

Communication Systems



Numerical

Q.1 A carrier wave with amplitude of 250 V is amplitude modulated by a sinusoidal base band signal of amplitude 150V. The ratio of minimum amplitude to maximum amplitude for the amplitude modulated wave is 50 : x, then value of x is _____.

1st Sep Evening Shift 2021

Q.2 A bandwidth of 6 MHz is available for A.M. transmission. If the maximum audio signal frequency used for modulating the carrier wave is not to exceed 6 kHz. The number of stations that can be broadcasted within this band simultaneously without interfering with each other will be _____.

31st Aug Evening Shift 2021

Q.3 If the sum of the heights of transmitting and receiving antennas in the line of sight of communication is fixed at 160 m, then the maximum range of LOS communication is _____ km. (Take radius of Earth = 6400 km)

31st Aug Morning Shift 2021

Q.4 A transmitting antenna has a height of 320 m and that of receiving antenna is 2000 m. The maximum distance between them for satisfactory communication in line of sight mode is 'd'. The value of 'd' is km.

27th Aug Morning Shift 2021

Q.5 An amplitude modulated wave is represented by $C_m(t) = 10(1 + 0.2 \cos 12560t) \sin(111 \times 10^4 t)$ volts. The modulating frequency in kHz will be

26th Aug Morning Shift 2021

Q.6 The maximum amplitude for an amplitude modulated wave is found to be 12V while the minimum amplitude is found to be 3V. The modulation index is $0.6x$ where x is _____.

27th July Evening Shift 2021

Q.7 The amplitude of upper and lower side bands of A.M. wave where a carrier signal with frequency 11.21 MHz, peak voltage 15 V is amplitude modulated by a 7.7 kHz sine wave of 5V amplitude are $\frac{a}{10} V$ and $\frac{b}{10} V$ respectively. Then the value of $\frac{a}{b}$ is _____.

27th July Morning Shift 2021

Q.8 A message signal of frequency 20 kHz and peak voltage of 20 volt is used to modulate a carrier wave of frequency 1 MHz and peak voltage of 20 volt. The modulation index will be :

25th July Evening Shift 2021

Q.9 A carrier wave $V_c(t) = 160 \sin(2\pi \times 10^6 t)$ volts is made to vary between $V_{\max} = 200 V$ and $V_{\min} = 120 V$ by a message

signal $V_m(t) = A_m \sin(2\pi \times 10^3 t)$ volts. The peak voltage A_m of the modulating signal is _____.

20th July Morning Shift 2021

Q.10 A TV transmission tower antenna is at a height of 20 m. Suppose that the receiving antenna is at.

(i) ground level

(ii) a height of 5 m.

The increase in antenna range in case (ii) relative to case (i) is $n\%$.

The value of n , to the nearest integer, is _____.

18th Mar Evening Shift 2021

Q.11 For VHF signal broadcasting, _____ km^2 of maximum service area will be covered by an antenna tower of height 30 m, if the receiving antenna is placed at ground. Let radius of the earth be 6400 km. (Round off to the Nearest Integer)
(Take π as 3.14)

17th Mar Morning Shift 2021

Q.12 If the highest frequency modulating a carrier is 5 kHz, then the number of AM broadcast stations accommodated in a 90 kHz bandwidth are _____.

26th Feb Evening Shift 2021

Q.13 The maximum and minimum amplitude of an amplitude modulated wave is 16V and 8V respectively. The modulation index for this amplitude modulated wave is $x \times 10^{-2}$. The value of x is _____.

26th Feb Morning Shift 2021

Q.14 A signal of 0.1 kW is transmitted in a cable. The attenuation of cable is -5 dB per km and cable length is 20 km. The power received at receiver is 10^{-x} W. The value of x is _____.

$$[\text{Gain in } dB = 10 \log_{10} \left(\frac{P_o}{P_i} \right)]$$

24th Feb Evening Shift 2021

Q.15 An audio signal $v_m = 20 \sin 2\pi(1500t)$ amplitude modulates a carrier $v_c = 80 \sin 2\pi(100,000t)$.

The value of percent modulation is _____.

24th Feb Morning Shift 2021

Numerical Answer Key

- | | |
|---------------|-----------------|
| 1. Ans. (200) | 10. Ans. (50) |
| 2. Ans. (500) | 11. Ans. (1206) |
| 3. Ans. (64) | 12. Ans. (9) |
| 4. Ans. (224) | 13. Ans. (33) |
| 5. Ans. (2) | 14. Ans. (8) |
| 6. Ans. (1) | 15. Ans. (25) |
| 7. Ans. (1) | |
| 8. Ans. (1) | |
| 9. Ans. (40) | |

Numerical Explanation

Ans 1. Given, the amplitude of the carrier wave, $A_c = 250 \text{ V}$

The amplitude of the message wave, $A_m = 150 \text{ V}$

We know that,

The maximum amplitude, $A_{\max} = A_c + A_m$

Substituting the values in the above equation, we get

$$A_{\max} = 250 + 150 = 400 \text{ V}$$

We know that,

The minimum amplitude, $A_{\min} = A_c - A_m$

Substituting the values in the above equation, we get

$$A_{\min} = 250 - 150 = 100 \text{ V}$$

Thus, the ratio of the minimum amplitude to the maximum amplitude of the modulated wave is

$$\frac{A_{\min}}{A_{\max}} = \frac{100}{400} = \frac{1}{4}$$

Comparing with, 1 : x

The value of the x = 4.

Ans 2.

Signal bandwidth = 2 fm = 12 kHz

$$\therefore N = \frac{6\text{MHZ}}{12\text{kHz}} = \frac{6 \times 10^6}{12 \times 10^3} = 500$$

Ans 3.

$h_T = h_R = 160$ (i)

$$d = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

$$d = \sqrt{2R} [\sqrt{h_T} + \sqrt{h_R}]$$

$$d = \sqrt{2R} [\sqrt{x} + \sqrt{160 - x}]$$

$$\frac{d(d)}{dx} = 0$$

$$\frac{1}{2\sqrt{x}} + \frac{1(-1)}{2\sqrt{160-x}} = 0$$

$$\frac{1}{\sqrt{x}} = \frac{1}{\sqrt{160-x}}$$

x = 80 m

$$d_{\max} = \sqrt{2 \times 6400} \left[\sqrt{\frac{80}{1000}} + \sqrt{\frac{20}{1000}} \right]$$

$$= \frac{80\sqrt{2} \times 2\sqrt{80}}{10\sqrt{10}}$$

$$= 8 \times 2 \times \sqrt{2} \times 2\sqrt{2} = 64 \text{ km}$$

Ans 4.

$$d_m = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

$$d_m = \left(\sqrt{2 \times 6400 \times 10^3 \times 320} + \sqrt{2 \times 6400 \times 10^3 \times 2000} \right) \text{m}$$

$$d_m = 224 \text{ km}$$

Ans 5.

$$W_m = 12560 = 2\pi f_m$$

$$f_m = \frac{12560}{2\pi}$$

$$= 2000 \text{ Hz}$$

Ans 6.

$$A_{\max} = A_c + A_m = 12$$

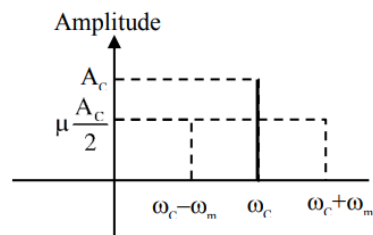
$$A_{\min} = A_c - A_m = 3$$

$$\Rightarrow A_c = \frac{15}{2} \text{ \& } A_m = \frac{9}{2}$$

$$\text{modulation index} = \frac{A_m}{A_c} = \frac{9/2}{15/2} = 0.6$$

$$\Rightarrow x = 1$$

Ans 7.



$$\frac{a}{10} = \frac{b}{10} = \frac{\mu A_C}{2}$$

$$\Rightarrow \frac{a}{b} = 1$$

Ans 8. Modulation index

$$\mu = \frac{A_m}{A_c} = \frac{20}{20} = 1$$

Ans 10. For calculation of Range from tower.

$$d = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

$\therefore h_T$ = height of tower

& h_R = height of receiver

For 1st case : $h_T = 20\text{m}$, $h_R = 0$

$$\therefore d_2 = \sqrt{2 \times 6400 \times 10^3 \times 20} + \sqrt{2 \times 6400 \times 10^3 \times 5}$$

$$= 16 + 8 = 24 \text{ km}$$

\therefore % change in range

$$= \frac{d_2 - d_1}{d_1} \times 100$$

$$= \frac{24 - 16}{16} \times 100$$

$$= \frac{8}{16} \times 100 = 50\%$$

Ans 11.

$$d = \sqrt{2hR}$$

$$\text{area} = \pi d^2$$

$$\text{Area} = \pi(2hR) = 3.14 \times 2 \times 30 \times 6400 \times 10^3 \text{ . m}^2$$

$$= 1205.76 \text{ km}^2$$

$$\approx 1206 \text{ km}^2$$

Ans 12.

B. W. (Bandwidth) = $2 \times$ maximum frequency at modulating signal

$$= 2 \times 5\text{kHz}$$

$$= 10\text{ kHz}$$

\therefore No of stations accommodate

$$= \frac{90}{10} = 9$$

Ans 13.

$$A_m = \frac{A_{\max} - A_{\min}}{2}$$

$$A_c = \frac{A_{\max} + A_{\min}}{2}$$

$$\text{Modulation index (mi)} = \frac{A_m}{A_c} = \frac{\frac{A_{\max} - A_{\min}}{2}}{\frac{A_{\max} + A_{\min}}{2}} = \frac{A_{\max} - A_{\min}}{A_{\max} + A_{\min}}$$

$$\text{mi} = \frac{16-8}{16+8} = \frac{8}{24} = \frac{1}{3} = 0.33$$

$$\text{mi} = 33 \times 10^{-2}$$

$$\therefore x = 33$$

Ans 14. Given, power of transmitted signal, $P_i = 0.1\text{ kW} = 0.1 \times 10^3\text{W} = 10^2\text{ W}$

Rate of attenuation, $R = -5\text{ dB/km}$

Length of cable, $l = 20\text{ km}$

Power received at receiver, $P_x = 10^{-x}\text{ W}$

Total loss, $\beta = R \times l = -5 \times 20 = -100\text{ dB}$

$$\therefore \text{Gain } (\beta) = 10 \log_{10} \frac{P_0}{P_i}$$

$$\therefore \beta = -100 = -10 \log_{10} \frac{P_0}{P_i}$$

$$\Rightarrow -10 = \log_{10} \frac{P_0}{P_i} \Rightarrow 10^{-10} = \frac{P_0}{P_i}$$

$$\Rightarrow P_0 = 10^{-10} P_i = 10^{-10} \times 10^2 = 10^{-8} \Rightarrow P_0 = 10^{-8} \text{ W}$$

Hence, $x = 8$

Ans 15. Given, audio signal,

$$V_m = 20 \sin 2\pi(1500t) \dots (i)$$

$$\text{Carrier signal, } V_c = 80 \sin 2\pi(100000t) \dots (ii)$$

We know that, modulation index,

$$m_f = \frac{A_m}{A_c}$$

From Eqs. (i) and (ii), we get

$$A_m = 20, A_c = 80$$

Percentage of modulation index,

$$m_f = \frac{A_m}{A_c} \times 100 = \frac{20}{80} \times 100 = 25\%$$

MCQ (Single Correct Answer)

Q.1 An antenna is mounted on a 400 m tall building. What will be the wavelength of signal that can be radiated effectively by the transmission tower upto a range of 44 km?

A 37.8 m

B 605 m

C 75.6 m

D 302 m

27th Aug Evening Shift 2021

Q.2 A transmitting antenna at top of a tower has a height of 50 m and the height of receiving antenna is 80 m. What is range of communication for Line of Sight (LoS) mode?

[use radius of earth = 6400 km]

A 45.5 km

B 80.2 km

C 144.1 km

D 57.28 km

26th Aug Evening Shift 2021

Q.3 In amplitude modulation, the message signal

$$V_m(t) = 10 \sin(2\pi \times 10^5 t) \text{ volts and}$$

Carrier signal

$$V_c(t) = 20 \sin(2\pi \times 10^7 t) \text{ volts}$$

The modulated signal now contains the message signal with lower side band and upper side band frequency, therefore the bandwidth of modulated signal is α kHz. The value of α is :

A 200 kHz

B 50 kHz

C 100 kHz

D 0

25th July Morning Shift 2021

Q.4 What should be the height of transmitting antenna and the population covered if the television telecast is to cover a radius of 150 km? The average population density around the tower is 2000/km² and the value of $R_e = 6.5 \times 10^6$ m.

Height = 1241 m

A

Population covered = 7×10^5

Height = 1731 m

B

Population covered = 1413×10^5

Height = 1800 m

C

Population covered = 1413×10^8

Height = 1600 m

D

Population covered = 2×10^5

22th July Evening Shift 2021

Q.5 A carrier signal $C(t) = 25 \sin(2.512 \times 10^{10}t)$ is amplitude modulated by a message signal $m(t) = 5 \sin(1.57 \times 10^8t)$ and transmitted through an antenna. What will be the bandwidth of the modulated signal?

A 50 MHz

B 8 GHz

C 1987.5 MHz

D 2.01 GHz

17th Mar Evening Shift 2021

Q.6 A 25 m long antenna is mounted on an antenna tower. The height of the antenna tower is 75 m. The wavelength (in meter) of the signal transmitted by this antenna would be :

A 200

B 400

C 100

D 300

16th Mar Morning Shift 2021

Q.7 If a message signal of frequency ' f_m ' is amplitude modulated with a carrier signal of frequency ' f_c ' and radiated through an antenna, the wavelength of the corresponding signal in air is :

A $\frac{c}{f_c + f_m}$

B $\frac{c}{f_c}$

C $\frac{c}{f_c - f_m}$

D $\frac{c}{f_m}$

25th Feb Evening Shift 2021

Q.8 Given below are two statements :

Statement I : A speech signal of 2 kHz is used to modulate a carrier signal of 1 MHz.
The bandwidth requirement for the signal is 4 kHz.

Statement II : The side band frequencies are 1002 kHz and 998 kHz.

In the light of the above statements, choose the correct answer from the options given below :

- ☒ A Statement I is false but Statement II is true
- ☐ B Both Statement I and Statement II are false
- ☐ C Statement I is true but Statement II is false
- ☐ D Both Statement I and Statement II are true

MCQ Answer Key

1. Ans. (b)
2. Ans. (d)
3. Ans. (a)
4. Ans. (b)
5. Ans. (a)
6. Ans. (c)
7. Ans. (b)
8. Ans. (d)

MCQ Explanation

Ans 1.

h : height of antenna

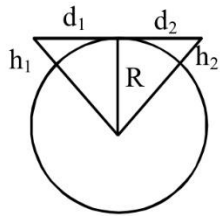
λ : wavelength of signal

$h < \lambda$

$\lambda > h$

$\lambda > 400 \text{ m}$

Ans 2.



$$d_t = \sqrt{2Rh_1} + \sqrt{2Rh_2}$$

$$= \sqrt{2R} (\sqrt{h_1} + \sqrt{h_2})$$

$$= (2 \times 6400 \times 10^3)^{1/2} (\sqrt{50} + \sqrt{80})$$

$$= 3578(7.07 + 8.94)$$

$$= 57.28 \text{ km}$$

Ans 3.

$$\text{Bandwidth} = 2 \times f_m$$

$$= 2 \times 10^5 \text{ HZ} = 200 \text{ KHZ}$$

Ans 4.

$$d = \sqrt{2R_e h}$$

$$\text{Area covered} = \pi d^2$$

$$h = \frac{d^2}{2R_e} = 1731 \text{ m}$$

Population covered = $2000 \times \pi(d^2)$

Ans 5.

$$\beta = 2f_{m(t)}$$

$$\Rightarrow \beta = 2 \times \frac{1.57 \times 10^8}{2\pi}$$

$$\Rightarrow \beta = 50 \text{ MHz}$$

Ans 6. Given that, height of peak of antenna : $H = 25 \text{ m}$.

As, we know that

$$\lambda = 4H$$

$$\therefore \lambda = 4 \times 25$$

$$\Rightarrow \lambda = 100 \text{ m}$$

Ans 7.

Given frequency of message signal = f_m

Frequency of carrier signal = f_c

The wavelength of the corresponding signal in air is $\Rightarrow \lambda = \frac{c}{f_c}$

Ans 8.

$$\text{Side band} = (f_c - f_m) \text{ to } (f_c + f_m)$$

$$= (1000 - 2) \text{ KHz to } (1000 + 2) \text{ KHz}$$

$$= 998 \text{ KHz to } 1002 \text{ KHz}$$

$$\text{Band width} = 2f_m$$

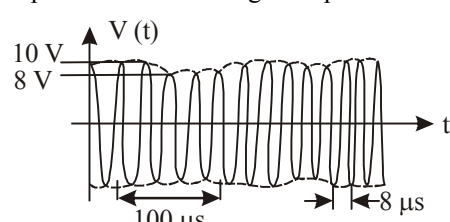
$$= 2 \times 2 \text{ KHz}$$

$$= 4 \text{ KHz}$$

Both statements are true.

TOPIC 1 Communication Systems



- An amplitude modulated wave is represented by the expression $v_m = 5(1 + 0.6 \cos 6280t) \sin(211 \times 10^4 t)$ volts. The minimum and maximum amplitudes of the amplitude modulated wave are, respectively : **[Sep. 02, 2020 (I)]**
 - $\frac{3}{2}$ V, 5 V
 - $\frac{5}{2}$ V, 8 V
 - 5 V, 8 V
 - 3 V, 5 V
- In an amplitude modulator circuit, the carrier wave is given by, $C(t) = 4 \sin(20000 \pi t)$ while modulating signal is given by, $m(t) = 2 \sin(2000 \pi t)$. The values of modulation index and lower side band frequency are : **[12 April 2019 II]**
 - 0.5 and 10 kHz
 - 0.4 and 10 kHz
 - 0.3 and 9 kHz
 - 0.5 and 9 kHz
- A message signal of frequency 100 MHz and peak voltage 100 V is used to execute amplitude modulation on a carrier wave of frequency 300 GHz and peak voltage 400 V. The modulation index and difference between the two side band frequencies are : **[10 April 2019 II]**
 - 4 ; 1×10^8 Hz
 - 4 ; 2×10^8 Hz
 - 0.25 ; 2×10^8 Hz
 - 0.25 ; 1×10^8 Hz
- A signal $A \cos \omega t$ is transmitted using $v_0 \sin \omega_0 t$ as carrier wave. The correct amplitude modulated (AM) signal is: **[9 April 2019 I]**
 - $v_0 \sin \omega_0 t + \frac{A}{2} \sin(\omega_0 - \omega)t + \frac{A}{2} \sin(\omega_0 + \omega)t$
 - $v_0 \sin[\omega_0(1 + 0.01 A \sin \omega t)t]$
 - $v_0 \sin \omega_0 t + A \cos \omega t$
 - $(v_0 + A) \cos \omega t \sin \omega_0 t$
- The physical sizes of the transmitter and receiver antenna in a communication system are: **[9 April 2019 II]**
 - independent of both carrier and modulation frequency
 - inversely proportional to carrier frequency
 - inversely proportional to modulation frequency
 - proportional to carrier frequency
- The wavelength of the carrier waves in a modern optical fiber communication network is close to : **[8 April 2019 I]**
 - 2400 nm
 - 1500 nm
 - 600 nm
 - 900 nm
- In a line of sight radio 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 of the transmitting antenna should be : **[8 April 2019 II]**
(Radius of the Earth = 6.4×10^6 m).
 - 20 m
 - 51 m
 - 32 m
 - 40 m
- A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index? **[12 Jan. 2019 I]**
 - 0.3
 - 0.5
 - 0.6
 - 0.4
- To double the covering range of a TV transmission tower, its height should be multiplied by: **[12 Jan 2019 II]**
 - $\frac{1}{\sqrt{2}}$
 - 2
 - 4
 - $\sqrt{2}$
- An amplitude modulated signal is given by $V(t) = 10[1 + 0.3 \cos(2.2 \times 10^4 t)] \sin(5.5 \times 10^5 t)$. Here t is in seconds. The sideband frequencies (in kHz) are, [Given $\pi = 22/7$] **[11 Jan 2019 II]**
 - 1785 and 1715
 - 178.5 and 171.5
 - 89.25 and 85.75
 - 892.5 and 857.5
- An amplitude modulated signal is plotted below :
 

Which one of the following best describes the above signal? **[11 Jan. 2019 II]**

 - $(9 + \sin(2.5 \pi \times 10^5 t)) \sin(2\pi \times 10^4 t)$ V
 - $(1 + 9 \sin(2\pi \times 10^4 t)) \sin(2.5 \pi \times 10^5 t)$ V

- (c) $(9 + \sin(2\pi \times 10^4 t)) \sin(2.5\pi \times 10^5 t)$ V
 (d) $(9 + \sin(4\pi \times 10^4 t)) \sin(5\pi \times 10^5 t)$ V
12. 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 upto which signals can be broadcasted from this tower in LOS (Line of Sight) mode? (Given : radius of earth = 6.4×10^6 m). **[10 Jan. 2019 I]**
 (a) 65 km (b) 48 km (c) 80 km (d) 40 km
13. 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 will you allot? **[10 Jan. 2019 I]**
 (a) 2750 kHz (b) 2900 kHz
 (c) 2250 kHz (d) 2000 kHz
14. In a communication system operating at wavelength 800 nm, only one percent of source frequency is available as signal bandwidth. The number of channels accommodated for transmitting TV signals of band width 6 MHz are (Take velocity of light $c = 3 \times 10^8$ m/s, $h = 6.6 \times 10^{-34}$ J-s) **[9 Jan. 2019 II]**
 (a) 3.75×10^6 (b) 3.86×10^6
 (c) 6.25×10^5 (d) 4.87×10^5
15. 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? **[2018]**
 (a) 2×10^3 (b) 2×10^4 (c) 2×10^5 (d) 2×10^6
16. A carrier wave of peak voltage 14 V is used for transmitting a message signal. The peak voltage of modulating signal given to achieve a modulation index of 80% will be: **[2018]**
 (a) 11.2 V (b) 7 V (c) 22.4 V (d) 28 V
17. The number of amplitude modulated broadcast stations that can be accommodated in a 300 kHz band width for the highest modulating frequency 15 kHz will be: **[Online April 15, 2018]**
 (a) 20 (b) 10 (c) 8 (d) 15
18. The carrier frequency of a transmitter is provided by a tank circuit of a coil of inductance $49 \mu\text{H}$ and a capacitance of 2.5 nF . It is modulated by an audio signal of 12 kHz. The frequency range occupied by the side bands is: **[Online April 15, 2018]**
 (a) 18 kHz–30 kHz (b) 63 kHz–75 kHz
 (c) 442 kHz–466 kHz (d) 13482 kHz–13494 kHz
19. In amplitude modulation, sinusoidal carrier frequency used is denoted by ω_c and the signal frequency is denoted by ω_m . The bandwidth ($\Delta\omega_m$) of the signal is such that $\Delta\omega_m < \omega_c$. Which of the following frequencies is not contained in the modulated wave? **[2017]**
 (a) $\omega_m + \omega_c$ (b) $\omega_c - \omega_m$
 (c) ω_m (d) ω_c
20. A signal is to be transmitted through a wave of wavelength λ , using a linear antenna. The length l of the antenna and effective power radiated P_{eff} will be given respectively as :
 (K is a constant of proportionality) **[Online April 9, 2017]**
 (a) $\lambda, P_{\text{eff}} = K \left(\frac{1}{\lambda}\right)^2$ (b) $\frac{\lambda}{8}, P_{\text{eff}} = K \left(\frac{1}{\lambda}\right)$
 (c) $\frac{\lambda}{16}, P_{\text{eff}} = K \left(\frac{1}{\lambda}\right)^3$ (d) $\frac{\lambda}{5}, P_{\text{eff}} = K \left(\frac{1}{\lambda}\right)^{\frac{1}{2}}$
21. A signal of frequency 20 kHz and peak voltage of 5 Volt is used to modulate a carrier wave of frequency 1.2 MHz and peak voltage 25 Volts. Choose the correct statement. **[Online April 8, 2017]**
 (a) Modulation index = 5, side frequency bands are at 1400 kHz and 1000 kHz
 (b) Modulation index = 5, side frequency bands are at 21.2 kHz and 18.8 kHz
 (c) Modulation index = 0.8, side frequency bands are at 1180 kHz and 1220 kHz
 (d) Modulation index = 0.2, side frequency bands are at 1220 kHz and 1180 kHz
22. Choose the correct statement : **[2016]**
 (a) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
 (b) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.
 (c) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
 (d) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
23. A modulated signal $C_m(t)$ has the form $C_m(t) = 30 \sin 300\pi t + 10 (\cos 200\pi t - \cos 400\pi t)$. The carrier frequency f_c , the modulating frequency (message frequency) f_m and the modulation index μ are respectively given by : **[Online April 10, 2016]**
 (a) $f_c = 200 \text{ Hz}; f_m = 50 \text{ Hz}; \mu = \frac{1}{2}$
 (b) $f_c = 150 \text{ Hz}; f_m = 50 \text{ Hz}; \mu = \frac{2}{3}$
 (c) $f_c = 150 \text{ Hz}; f_m = 30 \text{ Hz}; \mu = \frac{1}{3}$
 (d) $f_c = 200 \text{ Hz}; f_m = 30 \text{ Hz}; \mu = \frac{1}{2}$

24. 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 : **[Online April 9, 2016]**

(a) 2 (b) 5 (c) 6 (d) 3

25. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. The frequencies of the resultant signal is/are : **[2015]**

(a) 2005 kHz, 2000 kHz and 1995 kHz
(b) 2000 kHz and 1995 kHz
(c) 2 MHz only
(d) 2005 kHz and 1995 kHz

26. Long range radio transmission is possible when the radio waves are reflected from the ionosphere. For this to happen the frequency of the radio waves must be in the range:

[Online April 19, 2014]

(a) 80 - 150 MHz (b) 8 - 25 MHz
(c) 1 - 3 MHz (d) 150 - 1500 kHz

27. For sky wave propagation, the radio waves must have a frequency range in between: **[Online April 12, 2014]**

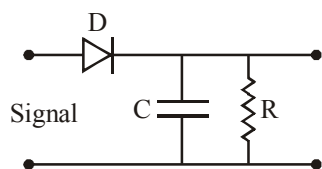
(a) 1 MHz to 2 MHz (b) 5 MHz to 25 MHz
(c) 35 MHz to 40 MHz (d) 45 MHz to 50 MHz

28. A transmitting antenna at the top of a tower has height 32 m and height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in line of sight (LOS) mode?

[Online April 9, 2014]

(a) 55.4 km (b) 45.5 km (c) 54.5 km (d) 455 km

29. 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 which could be detected by it. **[2013]**



(a) 10.62 MHz (b) 10.62 kHz
(c) 5.31 MHz (d) 5.31 kHz

30. Which of the following modulated signal has the best noise-tolerance ? **[Online April 25, 2013]**

(a) Long-wave (b) Short-wave
(c) Medium-wave (d) Amplitude-modulated

31. Which of the following statement is NOT correct?

[Online April 23, 2013]

(a) Ground wave signals are more stable than the sky wave signals.

- (b) The critical frequency of an ionospheric layer is the highest frequency that will be reflected back by the layer when it is vertically incident.
(c) Electromagnetic waves of frequencies higher than about 30 MHz cannot penetrate the ionosphere.
(d) Sky wave signals in the broadcast frequency range are stronger at night than in the day time.

32. This question has Statement-1 and Statement-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement-1: Short wave transmission is achieved due to the total internal reflection of the e-m wave from an appropriate height in the ionosphere.

Statement-2: Refractive index of a plasma is independent of the frequency of e-m waves. **[Online April 22, 2013]**

- (a) Statement-1 is true, Statement-2 is false.
(b) Statement-1 is false, Statement-2 is true.
(c) Statement-1 is true, Statement-2 is true but Statement -2 is **not** the correct explanation of statement-1.
(d) Statement-1 is true, Statement-2 is true and Statement -2 is the correct explanation of Statement-1.

33. If a carrier wave $c(t) = A \sin \omega_c t$ is amplitude modulated by a modulator signal $m(t) = A \sin \omega_m t$ then the equation of modulated signal $[C_m(t)]$ and its modulation index are respectively **[Online April 9, 2013]**

(a) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_c t$ and 2
(b) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_m t$ and 1
(c) $C_m(t) = A(1 + \sin \omega_m t) \sin \omega_c t$ and 1
(d) $C_m(t) = A(1 + \sin \omega_c t) \sin \omega_m t$ and 2

34. 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 upto which it can detect object located on the surface of the earth

(Radius of earth = 6.4×10^6 m) is : **[2012]**

(a) 80 km (b) 16 km (c) 40 km (d) 64 km

35. A radio transmitter transmits at 830 kHz. At a certain distance from the transmitter magnetic field has amplitude 4.82×10^{-11} T. The electric field and the wavelength are respectively **[Online May 26, 2012]**

(a) 0.014 N/C, 36 m (b) 0.14 N/C, 36 m
(c) 0.14 N/C, 360 m (d) 0.014 N/C, 360 m

36. Given the electric field of a complete amplitude modulated wave as

$$\vec{E} = \hat{i} E_c \left(1 + \frac{E_m}{E_c} \cos \omega_m t \right) \cos \omega_c t.$$

Where the subscript c stands for the carrier wave and m for the modulating signal. The frequencies present in the modulated wave are **[Online May 19, 2012]**

(a) ω_c and $\sqrt{\omega_c^2 + \omega_m^2}$
(b) $\omega_c, \omega_c + \omega_m$ and $\omega_c - \omega_m$

- (c) ω_c and ω_m
(d) ω_c and $\sqrt{\omega_c \omega_m}$
37. A 10 kW transmitter emits radio waves of wavelength 500 m. The number of photons emitted per second by the transmitter is of the order of **[Online May 12, 2012]**
(a) 10^{37} (b) 10^{31} (c) 10^{25} (d) 10^{43}
38. This question has Statement – 1 and Statement – 2. Of the four choices given after the statements, choose the one that best describes the two statements. **[2011]**
Statement – 1 : Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.
Statement – 2 : The state of ionosphere varies from hour to hour, day to day and season to season.
- (a) Statement–1 is true, Statement–2 is true, Statement–2 is the correct explanation of Statement–1.
(b) Statement–1 is true, Statement–2 is true, Statement–2 is not the correct explanation of Statement – 1.
(c) Statement – 1 is false, Statement – 2 is true.
(d) Statement – 1 is true, Statement – 2 is false.
39. Which of the following four alternatives is not correct ? We need modulation : **[2011 RS]**
(a) to reduce the time lag between transmission and reception of the information signal
(b) to reduce the size of antenna
(c) to reduce the fractional band width, that is the ratio of the signal band width to the centre frequency
(d) to increase the selectivity



Hints & Solutions



1. (b) From the given expression,
 $V_m = 5(1 + 0.6 \cos 6280t) \sin(211 \times 10^4 t)$
 Modulation index, $\mu = 0.6$

$$\therefore A_m = \mu A_c$$

$$\frac{A_{\max} + A_{\min}}{2} = A_c = 5 \quad \dots(i)$$

$$\frac{A_{\max} - A_{\min}}{2} = A_m = 3 \quad \dots(ii)$$

From equation (i) + (ii),

Maximum amplitude, $A_{\max} = 8$.

From equation (i) - (ii),

Minimum amplitude $A_{\min} = 2$.

2. (d) Modulation index, $\mu = \frac{A_m}{A_c} = \frac{2}{4} = 0.5$

$$\text{Given, } f_c = \frac{20000\pi}{2\pi} = 10000 \text{ Hz.}$$

$$\text{and } f_m = \frac{2000\pi}{2\pi} = 1000 \text{ Hz.}$$

$$\therefore \text{LSB} = f_c - f_m = 10000 - 1000 = 9000 \text{ Hz.}$$

3. (c) Range of frequency = $(f_c - f_m)$ to $(f_c + f_m)$
 \therefore Band width = $2f_m = 2 \times 100 \times 10^6 \text{ Hz}$
 $= 2 \times 10^8 \text{ Hz}$

$$\text{and Modulation index} = \frac{A_m}{A_c} = \frac{100}{400} = 0.25$$

4. (a)

5. (b) Size of antenna,

$$l = \frac{\lambda}{4}. \text{ As } \lambda = \frac{c}{f} \therefore l \propto \frac{1}{f}$$

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

7. (c) $\text{LOS} = \sqrt{2h_T R} + \sqrt{2h_R R}$

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

On solving, $h_T = 32 \text{ m}$

8. (c) Maximum amplitude = $E_m + E_c = 160$

$$E_m + 100 = 160$$

$$E_m = 160 - 100 = 60$$

Modulation index,

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

$$\mu = 0.6$$

9. (c) As we know, Range = $\sqrt{2hR}$

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

10. (c) Equation given

$$V(t) = 10[1 + 0.3 \cos(2.2 \times 10^4)]$$

$$\sin(5.5 \times 10^5 t)$$

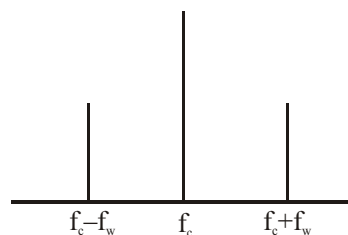
$$= 10 + 1.5[\sin(57.2 \times 10^4 t) + \sin(52.8 \times 10^4 t)]$$

$$\omega_c + \omega_w = 57.2 \times 10^4 = 2\pi f_1$$

$$f_1 = \frac{57.2 \times 10^4}{2 \times \left(\frac{22}{7}\right)} = 9.1 \times 10^4 \approx 91 \text{ KHz}$$

$$\omega_c - \omega_w = 52.8 \times 10^4$$

$$f_2 = \frac{52.8 \times 10^4}{2 \times \left(\frac{22}{7}\right)} \approx 84 \text{ KHz}$$



Upper side band frequency (f_1) is

$$f_1 = f_c - f_w = \frac{52.8 \times 10^4}{2\pi} \approx 85.00 \text{ kHz}$$

Lower side band frequency (f_2) is

$$f_2 = f_c + f_w = \frac{57.2 \times 10^4}{2\pi} \approx 90.00 \text{ kHz}$$

11. (c) After analysing the graph we may conclude that

(i) Amplitude varies as $8-10 \text{ V}$ or 9 ± 1

(ii) Two time period as

$100 \mu\text{s}$ (signal wave) & $8 \mu\text{s}$ (carrier wave)

So, equation of AM signal is

$$\left[9 \pm 1 \sin\left(\frac{2\pi t}{T_1}\right) \sin\left(\frac{2\pi t}{T_2}\right) \right]$$

$$= [9 \pm \sin(2\pi \times 10^4 t)] \sin(2.5\pi \times 10^5 t) \text{ V}$$

12. (a) 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, hT and hR

$$d_{\max} = \sqrt{2 \times 6.4 \times 106} \left[\sqrt{140} + \sqrt{40} \right]$$

or, $d_{\max} \approx 65 \text{ km}$

13. (d) According to question, modulation frequency, 250 Hz is 10% of carrier wave

$$f_{\text{carrier}} = \frac{250}{0.1} = 2500 \text{ KHz}$$

\therefore Range of signal $2500 \pm 250 \text{ KHz} = 2250 \text{ Hz to } 2750 \text{ Hz}$ For 2000 KHz

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

\therefore Range = 1800 KHz to 2200 KHz

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

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

$$1\% \text{ of } f = 0.0375 \times 10^{14} \text{ Hz}$$

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

As we know, number of channels accommodated for transmission =

$$\frac{\text{total bandwidth of Channel}}{\text{bandwidth needed per channel}} = \frac{3.75 \times 10^6}{6} = 6.25 \times 10^5$$

15. (c) If n = no. of channels

$$10\% \text{ of } 10 \text{ GHz} = n \times 5 \text{ KHz or,}$$

$$\Rightarrow n = 2 \times 10^5$$

16. (a) Given : modulation index $m = 80\% = 0.8$

$$E_c = 14 \text{ V, } E_m = ?$$

$$\text{using, } m = \frac{E_m}{E_c} \Rightarrow E_m = m \times E_c = 0.8 \times 14 = 11.2 \text{ V}$$

17. (b) Given, modulating frequency $f_m = 15 \text{ KHz}$

$$\therefore \text{ Bandwidth of one channel} = 2f_m = 30 \text{ KHz}$$

$$\therefore \text{ No of channels accommodate} = \frac{300 \text{ KHz}}{30 \text{ KHz}} = 10$$

18. (c) Given : Inductance, $L = 49 \mu\text{H} = 49 \times 10^{-6} \text{ H}$, capacitance $C = 2.5 \text{ nF} = 2.5 \times 10^{-9} \text{ F}$

$$\text{Using } \omega = \frac{1}{\sqrt{LC}}$$

$$= \frac{1}{\sqrt{49 \times 10^{-6} \times \frac{2.5}{10} \times 10^{-9}}} = \frac{1}{7 \times 5 \times 10^{-8}} = \frac{10^8}{7 \times 5}$$

$$\text{or, } \frac{10^8}{7 \times 5} = 2\pi \times f = 2 \times \frac{22}{7} \times f \quad (\because \omega = 2\pi f)$$

$$\text{or, } f = \frac{10^7}{22} = \frac{10^4}{22} \text{ kHz} = 454.54 \text{ kHz}$$

Therefore frequency range $454.54 \pm 12 \text{ kHz}$

i.e., 442 kHz – 466 kHz

19. (c) Modulated carrier wave contains frequency ω_c and $\omega_c \pm \omega_m$

20. (a) Length of antenna = comparable to λ

Power radiated by linear antenna inversely depends on the square of wavelength and directly on the length of the antenna. Hence,

$$\text{Power } P = \mu \left(\frac{1}{\lambda} \right)^2$$

here $\mu = K$

21. (d) Modulation index (m) = $\frac{V_m}{V_0} = \frac{5}{25} = 0.2$

Given, frequency of carrier wave (f_c) = $1.2 \times 10^6 \text{ Hz}$
= 1200 kHz.

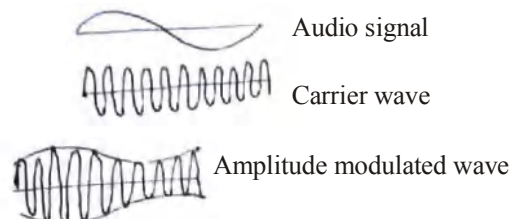
Frequency of signal (f_0) = 20 kHz.

Side frequency bands = $f_c \pm f_0$

$$f_1 = 1200 - 20 = 1180 \text{ kHz}$$

$$f_2 = 1200 + 20 = 1220 \text{ kHz}$$

22. (c) In amplitude modulation, the amplitude of the high frequency carrier wave made to vary in proportional to the amplitude of audio signal.



23. (b) Comparing the given equation with standard modulated signal wave equation, $m = A_c \sin \omega_c t + \frac{\mu A_c}{2}$

$$\cos(\omega_c - \omega_s)t - \frac{\mu A_c}{2} \cos(\omega_c + \omega_s)t$$

$$\mu \frac{A_c}{2} = 10 \Rightarrow \mu = \frac{2}{3} \text{ (modulation index)}$$

$$A_c = 30$$

$$\omega_c - \omega_s = 200\pi$$

$$\omega_c + \omega_s = 400\pi$$

$$\Rightarrow f_c = 150, f_s = 50 \text{ Hz.}$$

24. (c) Ratio of AM signal Bandwidths

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

25. (a) Amplitude modulated wave consists of three frequencies are $\omega_c + \omega_m$, ω_c , $\omega_c - \omega_m$

i.e. 2005 kHz, 2000 kHz, 1995 kHz

26. (b) Frequency of radio waves for sky wave propagation is 2 MHz to 30 MHz.

27. (b) Sky wave propagation is suitable for frequency range 5 MHz to 25 MHz.

28. (b) Given : $h_R = 32$ m

$$h_T = 50 \text{ m}$$

Maximum distance, $d_M = ?$

$$\text{Applying, } d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

$$= \sqrt{2 \times 6.4 \times 10^6 \times 50} + \sqrt{2 \times 6.4 \times 10^6 \times 32} = 45.5 \text{ km}$$

29. (b) **Given :** Resistance $R = 100$ kilo ohm

$$= 100 \times 10^3 \Omega$$

Capacitance $C = 250$ picofarad

$$= 250 \times 10^{-12} \text{ F}$$

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

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

$$= 2.5 \times 10^{-5} \text{ sec}$$

The higher frequency which can be detected with tolerable distortion is

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

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

$$= 10.61 \text{ KHz}$$

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 signal voltage for proper detection of modulated signal.

30. (b) Short-wave has the best noise tolerance.

31. (c) Above critical frequency (f_c), an electromagnetic wave penetrates the ionosphere and is not reflected by it.

32. (a) Effective refractive index of the ionosphere

$$n_{\text{eff}} = n_0 \left[1 - \frac{80.5N}{f^2} \right]^{1/2}$$

where f is the frequency of em waves

33. (c) Modulation index

$$m_a = \frac{E_m}{E_c} = \frac{A}{A} = 1$$

Equation of modulated signal $[C_m(t)]$

$$= E_{(c)} + m_a E_{(c)} \sin \omega_m t$$

$$= A (1 + \sin \omega_c t) \sin \omega_m t$$

$$(\text{As } E_{(c)} = A \sin \omega_c t)$$

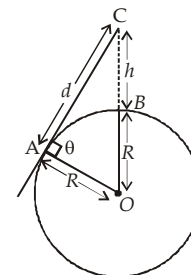
34. (a) Let d is the maximum distance, upto which it can detect the objects

From ΔAOC

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

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

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



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

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

35. (d) Frequency of EM wave $\nu = 830$ KHz

$$= 830 \times 10^3 \text{ Hz.}$$

$$\text{Magnetic field, } B = 4.82 \times 10^{-11} \text{ T}$$

As we know, frequency, $\nu = \frac{c}{\lambda}$

$$\text{or } \lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{830 \times 10^3}$$

$$\lambda \approx 360 \text{ m}$$

$$\text{And, } E = BC = 4.82 \times 10^{-11} \times 3 \times 10^8$$

$$= 0.014 \text{ N/C}$$

36. (b) The frequencies present in amplitude modulated wave are :

$$\text{Carrier frequency} = \omega_c$$

$$\text{Upper side band frequency} = \omega_c + \omega_m$$

$$\text{Lower side band frequency} = \omega_c - \omega_m$$

37. (b) Power = $\frac{nhc}{\lambda}$

(where, n = no. of photons per second)

$$\Rightarrow n = \frac{10 \times 10^3 \times 500}{6.6 \times 10^{-34} \times 3 \times 10^8} \approx 10^{31}$$

38. (b) For long distance communication, sky wave signals are used.

Also, the state of ionosphere varies every time.

So, both statements are correct.

39. (a) Low frequencies cannot be transmitted to long distances. Therefore, they are super imposed on a high frequency carrier signal by a process known as modulation. Speed of electro-magnetic waves will not change due to modulation. So there will be time lag between transmission and reception of the information signal.