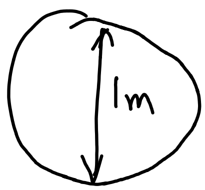
Free-Space Propagation

Exercise 1: For some types of antennas, such as reflectors, the effective aperture is closely approximated by the physical area of the antenna. What are the approximate effective aperture and gain of a 1-m diameter Ku-band ($\approx$ 15 GHz) satellite dish?



$$f = 15 \times 10^9$$

$$A_{(e)} = \frac{\pi}{4}$$

$$\lambda = c/f$$

$$A = \pi r^2$$

$$\lambda = \frac{3 \times 10^8}{15 \times 10^9} = 2 \times 10^{-2}$$

$$A = \pi \left(\frac{1}{2}\right)^2 = \frac{\pi}{4}$$

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi \, \pi/4}{(2 \times 10^{-2})^2} = \frac{\pi^2}{4 \times 10^{-4}}$$

$$\approx 2 \times 10^4 = 43 \text{ dB}$$

$$\left(G\,dB = 20 \log \frac{V_2}{V_1} = 10 \log \frac{P_2}{P_1} \right)$$

Exercise 2: A point-to-point link uses a transmit power of 1 Watt, transmit and receive antennas with gains of 20dB and operates at 3 GHz. How much power is received by a receiver 300m away?

$$P_R = P_T \, G_T \, G_R \left(\frac{\lambda}{4\pi d} \right)^2$$

$$P_T = 1 \text{ W} \qquad d = 300 \text{ m}$$

$$G_T = G_R = 10^{\frac{20}{10}} = 100$$

$$\lambda = c/f = \frac{3 \times 10^8}{3 \times 10^9} = 0.1 \text{ m}$$

$$P_R = 1 \cdot 10^2 \cdot 10^2 \cdot \left(\frac{0.1}{4\pi \cdot 300} \right)^2 = 7 \times 10^{-6}$$

Exercise 3: If we kept the *effective aperture* constant at one end of a link (transmitter or receiver), how would the path loss change as a function of frequency? What if we kept it constant at both ends? Is this a feasible approach for mobile systems?

path loss = $\frac{P_R G_R}{P_T G_T}$

$G = K$ (gain fixed) $A_e = K$ (effective aperture fixed)

$P_R = \cdot \frac{A_e}{\lambda^2}\left(\frac{\lambda}{\cdot}\right)^2$

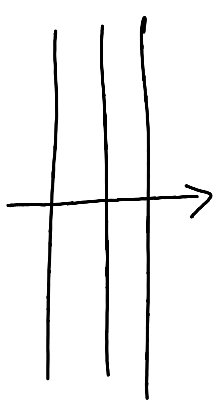
→ received power independent of frequency

$A_e = K$ $A_e = K$

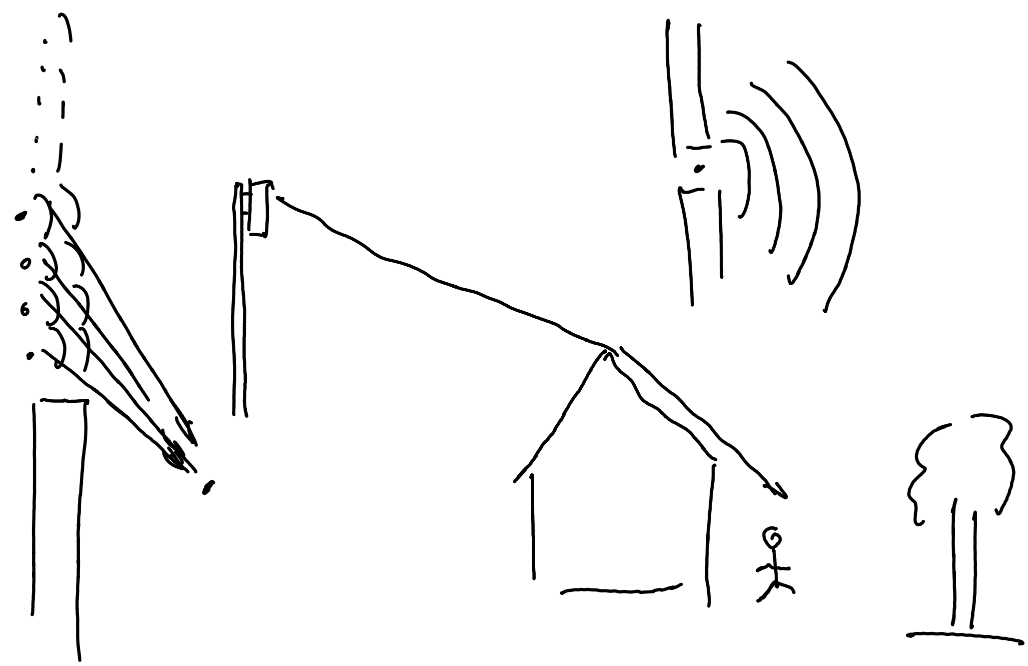
$P_R = \frac{\cdot}{\lambda^2}\frac{\cdot}{\lambda^2}\left(\frac{\lambda}{\cdot}\right)^2$

→ received power <u>increases</u>! with frequency

Examples of Diffraction



plane wave



diffraction