ACE Engineering Academy
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ESE – 2019 MAINS
OFFLINE TEST SERIES

ELECTRONICS & TELECOMMUNICATION ENGINEERING (E&T)

TEST – 10
SOLUTIONS

All Queries related to **ESE – 2019 MAINS Test Series** Solutions are to be sent to the following email address

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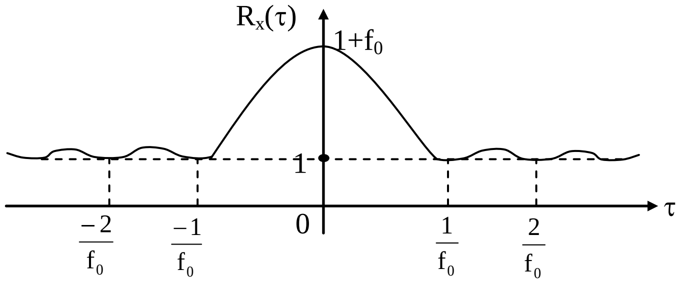
01. (a)
Sol:

(i) The power spectral density consists of 2 components

(1) A delta function $\delta(t)$ at the origin, whose inverse Fourier transform is one.

(2) A triangular component of unit amplitude and width $2f_0$, centered at the origin: the inverse Fourier transform of this component is $f_0 \,\text{sinc}^2 (f_0 \tau)$

$R_X(\tau) = 1 + f_0 \sin c^2(f_0 \tau)$



(ii) Since $R_X(\tau)$ contains a constant component of amplitude 1, it follows that the dc power contained in X(t) is 1.

(iii) The mean-square value of X(t) is given by $E[X^2(t)]$ or total power $= R_X(0)$

$= 1 + f_0$

AC power = Total power – DC power

$= E[X^2(t)] - 1 = 1 + f_0 - 1 = f_0$

The AC power contained in X(f) is therefore equal to f_0.

01. (b)
Sol:

(i) Assume that the set $\{\psi_n(t)\}$ is sufficient to represent the waveform.

$$\int_a^b w(t)\psi_m^*(t)dt = \int_a^b \left[\sum_n a_n \psi_n(t)\right]\psi_m^*(t)dt$$

$$= \sum_n a_n \int_a^b \psi_n(t)\psi_m^*(t)dt$$

$$= \sum_n a_n K_n \delta_{mn}$$

$$= a_n K_n$$

$$\therefore a_n = \frac{1}{K_n}\int_a^b w(t)\psi_n^*(t)dt$$

(ii) $m(t) = \dfrac{0.8}{2j}\left(e^{j2\pi(1000\,t)} - e^{-j2\pi(1000\,t)}\right)$

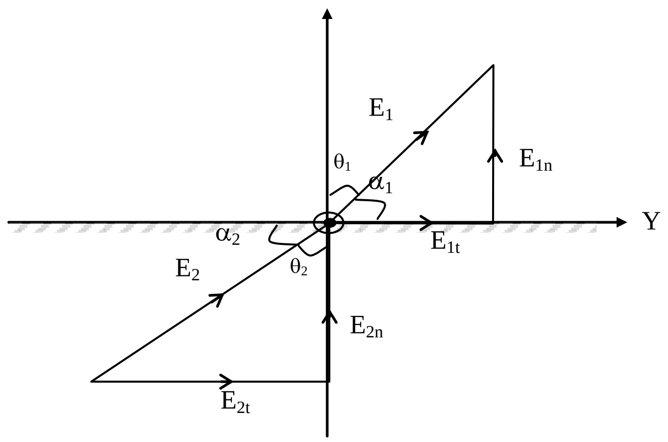
$M(f) = -0.4j\delta(f - 1000) + j0.4\delta(f + 1000)$

Voltage spectrum of the AM signal:

$S(f) = 250\,\delta(f - f_c) - j100\delta(f - f_c - 1000) + j100\delta(f - f_c + 1000)$
$\quad + 250\delta(f + f_c) - j100\delta(f + f_c - 1000) + j100\delta(f + f_c + 1000)$

01. (c)

Sol:



The tangential component in region I is

$\overline{E}_{1t} = 3\hat{a}_x + 5\hat{a}_y$

The normal component in region I is

$\overline{E}_{1n} = 2\hat{a}_z$

The tangential component of the second region is

$\overline{E}_{2t} = \overline{E}_{1t} = 3\hat{a}_x + 5\hat{a}_y$

For free of charge $\overline{D}_{2n} = \overline{D}_{1n}$

$\varepsilon_{r_2}\overline{E}_{2n} = \varepsilon_{r_1}\overline{E}_{1n}$

$\overline{E}_{2n} = \dfrac{\varepsilon_{r_1}}{\varepsilon_{r_2}}\overline{E}_{1n}$

$= \dfrac{2}{4}\times 2\hat{a}_z$

$\therefore \hat{E}_{2n} = 1\hat{a}_z$

$\tan\theta_2 = \dfrac{E_{2t}}{E_{2n}} = \dfrac{\sqrt{3^2+5^2}}{1} = \sqrt{34}$

$\therefore \theta_2 = \tan^{-1}\left(\sqrt{34}\right) = 80.27^o$

$\therefore\ \alpha_2 = 90 - \theta_2 = 9.73^o$

$\tan\alpha_1 = \dfrac{E_{1n}}{E_{1t}} = \dfrac{2}{\sqrt{3^2+5^2}} = \dfrac{2}{\sqrt{34}} = 0.343$

$\therefore \alpha_1 = \tan^{-1}(0.343) = 18.93^o$

$\therefore\ \alpha_1 = 18.93^o,\ \alpha_2 = 9.73^o$

01. (d)

Sol: The reflection coefficient at the load is

$\Gamma_L = \dfrac{Z_L - Z_0}{Z_L + Z_0} = \dfrac{-50 - j50}{150 - j50} = \dfrac{-1 - j1}{3 - j1}$

$= \dfrac{-1 - j2}{5} = \dfrac{1}{\sqrt{5}}e^{-j0.3524\pi}$

The total amplitude at the load is

$V_L = V^+(1+\Gamma_L)$

$$V^+ = \frac{V_L}{1+\Gamma_L} = \frac{50}{1+\left(\frac{-1-j2}{5}\right)} = \frac{125}{2-j1}$$

$$V^+ = 25(2+j)$$

$$|V^+| = |25(2+j)| = 25\sqrt{5} = 55.9\text{V}$$

Thus, the maximum and minimum voltages are

$$V_{max} = |V^+|[1+|\Gamma_L|]$$

$$= (55.9)\left(1+\frac{1}{\sqrt{5}}\right)$$

= 80.9 V

$$V_{min} = |V^+|[1-|\Gamma_L|]$$

$$= (55.9)\left(1-\frac{1}{\sqrt{5}}\right)$$

= 30.9 V

01. (e)

Sol: (i) Number of forward (uplink) channels = 125

Number of reverse (downlink) channels = 125

Total number of channels = 125 + 125 = 250

Bandwidth of each channel allocated = 200 kHz

Bandwidth of uplink = number of uplink channels × Bandwidth of each channel

= 125×200K

= 25 MHz

Band width of downlink = 125×200K = 25MHz

(ii) Number of time slots in each channel = 16

$$\text{Sub channel spacing } = \frac{\text{channel space}}{\text{time slot in each channel}}$$

$$= \frac{200\text{K}}{16}$$

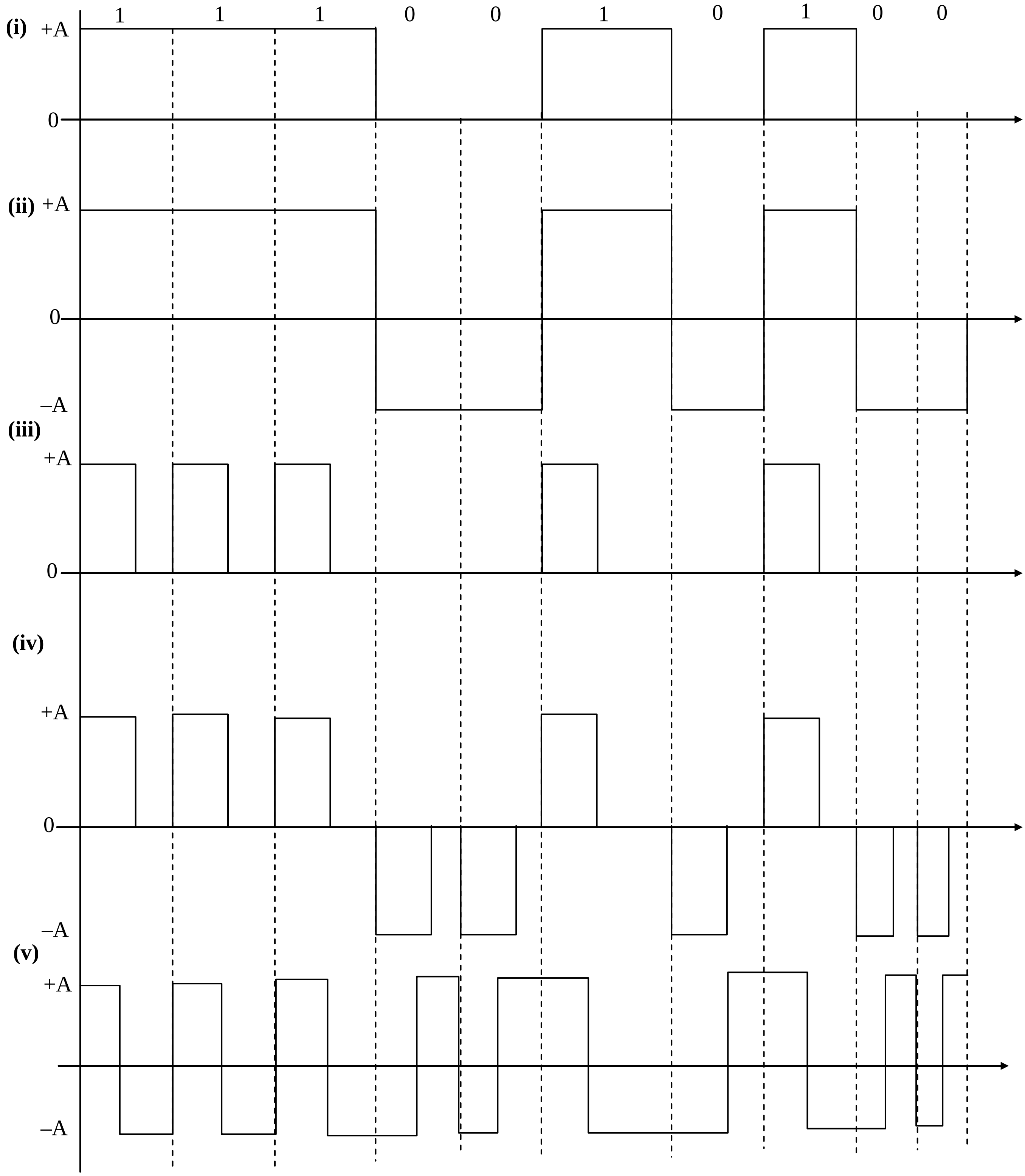
= 12.5kHz

(iii) Number of users shared in each channel = 16

Total number of users per cell = 125×16

= 2000 users.

02. (a)
Sol:



02. (b)

Sol: Given

$$\overline{E} = \left(-\hat{i} - 2\sqrt{3}\,\hat{j} + 3\hat{k}\right)e^{-j0.04\pi\left(\sqrt{3}x-2y-3z\right)}$$

(i) Vertical direction of propagation

$$\overline{E} = \left(-\hat{i} - 2\sqrt{3}\hat{j} + 3\hat{k}\right)e^{-j(0.2176\,x - 0.2513\,y - 0.377\,z)}$$

In the above equation

$\beta_x = \beta \cos \phi_x \quad = 0.2176$

$\beta_y = \beta \cos \phi_y \quad = 0.2513$

$\beta_z = \beta \cos \phi_z \quad = 0.377$

$$\beta_x^2 + \beta_y^2 + \beta_z^2 = \beta^2\left(\underbrace{\cos^2\phi_x + \cos^2\phi_y + \cos^2\phi_z}_{1}\right)$$

$$= 0.2176^2 + 0.2513^2 + 0.377^2$$

$\therefore\ \beta^2 = 0.2526$

$\therefore\ \beta \approx 0.5$ rad/m

$\beta\cos\phi_x = 0.2176$

$$\therefore \cos\phi_x = \frac{0.2176}{0.5}$$

$$= 0.4352$$

$\beta \cos \phi_y = 0.2513$

$$\cos\phi_y = \frac{0.2513}{0.5}$$

$$= 0.5026$$

$\beta\cos \phi_z = 0.377$

$$\cos\phi_z = \frac{0.377}{0.5}$$

$$= 0.754$$

$\therefore$ The vertical direction of propagation is $\cos \phi_x \hat{a}_x + \cos\phi_y \hat{a}_y + \cos\phi_z \hat{a}_z$

$= 0.4352\,\hat{a}_x + 0.5026\,\hat{a}_y + 0.754\,\hat{a}_z$

(ii) The wave length of the propagating wave

$$\beta = \frac{2\pi}{\lambda}$$

$$\lambda = \frac{2\pi}{\beta}$$

$$= \frac{2\pi}{0.5} = 4\pi = 12.56\text{m}$$

(iii) The wave is travelling in free space

$\lambda f = c = 3\times10^8$ m/sec

$$\therefore f = \frac{3\times10^8}{\lambda}$$

$$= \frac{3\times10^8}{12.56} = 0.2388\times10^8\,\text{Hz}$$

$= 23.88$MHz

(iv) Phase velocity

$$v_p = \frac{\omega}{\beta}$$

$$= \frac{2\pi f}{2\pi/\lambda} = \lambda f = 3\times10^8\,\text{m/sec}$$

Phase velocity vector

$$\bar{v}_p = v_{px}\hat{a}_x + v_{py}\hat{a}_y + v_{pz}\hat{a}_z$$

$$= \frac{\omega}{\beta_x}\hat{a}_x + \frac{\omega}{\beta_y}\hat{a}_y + \frac{\omega}{\beta_z}\hat{a}_z$$

$$= 2\pi\times23.88\times10^6\left(\frac{1}{0.2176}\hat{a}_x + \frac{1}{0.2513}\hat{a}_y + \frac{1}{0.377}\hat{a}_z\right)$$

$$= 150\times10^6\left(4.595\hat{a}_x + 3.98\hat{a}_z + 2.65\hat{a}_z\right)$$

Now,

$$\bar{v}_p = \left(689.25\hat{a}_x + 597\hat{a}_y + 397.5\hat{a}_z\right)\times10^6\,\text{m/sec}$$

Apparent velocities & wave lengths

Along x is $\nu_{p_x} = 6.89\times10^8$ m/sec

$\lambda_x f = \nu_{px}$

$$\therefore \lambda_x = \frac{\nu_{p_x}}{f}$$

$$= \frac{6.89\times10^8}{23.88\times10^6} = 0.2885\times10^2$$

$\lambda_x = 28.85$ m

Along ‘y’ is

$\nu_{p_y} = 5.97\times10^8\,\text{m/sec}$

$$\therefore \lambda_y = \frac{\nu_{p_y}}{f} = \frac{5.95\times10^8}{23.88\times10^6}$$

$\therefore\ \lambda_y = 0.249\times 10^2 = 24.91\text{m}$

Along ‘z’ is`

$\nu_{p_z} = 3.98\times10^8\,\text{m/sec}$

$$\therefore \lambda_z = \frac{\nu_{p_z}}{f}$$

$$= \frac{3.98\times10^8}{23.88\times10^6}$$

$$= 0.1666\times10^2$$

$\therefore \lambda_z = 16.66\text{m}$

02. (c)

Sol:

<table>
<tr><td colspan="4">16 bits</td><td colspan="4">16 bits</td></tr>
<tr><td>Version
(4 bits)</td><td colspan="2">Header
Length
(4 bits)</td><td>Type of
Service
(8 bits)</td><td colspan="4">Total length (16 bits)</td></tr>
<tr><td colspan="4">Identification
(16 bits)</td><td>0</td><td>D
F</td><td>M
F</td><td>Fragment Offset
(13 bits)</td></tr>
<tr><td colspan="2">Time to live (8 bits)</td><td colspan="2">Protocol (8 bits)</td><td colspan="4">Header Checksum (16 bits)</td></tr>
<tr><td colspan="8">Source IP Address (32 bits)</td></tr>
<tr><td colspan="8">Destination IP Address (32 bits)</td></tr>
<tr><td colspan="8">Options
(0 – 40 bytes)</td></tr>
<tr><td colspan="8">Data</td></tr>
</table>

Version(4 bits): Indicates the format of the internet header, for version 4 it should be 0100.

Header length (4 bits): Header length in words of 32 bits.
Min. header size is 5 words (20 bytes) and max. header size is 15 words (60 bytes).

Total length (16 bits):
IP packet size in bytes

Identification No. (16 bits):
Used to identify fragments of same segment.

3 flag bits:
1. Unused (must be zero)
2. Don't Fragment (DF)
3. More Fragment (MF) - Used to identify last fragment.

Fragmentation offset (13 bits):
Used to identify sequence of fragments of same segment while integration.

Time to Live(TTL) (8 bits):
Used to avoid indefinite traversing of packets over network.

Protocol Type (8 bits):
Used to define higher layer protocol.

Header checksum (16 bits):
Used to detect error in IPv4 packet header only

Source IP: 32 bits

Destination IP: 32 bits

03. (a)

Sol: Given a = 2.286, b = 1.016

$E_{max} = 3\times10^{6}$V/m

f = 9GHz

For TE_{10} mode

Cut off frequency (f_c)

$$= \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}$$

$$= \frac{c}{2}\sqrt{\left(\frac{1}{a}\right)^2+0}$$

$$= \frac{c}{2a} = \frac{3\times10^8}{2\times2.286\times10^{-2}}$$

= 6.56GHz

Wave impedance (Z_{TE}) = $\dfrac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$

$$= \frac{120\pi}{\sqrt{1-\left(\frac{6.56}{9}\right)^2}} = \frac{120\pi}{0.684}$$

= 551.15Ω

Maximum power (P_{max}) = $\dfrac{1}{4Z_{TE}}(E_{max})^2 ab$

$$= \frac{1}{4\times551.15}(3\times10^6)^2\, 2.286\times10^{-2}\times1.016\times10^{-2}$$

$= 9.4816\times10^{-3}\times10^{-2}\times10^{-2}\times10^{12}$

$= 9.4816\times10^{5}$

= 948.16KW

Derivation of necessary equation

Cut off frequency

We have $\gamma^2 + \omega^2\mu\in = \left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2$

$\Rightarrow \gamma^2 = \left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2 - \omega^2\mu\in$

The frequency at which $\gamma = 0$ is known as cutoff frequency.

So, $0 = \left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2 - \omega_c^2\mu\in$

$\Rightarrow \omega_c^2\mu\in = \left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2$

$$\Rightarrow \omega_c = \frac{1}{\sqrt{\mu\varepsilon}}\left[\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2\right]^{1/2}$$

$$\Rightarrow f_c = \frac{c}{2\pi}\left[\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2\right]^{1/2}$$

$$= \frac{c}{2}\left[\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2\right]^{1/2}$$

Wave impedance

$$Z_{TE} = \frac{E_x}{H_y} = \frac{\frac{-\gamma}{h^2}\frac{\partial E_Z}{\partial x} - \frac{j\omega\mu}{h^2}\frac{\partial H_Z}{\partial y}}{\frac{-\gamma}{h^2}\frac{\partial H_Z}{\partial y} - \frac{j\omega\varepsilon}{h^2}\frac{\partial E_Z}{\partial x}}$$

For TE wave, $E_z = 0$ and $\gamma = j\beta$

$$\text{Then } Z_{TE} = \frac{0 - \frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}}{\frac{-\gamma}{h^2}\frac{\partial H_z}{\partial y} - 0} = \frac{\frac{j\omega\mu}{h^2}}{\frac{\gamma}{h^2}}$$

$$= \frac{j\omega\mu}{h^2} \times \frac{h^2}{\gamma} = \frac{j\omega\mu}{\gamma} = \frac{j\omega\mu}{j\beta} = \frac{\omega\mu}{\beta}$$

As we know

$$\beta = \sqrt{\omega^2\mu\varepsilon - \omega_c^2\mu\varepsilon}$$

$$\text{So } Z_{TE} = \frac{\omega\mu}{\sqrt{\mu\varepsilon}\sqrt{\omega^2 - \omega_c^2}} = \sqrt{\frac{\mu}{\varepsilon}}\frac{\omega}{\sqrt{\omega^2 - \omega_c^2}}$$

$$= \frac{\eta}{\sqrt{\frac{\omega^2 - \omega_c^2}{\omega^2}}} = \frac{\eta}{\sqrt{1 - \frac{\omega_c^2}{\omega^2}}}$$

$$= \frac{\eta}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}}$$

Power flow

For TE_{10} mode m = 1, n = 0

$$\text{So } E_x = 0.\ H_x = \frac{E_{oy}}{Z_g}\sin\left(\frac{\pi x}{a}\right)e^{-j\beta_g z}$$

$$E_y = E_{0y}\sin\left(\frac{\pi x}{a}\right)e^{-j\beta_g z} \quad H_y = 0$$

$$\text{Where } Z_g = \frac{\omega\mu_0}{\beta_g}$$

The power delivered in Z- direction by the guide is

$$P = \text{Re}\left[\frac{1}{2}\int_0^b\int_0^a \left(E\times H^*\right)\right].dxdya_z \;=\frac{1}{2}\int_0^b\int_0^a\left[\begin{array}{l}\left(E_{0y}\sin\left(\frac{\pi x}{a}\right)e^{-j\beta_g z}a_y\right)\times\\ \left(\frac{-\beta_g}{\omega\mu_0}E_{oy}\sin\left(\frac{\pi x}{a}\right)e^{+j\beta_g z}a_x\right)\end{array}\right].dxdya_z$$

$$=\frac{1}{2}\int_0^b\int_0^a\left[\left(E^2_{0y}\sin^2\left(\frac{\pi x}{a}\right)\left(\frac{-\beta_g}{\omega\mu_o}\right)(-a_z)\right)\right].dxdya_z \;=\frac{1}{2}\int_0^b\int_0^a E^2_{0y}\sin^2\left(\frac{\pi x}{a}\right)\left(\frac{\beta_g}{\omega\mu_o}\right)dxdy$$

$$=\frac{1}{2}\left(\frac{\beta_g}{\omega\mu_o}\right)E^2_{0y}\int_0^b dy\int_0^a \sin^2\left(\frac{\pi x}{a}\right)dx \;=\frac{1}{2}\left(\frac{\beta_g}{\omega\mu_o}\right)E^2_{0y}[b-0]\int_0^a\frac{1-\cos\frac{2\pi x}{a}}{2}dx$$

$$=\frac{1}{2}\left(\frac{\beta_g}{\omega\mu_o}\right)E^2_{0y}\,b\left[\frac{1}{2}\int_0^a dx-\frac{1}{2}\int_0^a\cos\frac{2\pi x}{a}dx\right]$$

$$=\frac{1}{2}\left(\frac{\beta_g}{\omega\mu_o}\right)E^2_{0y}\,b\left[\frac{a}{2}-0\right]$$

$$=\frac{1}{4}\left(\frac{\beta_g}{\omega\mu_o}\right)E^2_{0y}\,ab$$

$$=\frac{1}{4}\frac{E^2_{0y}}{Z_{TE}}ab$$

As $Z_{TE}=\dfrac{\omega\mu_0}{\beta_g}$

For maximum power, electric field intensity is also be maximum

So, $P_{max}=\dfrac{1}{4}\dfrac{E^2_{max}}{Z_{TE}}ab$

03. (b)

Sol:

S_0	0.25(10)	0.25(10)	0.25(01)	0.25(00)	0.5(1)	0.5(0)
S_1	0.25(11)	0.25(11)	0.25(10)	0.25(01)	0.25(00)	0.5(1)
S_2	0.125(001)	0.125(000)	0.25(11)	0.25(10)	0.25(01)	
S_3	0.125(010)	0.125(001)	0.125(000)	0.25(11)		
S_4	0.125(011)	0.125(010)	0.125(001)			
S_5	0.0625(0000)	0.125(011)				
S_6	0.0625(0001)					

The Huffman code is therefore

S_0 10
S_1 11
S_2 001
S_3 010
S_4 011
S_5 0000
S_6 0001

The average code word length is

$$L = \sum_{K=0}^{6} P_K \ell_K$$

$L = (0.25 \times 2) + (0.25 \times 2) + (0.125 \times 3) + (0.125 \times 3) + (0.125 \times 3) + (0.0625 \times 4) + (0.0625 \times 4)$
$= 2.625$

The entropy of the source is

$$H(S) = \sum_{K=0}^{6} P_K \log_2\left(\frac{1}{P_K}\right)$$

$= -[0.25 \log_2 0.25 + 0.25 \log_2 0.25 + 0.125 \log_2 0.125 + 0.125 \log_2 0.125 + 0.125 \log_2 0.125 + 0.0625 \log_2 0.0625 + 0.0625 \log_2 0.0625]$

$= +[(0.5 \times 2) + (0.375 \times 3) + (0.25 \times 2)]$
$= 2.625$

The efficiency of the code is $\eta = \frac{H(S)}{L} = \frac{2.625}{2.625} = 1$

$\therefore$ Efficiency of the code is 100%

03. (c)
Sol:

Category	**Symmetric key Cryptography**	**Asymmetric key Cryptography**
1. Key	• Private key cryptography • Same (common/secret) key is used for encryption and decryption	• Public key cryptography • Different (public & private) keys are used for encryption and Decryption
2. Speed	• Block cipher • Block by block encryption and Decryption • Relatively Faster	• Byte by Byte encryption and decryption • Relatively slower
3. Number of keys	• If N no. of hosts then $\frac{N\times(N-1)}{2}$ keys required • Separate key between every pair of host	• If N no. of hosts then 2N keys required • Two key set per host (public and private key)
4. Algorithm	• Decryption is reverse process of encryption • Separate algorithm for encryption and decryption • DES & AES are types of method	• Encryption and Decryption are performed by same algorithm • Decryption is same as encryption • RSA is mostly used method

04. (a)

Sol:

(i) The selectivity of a super heterodyne receiver is mainly decided by IF amplifier The tuned circuit associated with the IF amplifier operates at a fixed frequency and a fixed Bandwidth.

The value of centre frequency and bandwidth are chosen such that we get a value of Q which is reasonable and easy to design in a circuit. This leads to better selectivity.

(ii) F_{IF}: intermediate frequency = 0.455 MHz

f_m : centre frequency of incoming signal.

f_{LO} : local oscillator freq.

Now, $f_{LO} = f_{If} + f_m$

When f_m = 0.535 MHz & f_{IF} = 0.455 MHz

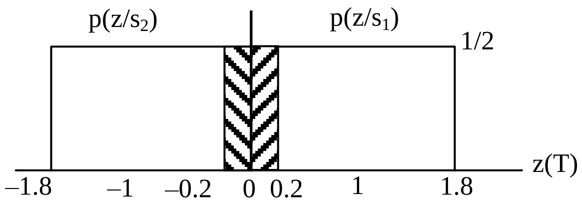
f_{LO} = 0.990 MHz

when f_m = 1.605 MHz & f_{IF} = 0.455 MHz

f_{LO} = 2.06 MHz

$\therefore$ Tuning range of oscillator: 0.99 MHz to 2.06 MHz

(iii)



$$P_E = P(s_1)\int_{-0.2}^{0} \frac{1}{2}\,dz + P(s_2)\int_{0}^{0.2} \frac{1}{2}\,dz$$

$$= \left[\frac{1}{2}z\right]_{-0.2}^{0} = \frac{0.2}{2} = 0.1$$

(iv) For AM with envelope detection and assuming 100% sinusoidal modulation, the output SNR is given by.

$$(S/N)_{0_{AM}} = \frac{1}{3}\gamma \qquad [\text{where } \gamma \text{ is } (S/N)_i]$$

For FM with sinusoidal modulation, the output SNR is given by,

$$(S/N)_{0_{FM}} = \frac{3}{2}\beta^2\gamma \quad [\beta : \text{modulation index of FM}]$$

Hence, we see that use of FM offers the possibility of improved SNR over AM, when

$$3/2\beta^2 > 1/3$$

Or $\beta > 0.47$

However, a value of $\beta < 0.2$ is considered to define FM signal to be narrow band.

Hence we can conclude that narrow band FM offers no improvement in SNR over AM.

04. (b)

Sol: $V_{AB} = -\frac{\rho_L}{2\pi\varepsilon_o}\left[\ln d_A - \ln d_B\right]$

If the line charge ρ_L lies on the x axis, then the equations of the line charge are y = 0 and z = 0. Coordinates of point A are (1,2,3). Coordinates of the foot of perpendicular dropped from point A on the line charge are (1,0,0)

$$\therefore d_A = \sqrt{(1-1)^2 + (2-0)^2 + (3-0)^2} = \sqrt{13}$$

Coordinates of point B are (6,8,10). Coordinates of the foot of perpendicular dropped from point B on the line charge are (6,0,0).

$$\therefore d_B = \sqrt{(6-6)^2 + (8-0)^2 + (10-0)^2} = \sqrt{164}$$

$$\therefore V_{AB} = -\frac{20\times10^{-9}}{2\Pi\varepsilon_o}\left[\ln\sqrt{13} - \ln\sqrt{164}\right] = 455.664\text{ V}$$

If the line charge lies on the y-axis, then the equations of the line charge are x = 0 and z = 0. Coordinates of point A are (1,2,3). Coordinates of the foot of perpendicular dropped from point A on the line charge are (0,2,0).

$$\therefore d_A = \sqrt{(1-0)^2 + (2-2)^2 + (3-0)^2} = \sqrt{10}$$

Coordinates of point B are (6,8,10). Coordinates of the foot of perpendicular dropped from point B on the line charge are (0,8,0).

$$d_B = \sqrt{(6-0)^2 + (8-8)^2 + (10-0)^2} = \sqrt{136}$$

$$\therefore V_{AB} = -\frac{20\times10^{-9}}{2\pi\varepsilon_o}\left[\ln\sqrt{10} - \ln\sqrt{136}\right] = 469.173\text{ V}$$

If the line charge lies on the z axis, then the equations of the line charge are x = 0 and y = 0. Coordinates of point A are (1,2,3). Coordinates of the foot of perpendicular dropped from point A on the line charge are (0,0,3).

$$d_A = \sqrt{(1-0)^2 + (2-0)^2 + (3-3)^2} = \sqrt{5}$$

Coordinates of point B are (6,8,10). Coordinates of the foot of perpendicular dropped from point B on the line charge are (0,0,10)

$$\therefore d_B = \sqrt{(1-0)^2 + (8-0)^2 + (10-10)^2} = \sqrt{100}$$

$$V_{AB} = -\frac{20\times10^{-9}}{2\pi\varepsilon_o}\left[\ln\sqrt{5} - \ln\sqrt{100}\right] = 538.497\text{ V}$$

$$\therefore V_{AB} = 455.664 + 469.173 + 538.497 = 1463.334\text{ V}$$

04. (c)

Sol: HTTP:

- Hyper-text transfer protocol
- Application layer protocol which uses TCP as transport protocol
- Stateless protocol (Server never maintain state information of clients)
- Used to transfer resources between HTTP client and HTTP server (resources can be HTML, XML or user files)

FTP:

- File Transfer Protocol
- Application protocol which uses TCP
- State full protocol (Server maintain state information of clients)
- Used to transfer user files between FTP client and server

SMTP:

- Simple mail transfer protocol
- Application protocol which uses TCP
- State full protocol
- Used to transfer electronic mail(e-mail) from mail client to mail server

POP:

- Post-office protocol
- State full protocol
- Application protocol which uses TCP
- Used to download e-mail from mail server to mail client

DNS:

- Domain name server
- Application protocol which uses UDP
- Used to map web server name into web server IP address from DNS directory

05. (a)
Sol:

(i) (A) For a unity rolloff, raised cosine pulse spectrum, the bandwidth B equals 1/T, where T is the pulse length. Therefore, T in this case 1/12kHz. Quarternary PAM ensures 2 bits per pulse, so the rate of information is $\frac{2\,\text{bits}}{T} = 24$ kilobits per second.

(B) For 128 quantizing levels, 7 bits are required to transmit an amplitude. The additional bit for synchronization makes each code word 8 bits. The signal is transmitted at 24 kilobits/s, so it must be sampled at

$$\frac{24\ \text{kbits/s}}{8\,\text{bits/sample}} = 3\ \text{kHz}\ .$$

The maximum possible value for the signal's highest frequency component is 1.5 kHz, in order to avoid aliasing.

(ii) $B = \frac{R}{2}(1+\alpha)$

B = 75 kHz

$$R = \frac{1}{10\mu} = 100\text{kHz}$$

$$\frac{75\times 2}{100} = 1+\alpha$$

$\alpha = 0.5$

05. (b)

Sol: $R_LC = 400 \times 10^3 \times 100 \times 10^{-12} = 4 \times 10^{-5}$ s

To avoid diagonal clipping

$$R_L C \le \frac{1}{2\pi f_m} \frac{\sqrt{1-\mu^2}}{\mu}$$

Given that $\mu = 0.75$

$$f_m \le \frac{1}{2\pi R_L C} \frac{\sqrt{1-\mu^2}}{\mu}$$

$$f_m \le \frac{1}{2\pi \times 10^{-5} \times 4} \frac{\sqrt{1-(0.75)^2}}{0.75}$$

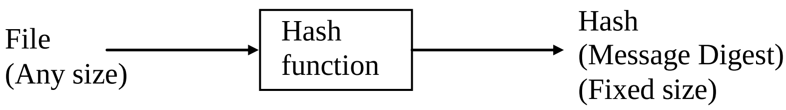
$f_m \le 3510.8$ Hz

$\therefore$ maximum frequency = 3510.8 Hz

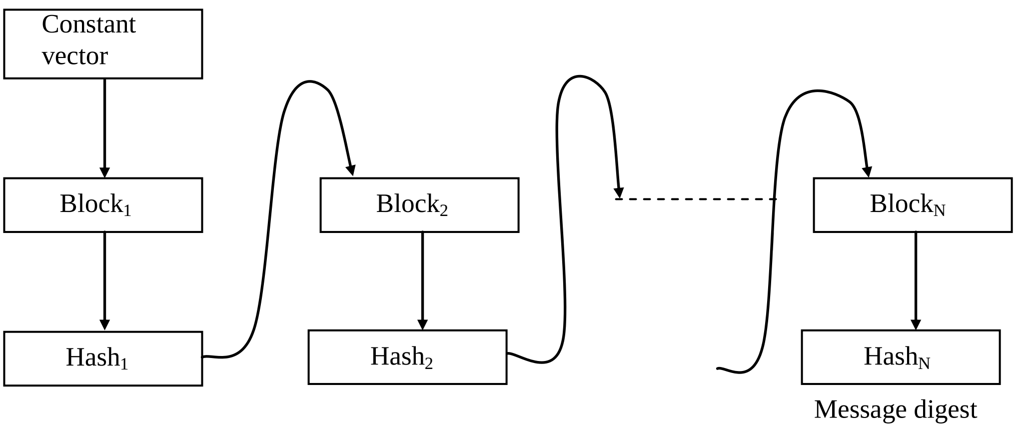
05. (c)

Sol: Cryptographic Hash Function:

- Used to generate Hash (known as message digest)
- Hash generation is one way process, reverse is not possible
- Hash function generate fixed size Hash from any size file



- Various hash functions are: MD4, MD5, SHA and SHA-1
- It will divide the file into blocks



05. (d)

Sol:

(i) We know that the bit rate for QPSK:

$$R_b = \frac{2}{1+\rho} \times B \qquad \text{where } \rho \text{ - roll off factor} = 0.2\text{(given)}$$

$$= \frac{2}{1+0.2} \times 36M \qquad \text{B - transponder BW} = 36\text{MHz (given)}$$

R_b = 60Mbps

$R_b(dB) = 10\log(60\times10^6)$

$R_b(dB)$ = 77.78 dBbps

(ii) $\left(\frac{C}{N_o}\right) = \left(\frac{E_b}{N_o}\right) + R_b$

$$\frac{E_b}{N_o} = 9.6\text{dB}(\text{given})$$

$$\left(\frac{C}{N_o}\right) = 9.6 + 77.78$$

$$\frac{C}{N_o} = 87.38\text{dBHz}$$

$$\text{EIRP} = \left(\frac{C}{N_o}\right) - \left(\frac{G}{T}\right) + \text{loss} - [K]\text{dB}$$

$$= 87.38 - 32 + 200 - 2286 \qquad (k = 228.6\text{dB})$$

EIRP = 26.8dBW

05. (e)

Sol: Given frequency = 9.2 GHz

dimensions = 2cm×1cm

(i) Cutoff frequency $f_{C|_{TE_{mn}}} = \frac{1}{2\sqrt{\mu\in}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

$$f_{C|_{TE_{10}}} = \text{dominant mode} = \frac{1}{2\sqrt{\mu\in}}\ \frac{1}{a}$$

$$= \frac{3\times10^8}{2} \times \frac{1}{2\times10^{-2}} = 7.5\,\text{GHz}$$

(ii) Guide wavelength $= \lambda_g = \frac{\lambda}{\sqrt{1 - \left(\frac{f_C}{f}\right)^2}}$

$$= \frac{(3\times10^8/9.2\times10^9)}{\sqrt{1-\left(\frac{7.5}{9.2}\right)^2}} = 5.6\text{ cm}$$

(iii) Phasevelocity $V_p = \frac{V}{\sqrt{1-\left(\frac{f_C}{f}\right)^2}}$

$$= \frac{3\times10^8}{\sqrt{1-\left(\frac{7.5}{9.2}\right)^2}} = 5.179\times10^8\text{ m/s}$$

(iv) Characteristic impedance

$$\eta_{TE} = \frac{\eta}{\sqrt{1-\left(\frac{f_C}{f}\right)^2}} = \frac{120\ \pi}{\sqrt{1-\left(\frac{7.5}{9.2}\right)^2}} = 650.94\ \Omega$$

05. (f)

Sol: Return loss = –20 log $[|\Gamma(\ell)|]$

For $l = 0$

$$\Gamma(0) = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{75-50}{75+50} = 0.2$$

For $\ell = \frac{\lambda}{4}$

$$\Gamma\left(\frac{\lambda}{4}\right) = \frac{Z_L - Z_0}{Z_L + Z_0} e^{-j2\frac{2\pi}{\lambda}\frac{\lambda}{4}}$$

$$\Gamma\left(\frac{\lambda}{4}\right) = \frac{75-50}{75+50} e^{-j\pi}$$

$= 0.2\ e^{-j\pi} = -0.2$

For $l = 0$

$\therefore$ Return loss = –20 log $[|\Gamma(0)|]$

= – 20 log (0.2)

= 13.98 dB

For $\ell = \frac{\lambda}{4}$

Return loss = –20log $\left[\left|\Gamma\left(\frac{\lambda}{4}\right)\right|\right]$

= –20log (0.2)

= 13.98 dB

06.(a)

Sol:

(i) Probability of error $Pe = Q\left(\sqrt{\frac{E_b}{\eta}}\right)$

$E_b = A^2T$

$$\Rightarrow \sqrt{\frac{E_b}{\eta}} = 3$$

$$\frac{E_b}{\eta} = 9$$

$$\frac{A^2T}{\eta} = 9$$

$$T = \frac{9\eta}{A^2} = \frac{9\times10^{-4}}{9} = 10^{-4}$$

T = 0.1 ms

Maximum time-slot duration = 0.1ms

(ii) $P_e = Q\sqrt{\dfrac{E_b}{\eta}}$

$$E_b = \frac{A^2T}{2}$$

$$\sqrt{\frac{E_b}{\eta}} = 3$$

$E_b = 9\eta$

$$\frac{A^2T}{2} = 9\eta$$

$$T = \frac{9\times\eta\times 2}{A^2} = \frac{18\times 10^{-4}}{9} = 2\times 10^{-4}$$

T = 0.2 ms

06. (b)

Sol: Poynting theorem states that the net power flowing out of a given volume 'v' is equal to the time rate of decrease in the energy stored within v minus the conduction loss.

From Maxwell's equation

$$\nabla\times\overline{E} = -\mu\frac{\partial\overline{H}}{\partial t} \qquad \text{……….. (1)}$$

And $\nabla\times\overline{H} = \sigma\overline{E} + \varepsilon\dfrac{\partial\overline{D}}{\partial t}$ ……….. (2)

Dotting both sides of equation (2) with $\overline{E}$, gives

$$\overline{E}.\left(\nabla\times\overline{H}\right) = \sigma E^2 + \overline{E}.\varepsilon\frac{\partial\overline{E}}{\partial t} \qquad \text{……….. (3)}$$

From vector identity, we know,

$$\nabla.\left(\overline{A}\times\overline{B}\right) = \overline{B}.\left(\nabla\times\overline{A}\right) - \overline{A}.\left(\nabla\times\overline{B}\right)$$

If $\overline{A} = \overline{H}$ and $\overline{B} = \overline{E}$, Applying this above vector identify in (3), we get

$$\nabla.\left(\overline{H}\times\overline{E}\right) + \overline{H}.\left(\nabla\times\overline{E}\right) = \sigma E^2 + \overline{E}.\varepsilon\frac{\partial\overline{E}}{\partial t}$$

$$= \sigma E^2 + \frac{1}{2}\varepsilon\frac{\partial E^2}{\partial t} \qquad \text{……… (4)}$$

Now dotting both sides of equation (1) with $\overline{H}$

$$\overline{H}.\left(\nabla\times\overline{E}\right) = \overline{H}.\left(-\mu\frac{\partial\overline{H}}{\partial t}\right)$$

$$= -\frac{\mu}{2}\frac{\partial}{\partial t}\left(\overline{H}.\overline{H}\right) \qquad \text{……….. (5)}$$

Now putting equation (5) in (4)

$$-\frac{\mu}{2}\frac{\partial H^2}{\partial t} - \nabla.\left(\overline{E}\times\overline{H}\right) = \sigma E^2 + \frac{1}{2}\varepsilon\frac{\partial E^2}{\partial t}$$

$$\Rightarrow \nabla.\left(\overline{E}\times\overline{H}\right) = -\sigma E^2 - \frac{\partial}{\partial t}\left[\frac{1}{2}\varepsilon E^2 + \frac{1}{2}\mu H^2\right]$$

Now taking volume integral on both side, we get

$$\int_s \nabla.(\overline{E}\times\overline{H})dv = -\frac{\partial}{\partial t}\int_v\left[\frac{1}{2}\varepsilon E^2 + \frac{1}{2}\mu H^2\right]dv - \int_v \sigma E^2 dv$$

Now applying divergence theorem to the left hand side of above equation, we have

$$\underbrace{\int_s (\overline{E}\times\overline{H})\overline{ds}}_{\text{totoal power leavingthe volume}}$$

$$= \underbrace{-\frac{\partial}{\partial t}\int_v\left[\frac{1}{2}\varepsilon E^2 + \frac{1}{2}\mu H^2\right]dv}_{\substack{\text{rate of decrease in energy stored}\\ \text{\in electric and magnetic field}}} - \underbrace{\int_v \sigma E^2 dv}_{\text{ohmic power dissipated}}$$

The above equation referred to as poynting's theorem.

06. (c)

Sol: At r = 3cm = 0.03m , V = 100V

At r = 5cm = 0.05m, V = –100V

(i) The potential changes with respect to r.

Hence change of potential with θ and ϕ is zero. That is $\frac{\partial V}{\partial \theta} = \frac{\partial V}{\partial \phi} = 0$

$$\overline{\nabla}^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial\phi^2}$$

$$= \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) = 0$$

Assuming r ≠ 0, we have $\frac{d}{dr}\left(r^2\frac{dV}{dr}\right) = 0$

Integrating this equation twice, we get

$$r^2\frac{dV}{dr} = A \text{ or } dV = \frac{Adr}{r^2} \text{ or } V = -\frac{A}{r} + B$$

Substituting the boundary conditions in the expression of potential, we have

$$100 = \frac{-A}{0.03} + B \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

$$-100 = \frac{-A}{0.05} + B \qquad \ldots\ldots\ldots\ldots\ldots(2)$$

From equation (1) and (2) A = –15 and B = –400.

Hence $V(r) = \frac{15}{r} - 400$

(ii) $\overline{E} = -\overline{\nabla}V = -\frac{\partial V}{\partial r}\hat{a}_r = \left(\frac{A}{r^2}\right)\hat{a}_r = -\left(\frac{-15}{r^2}\right)\hat{a}_r = \frac{15}{r^2}\hat{a}_r\ V/m$

Hence $E_r(r) = \frac{15}{r^2} V/m^2$

(iii) $r = \frac{(0.03+0.05)}{2} = 0.04m$

$$V(r = 0.04m) = \frac{15}{0.04} - 400 = -25V$$

(iv) $V = 0 = \dfrac{15}{r} - 400$ hence r = 3.75 cm

(v) $\overline{D} = \varepsilon_0\varepsilon_r\overline{E} = \varepsilon_0 \times 5 \times \dfrac{15}{r^2}\hat{a}_r = \dfrac{75\varepsilon_0}{r^2}\hat{a}_r\ C/m^2$

$\rho_s = \left|\overline{D}_N\right| = \left|\overline{D}\right| = \dfrac{75\varepsilon_0}{r^2}C/m^2$

$Q = \rho_s \times \text{area} = \dfrac{75\varepsilon_0}{r^2} \times 4\pi r^2 = 300\pi\varepsilon_0 = 8.345\,nC$

06. (d)

Sol: Antenna gain G = 10log($109.66f^2d^2n$)

where, d - diameter

f - frequency

η - efficiency

$G_t = G_r$ = 10log($109.66\times(12)^2\times3^2\times0.55$)

$G_t = G_r$ = 48.93dB

EIRP = $P_t + G_t$ = 10log(10) + 48.93

EIRP = 58.93 dBw

free space loss

$P_L = 32.4 + 20\log F_{MHz} + 20\log d_{km}$

P_L = 32.4 + 20log(12000) + 20log(35,9000)

P_L = 205.1dB

Power received P_r = EIRP + G_r – P_L

= 38.93 + 48.93 – 205.1

P_r(dB) = – 97.24 dBw

$P_r = 10^{\frac{-97.24}{10}}$

$P_r = 1.89\times10^{-10}$w

Power flux density

$(PFD)_r = EIRP - 20\log(d)_m - 10.99$

$= 58.93 - 20\log(3.59\times10^7) - 10.99$

$(PFD)_r = -103.14$ dB(w/m^2)

07. (a)

Sol:

(i) Given that, Radius R = 5km

Frequency reuse factor N = 4

Path loss exponent r = 4

Now, reuse ratio $q = \sqrt{3N} = \sqrt{3\times4}$

$= \sqrt{12}$

q = 3.464

(A) The carrier to interference power ratio for no cell sectoring

$$\text{CIR} = \frac{1}{q^{-r}} = \frac{1}{(3.464)^{-4}}$$

$= 143.31$

CIR (dB) = 10log(143.31)

CIR(dB) = 21.56 dB

(B) CIR when 120° cell sectoring is used

$$\text{CIR} = \frac{1}{3\times q^{-r}}$$

$$= \frac{1}{3\times(3.464)^{-4}}$$

$= 47.99$

$= 10\log(47.99)$

CIR = 16.81 dB

(C) CIR when 60° cell sectoring is used

$$\text{CIR} = \frac{1}{6(q)^{-r}}$$

$$= \frac{1}{6(3.464)^{-4}}$$

$= 23.85$

$= 10\log(23.85)$

CIR = 13.80 dB

(ii) (A) Given that,

Channel data rate = 270.833kbps

Time duration of a bit $T_b = \frac{1}{\text{data rate}}$

$$T_b = \frac{1}{270.833\text{k}}$$

$T_b = 3.69\mu s$

(B) Number of bits per time slot = 156.25

Time duration of a time slot $T_{slot} = 156.25\times T_b$

$= 156.25\times 3.69$

$T_{slot} = 577\mu s$

(C) Number of time slots per TDMA frame = 8

Time duration of a frame, T_f = number of time slots×T_{slot}

$= 8\times 577\mu s$

$T_f = 4.616\text{ms}$

(D) To find time duration for a user occupying a single time slot between two successive transmissions has to wait for the time duration of a frame. Hence, a user has to wait for 4.616ms between two successive transmissions.

07. (b)

Sol: l = 1cm, P_{rad} = 1mW, f = 100 MHz, θ = 90°

(i) For Hertzian dipole,

$$P_{rad} = 40\pi^2 \times I^2\left(\frac{l}{\lambda}\right)^2$$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{10^8} = 3m$$

$$1\times10^{-3} = 40\times\pi^2\times I^2\times\left(\frac{10^{-2}}{3}\right)^2$$

$$I = \sqrt{\frac{10^{-3}\times 9}{40\pi^2\times10^{-4}}} = 0.47746A$$

(ii) $E = \dfrac{\eta k I dl \operatorname{Sin}\theta}{4\pi r}$

$$= 120\pi\times\frac{2\pi}{3}\times\frac{0.47746\times10^{-2}}{4\pi\times100}\times\sin 90$$

$$= 3mV/m$$

$$H = \frac{E}{\eta}$$

$$= \frac{3\times10^{-3}}{120\pi} = 7.96\mu A/m$$

07.(c)

Sol:

(i) In an additive white Gaussian noise (AWGN) channel, the channel output Y is given by.

Y = X + n

Where X is channel input and n is additive bandlimited white Gaussian noise with zero mean & variance σ^2

The capacity C_s of an AWGN channel is given by $C_s = \frac{1}{2}\log_2\left(1+\frac{S}{N}\right)$ b/sample

Where S/N is signal to noise ratio at channel output

If the channel bandwidth 'B' Hz is fixed, then the output y(t) is also a bandlimited signal completely characterized by its periodic sample values taken at Nyquist rate 2B samples/sec.

Then the channel capacity C (b/sec) of AWGN channel is given by,

$C = 2B\times C_s = B\log_2\left(1+\frac{S}{N}\right) b/s$ this equation is known as Shannon-Hartley law.

Thus Shannon Hartley law undergoes the fundamental role of BW and S/N in communication. It also shows that we can exchange increased bandwidth for decreased signal power for a system with a given capacity C.

$$C = B\log_2\left(1+\frac{S}{NB}\right)$$

Let S/NB = λ

$$C = \frac{S}{N\lambda}\log_2(1+\lambda)$$

As $B \to \infty$ (i.e., when bandwidth approaches infinity)

$\Rightarrow \lambda \to 0$

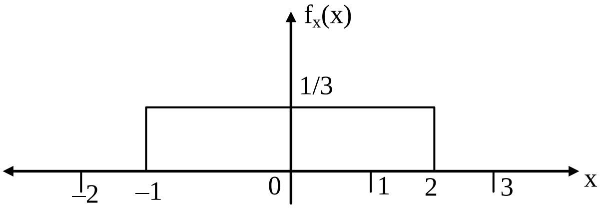
$$\underset{B\to\infty}{\text{Lt}}\ C = \underset{\lambda\to 0}{\text{Lt}} \frac{S}{N\lambda}\log_2(1+\lambda) = \frac{S}{N}\underset{\lambda\to 0}{\text{Lt}}\frac{1}{\lambda}\log_2(1+\lambda)$$

$$\underset{B\to\infty}{\text{Limit}}\ C = \frac{S}{N}\log_2 e \qquad \left[\because \lim_{x\to 0}\frac{1}{x}\log_2(1+x) = \log_2 e = 1.44\right]$$

$$\therefore \underset{B\to\infty}{\text{Lt}}\ C = 1.44\frac{S}{N}$$

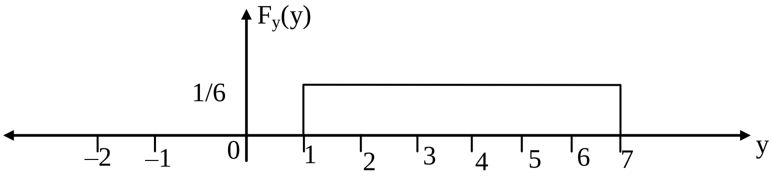
(ii) Given x, a random variable is uniformly distributed over [–1, 2]

$$\therefore f_x(x) = \begin{cases} 1/3; & -1 \le x \le 2 \\ 0; & \text{otherwise} \end{cases}$$



The equation $y = g(x) = 2x + 3$ has a single solution $x_1 = (y-3)/2$ & the range of y is [1, 7]

$$\therefore f_y(y) = \begin{cases} 1/6; & 1 \le y \le 7 \\ 0; & \text{otherwise} \end{cases}$$



08.(a)

Sol:

(i) The minimum number of bits per sample is "7" for a signal to quantization noise ratio of 40 dB.
The number of samples in a duration of
10 seconds = 8000×10
$= 8 \times 10^4$ samples
The minimum storage is $= 7 \times 8 \times 10^4$
$= 560$ k bits

(ii) The similarities between offset QPSK and MSK are that both have a half-symbol delay between the in-phase and quadrature components of each data symbol, and both have the same probability of error.
The differences between the two techniques are:
(1) The basis functions for offset QPSK are sinusoids multiplied by a rectangle function, while the basis functions for MSK are sinusoids multiplied by half a cosine pulse.
(2) Offset QPSK is a form of phase modulation while MSK is a form of frequency modulation.

(iii) Let x be a binomial random variable
(A) $p(x > 1) = 1 - p(x = 0) - p(x = 1)$

$$= 1 - {}^{10}c_0(0.01)^0(0.99)^{10} - {}^{10}c_1(0.01)^1(0.99)^9$$

$$\therefore p(x > 1) = 0.0042$$

(B) According to Poisson distribution,

$$p(x=k)=e^{-np_e}\frac{(np_e)k}{k!}\quad np_e=10(0.01)$$

$np_e = 0.1$

$$p(x>1) = 1 - p(x=0) - p(x=1)$$

$$=1-e^{-0.1}\frac{(0.1)^0}{0!}-e^{-0.1}\frac{(0.1)^1}{1!}$$

$\therefore$ p(x>1) = 0.0047

08. (b)

Sol:

TCP header format

32 bits

<table>
<tr><td colspan="8">Source port</td><td>Destination port</td></tr>
<tr><td colspan="9">Sequence number</td></tr>
<tr><td colspan="9">Acknowledgement number</td></tr>
<tr><td>Hlen</td><td>reserved</td><td>U
R
G</td><td>A
C
K</td><td>P
S
H</td><td>R
S
T</td><td>S
Y
N</td><td>F
I
N</td><td>window</td></tr>
<tr><td colspan="8">checksum</td><td>urgent pointer</td></tr>
<tr><td colspan="9">[options]</td></tr>
</table>

0 16 31

<table>
<tr><td colspan="8">16 bit source port number</td><td>16 bit destination port number</td></tr>
<tr><td colspan="9">32 bit sequence number</td></tr>
<tr><td colspan="9">32 bit acknowledgement number</td></tr>
<tr><td>4-bit header length</td><td>reserved (6 bits)</td><td>U
R
G</td><td>A
C
K</td><td>P
S
H</td><td>R
S
T</td><td>S
Y
N</td><td>F
I
N</td><td>16 bit window size</td></tr>
<tr><td colspan="8">16 bit TCP checksum</td><td>16 bit urgent pointer</td></tr>
<tr><td colspan="9">Options (if any)</td></tr>
<tr><td colspan="9">Data (if any)</td></tr>
</table>

20 bytes

Source port Number (16 bits):
Sending application port number.

Destination port Number (16 bits):
Receiving application port number.

Sequence Number (32 bits):
Specifies the number assigned to the first byte of data in the current message.

Acknowledgement Number (32 bits):
Contains the value of the next sequence number that the sender of the segment is expecting to receive, if the ACK control bit is set.

Header length (4 bits):
Header length in words of 32 bits.
Min header size is 5 words (20 bytes) and max header size is 15 words (60 bytes).

Reserved bits (6 bits):
Must be zero. This is for future use.

Flags bits (6 bits):
Contains the various flags.

URG: Indicates that some urgent data has been placed.

ACK: Indicates that acknowledgement number is valid.

PSH: Indicates that data should be passed to the application as soon as possible.

RST: Resets the connection.

SYN: Synchronizes sequence numbers to initiate a connection.

FIN: Means that the sender of the flag has finished sending data.

Window size (16 bits): Specifies the size of the sender's receive window (that is, buffer space available for incoming data).

Checksum (16 bits):
Used to detect error in TCP segment.

Urgent pointer (16 bits): Points to the first urgent data byte in the packet.

08. (c)
Sol:

(i) $$\nabla \times \overline{E} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 10^4 \cos(10^9 t - \beta z) & 0 & 0 \end{vmatrix}$$

$$= -\hat{a}_y\left[-10^4(-1)\sin(10^9 t - \beta z) \times (-\beta)\right]$$
$$= \hat{a}_y\left[\beta 10^4 \sin(10^9 t - \beta z)\right]$$

$$\nabla \times \overline{E} = -\frac{\partial \overline{B}}{\partial t}$$

Hence $\dfrac{d\overline{B}}{dt} = -\hat{a}_y\left[\beta 10^4 \sin(10^9 t - \beta z)\right]$

$$\therefore \overline{B} = -\hat{a}_y\left\{\beta 10^4(-1)\frac{\cos(10^9 t - \beta z)}{10^9}\right\}$$
$$= \beta 10^{-5} \cos\,(10^9\,t - \beta z)\ \hat{a}_y$$

$$\therefore \overline{H} = \frac{\overline{B}}{\mu_o \mu_r} = \frac{\beta 10^{-5}\cos(10^9 t - \beta z)\hat{a}_y}{\mu_0}$$

$$\overline{\nabla}\times\overline{H} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & \frac{\beta 10^{-5}\cos(10^9 t - \beta z)}{\mu_0} & 0 \end{vmatrix}$$

$$= \hat{a}_x\left[-\frac{\beta 10^{-5}}{\mu_0}(-1)\sin(10^9 t - \beta z)(-\beta)\right]$$

$$= -\frac{\beta^2 10^{-5}}{\mu_0}\sin(10^9 t - \beta z)\hat{a}_x$$

$$\overline{\nabla}\times\overline{H} = \sigma\overline{E} + \overline{J}_D = \overline{J}_D \text{ as } \sigma = 0$$

$$\therefore \overline{\nabla}\times\overline{H} = \frac{\partial\overline{D}}{\partial t} = \varepsilon_0\varepsilon_r\frac{\partial\overline{E}}{\partial t}$$

$$\Rightarrow -\frac{\beta^2 10^{-5}}{\mu_0}\sin(10^9 t - \beta z)\hat{a}_x = \varepsilon_0(25)10^4(-1)\sin(10^9 t - \beta z)\times\hat{a}_x\times(10^9)$$

$$\therefore \frac{\beta^2 10^{-5}}{\mu_0} = 25\times 10^{13}\times\varepsilon_0$$

Or β = 16.678 rad/m

(ii) $\overline{J}_D = -25\times 10^{13}\varepsilon_0\sin(10^9 t - \beta z)\hat{a}_x$

When z = 0

$\overline{J}_D = -2213.5\sin(10^9 t)\hat{a}_x \text{ A/m}^2$

(iii) $I_D = \int \overline{J}_D.\overline{dS}$

$$= \int\left[-2213.5\sin(10^9 t - \beta z)\hat{a}_x\right].\left[dy\,dz\,\hat{a}_x\right]$$

$$= \int_0^b\int_0^{0.1} -2213.5\sin(10^9 t - \beta z)\,dy\,dz$$

$$= -2213.5\left[\frac{-\cos(10^9 t - \beta z)}{-\beta}\right]_0^{0.1}[y]_0^b$$

$$= -\frac{2213.5b}{\beta}\left[\cos(10^9 t - 0.1\times 16.678) - \cos(10^9 t)\right]$$

$$= -\frac{2213.5b}{\beta}\left[\cos(10^9 t - 1.6678) - \cos(10^9 t)\right]$$

$$= -\frac{2213.5b}{\beta}\left[-0.09685\cos 10^9 t + 0.9953\sin 10^9 t - \cos 10^9 t\right]$$

$$= \frac{2213.5b}{\beta}\left[1.09685\cos 10^9 t - 0.9953\sin 10^9 t\right]$$

$$= \frac{2213.5\times 0.05}{16.678}\left[1.09685\cos 10^9 t - 0.9953\sin 10^9 t\right]$$

$$= 6.636\left[1.09685\cos 10^9 t - 0.9953\sin 10^9 t\right]\text{A}$$