VIT

Reg. No. :

Final Assessment Test (FAT) - July/August 2023

Programme	B.Tech.	Semester	Fall Inter Semester 22-23
Course Title	ANTENNA AND MICROWAVE ENGINEERING	Course Code	BECE305L
Faculty Name	Prof. Idayachandran G	Slot	C1+TC1
		Class Nbr	CH2022232500127
Time	3 Hours	Max. Marks	100

Section A (5 X 5 Marks)
Answer All questions

01. In a long-range microwave communication system operating at 9 GHz, the transmitting and receiving antennas are identical and are separated by 10,000 m. To meet the receiver's signal-to-noise ratio, the received power must be at least 10 μW. Assuming the two antennas are aligned for maximum reception to each other, including being polarization-matched, what should the gains (in dB) of the transmitting and receiving antennas be when the input power to the transmitting antenna is 10 W? [5]

02. A uniform array of 3 elements is designed so that its maximum is directed toward the broadside. The spacing between the elements is λ/2. Determine (a) the half-power beamwidth (in degrees). **(2.5 marks)** [5]
(b) directivity (dimensionless and in dB) **(2.5 marks)**

03. Discuss the possible methods to feed the EM signal to a planar rectangular patch antenna with a neat sketch. [5]

04. Differentiate between Butterworth and Chebyshev filter response. [5]

05. Name five antennas and mention their corresponding applications. [5]

Section B (6 X 10 Marks)
Answer All questions

06. A small dipole antenna is carrying a uniform rms current of 10 A. Its far zone rms electric field at a distance of 'r' meters in a direction making angle θ with the conductor is given by $E = \frac{200}{r}\sin\theta$ V/m and radiation intensity $U = \frac{E^2}{120\pi}r^2$ W/steradian. Find [10]
a) the total power radiated **(8 marks)**
b) radiation resistance **(2 marks)**

07. Three isotropic sources, with spacing d between them, are placed along the z-axis. The excitation coefficient of each outside element is unity while that of the center element is 2. For a spacing of d = λ/4 between the elements, find the [10]
(a) array factor **(2 marks)**
(b) angles (in degrees) where the nulls of the pattern occur ($0° \le \theta \le 180°$) **(3 marks)**
(c) angles (in degrees) where the maxima of the pattern occur ($0° \le \theta \le 180°$). **(5 marks)**

08. Assuming the diameter of the parabolic reflector antenna is 1 meter, the frequency of operation is 4 GHz, and its aperture efficiency is 69%. If the power density of the wave incident upon the antenna is 10 μW/m^2, determine the following: [10]
(a) Physical area of the reflector. **(2 marks)**

(b) Maximum effective area of the antenna **(3 marks)**

(c) Maximum directivity (dB). **(5 marks)**

09. (a) Explain the avalanche effect. **(2 marks)** [10]

(b) Describe the operation of IMPATT and TRAPATT diode. **(4+4 marks)**

10. Design a stepped-impedance low-pass filter with a maximally flat response and a cut-off frequency of 2.4 GHz using Figure 1. It is necessary to have at least 30 dB attenuation at 4.0 GHz. The filter impedance is 50 ohms; the highest practical line impedance is 130 ohms & the lowest is 30 ohms. Determine the βl in degrees. The filter coefficients can be taken from below Table 1. [10]

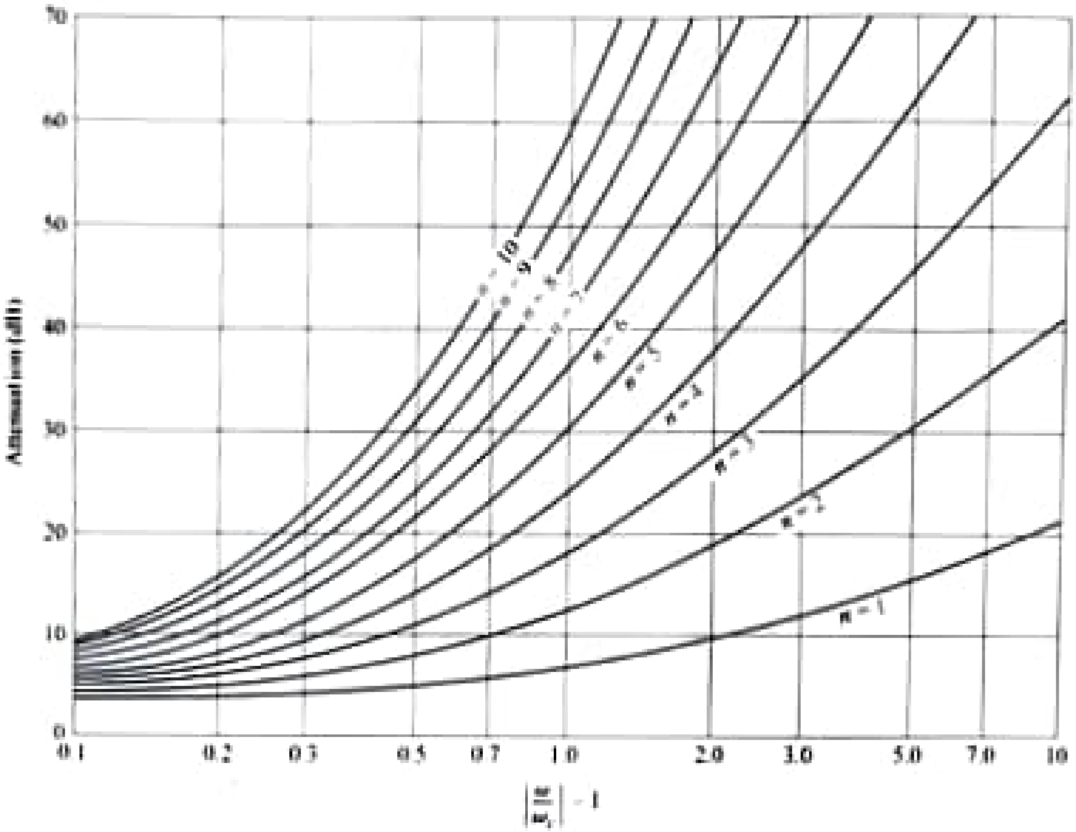

Fig.1

Table 1

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	2.0000	1.0000									
2	1.4142	1.4142	1.0000								
3	1.0000	2.0000	1.0000	1.0000							
4	0.7654	1.8478	1.8478	0.7654	1.0000						
5	0.6180	1.6180	2.0000	1.6180	0.6180	1.0000					
6	0.5176	1.4142	1.9318	1.9318	1.4142	0.5176	1.0000				
7	0.4450	1.2470	1.8019	2.0000	1.8019	1.2470	0.4450	1.0000			
8	0.3902	1.1111	1.6629	1.9615	1.9615	1.6629	1.1111	0.3902	1.0000		
9	0.3473	1.0000	1.5321	1.8794	2.0000	1.8794	1.5321	1.0000	0.3473	1.0000	
10	0.3129	0.9080	1.4142	1.7820	1.9754	1.9754	1.7820	1.4142	0.9080	0.3129	1.0000

11. A GaAs MESFET amplifier in Fig.2 has the following S-parameters at 4 GHz with a 50-ohm reference [10]

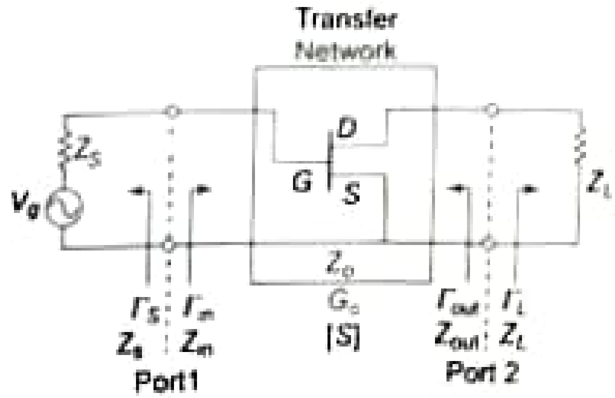

Fig. 2

$S_{11} = 0.4\angle 140^\circ$, $S_{12} = 0.08\angle 140^\circ$, $S_{21} = 1.8\angle 120^\circ$, $S_{22} = 0.3\angle 140^\circ$. Note: $Z_s = 35\Omega$ and $Z_L = 45\Omega$.

a) Calculate Γ_s, Γ_L, Γ_{in} *and* Γ_{out} **(8 marks)**

b) Find the transducer Gain G_T **(2 marks)**

Section C (1 X 15 Marks)
Answer All questions

12. (a) Write the scattering matrix for the ideal three-port circulator **(2 marks)** **[15]**

(b) A three-port circulator has an insertion loss of 2dB, Isolation of 30 dB and VSWR is 1.3. Find its scattering matrix. Assume the phases of all coefficients are zero. **(6 marks)**

(c) Show that any three port network cannot be lossless, reciprocal, and matched at the same time using S- matrix. **(7 marks)**

Some Formulae:

$P_{rad} = \int\int U \sin\theta \, d\theta \, d\phi$

$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2$

$D_{array} = 2N\left(\frac{d}{\lambda}\right)$

$\theta_{half\ power\ point} = \cos^{-1}\left(\pm\frac{1.391\lambda}{\pi N d}\right)$

$A_p = \frac{\pi D^2}{4}$

$A_e = \eta_{ap} A_p$

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

Power=power density x effective area

$\Gamma_L = \frac{(Z_L - Z_{out})}{(Z_L + Z_{out})}$

$\Gamma_S = \frac{Z_s - Z_o}{Z_s + Z_o}$

$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s}$

$\Gamma_{in} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L}$

$\Delta = S_{11}S_{22} - S_{12}S_{21}$

$$G_T = \frac{|S_{21}|^2\left(1 - |\Gamma_s|^2\right)\left(1 - |\Gamma_L|^2\right)}{|1 - \Gamma_s\Gamma_{in}|^2 |1 - S_{22}\Gamma_L|^2}$$

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}S_{21}|}$$

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