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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

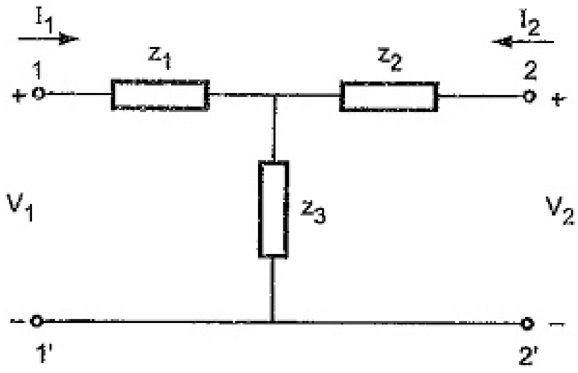
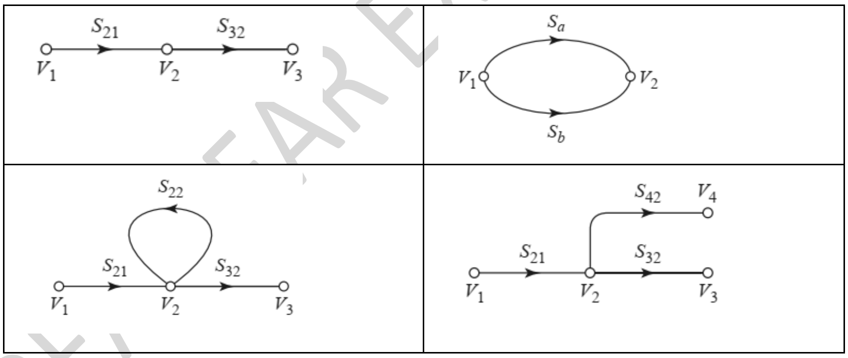
June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VII**
Branch: Electronics & Telecommunication Engineering **Duration: 3 hrs.**
Course Code: 22ET7PCMWR **Max Marks: 100**
Course: MICROWAVES AND RADAR

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Derive an expression for input impedance of a transmission line. Discuss any two special cases. Derive an expression for characteristic impedance Z_0 in terms of Zsc and Zoc (Short circuit Input Impedance and Open circuit Input Impedance respectively).	*CO2*	*PO1*	**06**
	b)	A 75 Ω coaxial line has a current i(z, t) = 1.8 cos(3.77 x 10^9t – 18.13z) mA. Determine i) the frequency ii) the phase velocity iii) relative permittivity of the line iv) the phasor form of the current.	*CO2*	*PO1*	**07**
	c)	A radio transmitter is connected to an antenna having an impedance of 80 + j40Ω with a 50 Ω coaxial cable. If the 50 Ω transmitter can deliver 30 W when connected to a 50 Ω load, how much power is delivered to the antenna?	*CO2*	*PO1*	**07**
		OR			
2	a)	A rectangular waveguide with a = 5cm, b = 2.5cm operates in fundamental mode with an operating frequency of f = 9GHz. Calculate the cutoff frequency and group velocity of the wave inside the waveguide.	*CO2*	*PO1*	**05**
	b)	A 75 ohm coaxial transmission line has a length of 2.0 cm and is terminated with a load impedance of 37.5 + j75 ohm. If the relative permittivity of the line is 2.56 and the frequency is 3.0 GHz, find the input impedance to the line, the reflection coefficient at the load, the reflection coefficient at the input, and the SWR on the line.	*CO2*	*PO1*	**08**
	c)	Consider a Teflon filled copper K band rectangular waveguide having dimension a = 1.07 cm and b = 0.43 cm. Find the cutoff frequencies of the first five propagating modes. The operating frequency is 15GHz.	*CO2*	*PO1*	**07**

			UNIT - II			
	3	a)	With relevant equations, briefly explain any 5 properties of the S-matrix. Also, support the statements with relevant proof and derivations.	*CO2*	*PO1*	**07**
		b)	Consider the network shown in figure fig 3(b), find the Z-matrix. $Z_1 = 5\Omega$, $Z_2 = 12\Omega$, $Z_3 = 8\Omega$.  **fig 3(b)**	*CO2*	*PO1*	**07**
		c)	For the signal flow graph edges shown in figure **fig 3(c)**, apply the relevant decomposition rule to reduce them to a single branch in each case, except for the last case, which will have two surviving branches.  **fig 3(c)**	*CO2*	*PO1*	**06**
			OR			
	4	a)	Derive S-matrix for Magic Tee	*CO2*	*PO1*	**08**
		b)	Consider the ABCD parameters of a 2-port network. Convert the parameters to Z –matrix $\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 2 & 50 \\ 0.01 & 1 \end{bmatrix}$	*CO2*	*PO1*	**06**

		c)	Consider the Scattering matrix given. i) is the network lossless. ii) is the network reciprocal iii) return loss at port 1 when all the ports are terminated with matched loads $$[S] = \begin{bmatrix} 0.178\angle 90^\circ & 0.6\angle 45^\circ & 0.4\angle 45^\circ & 0 \\ 0.6\angle 45^\circ & 0 & 0 & 0.3\angle -45^\circ \\ 0.4\angle 45^\circ & 0 & 0 & 0.5\angle -45^\circ \\ 0 & 0.3\angle -45^\circ & 0.5\angle -45^\circ & 0 \end{bmatrix}$$	*CO2*	*PO1*	**06**
			UNIT - III			
	5	a)	A T-Junction power divider operates at f=1GHz with a characteristic impedance Z_0=50Ω. The input power is P_{in}=12 W. Both output ports are terminated with a load impedance Z_L=60Ω. Calculate: i)The power delivered to each output port. ii)The reflection coefficient at each output port. iii)The reflected power back to the input due to the mismatch.	*CO2*	*PO1*	**06**
		b)	A quadrature hybrid operates at f = 4 GHz with a characteristic impedance Z_0=50 Ω. An input power of 20W is applied to Port 1 and Port 4 is terminated with Z_0. Calculate: i)The power delivered to Ports 2 and 3. ii) The power dissipated in a 100 Ω load connected at Port 4 due to leakage. iii) The phase difference between outputs at Ports 2 and 3.	*CO2*	*PO1*	**07**
		c)	A Wilkinson power divider operates at f = 2GHz with a characteristic impedance of Z_0=50 Ω. The isolation resistor R is used to maintain isolation between the output ports. Calculate: i)The value of the isolation resistor. ii) The S-parameters S_{21} and S_{31} for the divider in dB iii) If a load of Z_L=75Ω is connected to Port 2, calculate the reflection coefficient at Port 2, the power delivered to Port 2, and the new isolation between Ports 2 and 3.	*CO2*	*PO1*	**07**
			OR			
	6	a)	Design a 4th-order low-pass Butterworth microwave filter with a cutoff frequency ωc=2 GHz. The filter should have a maximum passband ripple of 0.1 dB. Compute the element values for the physical implementation and explain the significance of impedance scaling in microwave filters.	*CO3*	*PO2*	**10**
		b)	A two-port network has the following parameters: Input impedance Z_S=50 Ω, Load impedance Z_L=100 Ω, Forward transmission coefficient S_{21}=0.9, Reflection coefficient at input S_{11}=0.2 Calculate the following: i)Available power gain G_A, ii) Transducer power gain G_T.	*CO2*	*PO1*	**10**

			UNIT - IV			
	7	a)	Discuss two prominent types of errors that can occur during target detection in radar systems. Support your explanation with a relevant voltage vs. time plot, clearly indicating all significant voltage levels. Provide a detailed analysis of each possible error based on the plot.	*CO2*	*PO1*	**06**
		b)	A radar system operates at a frequency of 12 GHz and utilizes an antenna with a diameter of 2 meters. Calculate the angular resolution in degrees.	*CO2*	*PO1*	**04**
		c)	A ground-based search radar operates with a pulse repetition frequency (PRF) of 400 Hz, a beamwidth of 2 degrees, and an antenna scan rate of 8 RPM. Determine the number of pulses returned from a target.	*CO2*	*PO1*	**04**
		d)	A radar has 1.5 µs transmitted pulse width. Two boats in the same direction are separated by 198 m. Will the radar be able to detect both the targets? If not find the pulse width to be used by the radar such that both the targets are detected	*CO2*	*PO1*	**06**
			OR			
	8	a)	A continuous-wave (CW) radar operates at a transmission frequency of 8 GHz. Calculate the Doppler frequency observed by the stationary radar when the target is moving at a velocity of 126 km/h.	*CO2*	*PO1*	**04**
		b)	Determine the range and Doppler frequency of an approaching target using a triangular FMCW Radar. f_b(up) = 30kHz f_b(down) = 50kHz f_m = 1.5MHz, Δf = 2KHz f = 5GHz (operating)	*CO2*	*PO1*	**06**
		c)	An MTI Radar operates at 10GHz with PRF of 500 pps. Calculate the first three lowest blind speeds of the radar. Also derive the formula used	*CO2*	*PO1*	**06**
		d)	A ground based air surveillance radar operates at 1500 MHz. It maximum range is 200 **nmi** for the detection of a target with radar cross section of one square meter. Its antenna is 15 m wide and 5 m high and the antenna aperture efficiency is $\rho_a = 0.6$. The receiver minimum detectable signal is $S_{min} = 10^{-13}$ W. i) peak transmitted power iii) pulse repetition frequency to achieve a maximum unambiguous range of 200 **nmi**	*CO2*	*PO1*	**04**
			UNIT - V			
	9	a)	The bandwidth of an IF amplifier is 2 MHz and the average false alarm time that could be tolerated is 20 min. Find the probability of false alarm.	*CO2*	*PO1*	**04**
		b)	A radar transmits a pulse of duration Tp = 20 µs with a bandwidth of 2MHz. The signal to noise ratio at the input is 20dB. What is the SNR at the output of the matched filter?	*CO2*	*PO1*	**06**
		c)	An ISAR system operates at a frequency of 10 GHz and captures a target rotating at 5°/s. If the radar's bandwidth is 100 MHz and	*CO2*	*PO1*	**04**

			the observation time is 10 seconds, determine the achievable range and cross-range resolution.			
		d)	A radar transmits a rectangular pulse with a duration of Tp = 8μs. Calculate the ambiguity function for Zero Doppler shift and a time delay of τ = 4 μs.	*CO2*	*PO1*	**06**
			OR			
	10	a)	A radar operating at freqnecy of 10GHz is used for ISAR imaging of a rotating target. If the target rotates by 0.01 radians during the observation period, what is the cross-range resolution $\Delta\rho$.	*CO2*	*PO1*	**04**
		b)	A radar system transmits a pulse of τ = 50 μs and compresses it to a width of τc = 0.5 μs. If the transmitted pulse has a bandwidth B = 2MHz, calculate the pulse compression ratio and the range resolution	*CO2*	*PO1*	**04**
		c)	A human body is exposed to an electric field of strength 100V/m. The tissue conductivity is 0.8 S/m, and the density of the tissue is 1000 kg/m^3. Calculate the specific absorption rate (SAR). What is the acceptable SAR as per US standards?	*CO2*	*PO1*	**05**
		d)	Four Swerling models are proposed to find Rmax for a RADAR. For a given Radar, Pt = 1000W, G = 30dB, λ = 0.03m, σ = 1m^2, Pmin = $1x10^{-12}$W, Ls = 1.5. Find Rmax for each of the Swerling models.	*CO2*	*PO1*	**07**

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