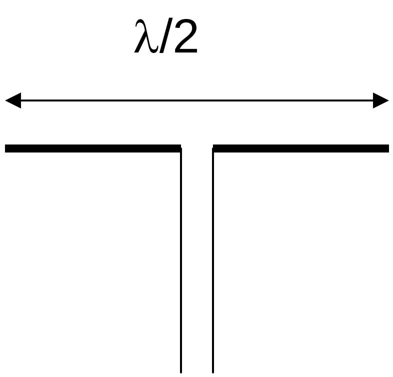
Antennas – Part B

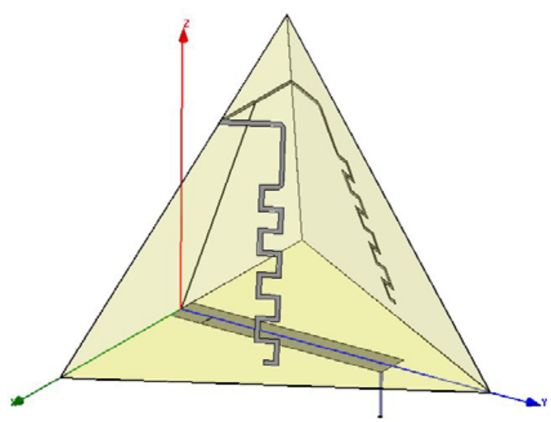
muse

Design & Technology Issues

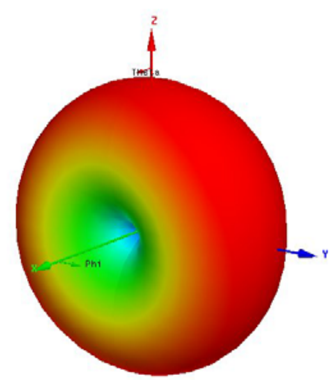
- Size
  - Typical “small” antenna is at least ~$\lambda/4$ (this is 8 cm @ 915 MHz)
  - As antennas become smaller their efficiency goes down
- Bandwidth
  - Impedance Bandwidth – frequency range over which the input impedance is close to 50 Ω
  - Pattern Bandwidth – frequency range over which radiation pattern is acceptable (usually not as difficult to achieve as impedance bandwidth)
- Packaging – conformal antennas are desirable but difficult to design



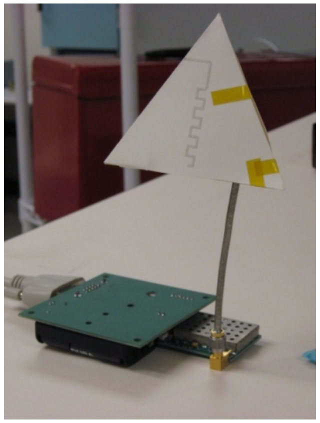
Simple Dipole



Conformal Dipole



Pattern



Demonstration

Size / Bandwidth / Efficiency

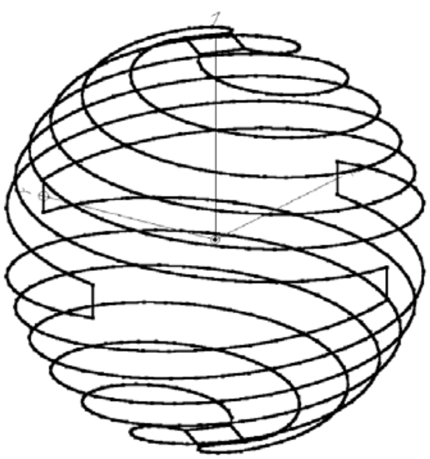
- Bandwidth is proportional to 1/Q, where Q is the *quality factor* (energy stored over energy dissipated) → if Q goes up then bandwidth goes down
- A theoretical limit for the lowest Q-factor for an antenna is:

$$Q_{lb} = \eta_r \left(\left(\frac{1}{ka} \right)^3 + \left(\frac{1}{ka} \right) \right)$$

η_r = efficiency

$k = 2\pi/\lambda$

a = radius of volume enclosing antenna



→ The more efficiently an antenna fills the volume of space surrounding the antenna the higher its radiation efficiency will be! Small, flat, 2-D antennas are not very efficient.

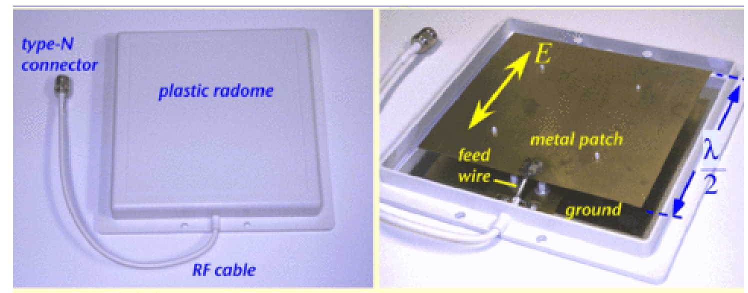
Best, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 53, NO. 3, MARCH 2005

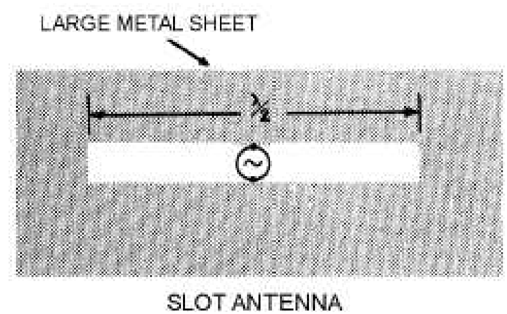
Wire Antennas

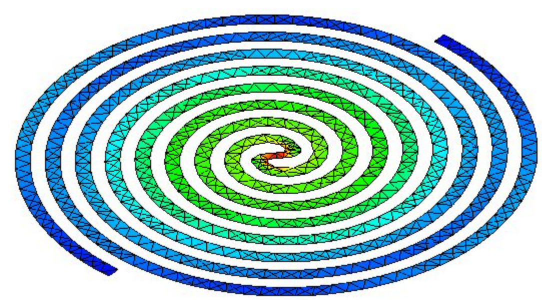
- Common:
  - Short Dipole
    - $Z_{in} \sim 80\pi^2(l/\lambda)^2$ @ resonance
    - $D_o \sim 1.8$ dB
  - Half-wavelength Dipole
    - $Z_{in} \sim 73$ Ohms @ resonance
    - $D_o \sim 2.2$ dB
  - Quarter-wavelength Monopole
    - $Z_{in} \sim 36.5$ Ohms @ resonance
    - $D_o \sim 2.2$ dB

Planar 2-D Antennas

- Common:
  - Microstrip (patch)
    - Z_{in} ~ varies
    - Bandwidth ~ narrow
    - D_o ~ 6 dB
  - Slot
    - Z_{in} ~ 500 Ohms @ resonance
    - Bandwidth ~ medium
    - D_o ~ 2.2 dB
  - Spiral
    - Z_{in} ~ 100 Ohms
    - Bandwidth ~ large
    - D_o ~ 3 dB







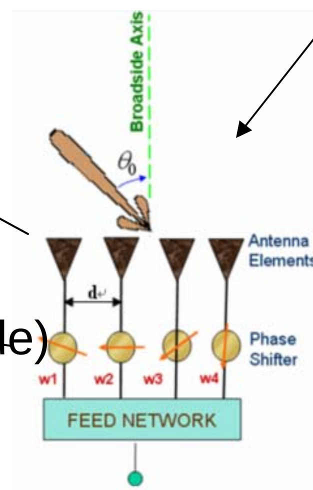
Array Antennas

- “gain” for an antenna is similar to “magnification” for a microscope – the larger the lens (aperture) the higher the magnification (gain)
- In array antennas many individual antenna elements are separated in space to form a large aperture
- The signal to each elements is controlled (magnitude and phase) allowing the direction of radiation to be varied

Wikipedia.com

Individual Elements (Antennas)

Signal Control (Phase & Amplitude)



Impact on Sensor Network Design

- Antennas with high gain will increase communications range
- Higher gain antennas require more careful alignment with distant receiver/transmitter

→ High gain antennas typically used only for fixed installations

→ Sensor nodes typically use low gain antennas in order to receive/transmit effectively in all (or most) directions

Antennas – Conclusions

- Antennas lie at the boundary between electromagnetic and circuit design
- They control the direction, concentration and polarization of the electromagnetic wave transmitted between two wireless devices
- They are often the size-limiting aspect of "small devices" and performance generally degrades as they are made smaller