CBCS SCHEME

USN | | | | | | | | | |

17EC71

Seventh Semester B.E. Degree Examination, July/August 2021
Microwaves and Antennas

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Describe the mechanism of oscillations in case of Reflex klystron. **(07 Marks)**
b. Give the solutions of Transmission line equations and find the expression for phase velocity. **(08 Marks)**
c. A transmission line has following parameters $R = 2\Omega/m$, $G = 0.5$mmho/m, $f = 1$GHz, $L = 8$nH/m, $C = 0.23$PF.
Calculate:
i) Characteristic impedance
ii) Propagation Constant. **(05 Marks)**

2 a. Define reflection coefficient. Derive the equation for reflection coefficient at the load end at a dist "d" from the load. **(07 Marks)**
b. Describe the different mode curve in the case of reflex klystron. **(07 Marks)**
c. A transmission line has a characteristic impedance of $50 + j0.01\Omega$ and is terminated in a load impedance of $73 - j42.5\Omega$. Calculate:
i) Reflection coefficient
ii) Standing wave ratio. **(06 Marks)**

3 a. State and explain the properties of s-parameters. **(07 Marks)**
b. Explain the working of precision type variable attenuator with a neat diagram. **(06 Marks)**
c. Two transmission lines of characteristic impedance Z_1 and Z_2 are joined at plane PP′. Express s-parameters in terms of impedances. **(07 Marks)**

4 a. Draw the diagrams of coaxial connectors and explain. **(07 Marks)**
b. Discuss E plane Tee. Derive its scattering matrix. **(06 Marks)**
c. A 20mW signal is fed into one of collinear port 1 of a lossless H-plane T-junction. Calculate the power delivered through each port when other ports are terminated in matched load. **(07 Marks)**

5 a. Find the Quality factor Q_d of microstrip lines. **(07 Marks)**
b. Draw the diagram of parallel strip lines. Find the characteristic impedance of a lossless parallel strip lines. **(07 Marks)**
c. Define the following :
i) Antenna ii) Beam efficiency iii) Effective Aperture iv) Directivity. **(06 Marks)**

6 a. Explain the concept of shielded strip line and co-planar strip lines with diagrams. **(07 Marks)**
b. Define the following :
i) Radiation pattern
ii) Radiation Intensity
iii) Gain
iv) Effective Height. **(07 Marks)**

c. A radio link has a 15w transmitter connected to an antenna of $2.5m^2$ effective aperture at 5GHz. The receiving antenna has effective aperture of $0.5m^2$ and is located at a 15km line of sight distance from the transmitting antenna. Assuming lossless matched antennas, find the power delivered to the receiver. **(06 Marks)**

7 a. Explain power theorem and its application to an Isotropic source. **(07 Marks)**
b. Explain the principle of pattern multiplication. **(07 Marks)**
c. A source has a radiation intensity power pattern given by $U = U_m \sin^2\theta$ for $0 \le \theta \le \pi$; $0 \le \phi \le 2\pi$. Find the total power and directivity. Draw pattern. **(06 Marks)**

8 a. Derive the equation for radiation Intensity. Explain the concept of field patterns. **(07 Marks)**
b. Find the radiation resistance of a $\frac{\lambda}{2}$ Antenna. **(07 Marks)**
c. With diagram, explain the concept of Thin linear Antenna. **(06 Marks)**

9 a. Draw the diagram of a loop Antenna and explain. **(07 Marks)**
b. Find the radiation resistance of loops, as related of Antenna. **(07 Marks)**
c. Explain the working and design consideration of log periodic antenna. **(06 Marks)**

10 a. Explain the concept of Rectangular Horn Antenna. **(07 Marks)**
b. Write short notes on :
i) Yagi-uda Array ii) Parabolic reflector. **(07 Marks)**
c. A 16 turn helical beam Antenna has a circumference of λ and turn spacing of $\frac{\lambda}{4}$. Find
i) HPBW ii) Axial Ratio iii) Directivity. **(06 Marks)**

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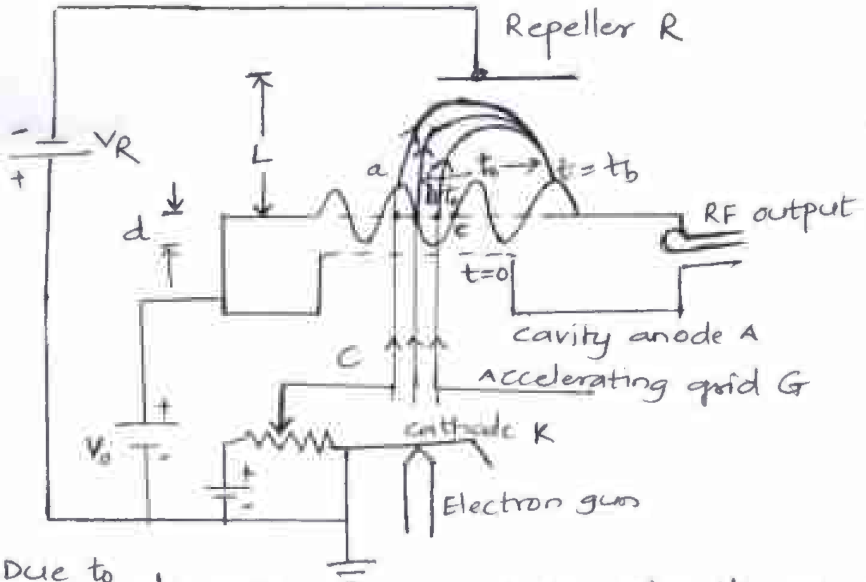
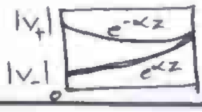
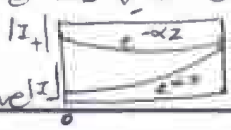
Scheme & Solutions

Signature of Scrutinizer

Subject Title: Microwave & Antennas **Subject Code:** 17EC71

Question Number	Solution	Marks Allocated
1 a)	 Due to dc voltage in the cavity circuit, RF noise is generated in the cavity. This electromagnetic noise field in the cavity becomes pronounced at cavity resonant freq. The electrons passing thro' the cavity gap d experience this RF field & are velocity modulated. Bunching process:- The RF power is coupled to the output load by means of a small loop which forms the centre conductor of the coaxial line. When the power delivered by the electrons becomes equal to the total power loss in the cavity system, a steady microwave oscillation is generated at resonant freq of the cavity.	2+5
1 b)	one possible solution is for V & I is $V = V_+e^{-\gamma z} + V_-e^{\gamma z} = V_+e^{-\alpha z}e^{-j\beta z} + V_-e^{\alpha z}e^{j\beta z}$ $I = Y_0(V_+e^{-\alpha z}e^{-j\beta z} - V_-e^{\alpha z}e^{j\beta z})$  a) voltage wave  b) current wave	2+6

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Question Number	Solution	Marks Allocated

$$Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \cong \sqrt{\frac{L}{C}}$$

Phase velocity is $v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$

1 c) a) $Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{\frac{2+j2\pi\times10^9\times8\times10^{-9}}{0.5\times10^{-3}+j2\pi\times10^9\times0.23\times10^{-12}}}$ — 2+3

characteristic impedance $Z_0 = 179.44+j26.50 = 181.39\angle 8.4^\circ$

b) propogation constant $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$

$$= \sqrt{(50.31\angle 87.72^\circ)(15.29\times10^{-4}\angle 70.9)}$$

$$= 0.2774\angle 79.31^\circ$$

$$= 0.051+j0.273$$

2 a) Reflection coefficient Γ is — 2+5

$$\text{Reflection coefficient} = \frac{\text{reflected voltage or current}}{\text{incident voltage or current}}$$

$$\Gamma = \frac{V_{ref}}{V_{inc}} = \frac{-I_{ref}}{I_{inc}}$$

Generalized reflection coefficient is defined as $\Gamma = \frac{V_- e^{\gamma z}}{V_+ e^{-\gamma z}}$

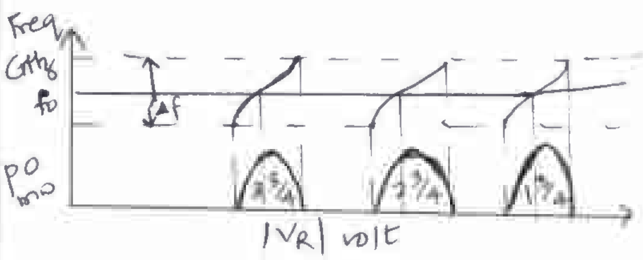
reflection coefficient at some point located a dist 'd' from the receiving end is

$$\Gamma_d = \frac{V_- e^{\gamma(l-d)}}{V_+ e^{-\gamma(l-d)}} = \Gamma_l e^{-2\gamma d}$$

in terms of reflection coefficient at the receiving end as

$$\Gamma_d = \Gamma_l e^{-2\alpha d} e^{-j2\beta d} = |\Gamma_l| e^{-2\alpha d} e^{j(\theta_l - 2\beta d)}$$

2 b) — 2+5



Subject Title : Microwave & Antennas   Subject Code : 17EC71

Question Number	Solution	Marks Allocated
	Since the output power & freq can be electronically controlled by varying the repeller voltage expansions for these parameters in terms of repeller voltage are important to draw mode curves.	
	$$P_{RF} = \frac{0.3986\, V_0 I_0 (V_0+V_R)}{2\pi f L}\sqrt{\frac{e}{2mV_0}}$$	
	Operation freq $$f_{MHz} = \frac{(V_0+V_R)N}{L_{cm}\sqrt{V_0}\times 13.34\times 10^{-3}}$$	
	& $$\lvert V_R\rvert = \sqrt{\left(\frac{8m}{e}\right)}\cdot\left(\frac{fL}{N}\right)\cdot\sqrt{V_0} - V_0$$ $$= 6.743\times 10^{-6}\frac{fL}{N}\sqrt{V_0} - V_0$$	
	$f \rightarrow Hz$ & $L \rightarrow$ mtrs.	
2 c)	Reflection coefficient is $$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{73 - j42.5 - (50 + j0.01)}{73 - j42.5 + (50 + j0.01)}$$ $$= 0.377\angle -42.7^\circ$$	3+3
	SWR is $$\rho = \frac{1+\lvert\Gamma\rvert}{1-\lvert\Gamma\rvert} = \frac{1+0.377}{1-0.377} = 2.21$$	
3 a)	i) Zero diagonal elements for perfect matched N/w:- For an ideal N-port network with matched termination, $S_{ii} = 0$, since there is no reflection from any port. therefore, under perfect matched condition the diagonal elements of [S] are zero.	1+1+1 +4
	ii) Symmetry of [S] for a reciprocal network. A reciprocal device has the same transmission characteristics in either direction of a pair of ports & is characterised by a symmetric scattering matrix. $$S_{ij} = S_{ji}$$	
	iii) Unitary property of a lossless junction:	

Question Number	Solution	Marks Allocated

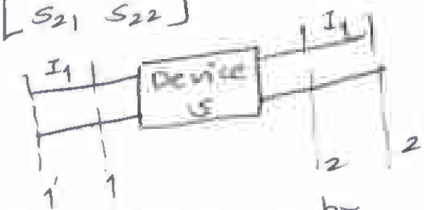
For any lossless network the sum of the products of each term of any one row or of any column of the S-matrix multiplied by its complex conjugate is unity.

$$\sum_{n=1}^{N} |b_n|^2 = \sum_{n=1}^{N} |a_n|^2$$

phase shift property:

S-parameters have definite complex values

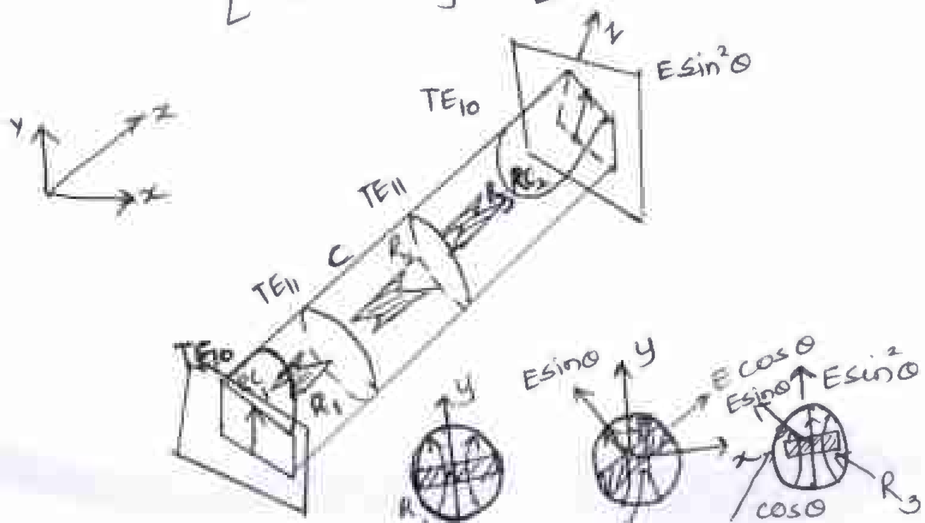
$$[S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$



New S-matrix is then given by

$$[S'] = \begin{bmatrix} e^{-j\phi_1} & 0 \\ 0 & e^{-j\phi_2} \end{bmatrix} [S] \begin{bmatrix} e^{-j\phi_1} & 0 \\ 0 & e^{-j\phi_2} \end{bmatrix}$$

3 b)



2+4

R_1, R_2, R_3 – Tapered resistive cards

RC_1 & RC_2 – Rectangular to circular waveguide transitions

C – circular waveguide section

Makes use of a circular waveguide section (C) containing a very thin tapered resistive card (R_2) to both sides of which are connected axis symmetric sections of circular to rectangular waveguide, tapered transitions (RC_1 & RC_2). Centre circular section with the resistive card

Question Number	Solution	Marks Allocated
	can be precisely rotated by 360° w.r.t two fixed sections of circular to rectangular waveguide transitions. The induced current on the resistive card R_3 due to incident signal is dissipated as heat producing attenuation of the transmitted signal. Incident TE_{10} dominant wave in the rectangular waveguide is converted into a dominant TE_{11} mode in the circular waveguide. A very thin tapered resistive card is placed ⊥r to the E-field at the circular end of each transition section so that it has a negligible effect on the field ⊥r to it but absorbs any component parallel to it.	
	Attenuation of incident wave is $$\alpha = \frac{E}{E\sin^2\theta} = \frac{1}{\sin^2\theta} = \frac{1}{\lvert S_{21}\rvert}$$ or $$\alpha\,(dB) = -40\log(\sin\theta) = -20\log\lvert S_{21}\rvert$$	
3 c)	Incident & scattered wave amplitude are related by $[b]=[S][a]$. Assuming that the output line to be matched $(a_2=0)$ the input impedance Z_{in} at the junction $= Z_2 =$ load of line Z_1.	2+5
	∴ $S_{11} = \frac{Z_2-Z_1}{Z_2+Z_1}$ = Reflection coefficient on the input side.	
	(ii) Similarly, for symmetry, assuming I/p side is matched $(a_1=0)$ $$S_{22} = \frac{Z_1-Z_2}{Z_1+Z_2} = -S_{11}$$	
	(iii) In general $$b_1 = S_{11}a_1 + S_{12}a_2$$ $$b_2 = S_{21}a_1 + S_{22}a_2$$ $$S_{21} = \frac{2Z_2}{Z_2+Z_1} \qquad S_{12} = \frac{2Z_1}{Z_1+Z_2}$$ $$[S] = \begin{bmatrix} \frac{Z_2-Z_1}{Z_2+Z_1} & \frac{2Z_1}{Z_1+Z_2} \\ \frac{2Z_2}{Z_1+Z_2} & \frac{Z_1-Z_2}{Z_1+Z_2} \end{bmatrix}$$	

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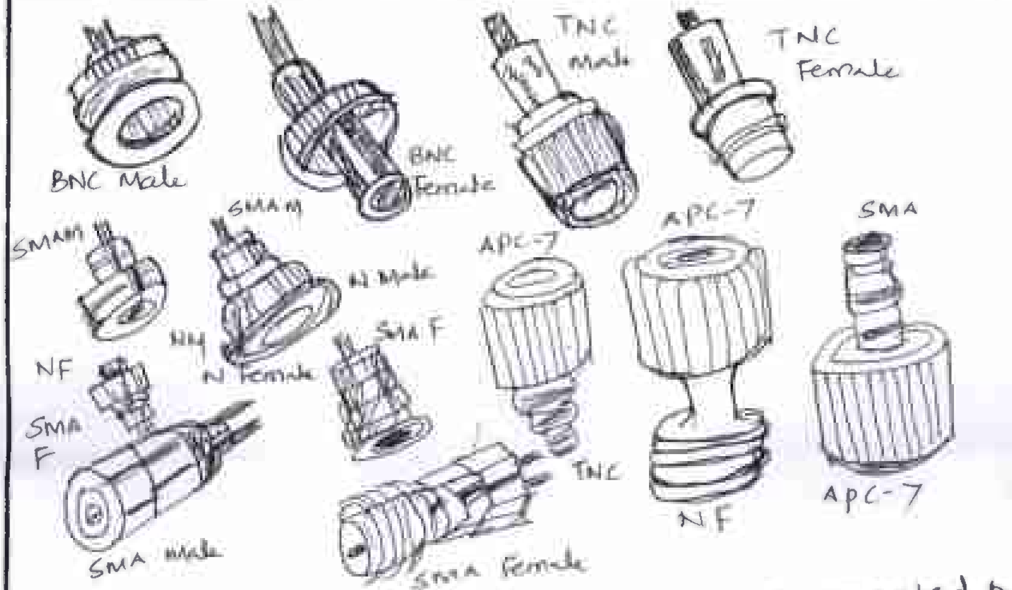
Question Number	Solution	Marks Allocated
4 a)	(see below)	4+3
4 b)	(see below)	2+4

4 a)



coaxial cables are terminated or connected to other cables & components by means of shielded standard connectors.

Type N connector is 50 & 75 Ωs.

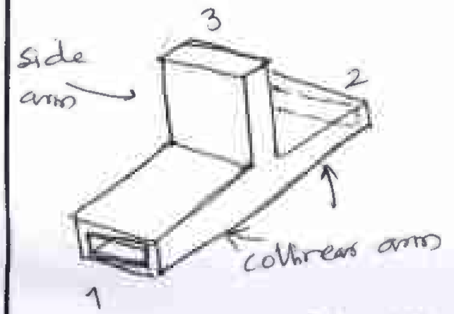
BNC is suitable for 0.25 inch 50 Ω or 75 Ω

TNC – like BNC

SMA – used for thin flexible or semirigid cables

APC-7 is a very accurate 50 Ω.

4 b)



$S_{31} = S_{13} = -S_{23} = -S_{32}$

$S_{12} = S_{21}$

If two input waves are fed into ports 1 & 2 of the collinear arm, o/p wave at port 3 will be opposite in phase & subtractive.

For an input power at port 3, Net input power to port 3 is $|a_3|^2 = |b_3|^2 = |a_3|^2(1-|S_{33}|^2)$

o/p power is $|b_1|^2 + |b_2|^2 = 2|a_3|^2|S_{13}|^2$

$|S_{31}| = |S_{32}|$ by symmetry.

S-Matrix of E-plane Tee

$$[S] = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

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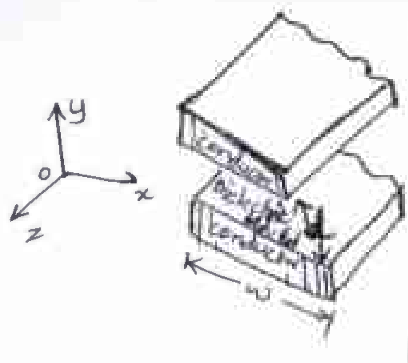
Question Number	Solution	Marks Allocated
4 c)	Since ports 2 & 3 are matched terminated $a_2=a_3=0$, $S_{11}=\frac{1}{2}$. The total effective power input to port 1 is $P_1=\lvert a_1\rvert^2(1-\lvert S_{11}\rvert^2)$ $=20(1-0.5^2)=15\,mW$ Power transmitted to port 3 is $P_3=\lvert a_1\rvert^2\lvert S_{31}\rvert^2$ $=20*(1/\sqrt{2})^2=10\,mW$ Power transmitted to port 2 is $P_2=\lvert a_1\rvert^2\lvert S_{21}\rvert^2$ $=20\times(1/2)^2=5\,mW$. $P_1=P_3+P_2$	2+5
5 a)	quality factor Q of a microstrip line is very high, but it is limited by the radiation losses of the substrates & with low dielectric constant, $Q_c=0.63\,h\sqrt{\sigma f_{GHz}}$ $\sigma\rightarrow$ conductivity of the dielectric substrate board in ℧/m. Q_d is related to the dielectric attenuation constant $Q_d=\frac{27.3}{\alpha_d}$ α_d is in dB/λ_g $Q_d=\frac{\lambda_0}{\sqrt{\epsilon_{re}}\tan\theta}=\frac{1}{\tan\theta}$	2+5
5 b)	 A parallel strip line consists of two perfectly parallel strips separated by a perfect dielectric slab of uniform thickness $L=\frac{\mu d}{w}$ H/m $C=\frac{\epsilon_d w}{d}$ $R=\frac{2R_s}{w}=\frac{2}{w}\sqrt{\frac{\pi f\mu_c}{\sigma_c}}$ $G=\frac{\sigma_d w}{d}$	2+5

Question Number	Solution	Marks Allocated

characteristic impedance

$$Z_o = \sqrt{\frac{L}{C}} = \frac{377}{\sqrt{\epsilon_{rd}}}\frac{d}{w} \quad \text{for } w \gg d$$

5 c)

i) A radio antenna may be defined as the structure associated with the region of transition between a guided wave & a free space or vice-versa. — 1.5×4 = 6

ii) The beam area Ω_A consists of the main beam area Ω_M plus the minor-lobe area Ω_m. Thus

$$\Omega_A = \Omega_M + \Omega_m$$

The ratio of the main beam area to the beam area is called beam efficiency ϵ_M. Thus

$$\text{Beam efficiency} = \epsilon_M = \frac{\Omega_M}{\Omega_A}$$

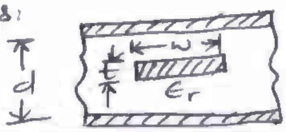
iii) Effective Aperture :- is the ratio of power radiated in watts to the poynting vector(p) of the incident wave. The effective aperture accounts for the captured/collected power.

iv) The directivity of an antenna is equal to the ratio of the maximum power density $P(\theta,\phi)_{max}$ W/m² to its average value over a sphere as observed in the far field of an antenna.

$$D = \frac{P(\theta,\phi)_{max}}{P(\theta,\phi)_{av}}$$

$$D = \frac{P(\theta,\phi)_{max}}{\left(\frac{1}{4\pi}\right)\iint_{4\pi} P(\theta,\phi)\,d\Omega} = \frac{1}{\left(\frac{1}{4\pi}\right)\iint_{4\pi}\left[P(\theta,\phi)/P(\theta,\phi)_{max}\right]d\Omega}$$

6 a) shielded strip lines: — 2+5



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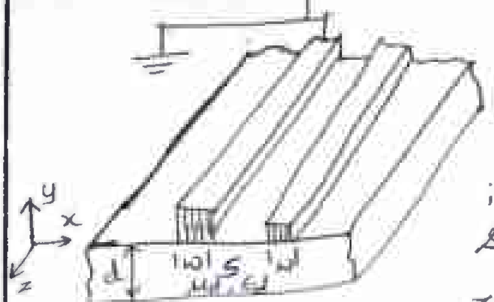
Question Number	Solution	Marks Allocated
	The characteristic impedance for a wide strip $Z_0 = \frac{94.15}{\sqrt{\epsilon_r}}\left(\frac{w}{d}K + \frac{C_f}{8.854\epsilon_r}\right)^{-1}$ where $K = \frac{1}{1-t/d}$ A partially shielded strip line has its strip conductor embedded in a dielectric medium & its top & bottom ground planes have no connection. coplanar strip lines consists of two conducting strips on one substrate surface with one strip grounded.  The characteristic impedance of a coplanar strip line is $Z_0 = \frac{2P_{avg}}{I_0^2}$ $I_0 \rightarrow$ Total peak current $P_{avg} \rightarrow$ Average power flowing in +ve z direction $P_{avg} = \frac{1}{2} Re \iint (E \times H^*) \cdot u_z \, dx\, dy$	
6 b)	i) Radiation pattern:- are three-dimensional (3D) quantities involving the variation of field or power as a function of the spherical coordinates θ & ϕ. ii) The power radiated from an antenna per unit solid angle is called the radiation intensity U. The normalized power pattern of the ~~[illegible]~~ can be expressed in terms of the parameter as the ratio of radiation intensity $U(\theta,\phi)$ as a function of angle, to its max value. $P_n(\theta,\phi) = \frac{U(\theta,\phi)}{U(\theta,\phi)_{max}} = \frac{S(\theta,\phi)}{S(\theta,\phi)_{max}}$	1.5+1.5 +1.5+2.5

Question Number	Solution	Marks Allocated
	iii) Gain G is an actual or realized quantity. Gain can be measured by comparing the max power density of the antenna under test (AUT) with a reference antenna of known gain, such as a short dipole. Thus $$\text{Gain} = G = \frac{P_{max}(AUT)}{P_{max}(ref.ant)} \times G(ref.ant)$$	
	iv) Effective Height:- May be defined as the ratio of the induced voltage to the incident field or $$h = \frac{V}{E} \ (m)$$	
6 c)	$$P = P_t \frac{A_{et}A_{er}}{r^2\lambda^2} = 15 \frac{2.5 \times 0.5}{15^2 \times 10^6 \times (0.06)^2} = 234W$$	2+4
7 a)	If the poynting vector is known at all points on a sphere of radius r from a point source in a lossless medium, the total power radiated by the source is the integral over the surface of the sphere of the radial component S_r of the average poynting vector. Thus $$P = \oint\oint S \cdot ds = \oint\oint S_r\, ds$$ P - power radiated; S_r - radial component of average poynting vector; ds - infinitesimal element of area of sphere $= r^2 \sin\theta\, d\theta\, d\phi\, m^2$ & $$S_r = \frac{P}{4\pi r^2} \ W/m^2$$	2+3
b)	Principle of Pattern Multiplication: The field pattern of an array of nonisotropic but similar point sources is the product of the pattern of the individual source & the pattern of an array of isotropic point sources having the same locations, relative amplitudes & phase as the nonisotropic point sources.	2+5

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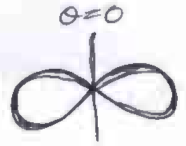
Question Number	Solution	Marks Allocated
7 c)	The total power radiated is	4+2

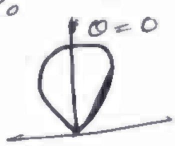
$$P = U_m \int_0^{2\pi}\int_0^{\pi} \sin^3\theta \, d\theta \, d\phi = \frac{8}{3}\pi U_m$$

If p is the same as for the isotropic source

$$\frac{8}{3}\pi U_m = 4\pi U_0$$

& $\text{Directivity} = \frac{U_m}{U_0} = \frac{3}{2} = 1.5 = D$





8 a)	power per steradian	2+5

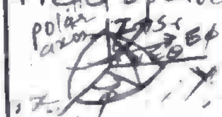
$$r^2 S_r = \frac{P}{4\pi} = U \quad (W/sr)$$

The max value of U_m is in the θ=0 direction.

Relative poynting vector & relative radiation intensity patterns are identical.

Applying power theorem to an isotropic source $P = 4\pi U_0$ (W). U_0 → Intensity of isotropic source

Field patterns: conditions characterizing the far field



1. Poynting vector radial (S_r component only)
2. Electric field transverse (E_θ & E_ϕ components)

8 b)	The poynting vector is integrated over a large sphere yielding the power radiated, & this power is ~~then~~ equated to $\left(\frac{I_0}{\sqrt{2}}\right)^2 R_0$	2+5

R_0 → radiation resistance at a current max point & I_0 is peak value in time of the current at this point.

The total power p radiated was in terms of H_ϕ for a short dipole.

$|H_\phi|$ is the absolute value.

$$P = \frac{15 I_0^2}{\pi} \int_0^{2\pi}\int_0^{\pi} \frac{\left\{\cos\left[\left(\frac{\beta L}{2}\right)\cos\theta\right] - \cos\left(\frac{\beta L}{2}\right)\right\}^2}{\sin\theta} \, d\theta \, d\phi$$

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Question Number	Solution	Marks Allocated

$$= 30 I_0^2 \int_0^{\pi} \frac{\{\cos[(\frac{\beta L}{2})\cos\theta] - \cos(\frac{\beta L}{2})\}^2}{\sin\theta} d\theta$$

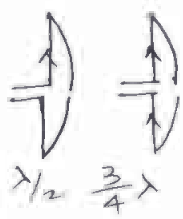
Equating the radiated power to $\frac{I_0^2 R_0}{2}$

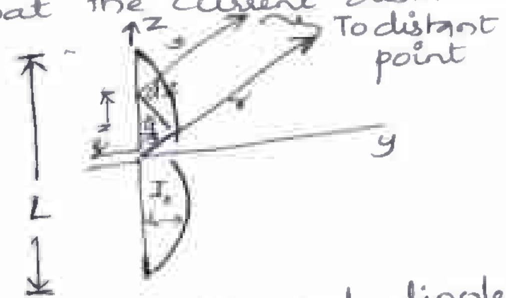
$$P = \frac{I_0^2 R_0}{2} \quad \&$$

$$R_0 = 60 \int_0^{\pi} \frac{\{\cos[(\frac{\beta L}{2})\cos\theta] - \cos(\frac{\beta L}{2})\}^2}{\sin\theta} d\theta$$

$R_0 \rightarrow$ current max.

8 c) Antennas are symmetrically fed at the center by a balanced two-wire transmission line. The antennas may be of any length, but it is assumed that the current distribution is sinusoidal. 2+4





The far fields of center fed dipole can be given as

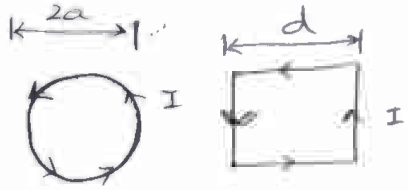
$$H_\phi = \frac{j[I_0]}{2\pi r}\left[\frac{\cos[(\beta L\cos\theta)/2] - \cos(\frac{\beta L}{2})}{\sin\theta}\right]$$

$$E_\theta = \frac{j\,60[I_0]}{r}\left[\frac{\cos(\beta L\cos\theta)/2 - \cos(\frac{\beta L}{2})}{\sin\theta}\right]$$

where $[I_0] = I_0 e^{j\omega[(t-(r/c))]}$ &

$$E_\theta = 120\pi H_\phi$$

9 a)



A loop may be small or large & circular or rectangular. 2+5

The field pattern of a small circular loop of radius a may be determined by considering a square loop of the same

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area, that is

$$d^2 = \pi a^2 \qquad d \rightarrow \text{side length of square loop.}$$

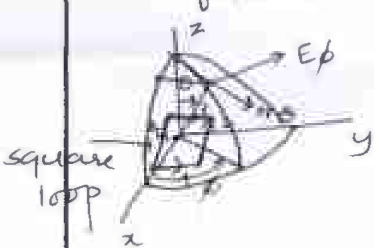
Thus

$$E_\phi = -E_\phi e^{j\psi/2} + E_\phi e^{-j\psi/2}$$

E_{ϕ_0} – electric field from individual dipole &

$$\psi = \frac{2\pi d}{\lambda}\sin\theta = d_r \sin\theta$$

It follows that $E_\phi = -2jE_{\phi_0}\sin\left[\frac{d_r}{2}\sin\theta\right]$



small loop

$$E_\phi = \frac{120\pi^2\,[I]\sin\theta}{r}\,\frac{A}{\lambda^2}$$

Far E_ϕ field

$$H_\theta = \frac{E_\phi}{120\pi} = \frac{\pi\,[I]\sin\theta}{r}\,\frac{A}{\lambda^2}$$

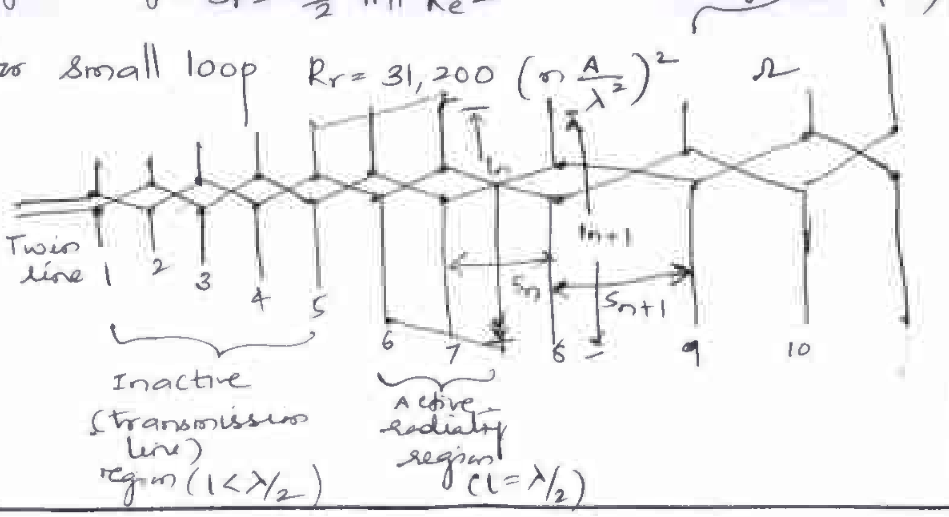
9 b) To find Radiation resistance of a loop antenna, poynting vector is integrated over a large sphere yielding the total power p radiated. This power is then equated to the square of the effective current on the loop times the radiation resistance R_r — 2+5

$$P = \frac{I_0^2}{2} R_r$$

The average poynting vector of a far field is given by $S_r = \frac{1}{2}|H|^2 R_e Z$

for small loop $R_r = 31,200\left(n\frac{A}{\lambda^2}\right)^2\ \Omega$

9 c) — 2+4



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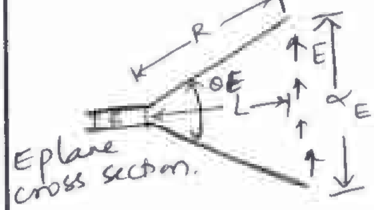
The dipole array of logic periodic is a periodic design. The dipole lengths increase along the antenna so that the included angle α is a Constant, & the lengths l & spacing s of adjacent elements are scaled so that

$$\frac{l_{n+1}}{l_n} = \frac{s_{n+1}}{s_n} = K \qquad K \rightarrow \text{Constant}$$

The elements in this active region are about $\lambda/2$ long.

Elements 9, 10 & 11 are in the neighbourhood of 1λ long & carry only small currents. The small currents in elements 9, 10 & 11 mean that antenna is effectively truncated at the right of the active region.

10 a) 2+5



The H-plane pattern of an H-plane sectoral horn is the same as the H-plane pattern of a pyramidal horn with the same H-plane cross section.

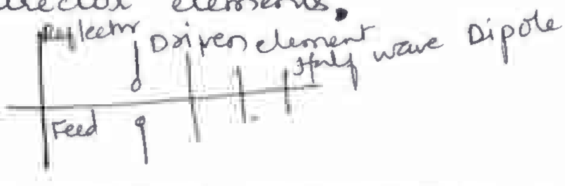
The aperture in both planes of a rectangular horn substz exceeds 1λ, the pattern in one plane is substantially independent of the aperture in the other plane.

The directivity of a horn antenna can be expressed in terms of its effective aperture. Thus

$$D = \frac{4\pi A_e}{\lambda^2}$$

10 b) i) 2+5

Yagi Uda uses a driven element & some passive (parasitic) elements. Constructed with one or more reflector elements & one or more director elements.



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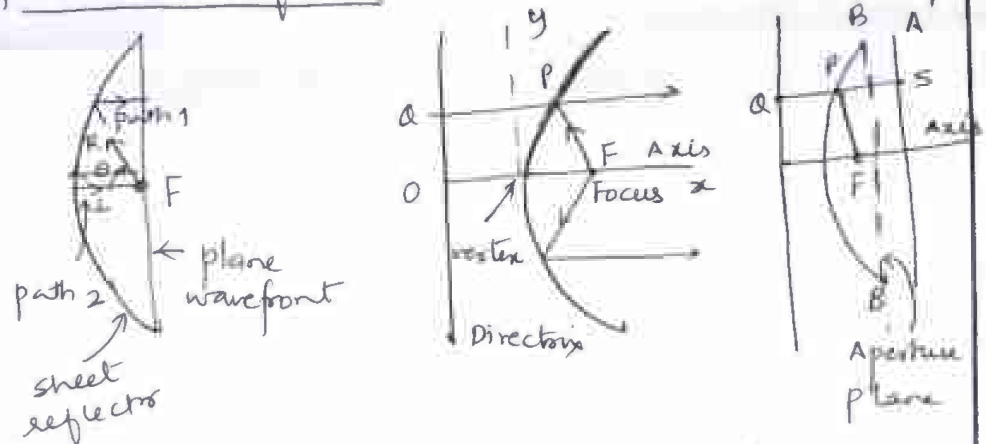
	The increase of the number of directors results in the increase of gain & decrease of beam width of yagi. The antenna can be mounted to support either the horizontal or the vertical polarization. It is often used for point-to-point applications, as between the base station & repeater-station sites.	
ii)	Parabolic reflector.	



The dist from the source to the plane wave front via path 1 & 2 be equal so

$$2L = R(1+\cos\theta)$$

& $$R = \frac{2L}{1+\cos\theta}$$

10 c) 2+2+2

$$HPBW = \frac{52}{C_\lambda \sqrt{n S_\lambda}}$$

$$= \frac{52}{\lambda} \times \sqrt{\frac{\lambda^3}{16 \times \left(\frac{\lambda}{4}\right)}} = \frac{52}{\lambda} \times \frac{\lambda}{2}$$

$$HPBW = 26^\circ$$

Axial Ratio $AR = \frac{2n+1}{2n} = \frac{2\times 16+1}{2\times 16} = \frac{33}{32}$

$= 1.03$

or only 3 percent from perfect circular polarization

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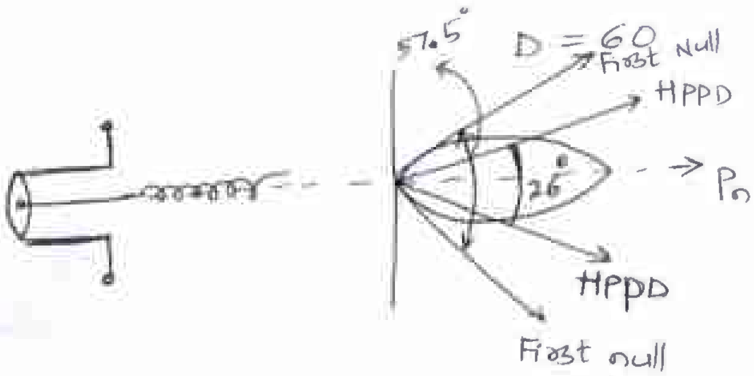
	iii) $G_{Dmax} = D = \frac{15NSC^2}{\lambda^3} = \frac{15 \times 16 \times (\lambda/4) \times \lambda^2}{\lambda^3} = \frac{60\lambda^3}{\lambda^3}$ $D = 60$  Radiation pattern	