

Department of Electronics & Communication Engineering

Course Name	:	Microwave Engineering (MWE)
Course Code	:	A70422
Class	:	IV - B. Tech
Branch	:	Electronics and Communication Engineering
Year	:	2017 – 2018
Course Faculty	:	N. Syamala, T. Immanuel, K. V. Suresh Kumar

Course objective:

The objectives of the course are:

- To develop the knowledge on transmission lines for microwaves, cavity resonators and wave guide components and applications.
- To enable the students understand and analyze the operation of Microwave tubes like klystron, magnetron, travelling wave tube, etc.,
- To familiarize with microwave solid state devices.
- To understand the scattering matrix parameters and its use.
- To introduce the student the microwave test bench for measure
- different parameters like attenuation, VSWR, etc.,

UNIT – I: Microwave Transmission Lines – I, Rectangular Guides				
S. No.	Question	Blooms Taxonomy Level	COs	POs
1.	List the typical applications of microwaves.	Remember	2,3	a,e,k,l
2.	Define the dominant mode of a waveguide?	Understand	1,3,4	a,e,k,l
3.	Define cutoff frequency of a waveguide	Evaluate	1,2,4	a,e,k,l
4.	Give the dominant mode of a rectangular and circular waveguide for TE and TM modes.	Remember	2,5	a,e,k,l
5.	Differentiate Waveguide and Co-axial cable.	Remember	4,5,6	a,e,k,l
6.	Find the cut – off frequency of the dominant mode for an air filled rectangular WG when $a/b = 2$ with $a = 6$ cm.	Understand	1,2,5	a,e,k,l
7.	Name the microwave frequency bands and spectrums.	Understand	3,4,5	a,e,k,l
8.	Classify the basic advantages of microwaves.	Understand	2,3	a,e,k,l
9.	Apply the boundary conditions for TE mode along the boundary walls of the waveguide.	Evaluate	1,3,4	i
10.	Define phase velocity.	Understand	1,2,4	i
11	What is meant by group velocity?	Understand	2,5	n
12	What is the relation between phase and group velocities interms of light velocity?	Understand	4,5,6	n
13	Define guide wavelength.	Evaluate	1,2,5	n
14	What is meant by mode characteristics.	Analyze	3,4,5	h
15	Define modes.	Understand	2,3	n
16	Write the expression for cutoff frequency.	Remember	1,3,4	n
17	Summarize the advantages of microwaves.	Understand	1,2,4	h
18	Sketch the TE ₁₀ pattern.	Evaluate	2,5	h
19	Calculate the cutoff wave length for rectangular wave guide with a=2cm which is operating in dominant mode.	Evaluate	4,5,6	h
20	Write the expression for phase constant.	Analyze	1,2,5	h

GROUP - A (SHORT ANSWER QUESTIONS)

GROUP - A (SHORT ANSWER QUESTIONS)

	UNIT – II : Cavity Resonators, Waveguide Components and Applications				
S. No.	Question	Blooms Taxonomy Level	COs	POs	
1.	Calculate the attenuation of a rotary Vane attenuator if the angle of rotation is 34 degrees.	Understand	2,4,5	a,e,k,l	
2.	Define the quality factor of a resonator.	Remember	1,3,6	a,e,k,l	
3.	List out the advantages of micro-strip line over rectangular wave guide.	Understand	2,4	j,d	
4.	List few applications of a cavity resonator.	Remember	1,3	j,d	
5.	What are the advantages of dominant mode propagation?.	Evaluate	2,4,5	j,d	
6.	What is micro strip line?	Understand	1,4,6	a,e,d,j	
7.	What are the differences between micro strip lines and strip line?	Understand	2,4,5	a,e,d,j	
8.	Write the applications of micro strip lines.	Evaluate	1,3,6	a,e,d,j	
9.	Draw the strip lines.	Evaluate	2,4	a,e,l,k h	
10.	What are the advantages of micro strip lines?	Analyze	1,3	a,e,l,k h	
11	What are the disadvantages of micro strip lines?	Understand	2,4,5	h	
12	Define the attenuation constant.	Remember	1,4,6	h	
13	What is meant by cavity resonator?	Understand	3,4,5	j,d	
14	Define effective dielectric constant.	Remember	2,3	j,d	
15	What are the different expressions for effective dielectric constant in terms of w/h.	Evaluate	1,3,4	h	
16	Define resonant frequency and give its expression.	Understand	1,2,4	j,d	
17	Derive the resonant frequency for TE_{101} mode.	Understand	2,5	h	
18	What are the applications of cavity resonator?	Understand	4,5,6	h	
19	Define quality factor.	Understand	1,2,5	n	
20	Give the expression for power losses.	Understand	2,5	h	

GROUP A (SHORT ANSWER QUESTIONS)

UNIT – III:	Microwave T	ubes, Helix TTS

	UNIT – III: Microwave Tubes, Helix TTS				
S no	Question	Blooms Taxonomy Level	COs	POs	
1	Describe the phenomenon of loop coupling in waveguide in detail?	Understand	2,4,5	h	
2	Explain the waveguide discontinuities?	Remember	1,4,6	h	
3	Describe the characteristic features of resonant windows?	Understand	2,4,5	n	
4	Mention the applications of resonant windows?	Understand	1,3,6	n	
5	Describe the characteristic features of resonant Iris?	Understand	2,4	n	
6	Mention the applications of resonant Iris?	Understand	1,3	n	
7	Describe the characteristic features of capacitive Iris?	Understand	2,4,5	i	
8	Describe the characteristic features of Inductive Iris?	Understand	1,4,6	i	
9	Mention the applications of capacitive Iris?	Understand	3,4,5	k	
10	Mention the applications of Inductive Iris?	Understand	2,3	k	
11	With neat schematics, explain the need and functioning of a matched waveguide load? What should be the reflection coefficient and VSWR?	Understand	1,3,4	a,e,k,l	
12	Explain the waveguide matched termination in detail?	Remember	2,4,5	a,e,k,l	
13	Explain the characteristic features of tuning screws?	Understand	1,3,6	i	
14	Describe the characteristic features of tuning posts?	Understand	2,4	i	
15	Describe the applications of tuning screws and posts?	Understand	1,3	k	
16	Describe the principle of working of a wave guide attenuator, with neat schematics?	Understand	2,4,5	h	
17	Explain how a waveguide can be used as an attenuator & obtain the expression for attenuation constant?	Understand	1,4,6	i	
18	Write short notes on principle of working of a dielectric phase shifter?	Understand	3,4,5	k	
19	Mention the applications of dielectric phase shifter?	Understand	2,3	k	
20	What is the need for phase shifter at micro wave frequencies? Explain the concept of realizing phase shifting through dielectric materials?	Understand	1,3,4	i	

GROUP A (SHORT ANSWER QUESTIONS)

	UNIT – IV : M-Type Tubes					
S. No.	Question	Blooms Taxonomy Level	COs	POs		
1.	What are the ferrite materials?	Remember	1,3,6	a,e,k,l		
2.	Explain the faraday rotation.	Understand	2,4	a,e,k,l		
3.	What are the characteristics of ferrite materials?	Understand	1,3	j,d		
4.	Write short notes on Gyrator.	Evaluate	2,4,5	d,j		
5.	Write short notes on Isolator.	Understand	1,4,6	a,e,d,j		
6.	Write short notes on 3-port circulator.	Remember	3,4,5	a,e,d,j		
7.	Write short notes on 4-port circulator.	Understand	2,3	a,e,l,k		
8.	What is meant by scattering matrix?	Remember	1,3,4	a,e,l,k		
9.	Give the prosperities of S-matrix.	Understand	2,4,5	a,e,d,j		
10.	Compare Isolator, Gyrator and circulator.	Remember	1,3,6	a,e,l,k		
11	What are the applications of circulator?	Understand	2,4	n		
12	What are the applications of Gyrator?	Understand	1,3	i		
13	What are the applications of isolator?	Understand	2,4,5	i		
14	Give the s-matrix calculation for 2-port junctions.	Remember	1,3,6	i		
15	Give the S-matrix for isolator.	Understand	2,4	n		
16	Give the S-matrix for 3-port circulator.	Understand	1,3	i		
17	Give the S-matrix for Gyrator.	Remember	2,4,5	n		
18	Give the S-matrix for E-plane Tee.	Understand	1,3	i		
19	Give the S-matrix for H-plane Tee.	Remember	2,4,5	i		
20	Give the S-matrix for magic Tee.	Understand	1,3,6	i		

GROUP A (SHORT ANSWER QUESTIONS)

	UNIT V : Microwave Measurements				
S no	Question	Blooms Taxonomy	COs	Pos	
1	What is VSWR?	Understand	2,4	i	
2	Define reflection coefficient?	Remember	1,3	i	
3	Define square law device?	Understand	2,4,5	i	
4	Define standing wave.	Remember	1,4,6	h	
5	Draw the microwave test bench setup.	Understand	3,4,5	i	
6	Draw the microwave test bench setup for frequency measurement?	Remember	2,3	n	
7	Draw the microwave test bench setup for attenuation measurement?	Understand	1,3,4	i	
8	Draw the microwave test bench setup for phase measurement?	Understand	2,4,5	h	
9	Draw the microwave test bench setup for VSWR measurement?	Remember	1,3,6	i	
10	Draw the thermistor and barretter characteristics graph?	Understand	2,4	h	
11	Draw the balanced bolometer bridge circuit?	Remember	1,3	n	
12	Define scattering parameters?	Remember	2,4,5	n	
13	What are the properties of scattering matrix?	Understand	1,3,6	i	
14	What is 3dB slitter?	Remember	2,4	h	
15	Write the formula for attenuation measurement	Understand	1,3	i	
16	Write the S matrix for Isolator.	Remember	2,4	i	
17	Write the S matrix for circulator.	Understand	1,3	i	
18	Write the S matrix for gyrator.	Understand	2,4,5	h	
19	Write the S matrix for magic tee.	Remember	1,3,6	h	
20	Write the S matrix for E-plane and H-plane tee.	Remember	3,4,5	h	

GROUP - B (LONG ANSWER QUESTIONS)

	UNIT – I: Microwave Transmission Lines – I,	, Rectangular G	uides	
S. No.	Question	Blooms Taxonomy Level	COs	POs
1.	 A rectangular wave guide is filled by dielectric material of ε_r= 9 and has dimensions of 7 × 3.5 cm. It operates in the dominant TE mode Determine the cut off frequency. Find the phase velocity in the guide at a frequency of 2 GHz Find the guided wave length at 2GHz. 	Understand	2,4	k
2.	Determine the characteristic wave impedance of a rectangular wave guide with dimension of 3×2 cm operates in the TM ₁₁ mode at 10 GHz.	Remember	1,3	k
3.	Derive the expression for cutoff frequency of TE_{mn} mode in rectangular wave guide	Remember	2,4,5	k
4.	Prove that $v_p * v_g = c^2$	Remember	1,4,6	d,j
5.	A rectangular guide of inner dimensions $2.5 \text{ cm} \times 1.2 \text{ cm}$ is to propagate energy in TE10 mode. Calculate the cut off frequency. If the frequency of signal is 1.2 times this cut off frequency, compute the guide wave length, phase velocity and wave impedance. Derive the relations used.	Understand	3,4,5	d,j
6	Explain the advantages of microwaves.	Understand	2,3	f
7	Derive the wave equations for TE mode.	Remember	1,3,4	n
8	Derive the wave equations for TM mode.	Remember	2,4,5	n
9	Describe t he Dominant and degenerate modes.	Remember	1,3,6	d,j
10	Express the guide wave length interms of operating wavelength and cutoff wave length.	Understand	2,4	e
11	Summarize the mode characteristics.	Remember	1,3	k
12	When the dominant mode is propagated in air filled rectangular waveguide, the guide wavelength for a frequency of 9000MHz is 4cm. Calculate breadth of the guide.	Understand	2,4,5	k
13	Derive the expression for λ_g of TE _{mn} mode in rectangular waveguide.	Remember	1,3,6	d,j
14	Determine λ_c for the dominant mode in a rectangular waveguide of breadth 10cms. A 2.5 GHz signal propagated in the waveguide in the dominant mode. Calculate the guide wavelength, the group and phase velocities?	Evaluate	1,3,4	d,j
15	The dimensions of a guide are 2.5cmX1cm. The frequency is 8.6GHz. Find the following. a) Possible modes. b) Cut-off frequency. C) Guide wavelength.	Evaluate	2,4,5	k
16	A rectangular waveguide has dimensions of 2.5cmX5cm. Determine the guide wavelength , phase constant β , phase velocity v_p at a wave length of 4.5cm for the dominant mode	Evaluate	1,3,6	k
17	Derive an expression for microwave impedance for TE waves in rectangular wave guide.	Understand	2,4	k
18	Derive an expression for microwave impedance for TM waves in rectangular wave guide	Understand	1,3	d,j
19	Determine λ_c for the dominant mode in a rectangular	Evaluate	2,4,5	k

	waveguide of breadth 10cms. A 2 GHz signal			
	propagated in the waveguide in the dominant mode.			
	Calculate the guide wavelength, the group and phase velocities?			
20	Obtain an expression for the Dominant TE/TM mode	Understand	1,3,5	k
	propagation in a rectangular waveguide.			

GROUP – B (LONG ANSWER QUESTIONS)

S. No.	Question	Blooms Taxonomy	COs	POs
		Level		
1.	Explain about quality factor of a cavity resonator.	Understand	2,4,5	k
2.	Derive the expression for resonant frequency of a cavity resonator.	Remember	1,4,6	k
3.	Derive the expression for power transmission.	Remember	2,4,5	b
4.	Derive the expression for power losses.	Remember	1,3,6	b
5.	What are the types of coupling and give its relations interms of quality factor.	Evaluate	2,4	i
6.	Derive the quality factor of a cavity resonator.	Evaluate	1,3	i
7.	Explain briefly about impossibility of TEM Modes	Understand	2,4,5	b
8.	Write short notes on characteristic impedance.	Understand	1,4,6	b
9.	Derive the attenuation constant.	Evaluate	3,4,5	a,e,l,k
10.	Derive the dielectric attenuation constant.	Analyze	2,3	i
11	Give the different expressions for effective dielectric constant	Evaluate	1,3,4	b
12	An air filled wave guide with a cross section $2x1cm$ transport energy in TE ₁₀ at the rate of 0.5 HP the frequency of the wave is 30 GHz what is the peak value of field occurring in wave guide.	Remember	2,4,5	k
13	An air filled resonant cavity with dimension a=5cm, b=4cm & c=10cm is made of copper (σ_c =5.8x10 ⁷ mho/m). It is filled with a lossless material (μ_r =1 & ε_r = 3).Find the resonant frequency f_r and the quality factor for TE ₁₀₁ mode.	Understand	1,3,6	k
14	A certain micro strip line has the following parameters $\epsilon_{r=5.23}$, h=7miles, t=2.8miles, w=10miles. Calculate a) effective Dielectric constant. b) Diameter of the wire over ground. c) Characteristic impedance.	Remember	2,4	k
15	Explain the Q of a rectangular cavity resonator.	Evaluate	1,3	i
16	Find the frequency and wave length for a rectangular cavity, operating in the TE_{211} mode if the dimensions of the cavity are a=5cm, b=c=2.5cm with air as dielectric	Evaluate	2,4,5	b
17	An air filled resonant cavity with dimension a=3cm, b=2cm & c=8cm is made of copper (σ_c =5.8x10 ⁷ mho/m). It is filled with a lossless material (μ_r =1 & ε_r = 3).Find the resonant frequency f _r and the quality factor for TE ₀₁₁ mode.	Applying	1,4,6	b
18	Find the frequency and wave length for a rectangular cavity, operating in the TM_{211} mode if the dimensions of the cavity are a=5cm, b=c=2cm with air as dielectric	Applying	3,4,5	b
19	Calculate the lowest resonant frequency of a rectangular cavity resonator of dimension a=2cms, b=1cms, d=3cms.	Applying	2,3	i

Group B (LONG ANSWER QUESTIONS)

	UNIT – III: Microwave Tubes, Helix TTS					
S. No.	Question	Blooms Taxonomy Level	COs	POs		
1.	Explain the principle of working a H-plane Tee junction with neat schematics.	Understand	2,4	a,e,k,l		
2.	Explain the principle of working a E-plane Tee junction with neat schematics?	Analyze	1,3	a,e,k,l		
3.	Explain the principle of working a Magic Tee junction with neat schematics?	Evaluate	2,4,5	j,d		
4.	Explain the principle of working a EH-plane Tee junction with neat schematics?	Analyze	1,4,6	d,j		
5.	Explain the principle of working a Hybrid Tee junction with neat schematics?	Analyze	3,4,5	k		
6	Mention the applications of magic Tee junction?	Analyze	2,3	k		
7	Mention the applications of Hybrid Tee junction?	Evaluate	1,3,4	k		
8	Mention the applications of waveguide multiport Tee junction.	Analyze	2,4,5	n		
9	List out the three theorems associated with 3-port Tee junctions & mentions their applications?'	Evaluate	1,3,6	m		
10	What is directional coupler? List out the different types of couplers?	Evaluate	2,4	m		
11	Give the importance of Directional coupler?	Understand	1,3	a,e		
12	Explain the principle of working of two-hole Directional coupler with neat schematics?	Understand	2,4,5	m		
13	Incident power to a directional coupler is 90Watts.The directional coupler has coupling factor of 20 dB, directivity of 35 dB and insertion loss of 0.5 dB. Find the output power at main arm, coupled and isolated parts?	Evaluate	1,3,6	m		
14	Calculate the coupling factor of a directional coupler when incident power is 600 mW and power in auxiliary waveguide is 350 microwatts.	Analyze	1,3,4	a,b		
15	Explain Bethe hole Directional coupler and write applications of directional couplers?	Evaluate	2,4,5	c,d,e		
16	Explain the following characteristics related to Directional coupler i)Coupling factor ii)Directivity iii) Isolation	Remember	1,3,6	a,f		
17	Compare the characteristics of E-plane and H-plane Tee junction with neat schematics?	Evaluate	2,4	g,h		
18	Incident power to a directional coupler is 80Watts. The directional coupler has coupling factor of 20 dB, directivity of 35 dB. Find the back power (P_b) ?	Evaluate	1,3	i,j,k		
19	List out the different types of waveguide Irises?	Understand	2,4,5	j,k,l		
20	Incident power to a directional coupler is 60Watts.The directional coupler has coupling factor of 20 dB, directivity of 30dB .Find the Forward coupled power (P_f) and back power (P_b) ?	Evaluate	1,3,5	a,e,l		

GROUP B (LONG ANSWER QUESTIONS)

	UNIT – IV : M-Type Tube	s		
S. No.	Question	Blooms Taxonomy Level	COs	POs
1.	What is a parametric amplifier? How a varactor diode is made use of in building a parametric amplifier?	Evaluate	2,3	a,e,l,k
2.	Describe the operating principle of IMPATT diodes, giving their structure and characteristics.	Evaluate	1,3,4	a,e,l,k
3.	With neat schematics, explain the physical structure and doping profile of a TRAPATT diode, and sketch its voltage/current versus time characteristics.	Understand	1,2,4	a,e,l,k
4.	Explain the terms and account for the phenomenon of,i). Effective Massii). Negative Electron Mobility in GaAs compound materials	Apply	2,5	a,e,l,k
5.	Describe the mechanism of interaction between electrons and fields, and account for the energy delivery and buildup of oscillations in a Cylindrical Magnetron, with neat sketches.	Analyze	4,5,6	a,e,l,k
6.	List out the differences in performances and applications of Klystrons and TWTs.	Analyze	1,2,5	a,e,l,k
7.	Establish the mathematical relation for power gain in a TWT amplifier, and explain the parameters involved.	Evaluate	3,4,5	a,e,l,k
8.	Explain PI mode operation & mode separation.	Analyze	2,3	a,e,l,k
9.	In H-plane Tee junction 20mw power is applied to port 3 that is perfectly matched to the junction. Calculate the power delivered to the load 60Ω and 75 Ω connected to ports 1 and 2.	Evaluate	1,3,4	a,e,l,k
10.	What are the composition and characteristics of Ferrites?	Analyze	1,2,4	a,e,l,k
11	Explain the construction & working of 8-cavity cylindrical magnetron.	Analyze	2,5	i
12	Derive the S-matrix for Gyrator.	Analyze	2,5	a,e,l,k
13	Derive the s-matrix for 3-port circulator.	Evaluate	4,5,6	n
14	Derive the s-matrix for 4-port circulator.	Evaluate	1,2,5	i
15	Derive the s-matrix for directional coupler.	Understand	3,4,5	i
16	Derive the S-matrix for E-planeTee	Apply	2,3	i
17	Derive the S-matrix for H-plane Tee	Analyze	1,3,4	i
18	Determine the S-matrix for 3-port circulator having insertion loss of 0.5dB, isolation of 20dB and VSWR of 2.	Analyze	1,2,4	f
19	An isolator has an insertion loss of 0.5dB and isolation of 30dB. Determine the scattering matrix of the isolator if the ports are perfectly matched to the junction.	Evaluate	2,5	a,e,l,k
20	A signal of power 32mW is fed into one of the collinear ports of a lossless H-plane Tee .Determine the powers in the remaining ports when the other ports are terminated by means of matched loads.	Analyze	1,6	f
	An isolator has an insertion loss of 0.7dB and isolation of 20dB. Determine the scattering matrix of the isolator if the ports are perfectly matched to the junction.	Analyze		

GROUP B (LONG ANSWER QUESTIONS)

UNIT V : Microwave Measurements				
S no	Question	Blooms Taxonomy	COs	POs
		Level	005	2.00
1	Explain the properties of S-Matrix.	Evaluate	2,5	i
2	What is 3-port circulator and give its applications.	Evaluate	4,5,6	i
3	What is Gyrator and give its applications.	Understand	1,2,5	i
4	What is Isolator and give its applications.	Apply	3,4,5	h
5	Explain briefly about the operation of 4-port circulator.	Analyze	2,3	h
6	A 3-port circulator has an insertion loss of 1db, isolation 30db and VSWR=1.5. find S-matrix.	Analyze	1,3,4	i
7	Derive the S-matrix for magic Tee.	Evaluate	1,2,4	i
8	A matched isolator has insertion loss of 0.5db and isolation of 25db. Find the Scattering coefficients.	Analyze	2,5	i
9	In H-plane Tee junction 20mw power is applied to port 3 that	Evaluate	2,5	h
	is perfectly matched to the junction. Calculate the power			
10	delivered to the load 60Ω and 75 Ω connected to ports 1 and 2.	A 1	1 7 6	1
10	What are the composition and characteristics of Ferrites.	Analyze	4,5,6	h
11	Derive the S-matrix for Isolator.	Analyze	1,2,5	h
12	Derive the S-matrix for Gyrator.	Analyze	3,4,5	h
13	Derive the s-matrix for 3-port circulator.	Evaluate	2,3	i
14	Derive the s-matrix for 4-port circulator.	Evaluate	1,3,4	i
15	Derive the s-matrix for directional coupler.	Understand	1,2,4	i
16	Derive the S-matrix for E-planeTee	Apply	2,5	h
17	Derive the S-matrix for H-plane Tee	Analyze	2,3	h
18	Determine the S-matrix for 3-port circulator having insertion	Analyze	1,3,4	n
	loss of 0.5dB, isolation of 20dB and VSWR of 2.			
19	An isolator has an insertion loss of 0.5dB and isolation of	Evaluate	1,2,4	i
	30dB. Determine the scattering matrix of the isolator if the			
20	ports are perfectly matched to the junction.	A 1	2.5	
20	Determine the S-matrix for 3-port circulator having insertion $\log_2 \int dP$ isolation of 20dP and VSWP of 2	Analyze	2,5	n
	An isolator has an insertion loss of 0.5dB and isolation of	Evaluata		
	30dB Determine the scattering matrix of the isolator if the	Evaluate		
	ports are perfectly matched to the junction.			