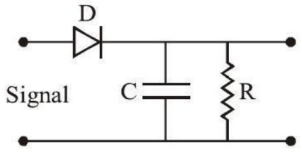
Communication Systems

1. An audio signal of amplitude 0.1 V is used in amplitude modulation of a carrier wave of amplitude 0.2 V. Calculate the modulation index.
2. A transmitting antenna at the top of a tower has height 32 m and the height of the receiving antenna is 50 m. The maximum distance (in km) between them for satisfactory communication in LOS mode is: (Given radius of earth 6400 km).
3. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10% of it is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz ?
4. For an amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum is found to be 2 V. The modulation index is:
5. A radar has a power of 1 kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance (in km) upto which it can detect object located on the surface of the earth (Radius of earth $= 6.4 \times 10^6$ m) is :
6. An audio signal consists of two distinct sounds, one a human speech signal in the frequency band of 200 Hz to 2700 Hz, while the other is a high frequency music signal in the frequency band of 10200 Hz to 15200 Hz. The ratio of the AM signal bandwidth required to send both the signals together to the AM signal bandwidth required to send just the human speech is $\frac{6}{x}$. Find the value of x.
7. In a communication system operating at wavelength 800 nm, only one per cent of source frequency is available as signal bandwidth. The number of channels accommodated for transmitting TV signals of bandwidth 6 MHz are (Take velocity of light $c = 3 \times 10^8$ m/s, $h = 6.6 \times 10^{-34}$ J − s)
8. A TV transmission tower has a height of 140 m and the height of the receiving antenna is 40 m. What is the maximum distance (in km) upto which signals can be broadcasted from this tower in LOS (Line of Sight) mode? (Given: radius of earth $= 6.4 \times 10^6$ m).
9. The modulation frequency of an AM radio station is 250 kHz, which is 10% of the carrier wave. If another AM station approaches you for license what broadcast frequency 1800 kHz to kHz will you allot?
10. A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index?
11. To double the covering range of a TV transmission tower, its height should be multiplied by:
12. The wavelength (in nm) of the carrier waves in a modern optical fiber communication network is
13. In a line of sight ratio communication, a distance of about 50 km is kept between the transmitting and receiving antennas. If the height of the receiving antenna is 70 m, then the minimum height (in metre) of the transmitting antenna should be: (Radius of the Earth $= 6.4 \times 10^6$ m).
14. A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts. The side bands are 1010 kHz and kHz.
15. A diode detector is used to detect an amplitude modulated wave of 60% modulation by using a condenser of capacity 250 picofarad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency (in kHz) which could be detected by it.



SOLUTIONS

1. **(0.5)** $\mu = \frac{A_m}{A_c} = \frac{0.1}{0.2} = 0.5$

2. **(45.5)** $d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

3. **(2×10^5)** If n = no. of channels

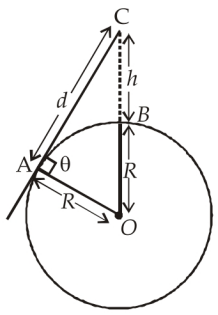
10% of 10 GHz = n × 5 KHz

or, $\frac{10}{100} \times 10 \times 10^9 = n \times 5 \times 10^3 \Rightarrow n = 2 \times 10^5$

4. **(0.66)** $M = \frac{A_m}{A_c} = \frac{M_1 - M_2}{M_1 + M_2} = \frac{10-2}{10+2} = \frac{2}{3}$

5. **(80)** Let d is the maximum distance, upto which it can detect the objects

From ΔAOC



$OC^2 = AC^2 + AO^2$

$(h+R)^2 = d^2 + R^2$

$\Rightarrow d^2 = (h+R)^2 - R^2$

$d = \sqrt{(h+R)^2 - R^2}$

$d = \sqrt{h^2 + 2hR}$

$d = \sqrt{500^2 + 2 \times 6.4 \times 10^6} = 80\,\text{km}$

6. **(1)** Ratio of AM signal Bandwidths

$= \frac{15200 - 200}{2700 - 200} = \frac{15000}{2500} = 6.$

7. **(6.25×10^5)** Frequency, $f = \frac{V}{\lambda} = \frac{3 \times 10^8}{8 \times 10^{-7}} = \frac{30}{8} \times 10^{14}$ Hz

$= 3.75 \times 10^{14}$ Hz

1% of f = 0.0375×10^{14} Hz

$= 3.75 \times 10^{12}$ Hz $= 3.75 \times 10^6$ MHz

As we know, number of channels accomodated for transmission $= \frac{\text{total bandwidth of Channel}}{\text{bandwidth needed per channel}}$

$= \frac{3.75 \times 10^6}{6} = 6.25 \times 10^5$

8. **(65)** Maximum distance upto which signal can be broadcasted

$$d_{max} = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

where h_T and h_R are heights of transmission tower and receiving antenna respectively.

Putting values R, h_T and h_R

$$d_{max} = \sqrt{2\times 6.4\times 10^6}\left[\sqrt{140} + \sqrt{40}\right]$$

or, $d_{max} = 65$ km

9. **(2200)** According to question, modulation frequency, 250 Hz is 10% of carrier wave

$$f_{carrier} = \frac{250}{0.1} = 2500\,kHZ$$

$\therefore$ Range of signal 2500 ± 250 KHz = 2250 Hz to 2750 Hz

For 2000 kHZ

$$f_{mod} = 200\,Hz$$

$\therefore$ Range = 1800 kHZ to 2200 KHZ

10. **(0.6)** Maximum amplitude $= E_m + E_c = 160$

$E_m + 100 = 160$

$E_m = 160 - 100 = 60$

Modulation index,

$$\mu = \frac{E_m}{E_c} = \frac{60}{100}$$

$\mu = 0.6$

11. **(4)** As we know, Range $= \sqrt{2hR}$

therefore to double the range height 'h' should be 4 times.

12. **(1500)** Carrier waves of wavelength 1500 nm is used in modern optical fiber communication.

13. **(32)** LOS $= \sqrt{2h_T R} + \sqrt{2h_R R}$

or $50 \times 10^3 = \sqrt{2h_T \times 6.4\times 10^6} + \sqrt{2\times 70\times 6.4\times 40^6}$

On solving, $h_T = 32$ m

14. **(990)**

15. **(10.61)** Given : Resistance R = 100 kilo ohm = $100 \times 10^3\ \Omega$

Capacitance C = 250 picofarad = 250×10^{-12}F

τ = RC = $100 \times 10^3 \times 250 \times 10^{-12}$ sec

= $2.5 \times 10^7 \times 10^{-12}$ sec = 2.5×10^{-5} sec

The higher frequency whcih can be detected with tolerable distortion is

$$f = \frac{1}{2\pi m_a RC} = \frac{1}{2\pi \times 0.6 \times 2.5 \times 10^{-5}} Hz$$

$$= \frac{100 \times 10^4}{25 \times 1.2\pi} Hz = 10.61 \text{ kHz}$$

This condition is obtained by applying the condition that rate of decay of capacitor voltage must be equal or less than the rate of decay modulated singnal voltage for proper detection of mdoulated signal.