SYED AMMAL ENGINEERING COLLEGE

(Approved by the AICTE, New Delhi, Govt. of Tamilnadu and Affiliated to Anna University, Chennai)
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SUBJECT : EC6701 – RF AND MICROWAVE ENGINEERING

SEM / YEAR: VII / IV year B.E.

OBJECTIVES

- To inculcate understanding of the basics required for circuit representation of RF networks.
- To deal with the issues in the design of microwave amplifier.
- To instill knowledge on the properties of various microwave components.
- To deal with the microwave generation and microwave measurement techniques

UNIT I TWO PORT NETWORK THEORY 9

Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, Different types of interconnection of Two port networks, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, RF behavior of Resistors, Capacitors and Inductors.

UNIT II RF AMPLIFIERS AND MATCHING NETWORKS 9

Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Stabilization Methods, Noise Figure, Constant VSWR, Broadband, High power and Multistage Amplifiers, Impedance matching using discrete components, Two component matching Networks, Frequency response and quality factor, T and Pi Matching Networks, Microstrip Line Matching Networks.

UNIT III PASSIVE AND ACTIVE MICROWAVE DEVICES 9

Terminations, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub and quarter wave transformers. Crystal and Schottkey diode detector and mixers, PIN diode switch, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Varactor diode, Introduction to MIC.

UNIT IV MICROWAVE GENERATION 9

Review of conventional vacuum Triodes, Tetrodes and Pentodes, High frequency effects in vacuum Tubes, Theory and application of two cavity Klystron Amplifier, Reflex Klystron oscillator, Traveling wave tube amplifier, and Magnetron oscillator using Cylindrical, Linear, Coaxial Voltage tunable Magnetrons, Backward wave Crossed field amplifier and oscillator.

UNIT V MICROWAVE MEASUREMENTS 9

Measuring Instruments : Principle of operation and application of VSWR meter, Power meter, Spectrum analyzer, Network analyzer, Measurement of Impedance, Frequency, Power, VSWR, Q-factor, Dielectric constant, Scattering coefficients, Attenuation, S-parameters.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of the course, students will be able to:

- Explain the active & passive microwave devices & components used in Microwave communication systems.
- Analyze the multi- port RF networks and RF transistor amplifiers.
- Generate Microwave signals and design microwave amplifiers.
- Measure and analyze Microwave signal and parameters.

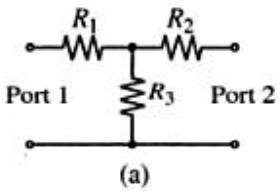
TEXT BOOKS:

1. Reinhold Ludwig and Gene Bogdanov, “RF Circuit Design: Theory and Applications”, Pearson Education Inc., 2011
2. Robert E Colin, “Foundations for Microwave Engineering”, John Wiley & Sons Inc., 2005

REFERENCES:

1. David M. Pozar, “Microwave Engineering”, Wiley India (P) Ltd, New Delhi, 2008.
2. Thomas H Lee, “Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits”, Cambridge University Press, 2004.
3. Mathew M Radmanesh, “RF and Microwave Electronics”, Prentice Hall, 2000.
4. Annapurna Das and Sisir K Das, “Microwave Engineering”, Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2005.

UNIT I. TWO PORT NETWORK THEORY		
Q. No	**Questions**	**Domain**
1.	Name the Low Frequency parameters.	**Remembering**
2.	What is Insertion Loss and Return loss?	**Remembering**
3.	A lossless Transmission line with a characteristics impedance of 300 ohm is fed by a generator of impedance 100 ohm. If the line is 100 m long and terminated by a resistive load of 200 ohms. Calculate the load reflection co efficient.	**Analyzing**
4.	Show the equivalent circuit of a practical capacitor	**Understanding**
5.	Justify the application of Thin-film chip resistors.	**Evaluating**
6.	List the properties of S- parameters	**Remembering**
7.	Discuss the principle advantage of microwave frequency over lower frequency.	**Creating**
8.	Point out the important properties of S-parameters?	**Analyzing**
9.	Define Reflection Co-efficient at the input side and output side of a two-port network in terms of S-parameters.	**Remembering**
10.	A 5dB attenuator is specified as having VSWR of 1.2. Assuming the device is reciprocal, Determine the S-parameters.	**Evaluating**
11.	Illustrate the electric equivalent circuit for a high frequency inductor and Resistor.	**Understanding**
12.	Model the Transmission matrix and its advantages.	**Applying**
13.	Examine the characteristics of reciprocal and symmetrical networks.	**Analyzing**
14.	How to express power input and power output under matched conditions for a two port network in terms of wave Components.	**Remembering**
15.	Elaborate on any four differences between low frequency and high frequency microwave circuits.	**Creating**

16.	With an example explain lossless network.	**Applying**
17.	Why the S- parameters are used in microwaves?	**Remembering**
18.	Given [Y]=|3.2 1| Identify the S parameters |1 3.2|	**Applying**
19.	Outline the limitations in measuring Z, Y and ABCD parameters at microwave frequencies.	**Understanding**
20.	Relate [S] parameter with [Z] parameter	**Understanding**
	PART B	
1.	(i) Identify the properties of S-parameters. (8) (ii) Prove that the S-Matrix for a reciprocal network is symmetric. (8)	**Applying**
2.	Write Short notes on (i) High Frequency resistors (5) (ii) inductors (5) (iii) Capacitors. (6)	**Remembering**
3.	The s parameters of a two port network are given by S11=0.2 90°, S22= 0.2 90°, S12=0.5 90°& S21=0.5 0° i) Show whether the network is lossy or not? (8) ii) Is the network symmetrical and reciprocal? Find the insertion loss of the network. (8)	**Remembering**
4.	i) Explain the transmission matrix for two port networks. (8) ii) Derive the S –matrix for n-port network. (8)	**Understanding**
5.	i) Define the S-parameters for a two-port network. (8) ii) Prove that the S-matrix for a lossless network is unitary. (8)	**Remembering**
6.	i) Explain the transmission matrix for a cascade connection of two-port networks. (8) (iii) Calculate the S-parameters of the 3-db attenuator circuit shown in fig Given Zo = 50 ohm. (8)  (a)	**Analyzing**

7.	The S parameters of a two port network are given by S11=0.2 0°, S22= 0.1 0°, S12=0.6 90°& S21=0.6 90° i) Prove that the network is reciprocal but not lossless. (6) ii) Find the return loss at port1 when port 2 is short circuited. (10)	**Applying**
8.	Categorize various losses in microwave devices and explain? (8) Explain in detail about low frequency parameters (8)	**Analyzing**
9.	(i)Outline the S-matrices of linear lossless Microwave devices. (8) (ii)What are transmission matrices? Explain them and obtain the relationship With S-Matrix. (8)	**Understanding**
10.	(i) A shunt impedance Z is connected across a transmission line with characteristic impedance Z_0. Find the S matrix of the junction. (8) (ii) List and explain the properties of S matrix. (8)	**Remembering**
11.	The S parameters of a two port network are given by S11=0.2∟0 degree, S12=0.6∟90 degree, S21=0.6∟90degree and S22=0.1∟0degree (i) Prove that the network is reciprocal but not lossless (8) (ii) Calculate the return loss at port 1 when port 2 is short circuited. (8)	**Analyzing**
12.	State and explain the properties of S parameters. Derive the S parameters of a Directional Coupler (8) Illustrate S Matrix for N port network compute ABCD for a T Network (8)	**Understanding**
13.	(i) Determine Z and Y matrix formulation of multiport network (8) (ii) Evaluate the symmetry of S matrix for a reciprocal network (8)	**Evaluating**
14.	(i) Elaborate the importance of low frequency and high frequency parameters of RF and two port networks. (6) (ii) The two port devices represented by the following matrices are cascaded. Find the scattering matrix of the resulting device. Estimate its properties (Symmetry, reciprocity, losses and match) 0.1 0.8 0.4 0.6 0.8 0.1 0.6 0.4 (10)	**Creating**

UNIT II RF AMPLIFIERS AND MATCHING NETWORKS		
PART A		
Q. No	**Questions**	**Domain**
1.	List the components required for impedance matching at low, mid and high frequencies.	**Remembering**
2.	What are the considerations in selecting the matching network?	**Remembering**
3.	Define unilateral power gain.	**Remembering**
4.	Show the VSWR circle for reflection coefficient 1.	**Remembering**
5.	Compare single stub matching network with double stub matching?	**Evaluating**
6.	What are the basic steps in the design process of RF amplifier circuits?	**Remembering**
7.	Determine power gain of amplifier in terms of S-parameters and reflection coefficient.	**Evaluating**
8.	Illustrate the diagram for stabilization of input port through series resistance and shunt conductance.	**Understanding**
9.	Sketch the typical output stability circle and input stability circle.	**Applying**
10.	Show the expression for noise figure of a two port amplifier	**Understanding**
11.	Distinguish between conditional and unconditional stabilities of amplifier	**Analyzing**
12.	Why impedance matching is required. What are the other constrains required.	**Remembering**
13.	Elaborate the parameters used to evaluate the performance of an amplifier?	**Creating**
14.	Demonstrate the Stability of a Microwave Amplifier.	**Understanding**
15.	With neat diagram draw and rxplain the frequency response of two component matching networks.	**Applying**
16.	Examine the contour of Nodal Quality factor Q=3.	**Analyzing**

17.	Develop the expression for nodal quality factor with loaded quality factor.	**Applying**
18.	Examine the discussion of Noise Figure of an amplifier and its effects.	**Analyzing**
19.	Discuss about Quality factor?	**Creating**
20.	Brief about transducer power gain.	**Understanding**
	PART B	
1.	i) Derive the expression for input stability circle equation. (8) ii) Develop the frequency dependent unilateral figure of merit equation. (8)	**Applying**
2.	Describe the following (i) Impedance matching Networks (8) (ii) Microstripline Matching Networks (8)	**Understanding**
3.	Derive the derivations for power gain, available gain and transducer gain of a microwave amplifier using S-parameters. (16)	**Analyzing**
4.	(i) Examine the transmission matrix for 2-port networks (8) (ii) Prove that the S-Matrix for a reciprocal network is symmetric. (8)	**Analyzing**
5.	Evaluate stability considerations for RF amplifier design with stabilization Methods. (16)	**Evaluating**
6.	The S-parameters for a transistor is given below. Find its stability and draw the input and output stability circles (use smith chart). S11=0.385∟-53degree, S12=0.045∟90degree, S12=2.7∟78degree and S22=0.89∟-26.5degree. (16)	**Remembering**
7.	(i) What is a matching network? Why is this required? (8) (ii) Design a lumped element 'LC' network for matching ZL=10+j10Ω to a 50Ω transmission line at 1 GHz. (8)	**Remembering**
8.	Derive the transducer power gain for a transistor amplifier. Design LC network to match source impedance Zs=50+j25Ω to the load ZL=25-j50Ω.Assume Zo=50 Ω; f=2GHz. use smith chart (16)	**Creating**
9.	Illustrate the smith chart approach to design the L-section and T-section matching Networks. (16)	**Understanding**
10.	With neat sketch describe the expression for input and output stability circle equation (16)	**Remembering**

11.	(i) Explain the theory of impedance matching conditions in a transistor amplifier circuit with relevant mathematical treatment. (8) (ii) From the basic amplifier theory, deduce the expressions for unilateral transducer power gain, maximum unilateral transducer gain and matched transducer gain (8)	**Analyzing**
12.	i) With reference to RF transistor amplifier, enumerate the considerations for stability and gain (8) ii)Show that the noise figure of a three stage amplifier is $F=F_1+(F_2-1)/GA_1+(F_3-1)/GA_2$ Where F_1 ,F_2 and F_3 are noise figures and GA_1 and GA_2 are power gains (8)	**Remembering**
13.	Outline in detail the concept of T and Micro stripline matching networks (8) Show the schematic of the smith chart. How can it be used to determine an un known impedance? (8)	**Understanding**
14.	Solve the following. A microwave transistor has the following S parameters at 10 GHz, with a 50 Ω reference impedance. S11=0.45∟150 degree, S12=0.01∟-10 degree, S21=2.05∟10 degree and S22= 0.40 ∟-150 degree The source impedance is Z_s= 20Ω and load impedance is Z_l= 30Ω Compute the power gain, Available power gain and transducer power gain. (16)	**Applying**

	UNIT III - PASSIVE AND ACTIVE MICROWAVE DEVICES	
	PART A	
Q.No	**Questions**	**Domain**
1.	Explain the high frequency effects of conventional tubes	**Analyzing**
2.	Explain Gunn effect? Name the materials that exhibit Gunn effect?	**Understanding**
3.	Name any two microwave passive devices which make use of Faraday rotation	**Remembering**
4.	Give a brief note on matched terminators?	**creating**
5.	Enumerate the principle of operation of a phase shifter?	Remembering
6.	The drift velocity of electrons is 2×10^{7} cm/s through the GaAs material of length 10×10^{-4}cm. Calculate the natural frequency of the diode.	Analyzing
7.	Demonstrate the Negative resistance in Gunn diode?	Understanding
8.	Distinguish between gyrator and phase changer?	Analyzing
9.	Identify the application of Gyrator and Isolator.	Applying
10.	Explain Faraday's rotation?	Understanding
11.	Sketch the two hole direction coupler.	Applying
12.	Estimate the resonant frequency of the TE_{101} mode of an air filled rectangular cavity of Dimensions 5cm× 4cm× 2.5cm.	Creating
13.	Give the significance of Rat-race junctions.	Remembering
14.	Power at input port is 900mw. If this power is incident on 20dB coupler with directivity 40dB, Determine the coupled power and transmitted power.	Evaluating
15.	Show the diagram of H-Plane Tee junction.	Remembering
16.	A Directional coupler is having coupling factor of 20dB and directivity of 40dB. If the incident power is 100mw, Evaluate the coupled power?	Evaluating
17.	What do the acronyms IMPATT, TRAPATT and BARITT stand for?	Remembering
18.	A wave guide termination having VSWR of 1.1 is used to dissipate 100W power, Estimate the reflected power?	Creating
19.	Ilustrate the voltage waveforms of TRAPATT diode.	Understanding

20.	List the various types of strip lines used in MMIC.	Remembering
	PART B	
1.	i) Recall the working principle of Gunn diode (8) ii)What are the various modes of operations of the Gunn diode (4) iii) Plot Gunn Diode characteristics. (4)	Remembering
2.	What are the avalanche transit time devices? (4) Explain the operation and construction of IMPATT diode. (12)	Remembering
3.	i) With neat diagram, explain the construction and characteristics of tunnel diode. (10)	Understanding
	ii) Compare tunnel diode and Gunn diode. (6)	
4.	i) Explain the properties of E- H Plane Tee? (8) ii)Derive the expression of scattering matrix for directional coupler (8)	Understanding
5.	i) Explain about Circulator and Isolator with its working principle (10) ii) Describe Magic Tee with neat sketch. (6)	Understanding
6.	i) With the help of two-valley theory, Identify how negative resistance is created in Gunn diodes. (10) ii)Analyze the concept of N Port scattering matrix representation clearly (6)	Applying
7.	Explain the characteristics and working of i) Avalanche transit time diode. (8) ii)Parametric amplifier (8)	Applying
8.	With neat diagram explain the various types of attenuators and phase shifters (8) Conclude the operating principles of schottky Barrier diode and step recovery diodes. (8)	Evaluating
9.	Identify the materials used for MMIC fabrication? (8) Examine with neat diagrams the fabrication process of MMICs. (8)	Applying
10.	(i) Draw and elaborate the operation of Magic Tee. Explain its application in the construction of a 4-port circulator (8) (ii) Find the directivity in dB for a coupler if same power is applied in turn to input and output of the coupler with output terminated in each case in a matched impedance. The auxiliary output readings are3 450 mW and 0.710 μW (8)	Creating

11.	(i) Design a maximally flat 20dB directional coupler so that D>40 dB in the band r=2. Assume other relevant parameters, if necessary.(10) (ii) Outline the principle of circulator. (6)	Analyzing
12.	i)Examine the PIN Diode Operation (8) ii)Discuss the performance parameters of PIN Diode (4) iii) Illustrate any one application of PIN Diode (4)	Remembering
13.	i)Show the construction of Varactor diode (8) ii)Draw and analyze the equivalent circuit of Varactor diode (4) iii)Estimate the Figure of Merit of a varactor diode (4)	Remembering
14.	i)Explain the operation and construction of Crystal diode detector and mixers (10) ii)Determine the [S] of a 3 port circulator given insertion loss of 0.5 dB, Isolation of 20dB and VSWR of 2 (3) iii)Mention the application of gyrator and Isolator (3)	Analyzing

	UNIT IV MICROWAVE GENERATION	
	PART A	
Q.No	**Questions**	**Domain**
1.	Name the advantages of parametric amplifiers.	Remembering
2.	Define transferred electron effect.	Remembering
3.	How would you distinguish between TWT and Klystron	Applying
4.	What is convection current of TWT?	Remembering
5.	How to compare tunnel diode with normal P-N Diode	Understanding
6.	List the advantages of Parametric amplifier	Remembering
7.	What are the matched terminators?	Remembering
8.	Why the ferrites are needed in circulators?	Understanding
9.	Summarize the factors of an ordinary vacuum tube that are important at microwave frequencies.	Understanding
10.	Compare the important features of TWTA and Klystron amplifier.	Understanding
11.	Identify the Power gain, power output and efficiency of two cavity Klystron amplifier.	Applying
12.	A Si Mw transistor has a maximum electric field intensity Em of 3×10^5 v/cm and its carrier has a drift velocity of 4×10^6cm/s. The emitter collector length is 4µm .Find maximum possible transit time	Applying
13.	Draw the equivalent circuit of Varactor diode.	Remembering
14.	Analyze the need for matching network?	Analyzing
15.	Categorize the applications of PIN diode	Analyzing
16.	Point out the applications of magnetron	Analyzing
17.	Assess the characteristics of Co-axial magnetron	Evaluating
18.	Choose the important applications of Low Q Oscillators and Amplifier circuits	Evaluating
19.	Justify why magnetron is called as Cross field Devices.	Creating
20.	Discuss about Bunching process in two cavity klystron.	Creating

	PART B	
1.	(i) What are the launching process of a two cavity klystron (8) (ii) Define optimum bunching distance L_{opt}. and derive the expression for it. (8)	Remembering
2.	(i) How would you describe the Pi mode of oscillations of magnetron (12) (ii) What is meant by strapping in magnetron and why it is done. (4)	Remembering
3.	(i) Explain briefly the working principle of the reflex klystron oscillator (6) (ii) Show the working principle of reflex klystron oscillator with necessary diagram (10)	Remembering
4.	(i) Write the operation of two cavity Klystron amplifier. (8) (ii) Find the comparison between two cavity Klystron amplifiers with travelling wave tube. (8)	Remembering
5.	(i) Explain the π mode of operation of magnetron. (12) (ii) Summarize few high frequency limitations. (4)	Understanding
6.	(i) Show the High frequency effects in vacuum tubes. (8) (ii) Explain the impact of frequency effects in real time vacuum tube applications. (8)	Understanding
7.	Explain coaxial voltage tunable magnetrons with necessary diagrams (16)	Understanding
8.	Identify the important points about (i) Backward wave Crossed field amplifier (8) (ii) Backward wave oscillator. (8)	Applying
9.	(i) Organize the different types of magnetrons with respect to its applications. (12) (ii) Write the advantages of coaxial magnetrons. (4)	Applying

10.	i) An X band pulsed cylindrical magnetron has the following operating parameters: Anode voltage V_0=26Kv Beam current I_0=27A Magnetic flux density B0=0.336wb/m^2 Radius of cathode cylinder a=5cm Radius of vane edge to center b=10cm Determine cyclotron angular frequency cutoff voltage for a fixed B_0 and cutoff magnetic flux density for a fixed V_0. (10) ii) Explain SWR measurement with neat block diagram. (6)	Analyzing
11.	(i) Analyze the theory of of oscillations in a magnetron (6) (ii) Examine the expressions for Hull Cut off magnetic and voltage equations. (10)	Analyzing
12.	(i) Derive the equation of velocity modulated wave (8) (ii) List out the concept of bunching effect in two cavity klystron (8)	Analyzing
13.	(i) Assess the operation mechanism of two cavity Klystron amplifier with neat sketch. (8) (ii) ATwo cavity klystron has the following parameters.V_0=1000V, R_0=40KΩ , I_0 =25mA, f=3GHzGap spacing in either cavity (d)=1mmSpacing between two cavities L=4cmEffective shunt impedance R_{th}=30KΩ.Estimate the input gap voltage, voltage gain and efficiency. (8)	Evaluating
14.	Discuss the principle of operation of the cavity klystron with neat sketch. A 250 KW pulsed cylindrical magnetron had the following parameters. Anode Voltage= 25 KV Peak anode current =25 A Magnetic Field B=0.35 Wb/m^2 Radius of cathode =4 cm Radius of cylinder= 8 cm Calculate the efficiency of magnetron, cyclotron frequency, cutoff magnetic field. (16)	Creating

	UNIT V MICROWAVEM EASUREMENTS	
	PART A	
Q.No	**Questions**	**Domain**
1.	Write the difference between Scalar and Vector network analyzers	Remembering
2.	What is the principle behind dielectric constant measurement?	Remembering
3.	What are the limitations of conventional vacuum devices?	Remembering
4.	Name the applications of VSWR meter.	Remembering
5.	How the VSWR meter is operated?	Understanding
6.	Choose the Significance of VSWR measurement?	Remembering
7.	What are the basic design considerations for the proper operation of a spectrum Analyzer?	Understanding
8.	What is the principle of biometric sensor?	Understanding
9.	Describe the errors in impedance measurement?	Understanding
10.	Define VSWR.	Remembering
11.	Identify the advantages of Power meter.	Applying
12.	Organize the importance of dielectric constant.	Applying
13.	What would results if error occurs in VSWR meter?	Applying
14.	Analyze the need of scattering co-efficients.	Analyzing
15.	Examine the S-parameter values of port networks.	Analyzing
16.	List the applications of Spectrum analyzer.	Analyzing
17.	Assess the desired attenuation level for microwave devices.	Evaluating
18.	Discuss about Q-factor.	Evaluating
19.	How will you determine the VSWR and return loss in reflecto meter method?	Creating

20.	Briefly explain the main purpose of slotted section with line carriage?	BTL 6	Creating
	PART – B		
1.	i) How do you measure microwave frequency? (4) ii) List the different types of Impedance measurement methods? (12)	BTL 1	Remembering
2.	i) What is the principle to measure the microwave power? (8) ii) How to measure the VSWR using slotted line method (8)	BTL 1	Remembering
3.	i) How the frequency of a given source in measured (8) ii) How would you explain the measurement of high VSWR with the help of block diagram (8)	BTL 1	Remembering
4.	i) What are the procedures to measure the frequency using different mechanical techniques? (8) ii) Define the electronic frequency measurement technique with relevant diagrams. (8)	BTL 1	Remembering
5.	i) Illustrate how the frequency of a given microwave source is measured. (8) ii) Explain VSWR measurement using a microwave bench with suitable diagrams. (8)	BTL 2	Understanding
6.	Explain the schemes for measuring Low and High VSWR at microwave frequencies. (16)	BTL 2	Understanding
7.	Summarize the short notes on i) Network Analyzer (8) ii) Q Measurement. (8)	BTL 2	Understanding
8.	Identify the applications of i) Power meter (8) ii) Spectrum Analyzer (8)	BTL 3	Applying
9.	i) How would you use the modern technique to measure the power at microwave frequencies? (8) ii) What procedures would you select to measure the impedance of a Load? (8)	BTL 3	Applying
10.	i) Examine Spectrum Analyzer with suitable diagrams. (8) ii) Analyze RF substitution method for Attenuation measurements. (8)	BTL 4	Analyzing
11	i) List the different types of Impedance measurement methods? (8) ii) Analyze the power ratio method to measure the attenuation with relevant diagrams. (8)	BTL 4	Analyzing

12	i) Distinguish how the power of a microwave generator can be measured using bolometer. (10) ii) Calculate the SWR of a transmission system operating at 10GHz.Assume TE10 wave transmissions inside a wave guide of dimensions a=4cm, b=2.5cm. The distance measured between twice minimum power points=1mm on a slotted line (6)	BTL 4	Analyzing
13	i) Estimate the desired parameters of Spectrum analyzer (6) ii) Explain how the network analyzer is used for high frequency applications. (10)	BTL 5	Evaluating
14	i) Discuss the dielectric constant measurement using necessary block diagrams. (10) ii) Elaborate about S-parameters and Scattering coefficients. (6)	BTL 6	Creating