DCAM classes
Dynamic Classes for Academic Mastery

Physics

NCERT Exemplar Problems

Chapter 15

Communication Systems

Answers

15.1	(b)
15.2	(a)
15.3	(b)
15.4	(a)
15.5	(b)
15.6	(c)
15.7	(b)
15.8	(b)
15.9	(c)
15.10	(a), (b), (d)
15.11	(b), (d)
15.12	(b), (c), (d)
15.13	(a), (b), (c)

15.14 (b), (d)

15.15 (i) analog

(ii) analog

(iii) digital

(iv) digital

15.16 No, signals of frequency greater than 30 MHz will not be reflected by the ionosphere, but will penetrate through the ionosphere.

15.17 The refractive index increases with increase in frequency which implies that for higher frequency waves, angle of refraction is less, i.e. bending is less. Hence, the condition of total internal relection is atained after travelling larger distance (by 3MHz wave).

15.18 $A_c + A_m = 15$, $A_c - A_m = 3$

$\therefore\ 2A_c = 18$, $2A_m = 12$

$$\therefore\ m = \frac{A_m}{A_c} = \frac{2}{3}$$

15.19 $$\frac{1}{2\pi\sqrt{LC}} = 1\text{MHz}$$

$$\sqrt{LC} = \frac{1}{2\pi \times 10^6}$$

15.20 In AM, the carrier waves instantaneous voltage is varied by modulating waves voltage. On transmission, noise signals can also be added and receiver assumes noise a part of the modulating signal.

However in FM, the carriers frequency is changed as per modulating waves instantaneous voltage. This can only be done at the mixing/modulating stage and not while signal is transmitting in channel. Hence, noise doesn't effect FM signal.

15.21 Loss suffered in transmission path

$= -2\ \text{dB km}^{-1} \times 5\ \text{km} = -10\ \text{dB}$

Total amplifier gain = 10 dB + 20 dB

= 30 dB

Overall gain of signal = 30 dB – 10 dB

= 20 dB

$$10\log\left(\frac{P_o}{P_i}\right) = 12 \text{ or } P_o = P_i \times 10^2$$

$$= 1.01 \text{ mW} \times 100 = 101 \text{ mW}.$$

15.22 (i) Range = $\sqrt{2 \times 6.4 \times 10^6 \times 20}$ = 16 km

Area covered = 803.84 km^2

(ii) Range = $\sqrt{2 \times 6.4 \times 10^6 \times 20} + \sqrt{2 \times 6.4 \times 10^6 \times 25}$

= (16 + 17.9) km = 33.9 km

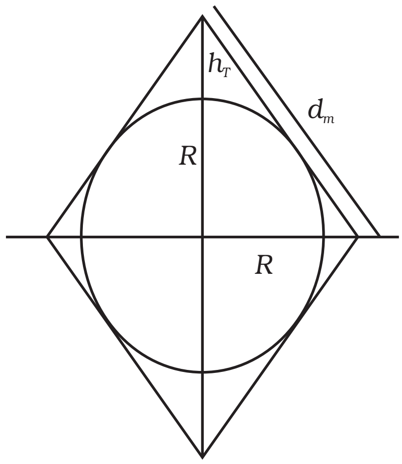
Area covered = 3608.52 km^2

$\therefore$ Percentage increase in area

$$= \frac{(3608.52 - 803.84)}{803.84} \times 100$$

= 348.9%

15.23 $d_m^2 = 2(R + h_T)^2$



$8Rh_T = 2(R+h_T)^2$ $\quad (\because dm = 2\sqrt{2Rh_T})$

$$4Rh_T = R^2 + h_T{}^2 + 2Rh_T$$

$(R - h_T)^2 = 0$

$R = h_T$

Since space wave frequency is used, $\lambda << h_T$, hence only tower height is taken to consideration.

In three diamensions, 6 antenna towers of $h_T = R$ would do.

15.24 For F_1 layer

$5 \times 10^6 = 9(N_{max})^{1/2}$ or $N_{max} = \left(\frac{5}{9} \times 10^6\right)^2 = 3.086 \times 10^{11}$ m^{-3}

For F_2 layer
$8 \times 10^6 = 9\ (N_{max})^{1/2}$ or

$$N_{max} = \left(\frac{8}{9} \times 10^6\right) = 7.9 \times 10^{11} \text{m}^{-3} = 7.9 \times 10^{11} \text{ m}^{-3}.$$

15.25 Of $\omega_c - \omega_m$, ω_c and $\omega_m + \omega_m$, only $\omega_c + \omega_m$ or $\omega_c - \omega_m$ contains information. Hence cost can be reduced by transmitting $\omega_c + \omega_m$, $\omega_c - \omega_m$, both $\omega_c + \omega_m$ & $\omega_c - \omega_m$

15.26 (i) $\dfrac{I}{I_o} = \dfrac{1}{4}$, so $\ln\left(\dfrac{1}{4}\right) = -\alpha x$

or $\ln 4 = \alpha x$ or $x = \left(\dfrac{\ln 4}{\alpha}\right)$

(ii) $10\log_{10}\dfrac{I}{I_o} = -\alpha x$ where α is the attunation in dB/km.

Here $\dfrac{I}{I_o} = \dfrac{1}{2}$

or $10\log\left(\dfrac{1}{2}\right) = -50\alpha$ or $\log 2 = 5\alpha$

or $\alpha = \dfrac{\log 2}{5} = \dfrac{0.3010}{5} = 0.0602 dB/km$

15.27 $\dfrac{2x}{\text{time}} = \text{velocity}$

$2x = 3 \times 10^8 \text{ m/s} \times 4.04 \times 10^{-3}\text{s}$

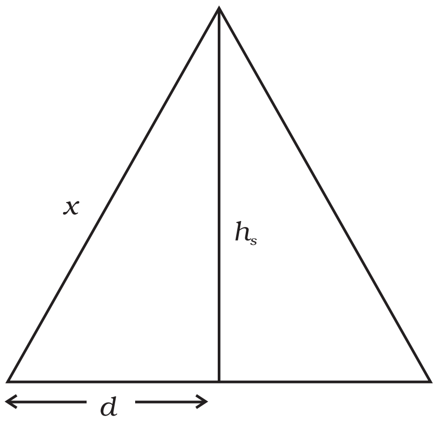
$x = \dfrac{12.12 \times 10^5}{2}\text{m} = 6.06 \times 10^5\text{m} = 606 \text{ km}$

$d^2 = x^2 - h_s^2 = (606)^2 - (600)^2 = 7236$; $d = 85.06$ km

Distance between source and receiver = 2d ≅170 km

$d_m = 2\sqrt{2Rh_T}$, $2d = d_m$, $4d^2 = 8\,Rh_T$

$\dfrac{d^2}{2R} = h_T = \dfrac{7236}{2 \times 6400} \approx 0.565$ km = 565m.



15.28 From the figure

$V_{max} = \dfrac{100}{2} = 50\text{V}$, $V_{min} = \dfrac{20}{2} = 10$ V.

(i) Percentage modulation

$$\mu(\%) = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} \times 100 = \left(\frac{50-10}{50+10}\right) \times 100 = \frac{40}{60} \times 100 = 66.67\%$$

(ii) Peak carrier voltage = $V_c = \dfrac{V_{\max} + V_{\min}}{2} = \dfrac{50+10}{2} = 30\text{V}$

(iii) Peak information voltage = $V_m = \mu V_c = \dfrac{2}{3} \times 30 = 20\text{V}$.

15.29 (a) $v(t) = A(A_{m_1}\sin\omega_{m_1}t + A_{m_2}\sin\omega_{m_2}t + A_c\sin\omega_c t)$

$$+ B(A_{m_1}\sin\omega_{m_1}t + A_{m_2}\sin\omega_{m_2}t + A_c\sin\omega_c t)^2$$

$$= A(A_{m_1}\sin\omega_{m_1}t + A_{m_2}\sin\omega_{m_2}t + A_c\sin\omega_c t)$$

$$+B((A_{m_1}\sin\omega_{m_1}t + A_{m_2}t)^2 + A_c^2\sin^2\omega_c t$$
$$+2A_c(A_{m_1}\sin\omega_{m1}t + A_{m_2}sin\omega_c t)$$

$$= A(A_1\sin\omega_{m_1}t + A_{m_2}\sin\omega_{m_2}t + A_c\sin\omega_c t)$$
$$+B[A_{m_1}^2\sin^2\omega_{m_1}t + A_{m_2}^2 sin^2\omega_{m_2}t + 2A_{m_1}A_{m_2}\sin\omega_{m_1}t\sin\omega_{m_2}t$$
$$+A_c^2\sin^2\omega_c t + 2A_c(A_{m_1}sin\omega_{m_1}t\sin\omega_c t + A_{m_2}\sin\omega_{m_2} + \sin\omega_c t]$$

$$= A(A_{m_1}\sin\omega_{m_1}t + A_{m_2}\sin\omega_{m_2}t + A_c\sin\omega_c t)$$
$$+B[A_{m1}^2\sin^2\omega_{m_1}t + A_{m_2}^2 sin^2\omega_{m_2}t + A_c^2\sin^2\omega_c t$$
$$+\frac{\cancel{2}A_{m_1}A_{m_2}}{\cancel{2}}[\cos(\omega_{m_2}-\omega_{m_1})t - \cos(\omega_{m_1}+\omega_{m_2})t]$$

$$+\frac{\cancel{2}A_c A_{m_2}}{\cancel{2}}[\cos(\omega_c-\omega_{m_1})t - \cos(\omega_c+\omega_{m_1})t]$$

$$+\frac{\cancel{2}A_c A_{m_1}}{\cancel{2}}[\cos(\omega_c-\omega_{m_2})t - \cos(\omega_c+\omega_{m_2})t]$$

$\therefore$ Frequencies present are

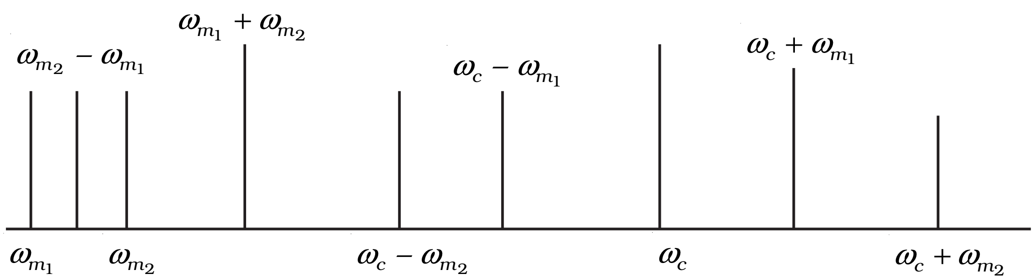
$\omega_{m_1}, \omega_{m_2}, \omega_c$

$(\omega_{m_2}-\omega_{m_1}), (\omega_{m_1}+\omega_{m_2})$

$(\omega_c-\omega_{m_1}), (\omega_c+\omega_{m_1})$

$(\omega_c-\omega_{m_2}), (\omega_c+\omega_{m_2})$

(i) Plot of amplitude versus ω is shown in the Figure.



(ii) As can be seen frequency spectrum is not symmetrical about ω_c. Crowding of spectrum is present for $\omega < \omega_c$.

(iii) Adding more modulating signals lead to more crowding in $\omega < \omega_c$ and more chances of mixing of signals.

(iv) Increase band-width and ω_c to accommodate more signals. This shows that large carrier frequency enables to carry more information (more ω_m) and which will in turn increase band-width.

15.30 f_m = 1.5kHz, $\frac{1}{f_m} = 0.7 \times 10^{-3}$ s

f_c = 20MHz, $\frac{1}{f_c} = 0.5 \times 10^{-7}$ s

(i) $RC = 10^3 \times 10^{-8} = 10^{-5}$ s

So, $\frac{1}{f_c} << RC < \frac{1}{f_m}$ is satisfied

So it can be demodulated.

(ii) $RC = 10^4 \times 10^{-8} = 10^{-4}$ s.

Here too $\frac{1}{f_c} << RC < \frac{1}{f_m}$.

So this too can be demodulated

(iii) RC = 104 × $10^{-12} = 10^{-8}$ s.

Here $\frac{1}{f_c} > RC$, so this cannot be demodulated.