



Small Antennas

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- Important parameters:
 - Electrical or magnetic nature
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Definition of a small antenna

- Greatest dimension is smaller than $\lambda/4$
- *Radiansphere*:
 - $r < \lambda/(2\pi)$
 - For a small antenna, mostly reactive power
 - Antenna element only a fraction of the sphere



Electric and magnetic dipole

- A small antenna can be considered
 - As a capacitor (electric dipole)
 - As an inductor (magnetic dipole)
- The antenna is tuned by a reactor
- Resonance is achieved with opposite type reactor



Effective volume

- Defined as

$$V' = kV$$

- k is *shape factor* (> 1)
- Depending on the antenna nature, k is different (C or L type antenna)
- V is volume occupied by the antenna structure
- Also used to compare antennas' bandwidths



Effective volume

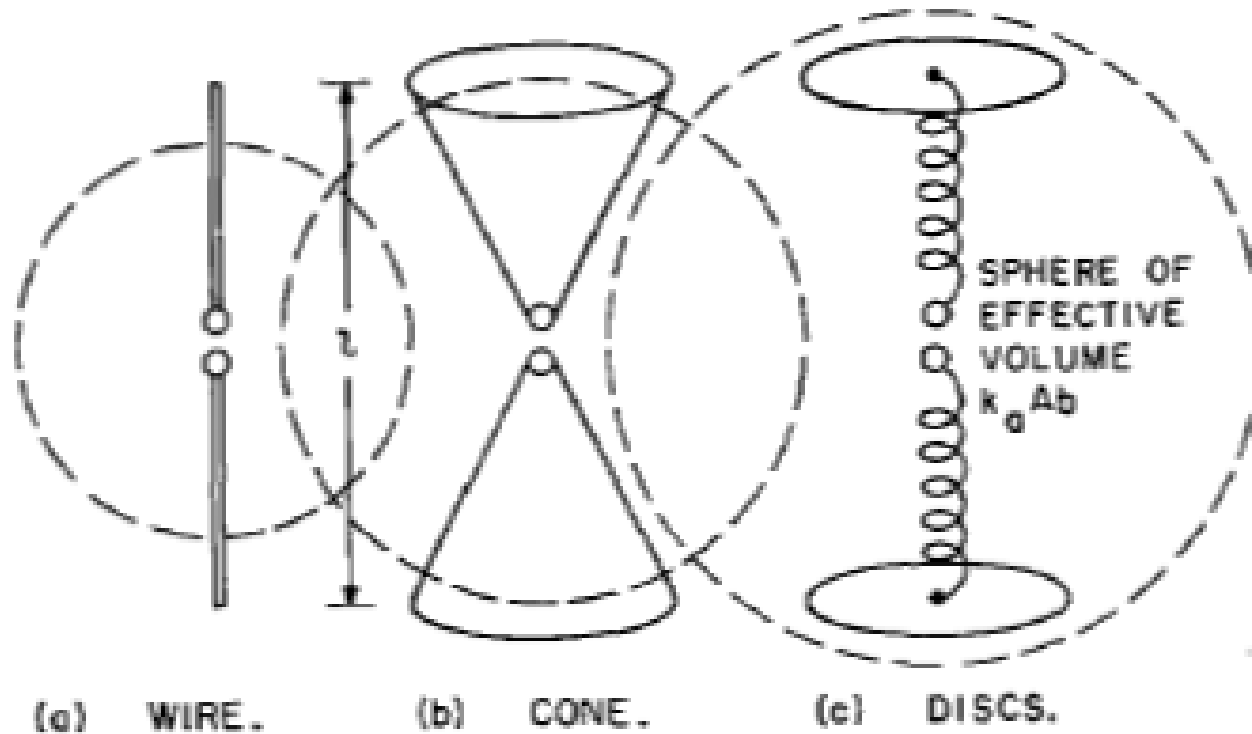


Fig. 6. Effective volume of axial electric dipole.

Source: Wheeler, Small Antennas

Effective volume

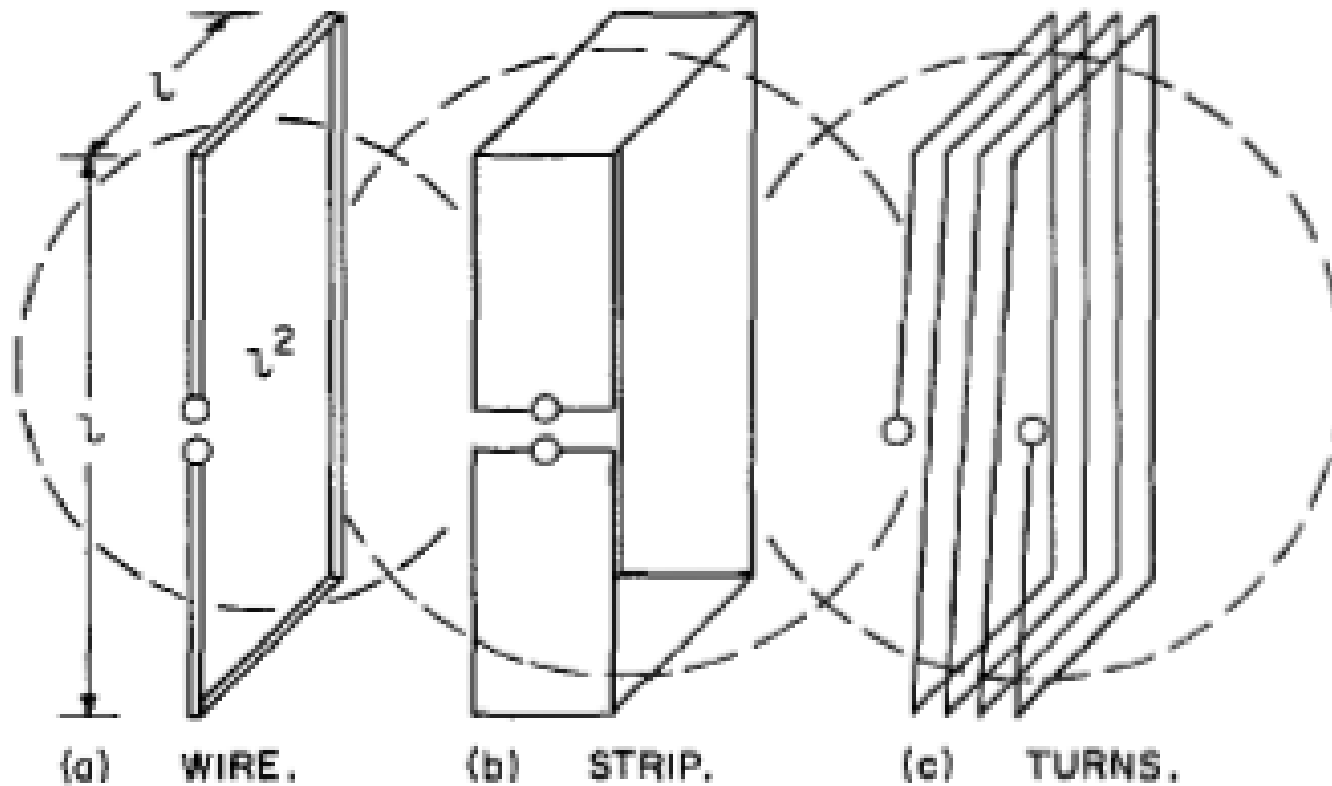


Fig. 7. Effective volume of square loop.

Source: Wheeler, Small Antennas



Radiation power factor

- Defined using

- Radiancube = $V_C = \left(\frac{\lambda}{2\pi}\right)^3 = \frac{3}{4\pi} V_S$ or

- Radiansphere = $V_S = \frac{4\pi}{3} \left(\frac{\lambda}{2\pi}\right)^3 = \frac{4\pi}{3} V_C$

- General formula:

- Rad. PF = $p = \frac{1}{6\pi} \frac{V'}{V_C} = \frac{2}{9} \frac{V'}{V_S}$



Equivalent circuit

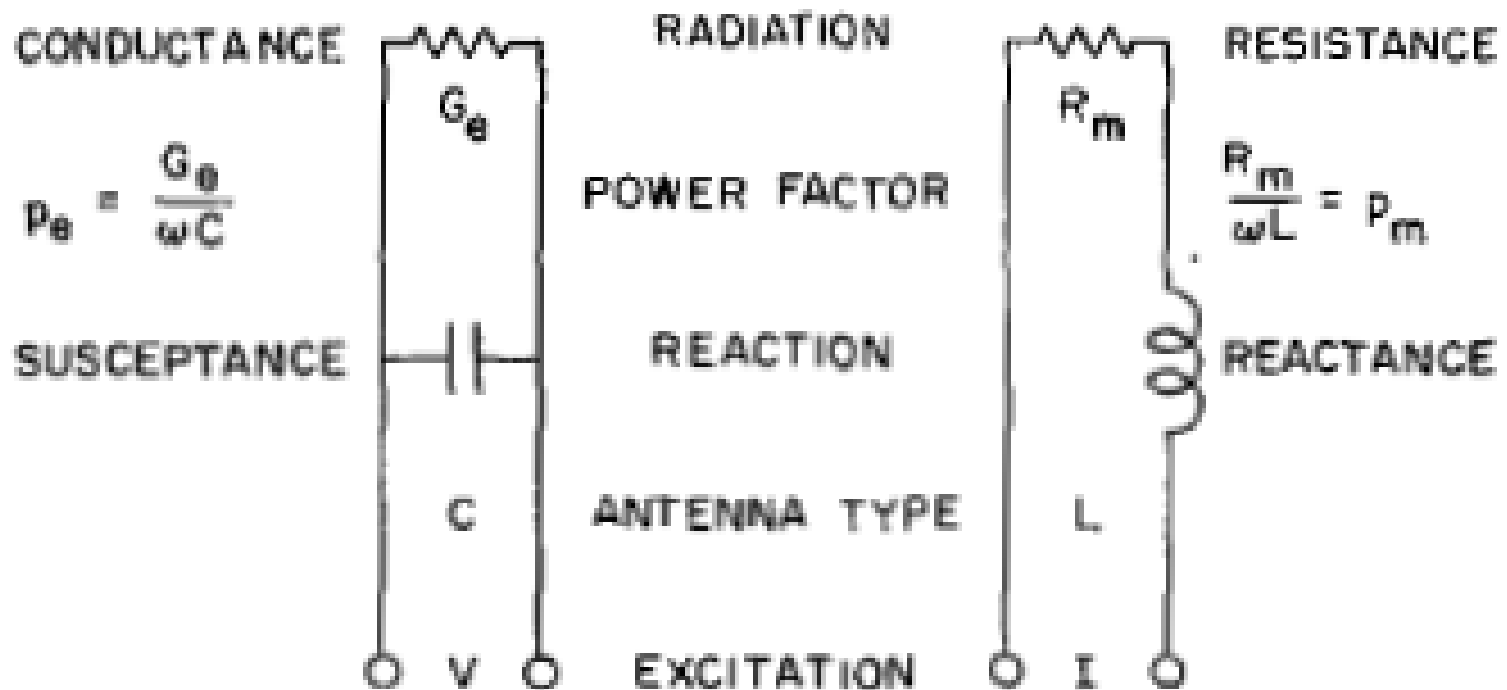


Fig. 2. Radiation power factor of small antenna.

Source: Wheeler, Small Antennas

Radiation shield

- A method to measure the rad. PF and loss PF
- Using a "shield box", rad. PF is removed
- Other properties stay about the same
- Measurements with and without the shield
- Comparison to evaluate useful radiation



Examples from the paper

- Very small loop antenna (0.04λ)
- Superseded multiturn loop designs
- Smallest 50% radiation efficiency antenna (at the time of article publication)



Examples from the paper

- Flush antenna configurations
- Flat antennas near a ground plane
- Antennas attached to aircraft hull



Examples from the paper

- Coil antenna
- Coil antenna's V' can be increased using ferrite core
- Coil turns can be used to set impedance
- Long coil as magnetic dipole, filled with PMC
 - V' is comparable to an electric dipole of coil's length



Conclusion

- If largest dimension $< \frac{\lambda}{4}$, small antenna
- C or L type
- Effective volume can be used to characterize a small antenna
- Radiation PF is small

