Slide Examples Solutions

Lecture 10,11,12

Lecture 10

Example – 1.1

- The audio power of the human voice is concentrated at about 300 Hz. a. What is the length of an antenna one-half wavelength long for sending radio at 300 Hz?

- We have, λ =c/f i.e wavelength= speed of light/frequency of wave. Actual wavelength = ($3*10^8$ m/sec) / 300Hz = 1000 Km
- So the length of an antenna which is one-half of wavelength long is λ /2 =1000 Km/2 =500 Km
- Antennas of the appropriate size for this frequency are impracticably large, so that to send voice by radio, the voice signal must be used to modulate a higher (carrier) frequency for which the natural antenna size is smaller.

- b. An alternative is to use a modulation scheme, for transmitting the voice signal by modulating a carrier frequency, so that the bandwidth of the signal is a narrow band centered on the carrier frequency.
- Suppose we would like a half-wave antenna to have a length of 1 m. What carrier frequency would we use?

- Length of a half-wave antenna λ /2=1m i.e Waveleng λ = 2m
- Therefore corresponding carrier frequency f = c/ λ = ($3* 10^8$ m/sec) / (2 m) = 150 MHz.

- Find the far-field distance for an antenna with maximum dimension of 1 m and operating frequency of 900 MHz.

Solution: ***by Younus - 131***

Far-field distance, R = $\frac{2\,D^2}{\lambda}$ = $\frac{2\,D^2 f}{c}$ = $\frac{2\ X\ 1^2\ X\ 900\ X\ 10^6}{3X10^8}$ = 6m
So, Far-field region > 6m

► An antenna has a diameter of 2m and frequency 16GHz. Calculate the 3 DB beamwidth for the antenna.

Solution: ***by Younus - 131***

Beamwidth = $\frac{70\,\lambda}{D}$ = $\frac{70\,c}{D\,f}$ = $\frac{70\ X\ 3\ X\ 10^8}{2\ X\ 16\ X\ 10^9}$ = 0.65625 degree

Example –2

1. For a parabolic reflective antenna with a diameter of 2 m, operating at 12 GHz, what is the effective area and gain?

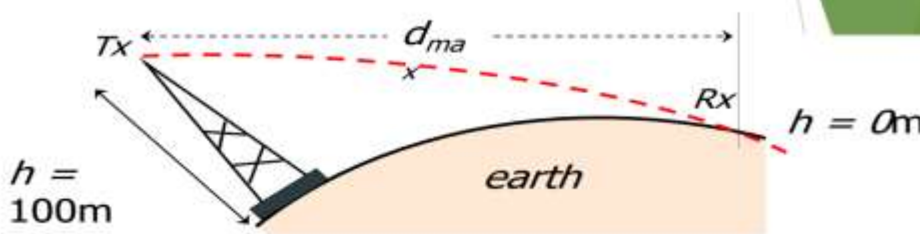
d=2m ∴ r=1m

Example 5.1 For a parabolic reflective antenna with a diameter of 2 m, operating at 12 GHz, what is the effective area and the antenna gain? We have an area of $A = \pi r^2 = \pi$ and an effective area of $A_e = 0.56\pi$. The wavelength is $\lambda = c/f = (3 \times 10^8)/(12 \times 10^9) = 0.025$ m. Then

$$G = (7A)/\lambda^2 = (7 \times \pi)/(0.025)^2 = 35{,}186$$

$$G_{\pi B} = 45.46 \text{ dB}$$

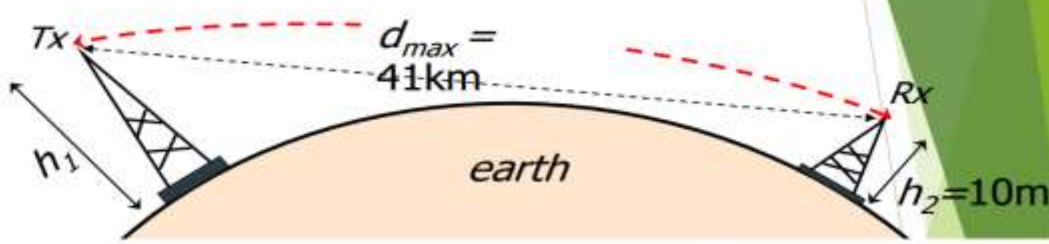
Example (1)



- What is the maximum distance between two antennas for LOS transmission if one antenna is 100m and the other is at ground level?

Solution: $$d_{max} = 3.57\left(\sqrt{Kh_1} + 0\right) = 3.57\sqrt{\frac{4}{3}\times 100} = 41\text{km}$$

Example (2)



- Now, suppose the receiving antenna is 10m high, what is the height of the transmitting antenna in order to achieve same distance above?

$$d_{max} = 3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right) \Rightarrow 41 = 3.57\left(\sqrt{Kh_1} + \sqrt{\frac{4}{3}\times 10}\right)$$

$$\sqrt{Kh_1} = \frac{41}{3.57} - \sqrt{13.33} = 7.84$$

$$\therefore \quad h_1 = 7.84^2/1.33 = 46.2\text{m} \quad \text{(Saving over 50m)}$$

1. Find the optimum distance from the ground level for a half-wave dipole antenna of frequency 15 MHz.

Solution: ***by Younus - 131***

Length of Half-wave dipole antenna, h1 = λ / 2

= c / (2f)

= 3 X 10^8 / (2 X 15 X 10^6)

= 10 m

$$d_{max} = 3.57\left(\sqrt{Kh_1} + 0\right) = 3.57\sqrt{\frac{4}{3}\times 10} = 13.0358\,\text{km}$$

2. Determine the height of an antenna for a TV station that must be able to reach customers up to 80 km away.

Solution: ***by Younus - 131***

$$d_{max} = 3.57\left(\sqrt{Kh_1} + 0\right)$$

$$\Rightarrow \sqrt{Kh_1} = \frac{d_{max}}{3.57}$$

$$\Rightarrow h_1 = \left(\frac{d_{max}}{3.57}\right)^2 \times \frac{1}{K} \quad \left[K = \frac{4}{3}\right]$$

$$\Rightarrow h_1 = \left(\frac{80}{3.57}\right)^2 \times \frac{3}{4} = 376.62\ m$$

1. Assume that two antennas are half-wave dipoles and each has a directive gain of 3 dB. If the transmitted power is 1 W and the two antennas are separated by a distance of 10 km, what is the received power? Assume that the antennas are aligned so that the directive gain numbers are correct and that the frequency used is 100 MHz.

Solution: ***by Younus - 131***

$$P_r = P_t G_t G_r \frac{\lambda^2}{(4\pi d)^2}$$

$$= 1 \times 1.995 \times 1.995 \times \frac{3^2}{(4 \times 3.1416 \times 10 \times 10^3)^2}$$

$$= 2.268 \times 10^{-9}\ \omega$$

$$G_t = 10^{\frac{3}{10}} = 1.995$$

$$G_r = 1.995$$

$$P_t = 1\ \omega$$

$$d = 10 \times 10^3\ m$$

$$\lambda = \frac{c}{f}$$

$$= \frac{3 \times 10^8}{100 \times 10^6}\ m = 3\ m$$

2. If a transmitter produces 50 watts of power, express the transmit power in units of (a) dBm, and (b) dBW. If 50 watts is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received power in dBm at a free space distance of 100 m from the antenna, What is P (10 km) ? Assume unity gain for the receiver antenna.

Solution: ***by Bindu - 126***

Solution to Example 3.2

Given:

Transmitter power, $P_t = 50$ **W.**

Carrier frequency, $f_c = 900$ **MHz**

Using equation (3.9).

(a) Transmitter power,

$$P_t(\text{dBm}) = 10\log[P_t(\text{mW})/(1\ \text{mW})]$$
$$= 10\log[50 \times 10^3] = 47.0\ \text{dBm}.$$

(b) Transmitter power,

$$P_t(\text{dBW}) = 10\log[P_t(\text{W})/(1\ \text{W})]$$
$$= 10\log[50] = 17.0\ \text{dBW}.$$

The received power can be determined using equation (3.1).

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} = \frac{50(1)(1)(1/3)^2}{(4\pi)^2(100)^2(1)} = 3.5 \times 10^{-6}\ \text{W} = 3.5 \times 10^{-3}\ \text{mW}$$

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$$P_r(\text{dBm}) = 10\log P_r(\text{mW}) = 10\log\left(3.5 \times 10^{-3}\ \text{mW}\right) = -24.5\ \text{dBm}.$$

The received power at 10 km can be expressed in terms of dBm using equation (3.9), where $d_0 = 100$ m and $d = 10$ km

$$P_r(10\ \text{km}) = P_r(100) + 20\log\left[\frac{100}{10000}\right] = -24.5\ \text{dBm} - 40\ \text{dB}$$
$$= -64.5\ \text{dBm}$$

Example-3

- Determine the **isotropic free space loss** at 4 GHz for the shortest path to a synchronous satellite from earth (35,863 km). What is the power received at the satellite antenna? (Assume antenna gain of both the satellite- and ground-based antennas are 44 dB and 48 dB, respectively. a transmit power of 250 W at the earth station.)

Example 5.3 Determine the isotropic free space loss at 4 GHz for the shortest path to a synchronous satellite from earth (35,863 km). At 4 GHz, the wavelength is $(3 \times 10^8)/(4 \times 10^9) = 0.075$ m. Then,

$$L_{dB} = -20\log(0.075) + 20\log(35.853 \times 10^6) + 21.98 = 195.6 \text{ dB}$$

Now consider the antenna gain of both the satellite- and ground-based antennas. Typical values are 44 dB and 48 dB respectively. The free space loss is:

$$L_{dB} = 195.6 - 44 - 48 = 103.6 \text{ dB}$$

Now assume a transmit power of 250 W at the earth station. What is the power received at the satellite antenna? A power of 250 W translates into 24 dBW, so the power at the receiving antenna is $24 - 103.6 = -79.6$ dBW.

Lecture 11

Example 3.6:

A mobile is located 5 km away from a base station and uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The E-field at 1 km from the transmitter is measured to be 10^{-3} V/m. The carrier frequency used for this system is 900 MHz.

(a) Find the length and the gain of the receiving antenna.

(b) Find the electric field and received power at the mobile using the 2-ray ground reflection model assuming the height of the transmitting antenna is 50 m and the receiving antenna is 1.5 m above ground.

Solution:

Example 3.7

- Compute the diffraction loss for the three cases. Assume λ=1/3m, d1 =1 km, d2 =1 km and (a)h =25m, (b)h =0, (c)h =-25m. For each of these cases, identify the Fresnel zone within which the tip of the obstruction lies.

Solution: 039

Solution to Example 3.7

Given:

$\lambda = 1/3$ m
$d_1 = 1$ km
$d_2 = 1$ km

(a) $h = 25$ m.

Using equation (3.56), the Fresnel diffraction parameter is obtained as

$$v = h\sqrt{\frac{2(d_1+d_2)}{\lambda d_1 d_2}} = 25\sqrt{\frac{2(1000+1000)}{(1/3)\times 1000\times 1000}} = 2.74.$$

From Figure 3.14, the diffraction loss is obtained as 22 dB.
Using the numerical approximation in equation (3.61.e), the diffraction loss is equal to 21.7 dB.
The path length difference between the direct and diffracted rays is given by equation (3.54) as

(a) For $h = F_n = 25$ m,

We know, $F_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1+d_2}}$

or, $n = \frac{F_n^2(d_1+d_2)}{\lambda d_1 d_2} = \frac{25^2(1000+1000)}{1000\times 1/3\times 1000} = 3.75$
≈ 4

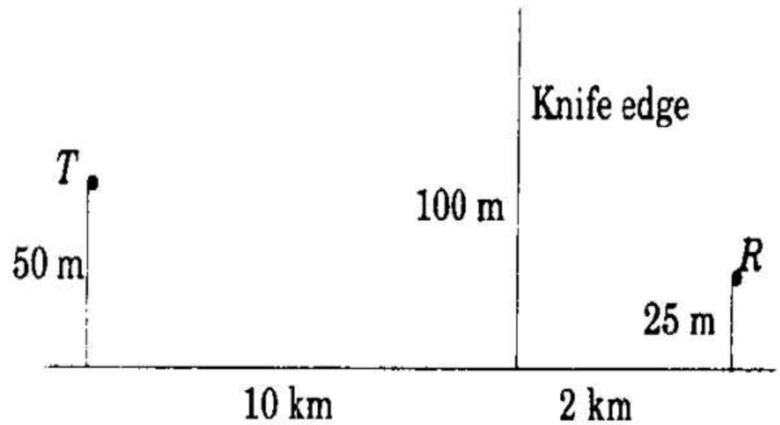
∴ For h = 25m, it is the 4^{th} fresnel zone.

(b) For h = 0, it lies in the 0^{th} zone.

(c) For h = -25m, it is in the -4^{th} zone

Example 3.8

Given the following geometry, determine (a) the loss due to knife-edge diffraction, and (b) the height of the obstacle required to induce 6 dB diffraction loss. Assume $f = 900$ MHz.



Solution: Check Origin42 6.c