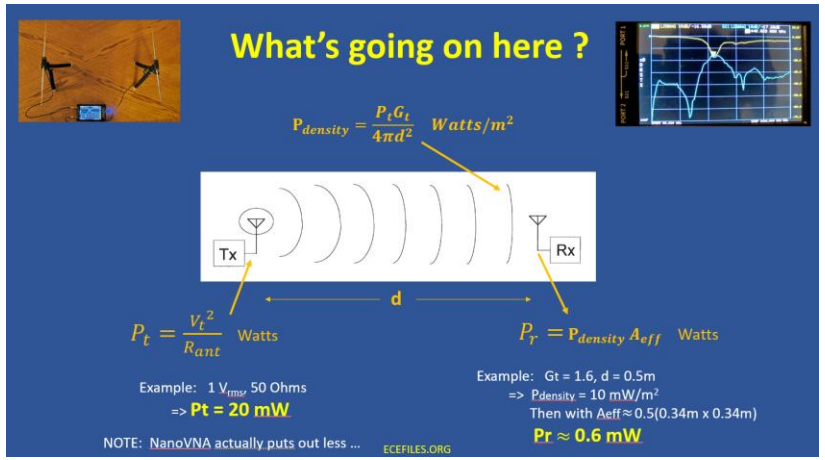
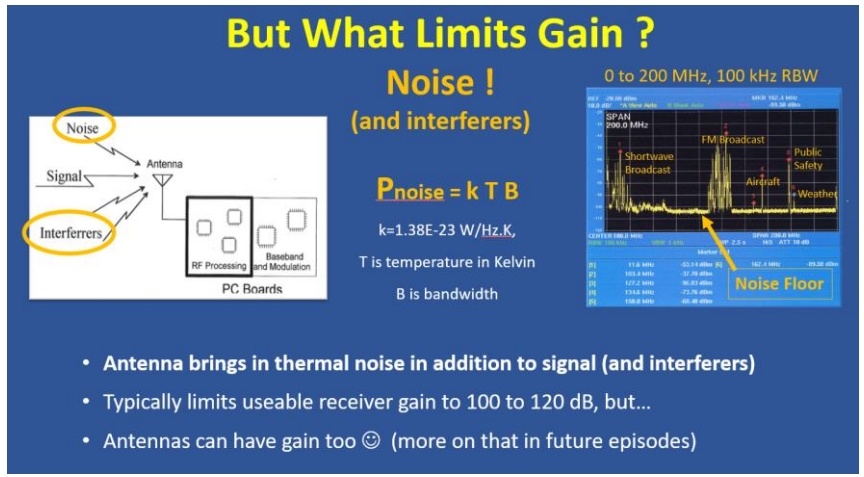
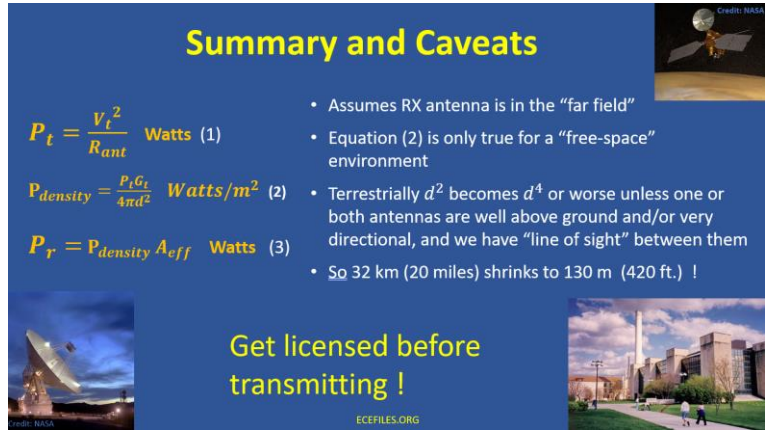
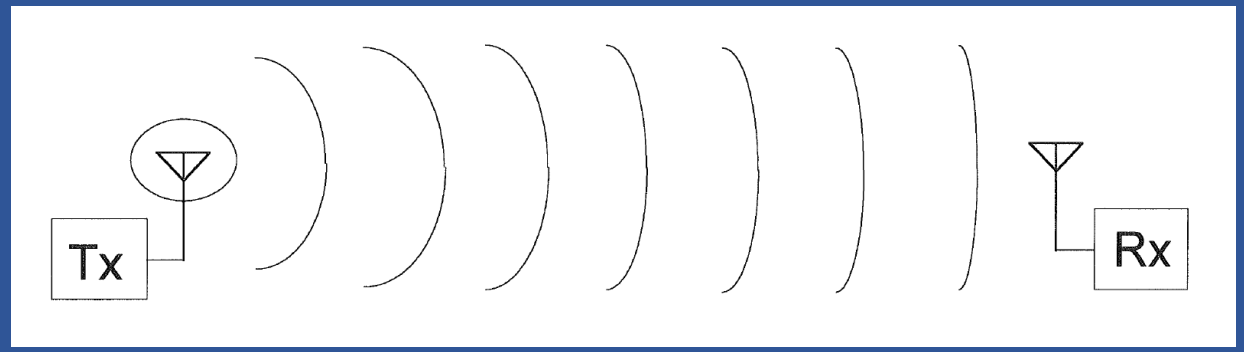
How far can radio / wireless signals transmit? In this second video in the Antenna Briefs series, we look at the relationship between power and range, and the antennas used. While the topic can be quite complex, the aim is to illustrate the core issues involved. Transmitter range values from 130 meters to millions of miles are possible once the concepts are understood. However, there are restrictions on antennas and power levels allowed, and transmitting in general requires a license. These issues and the key reasons for licensing are discussed.







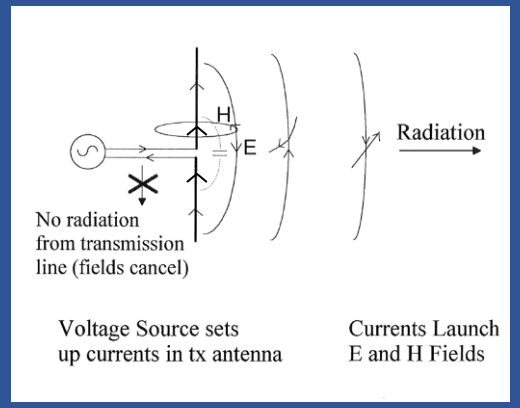
Antenna Briefs #2



Power, Range, and Licensing


Credit: NASA

Welcome (back) to “Antenna Briefs”

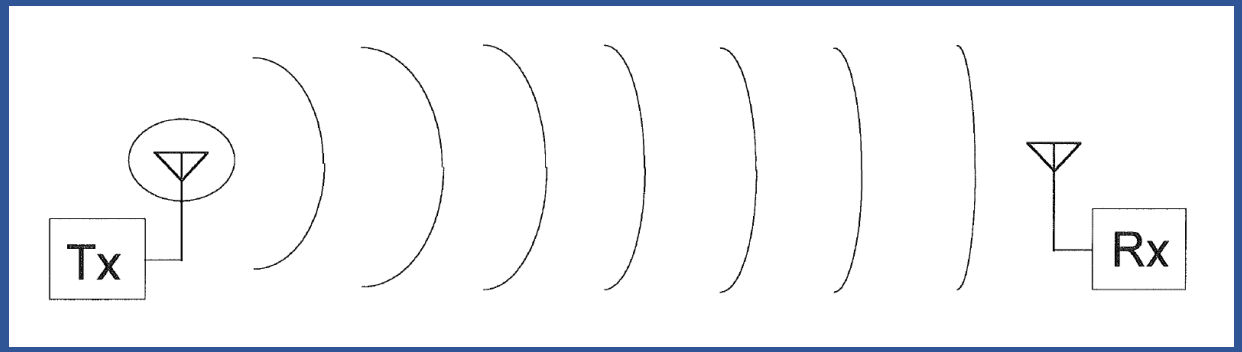


- **Previous Episode**
  - Frequency, wavelength, and antenna size
    - Radio waves and the formula for wavelength
    - Half-wave dipole antennas
    - Additional antenna types (non-directional and directional)
    - Real-world examples

- **Today’s topics:**
  - Power, Range, and Licensing
    - Quick review
    - Range – How far can we transmit?
      - Power transmitted
      - Power density at receiver
      - Receiving antenna effective aperture
      - Received power
      - Simple range estimates
      - Licensing !

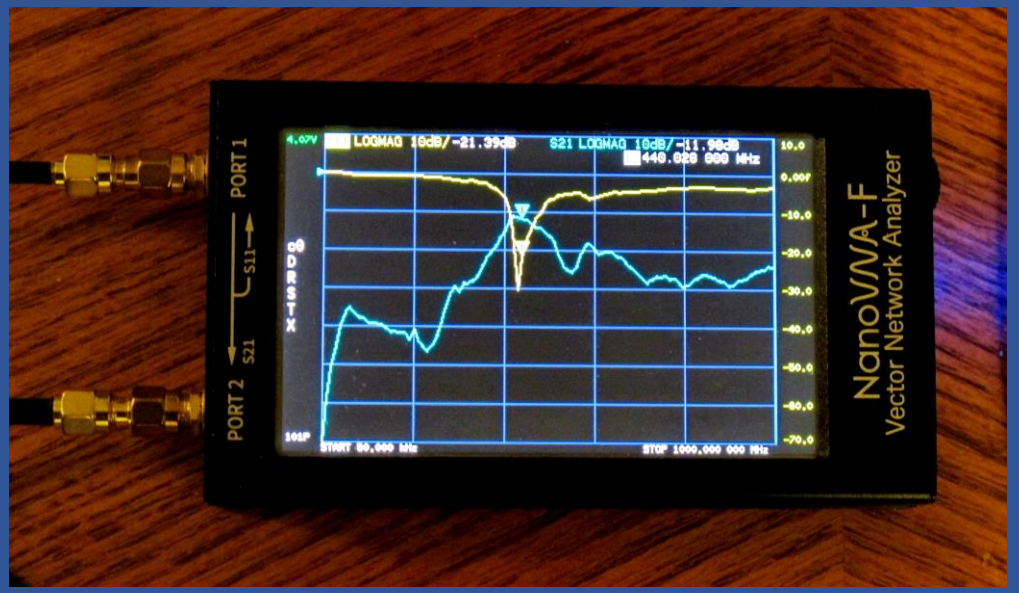

Credit: NASA

Recall Episode 1 Experiments



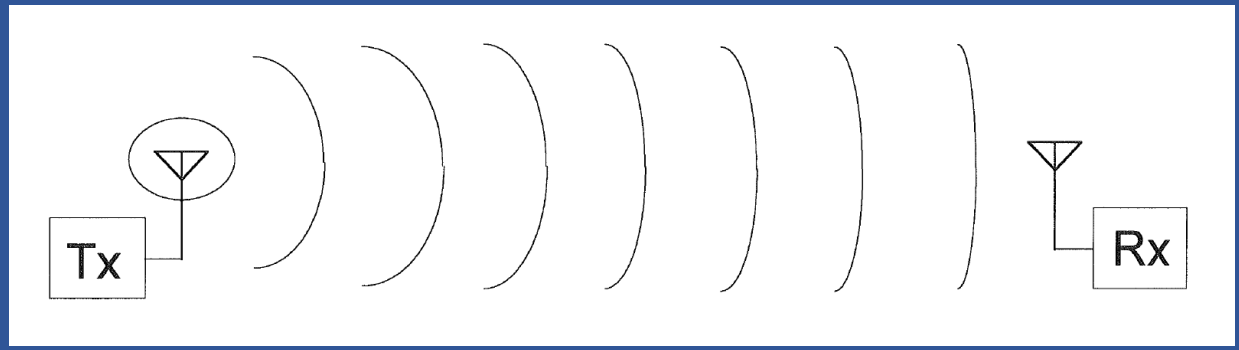
IMPORTANT: **Measurements performed at very low power in shielded environment !**

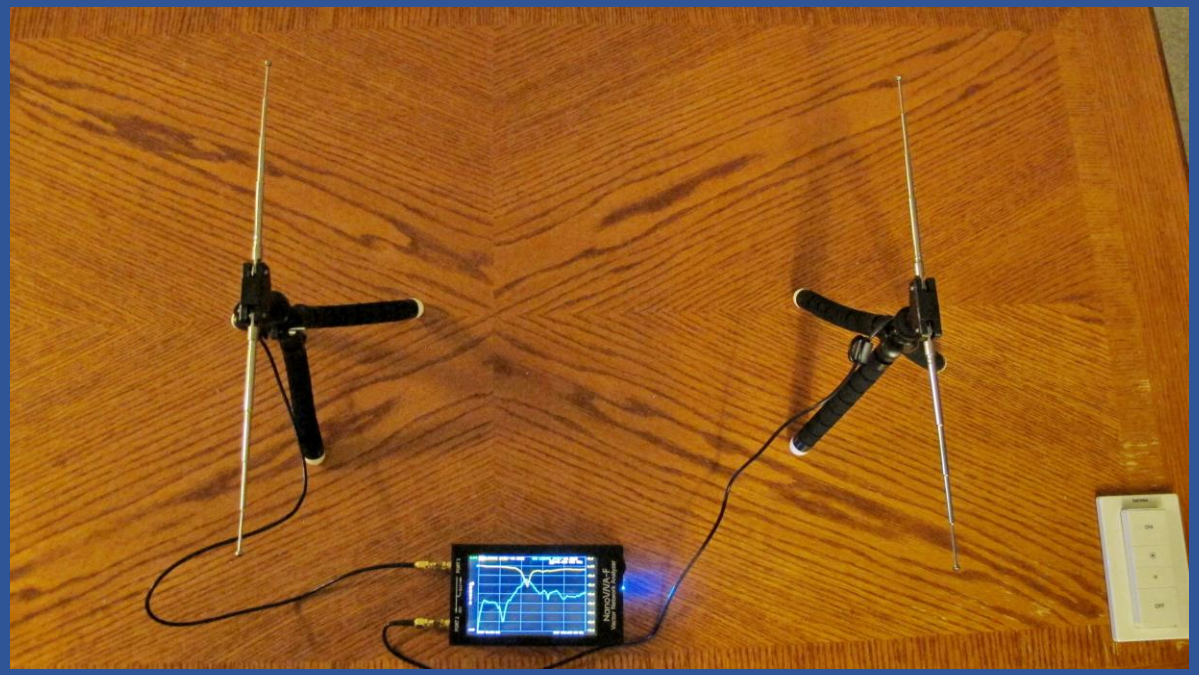
RTL-SDR Blog Multipurpose Dipole Antenna Kit (2)



NanoVNA

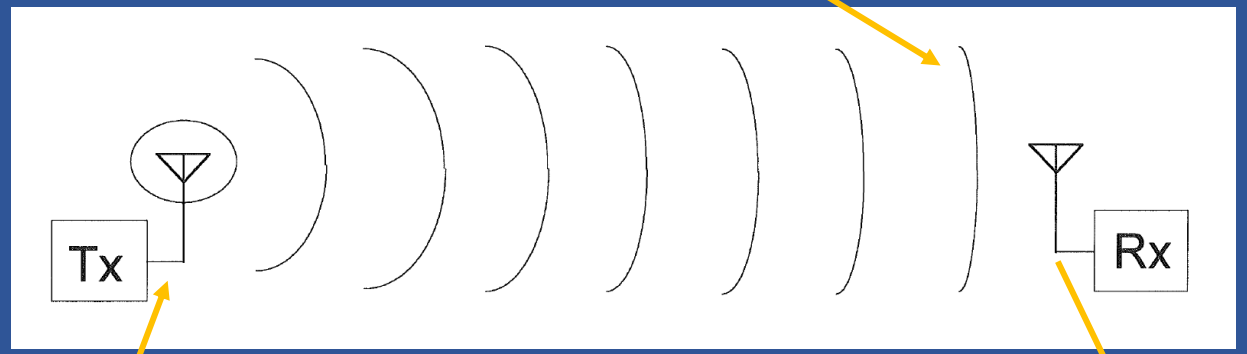
2X Distance Led to ¼ Received Power (-6 dB)





What's going on here ?

$$P_{density} = \frac{P_t G_t}{4\pi d^2} \quad Watts/m^2$$



$$P_t = \frac{{V_t}^2}{R_{ant}} \quad \text{Watts}$$

Example: 1 V_{rms}, 50 Ohms

=> **Pt = 20 mW**

NOTE: NanoVNA actually puts out less …

$$P_r = P_{density}\, A_{eff} \quad \text{Watts}$$

Example: Gt = 1.6, d = 0.5m

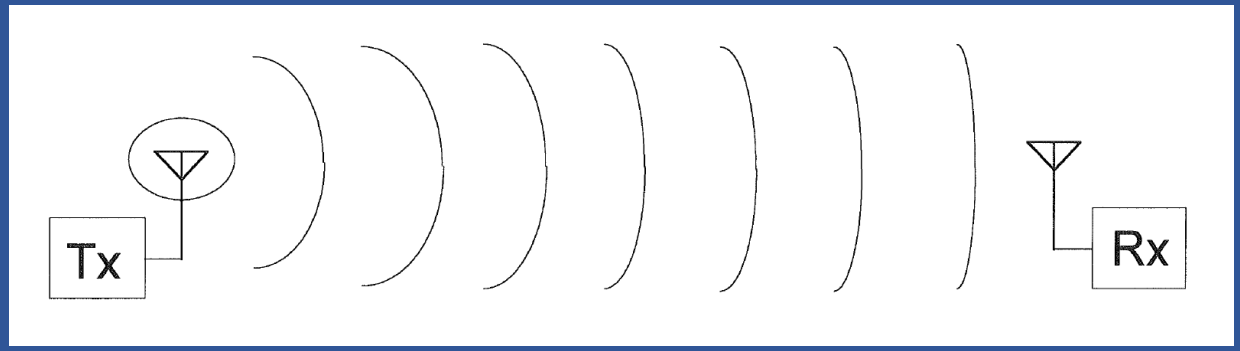
=> $P_{density}$ = 10 mW/m^2

Then with Aeff ≈ 0.5(0.34m x 0.34m)

Pr ≈ 0.6 mW

A Rough Back-of-the-envelope Estimate of Potential Range

$d_{max} = ?$



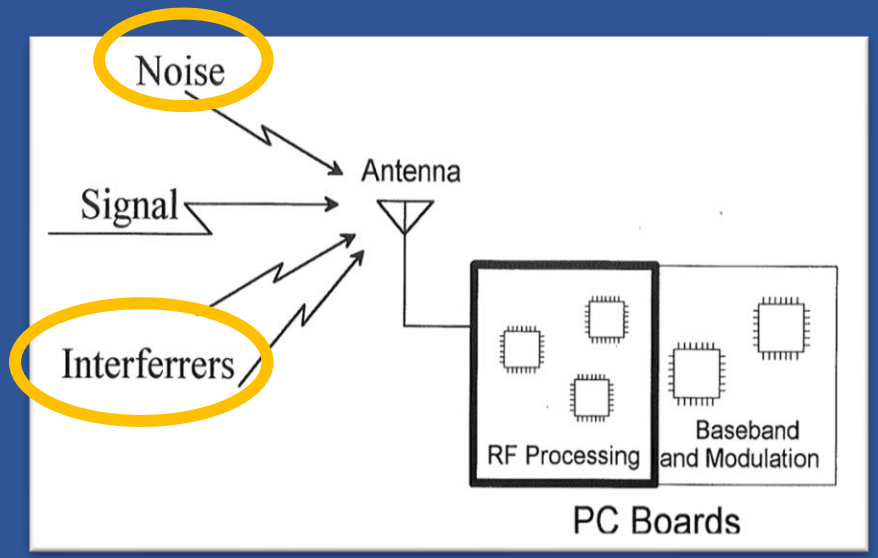
- **Recall that signal levels fall by 6dB* (one "S-unit") when distance is doubled**
- From Radio Design 101 series, receivers typically have ~ 100 dB of max gain
- 100/6 = 16.7, so we could double the 0.5m distance 16+ times if max gain is used

$$d_{max} \approx (2^{16})(0.5m) = (65,000)(0.5m) = 32\ km\ \ or\ \ 20\ miles$$

But What Limits Gain ?

Noise !

(and interferers)



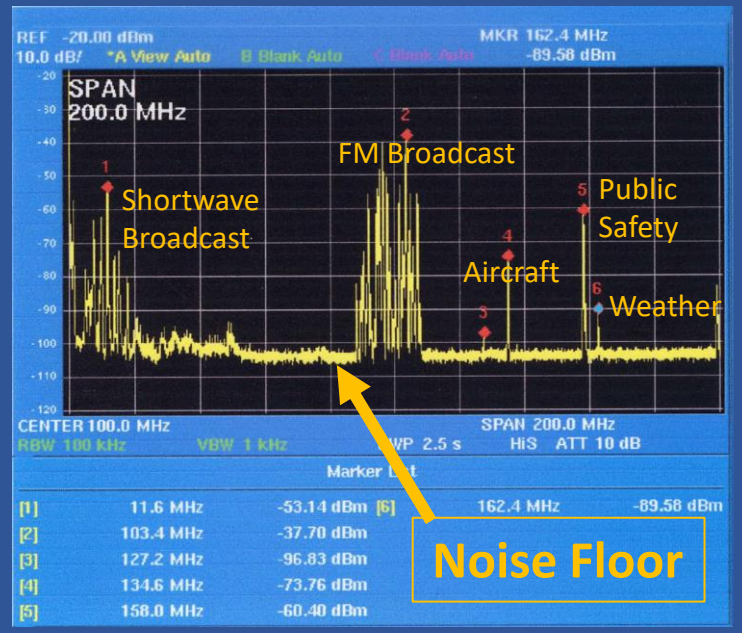
$$P_{noise} = k\,T\,B$$

k=1.38E-23 W/Hz.K,

T is temperature in Kelvin

B is bandwidth

0 to 200 MHz, 100 kHz RBW

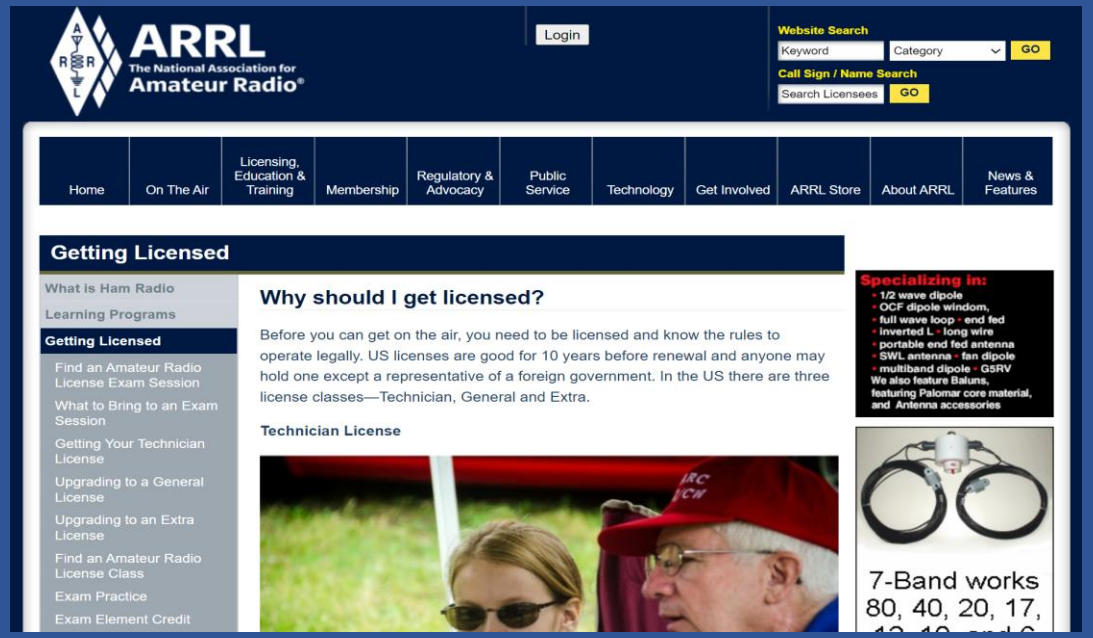


- **Antenna brings in thermal noise in addition to signal (and interferers)**
- Typically limits useable receiver gain to 100 to 120 dB, but…
- Antennas can have gain too ☺ (more on that in future episodes)

Licensing

- Interference between users needs to be managed
- Government bodies designate frequencies, max antenna height, power, etc., and license institutions and individuals to transmit
- Best path for individuals is arguably an “Amateur Radio” license

http://www.arrl.org/getting-licensed



https://www.worthpoint.com/worthopedia/

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HF Operation Videos

Summary and Caveats

$$P_t = \frac{{V_t}^2}{R_{ant}} \quad \textbf{Watts} \quad (1)$$

$$\mathrm{P}_{density} = \frac{P_t G_t}{4\pi d^2} \quad Watts/m^2 \quad \textbf{(2)}$$

$$P_r = \mathrm{P}_{density}\, A_{eff} \quad \textbf{Watts} \quad (3)$$

- Assumes RX antenna is in the “far field”
- Equation (2) is only true for a “free-space” environment
- Terrestrially d^2 becomes d^4 or worse unless one or both antennas are well above ground and/or very directional, and we have “line of sight” between them
- So 32 km (20 miles) shrinks to 130 m (420 ft.) !

Get licensed before transmitting !

Thanks for Watching…

Stay Tuned for more episodes !