GRT INSTITUTE OF ENGINEERING AND TECHNOLOGY-TIRUTTANI
DEPARTMENT OF ECE

Sub Name:	**TRANSMISSION LINES & RF**	**Sem:**	**VI ECE**
Sub Code :	**EC8651**	**Year**	**III**

UNIT -1 TRANSMISSION LINE THEORY

	PART – A Question & Answer
1.	**State the line parameters of a transmission line. (N/D 2018)** The transmission line has mainly four parameters, resistance, inductance, capacitance and shunt conductance. These parameters are uniformly distributed along the line. Hence, it is also called the distributed parameter of the transmission line.
2.	**What is a distortionless line? Give the condition for a distortionlessline. (N/D 2018, A/M 2018, N/D 2017, A/M 2019, N/D 2016)** A line in which there is no phase or frequency distortion and also it is correctly terminated is called a distortion less line. The condition for a distortion less line is R/L =G/C.
3.	**Define reflection loss. (A/M 2018, A/M 2016)** Reflection loss: It is defined as the number of nepers (or) decibels by which the current in the load under image matched condition would exceed the current actually flowing in the load. Reflection loss is the reciprocal of reflection factor.
4.	**Define characteristic impedance. (N/D 2017, A/M 2016)** The ratio of the voltage applied Es and the current flowing is the input impedance of the line. This input impedance of the infinite line is called characteristic impedance of transmission line and is denoted by Z_0.
5.	**Find the characteristic impedance of a line at 1600Hz. If Z_{OC} = 750∟-30° and Z_{SC} = 600∟-20° (A/M 2019, N/D 2016)** Wkt $Z_0 = \sqrt{Z_{oc} \bullet Z_{sc}}$ $Z_0 = \sqrt{750\angle -30^0 \bullet 600\angle -20^0} = \sqrt{4.5\times 10^5 \angle -50^0} = 670.82\angle -25^0$
6.	**A transmission line has Z_0 = 745∟-12° and is terminated in Z_R = 100Ω. Calculate the reflection factor. (A/M 2017)** Reflection factor is given by $= \dfrac{2\sqrt{Z_R Z_0}}{\lvert Z_R + Z_0 \rvert} = \dfrac{2\sqrt{(100)(745)}}{\lvert (100+j0)+(728.72-j154.894) \rvert} = 0.6475$ Reflection loss is given by $= 20\log\left(\dfrac{1}{\lvert K \rvert}\right) = 20\log\left(\dfrac{1}{\lvert 0.6475 \rvert}\right) = 3.7751dB$

7.	**Define smooth line. (A/M 2017)** When $Z_R=Z_0$, the wave travels smoothly down the line and the energy is observed in Z_0 load without setting up reflective wave. This is called smooth line.
8.	**State properties of infinite line.** (i) No waves will ever reach receiving end and hence there is no reflection. (ii) The Z_0 at the sending end decides the current flowing when voltage is applied. Z_R has no effect on the sending end current.
9.	**Define propagation constant of a transmission line. (N/D 2018)** The ratio I_S/I_1 can be represented as e^{γ} where γ is the complex quantity. This γ is called the propagation constant per unit length of the line. $\gamma = \alpha + j\beta$
10.	**What is wavelength of a line?** The distance between the two points along the line at which currents or voltages differ in phase by 2Π radians is called one wavelength of a line. It is given as $\lambda = 2\Pi/\beta$
11.	**What is phase velocity and group velocity?** The velocity of the waves along the line decided by ω and phase constant β is called phase velocity. $V = \omega/\beta$ The velocity which is produced by a group of frequencies travelling along the system is called group velocity. $V_g = d\omega/d\beta$
12.	**What are primary constants of the transmission line?** The four line parameters resistance (R), inductance (L), capacitance (C) and conductance (G) are also known as primary constants of the transmission line. Resistance (R) is defined as the loop resistance per unit length of the transmission line. It is measured in ohms/km.
13.	**What are secondary constants of the transmission line?** The propagation constant (Y), characteristic impedance (Z), attenuation constant (α), phase constant (β) are called secondary constants of a transmission line. The characteristic impedance of the transmission line is also a complex quantity.
14.	**What is the relationship between characteristic impedance and propagation constant?** The characteristic impedance and propagation constant both are the secondary constants of the line. Both depend on values of R, L, G, C. Moreover both dependent on ω, the angular frequency.
15.	**Write expressions for the phase constant and velocity of propagation for telephone cable.** For a telephone cable: Phase constant (β) = $\sqrt{(\omega RC /2)}$ rad/km

	Velocity of propagation (v) = $\sqrt{(2\omega/CR)}$ m/sec
16.	**What is phase or delay distortion?** For an applied voice voltage was the received waveform may not be identical with the input waveform at the sending end, since some frequency components will be delayed more than those of other frequencies. This phenomenon is known as delay or phase distortion.
17.	**What is frequency distortion?** The attenuation constant α is function of frequency. Hence the different frequencies transmitted along the line will be attenuated to the different extent. For example a voice signal consists of many frequencies. And all these frequencies will not be attenuated equally along the transmission line. Hence received signal will not be exact replica of the input signal at the sending end. such a distortion is called as frequency distortion.
18.	**What is meant by loading?** The process of achieving condition of distortionless line artificially by increasing L or decreasing C, is called loading of a line. Such a line is called loaded line.
19.	**How distortion can be reduced in the transmission line?** Distortion can be reduced in a transmission line by maintaining the condition, RC = LG.
20.	**What is insertion loss?** Insertion loss is the loss of signal power resulting from the insertion of a device in a transmission line or optical fiber and is usually expressed in decibels (dB).
21.	**Define reflection coefficient. What is its significance?** The ratio of the amplitudes of the reflected and incident voltage waves at the receiving end of the line is called the reflection coefficient. It is denoted by K. The reflection coefficient plays important role in analysis of RF transmission lines. It gives the measure of mismatch between load and characteristic impedance of line. K = Reflected voltage at load / Incident voltage at load
22.	**What is return loss? State its expression.** The ratio of power at the receiving end due to incident wave and power due to reflected wave by the load is called return loss. Return loss = 20 log $\| Z_R + Z_0/ Z_R - Z_0\|$ dB
23.	**Calculate the load reflection coefficient of an open and short circuited line.** For the short circuited line, $K = 0 - Z_0 / 0 + Z_0 = -1 = 1\angle 180°$ For the open circuited line, $K = 1 - Z_0/ Z_R / 1 - Z_0/ Z_R = 1\angle 0° = 1$

24.	**Prove that 1neper = 8.686 dB.** Neper means logarithm to the base i.e. natural logarithm while dB means [20 * logarithm to the base 10] Let x is to be represented in neper and dB then, Neper = ln x and dB = 20 log x Now it is known that, Ln x = 2.3025 $\log_{10}x$ Therefore $\log_{10}x$ = 1 / 2.3025 ln x 20 $\log_{10}x$ = 20 / 2.3025 ln x [dB] = 8.686 [nepers] So when there is 1 neper, corresponding dB is 8.686 Therefore 1 neper = 8.686 dB Thus 3.5 dB means 3.5 / 8.686 nepers = 0.4029 nepers.
25.	**What is meant by infinite line?** An infinite line is a transmission line of infinite length having the electrical constants per unit length identical to that of the transmission line considered.

PART – B Question

1.	Derive the equation of attenuation constant and phase constant of transmission lines in terms of line constants R, L, C and G. **(N/D 2018)**
2.	Explain the theory of open and short circuited lines and also derive all expressions for input impedance. **(N/D 2018)**
3.	Derive the general transmission line equations for voltage and current at any point on a line. (**A/M 2018, N/D 2017, A/M 2019, A/M 2017, M/J 2016)**
4.	A communication line has L = 3.67 mH/km, G = 0.08 * 10^{-6} mho/km, C = 0.0083 μF/km and R = 10.4 Ω/km. Determine the characteristic impedance, phase constant, velocity of propagation, wavelength, sending end current and receiving end current for given frequency f = 1000 Hz, sending end voltage is 1V and transmission line length is 100 kilometers.
5.	Derive the input impedance Z_0 from the transmission line equation and also find voltage reflection ratio at the load.
6.	Explain in detail about the reflection on a line not terminated by its characteristic impedance Z_0.
7.	A generator of 1..0 volt, 1000 cycles, supplies power to a 100 mile open-wire line terminated in Z_0 and having the following parameters: Series resistance R = 10.4 Ω/mile, Series inductance L= 0.00367 H/mile, Shunt conductance G = 0.8 x 10^{-6}mho/mile and capacitance between conductors C = 0.00835 x 10^{-6} F/mile. Find the characteristic impedance, Propagation constant, attenuation constant, phase shift constant, velocity of propagation and wavelength.
8.	Discuss in detail about lumped loading and derive the Campbell's equation. (**A/M 2017)**
9.	A 2 meter long transmission line with characteristic impedance of 60+ j40Ω is operating at ω = 10^6 rad/sec has attenuation constant of 0.921 Np /m and phase shift constant of 0 rad/m. If

	the line is terminated by a load of 20+j50, determine the input impedance of this line. (**N/D 2016)**
10.	(i) Explain in detail about the reflection on a line not terminated by its characteristic impedance Z_0. (ii)Derive the condition for minimum attenuation in a distortionless line. (**N/D 2016)**
	PART – C Question
1.	Discuss the following: (i) Reflection loss (ii) Return loss
2.	(i) Draw and explain the reflection loss due to mismatch between source and load impedances. (ii) Write short notes on reflection factor and reflection loss.
3.	Discuss in detail about inductance loading of telephone cables and derive the attenuation constant, phase constant, velocity of signal transmission for the uniformly loaded cable.
4.	Explain the different types of distortions in a transmission line and also derive the condition for distortionless transmission.
5.	Explain the reflection on lines not terminated in characteristic impedance with phasor diagrams. Define reflection coefficient and reflection loss.

UNIT -2 HIGH FREQUENCY TRANSMISSION LINES

	PART – A Question & Answer
1.	**Define insertion loss. (N/D 2018)** Insertion loss is the loss of signal power resulting from the insertion of a device in a transmission line or optical fiber and is usually expressed in decibels (dB).
2.	**Define propagation constant. (N/D 2018)** The ratio I_S/I_1 can be represented as e^{γ} where γ is the complex quantity. This γ is called the propagation constant per unit length of the line. $\gamma = \alpha + j\beta$
3.	**What are assumption to simply the analysis of line performance at high frequencies? (A/M 2018)** ✓ Due to skin effect, the currents are assumed to flow on the surface of the conductor. The internal inductance is zero. ✓ The resistance increases with while the line reactance increases directly with f since ✓ The conductance is zero.
4.	**Write the expression for the input impedance of open and short circuited, dissipation less line. (A/M 2018)** Input impedance : Open circuited line $Z_{OC} = -jR_0 / (\tan \beta S) = -jR_0 \cos (2\pi S/\lambda)$. Short circuited line $Z_{SC} = jR_0 \tan (2\pi S/\lambda)$.
5.	**Why is quarter wave line called an impedance inverter? (N/D 2017)** A quarter wave transformer may be considered as an impedance inverter here low impedance can be transformed into a high impedance and vice versa.
6.	**What is an impedance matching in stub? (N/D 2017)** Stubs can be used to match a load impedance to the transmission line characteristic impedance. This distance is chosen so that at that point the resistive part of the load impedance is made equal to the resistive part of the characteristic impedance by impedance transformer action of the length of the main line.
7.	**Write the expression for SWR in terms of reflection coefficient. (A/M 2019)** Standing wave ratio is the combination of reflected and incident wave. SWR =(1+k)/(1-k)
8.	**What are the nodes and antinodes on a standing wave represent? (A/M 2019)** The points along the line where magnitude of voltage or current is zero are called nodes while the points along the lines where magnitude of voltage or current is maximum are called antinodes or loops.

9.	**Define SWR.** **(A/M 2017)** Standing wave ratio is the combination of reflected and incident wave. SWR =(1+k)/(1-k)
10.	**A lossline line has a characteristic impedance of 400Ω. Determine the standing wave ratio if the receiving end impedance is 800 +j0.0Ω** **(A/M 2017)** Reflection coefficient is given by $K = Z_R - Z_0 / Z_R + Z_0 = 0.3333 \angle 0°$ The Standing wave ratio is given by S = 1 + |K| / 1 - |K| = 1.99985 = 2
11.	**Write the expression for input impedance of open and short circuited dissipationless line.** **(N/D 2016)** $$Z_{SC} = jR_0 \tan\frac{2\pi s}{\lambda} \qquad Z_{OC} = R_0\left(\frac{1}{j\tan\frac{2\pi s}{\lambda}}\right)$$
12.	**Calculate SWR and reflection coefficient on a line having the characteristic impedance $Z_0 = 300\Omega$ and terminating impedance $Z_R = 300+j400\Omega$.** **(N/D 2016)** The reflection coefficient is given by $K = \frac{Z_R - Z_0}{Z_R + Z_0}$ $$K = \frac{(300+j400)-(300)}{(300-j400)+(300)} = \frac{j400}{600+j400} = \frac{400\angle 90^0}{721.11\angle 33.69^0} = 0.5547\angle 56.31^0$$ The standing wave ratio is given by $S = \frac{1+\|K\|}{1-\|K\|}$ $$S = \frac{1+0.5547}{1-0.5547} = 3.4913$$
13.	**What is the nature and value of Z_0 for the dissipationless line?** For the dissipationless line, the Z_0 is purely resistive and given by $Z_0 = R_0 = \sqrt{L/C}$
14.	State the values of α and β for the dissipationless line. $\alpha = 0$ $\beta = \omega\sqrt{LC}$
15.	**What are standing waves?** When a line is not terminated correctly in to its characteristic impedance R_0, then the part of energy transmitted returns back to the source as reflected wave. Then the distribution of voltage along the length of the line is not uniform, but minimum along the length of the line is not uniform; but minimum or maximum at different lengths. The points of minimum and

	maximum voltage or current are called nodes and antinodes. A line reflected back from the load consisting nodes and antinodes is called standing wave.
16.	**For a line of zero dissipation, what will be the values of attenuation constant and characteristic impedance?** i) For a line of zero dissipation R is very small and G is assumed to be zero. ii) Attenuation constant $\alpha = 0$. iii) Phase constant $\beta = \omega \sqrt{LC}$ radians/m. iv) Characteristics impedance $Z_0 = R_0 = \sqrt{(L/C)}$ $Z_0 = R_0$ = resistive.
17.	**Write the relationship between SWR and reflection coefficient.** $S = (1 + \lvert K \rvert)/(1 - \lvert K \rvert)$ Or $\lvert K \rvert = (S - 1)/(S + 1)$
18.	**Explain SWR in terms of reflection coefficient.** Standing wave ratio $S = (1 + \lvert K \rvert)/(1 - \lvert K \rvert)$ $\lvert K \rvert$ = Reflection coefficient.
19.	**If the VSWR of the line is 1.5 then calculate its reflection coefficient.** VSWR = $1 + \lvert K\rvert / 1 - \lvert K\rvert = 1.5$ $1 + \lvert K\rvert = 1.5 - 1.5\lvert K\rvert$ $2.5\lvert K\rvert = 1.5 - 1 = 0.5$ $\lvert K\rvert = 0.2$
20.	**Determine K of the line. $Z_R = 200\Omega$, $Z_0 = 692 \angle -12°\Omega$.** $K = Z_R - Z_0 / Z_R + Z_0 = 0.55 \angle -153.6°$
21.	**A 50Ω line is terminated in load $Z_R = 90 + j60\Omega$. Determine the reflection coefficient.** $K = Z_R - Z_0 / Z_R + Z_0 = 0.4734 \angle 33.11°$
22.	**A lossless line has a characteristic impedance of 400Ω. determine SWR if the receiving end impedance is 800 + j0.0Ω.** $K = Z_R - Z_0 / Z_R + Z_0 = 0.3333 \angle 0°$ $S = (1 + \lvert K \rvert)/(1 - \lvert K \rvert) = 2$
23.	**A lossless transmission line has a shunt capacitance of 100 pF/m and series inductance of 4 μH/m. Determine the characteristic impedance.** Characteristics impedance $Z_0 = R_0 = \sqrt{(L/C)} = 200\Omega$
24.	**List parameters of open wire line at high frequency.** $L = \mu_0 \ln d/a$ H/m $C = \Pi\varepsilon / \ln d/a$ F/m

	$\delta = 1 / \sqrt{\Pi f \mu \sigma}$ $R_{dc} = K/\pi a^2$ $R_{ac} = K/2\pi a\ \delta$
25.	**Why do standing waves exist on transmission lines?** If voltage magnitudes are measured along the length of a line terminated in a load other than R_0, the plotted values appear as shown in fig. These waves are called standing waves.

PART – B Question

1.	Explain the parameters of open wire and coaxial lines at radio frequency. (**N/D 2018)**
2.	A transmission line has Z_0 =1.0, Z_L = 0.2-j0.2Ω (i) What is z at l = λ = 0.25λ? (ii) What is the VSWR on the line? (iii) How far from the load is at the first voltage minimum? Use smith chart. (**N/D 2018)**
3.	(i) Derive the line constants of a zero dissipation less line. (ii) Describe an experimental setup for the determination of VSWR of an RF transmission. (**A/M 2018, A/M 2019)**
4.	(i) Briefly explain on a) Standing wave b) Reflection loss (ii) Discuss in detail about the variation of input impedance along open and short circuit lines with relevant graphs. (**A/M 2018, A/M 2019)**
5.	Calculate the average input power at a distance from the load 'l' and find the impedance when the load is short circuited, open circuited and for a matched line. (**N/D 2017)**
6.	(i) A 30m long lossless transmission line with Z_0 = 50Ω operating at 2 MHz is terminated with a load Z_L = 60 + j40. If u = 0.6c (c is the velocity of light, u is the phase velocity) on the line, find a) The reflection coefficient Γ b) The standing wave ratio s c) The input impedance (ii) Draw the input impedance pattern for a lossless line when short circuited and open circuited. (**N/D 2017)**
7.	Derive an expression for power and find the input impedance of dissipation less line. When the load is short circuited, open circuited and for a matched line. (**A/M 2019)**
8.	Discuss in detail about the voltages and currents on the dissipation less line. (**A/M 2017)**
9.	(i) Derive the expression that permit easy measurements of power flow on a line of negligible losses. (ii) A radio frequency line with Z_0 = 70Ω is terminated by Z_L = 115-j80Ω at λ = 2.5m. Find the VSWR and the maximum and the minimum line impedances. (**A/M 2017)**
10.	Derive the expression that permit easy measurements of power flow on a line of negligible losses.
	PART – C Question
1.	A 50Ω lossless transmission line is connected to a load composed of a 75Ω resistor in series with a capacitor of unknown capacitance. If at 10 MHz the voltage standing wave ratio on the line was measured as 3, determine the capacitance C. (**N/D 2018)**
2.	A generator of 1V, 1 KHz supplies power to a 100 km open wire line terminated in Z_0 and having the following line parameter are R = 10.4 Ω/km, L = 3.8 mH/km, C= .0085 μF/km

	and G = $0.8*10^{-6}$ mho/km. Calculate Z0, α, β, λ, v. Also find the received power. (**A/M 2019)**
3.	Discuss the measurement of power and impedance on transmission line using phasor diagrams.
4.	Discuss the theory of open and short circuited lines with voltage and current distribution diagrams and also get the input impedance expression.
5.	Discuss the various parameters of open wire and coaxial lines at radio frequency.

UNIT -3 IMPEDANCE MATCHING IN HIGH FREQUENCY LINES

	PART – A Question & Answer
1.	**List the applications of smith chart. (N/D 2018)** The applications of the smith chart are: i. It is used to find the input impendence and input admittance of the line ii. The smith chart also used for lossy transmission lines iii. To implement single stub matching
2.	**What is the application of quarter line matching section? (N/D 2018)** A Quarter wave line can transform a low impedance into high impedance and vice versa, thus it can consider as an impedance inverter. One of the important applications is the impedance transformation in coupling a transmission line to a resistive load such as an antenna. Another application of a quarter wave section is the line with load which is not pure resistive. Other than the application the quarter wave line may be used to provide mechanical support to the open wire line or centre conductor of coaxial cable.
3.	**What is an impedance matching in stub? (A/M 2018)** For maximum power to be transferred from transmitter to receiver, the source and load impedance should be matched. But in many situations, source and load impedance connected to long transmission line does not match. So stub is used in between source and load to match the impedance.
4.	**What are the uses of smith chart? (A/M 2018)** To determine SWR, to send end impedance and load admittance. The solution of the stub matching problem may be easily carried out using smith chart.
5.	**What is the nature and value of Z_0 for the dissipation less line? (N/D 2017)** $Z_0=\sqrt{L/C}$
6.	**What are nodes and anti nodes on a line? (N/D 2017)** Nodes are points of zero voltage or current in the standing wave systems. Anti nodes or loops are points of maximum voltage or current.
7.	**Distinguish between single and double stub matching in a transmission line. (A/M 2019, N/D 2016)**

Single stub matching	Double stub matching
It requires one stub for impedance matching.	It requires two stub for impedance matching.
Two adjustments are required, these being the location and length of the	It requires only to alter the length of

	stub.	stubs.
	It requires the stub to be placed at definite place on the line.	The location of stubs are arbitrary.

8.	**How is impedance matching achieved with stubs? (A/M 2019)** Stubs can be used to match a load impedance to the transmission line characteristic impedance. This distance is chosen so that at that point the resistive part of the load impedance is made equal to the resistive part of the characteristic impedance by impedance transformer action of the length of the main line.
9.	**List the applications of a quarter wave line. (A/M 2017)** A Quarter wave line can transform a low impedance into high impedance and vice versa, thus it can consider as an impedance inverter. One of the important applications is the impedance transformation in coupling a transmission line to a resistive load such as an antenna. Another application of a quarter wave section is the line with load which is not pure resistive. Other than the application the quarter wave line may be used to provide mechanical support to the open wire line or centre conductor of coaxial cable.
10.	**Why a short circuited stub is ordinarily preferred to an open circuited stub? (A/M 2017)** Short circuited stub is preferred because of following reasons ✓ It radiates less power. ✓ Its effective length may be varied by means of a shorting bar.
11.	**Give the application of eight wave line. (N/D 2016)** The eight wave line is generally used to transform any resistance R_R to an impedance Z_{in} having its magnitude equal to the characteristic resistance R_0 of the line.
12.	**What is meant by electrical length of the line?** The length of the transmission line expressed in terms of wavelength is called an electrical length of line.
13.	**Why is the quarter wave line called as copper insulator?** As quarter wave line is shorted at ground, its input impedance is very high. So the signal on line passes to the receiving end, without any loss due to this mechanical support. Thus the line acts as an insulator at this point. Hence such line is referred as copper insulator.
14.	**Name few applications of half wave line.**

	Half wave line repeats its terminating impedance. In other words, the half wave line may be considered as one to one transformer.
15.	**Why are short circuited stubs preferred over open circuited stub?** A short circuited stub is preferred to open circuited stub because of the following reason: i. Easy in constructions ii. Lower loss of energy due to radiation iii. Effectively stopping all field propagation
16.	**What is smith chart?** The smith chart is a valuable graphical tool for solving radio frequency transmission line problems.
17.	**Write the procedure to find the impedance from the given admittance using smith chart.** First find normalized admittance for the given admittance. Then locate that point on the smith chart say at point P. Now to find impedance of the given admittance at point P, rotate point P along constant S circle by a distance λ/4 or 0.25λ (which is equivalent to 180°) and locate point P' which is located diametrically opposite to point P. Then check point P' for intersection of ri-circle and xi-circle and obtain normalized impedance value. Then multiply the obtained normalized impedance value by characteristic impedance Z_0 and get the actual impedance for given admittance using the smith chart.
18.	**What are the disadvantages of single stub matching?** i. Single stub matching is useful for a fixed frequency. As the frequency changes the location of single stub will also changed. So Double stub matching is preferred. ii. The single stub matching system is based on the measurement of voltage minimum. Hence for the coaxial line it is very difficult to get such voltage minimum, without using slotted line section.
19.	**Design a quarter wave transformer to match a load of 200Ω to a resistance of 500Ω. The operating frequency is 200 MHz.** Z_R = 200 ohm, Z_S = 500ohm, f = 200 MHz. $Z_S = R_0^2/ZR$ $R_0 = \sqrt{}ZS.ZR = \sqrt{}\ 500\ .\ 200 = 316.22\Omega$ Input impedance of λ/4 transformer R_0 = 316.22Ω The frequency of operation is f = 200 MHz. Wavelength $\lambda = C/f = (3 \times 10^8) / (200 \times 10^6) = 1.5$ m. The length of the quarter wave line s = λ/4 s = λ/4 = 1.5/4 = 0.375 m.

20.	**Mention the significance of λ/4 line.** A quarter wave line is used for impedance matching. ie., it matches the load with the source and ensures the maximum power is being transferred to the load.
21.	**What are the two independent measurements that must be made to find the location and length of the stub?** The standing wave ratio S and the position of a voltage minimum are the independent measurements that must be made to find the location and the length of the stub.
22.	**Why an open line is not frequently employed for impedance matching?** An open line is rarely used for impedance matching because of radiation losses from the open end due to capacitance effects and the difficulty of a smooth adjustment of length.
23.	**When does standing wave occur in a transmission line?** The standing wave occurs in a transmission line when the line is not terminated with its characteristic impedance. Due to this there is a reflection wave along the line.
24.	**Why is a quarter wave line called an impedance inverter?** A quarter wave line called an impedance inverter because the line can transform a low impendence in to a high impedance and vice versa.
25.	**What is the significance of a half wavelength line?** The significance of a half wavelength line is to connect load to a source where the load source cannot be made adjacent.

PART – B Question

1.	Explain the technique of single stub matching and discuss operation of quarter wave transformer. (**N/D 2018)**
2.	Explain the procedure for obtaining the smith chart using R & X circles. (**N/D 2018)**
3.	(i) Prove that input impedance of a quarter wave line is $Z_{in} = R_0^2 / Z_R$. (ii) Design a quarter wave transformer to match a load of 200Ω to a source resistance of 500Ω. Operating frequency is 200MHz. **(A/M 2018)**
4.	(i) Find the sending end impedance of a line with negligible losses when characteristic impedance is 55Ω and the load impedance is (115 + j75) Ω length of the line is 1.183 wavelength by using smith chart. (ii) Explain the significance of smith chart and its application in a transmission lines. (**A/M 2018)**
5.	Antenna with impedance 40 + j30Ω is to be matched to a 100Ω lossless line with a shorted stub. Determine the following using smith chart. a) The required stub admittance b) The distance between the stub and the antenna c) The stub length d) The standing wave ratio on each of the system (**N/D 2017)**
6.	Design a double stub shunt tuner to match a load impedance 60 - j80Ω to a 50Ω line. The stubs are to be short circuited stubs and are spaced λ/8 apart. Find the length of the two stubs using smith chart. (**N/D 2017)**

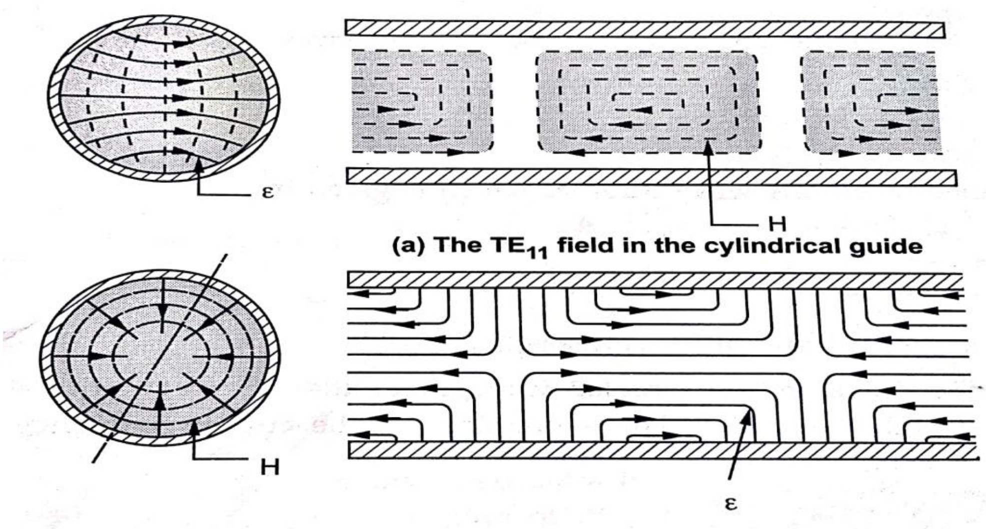
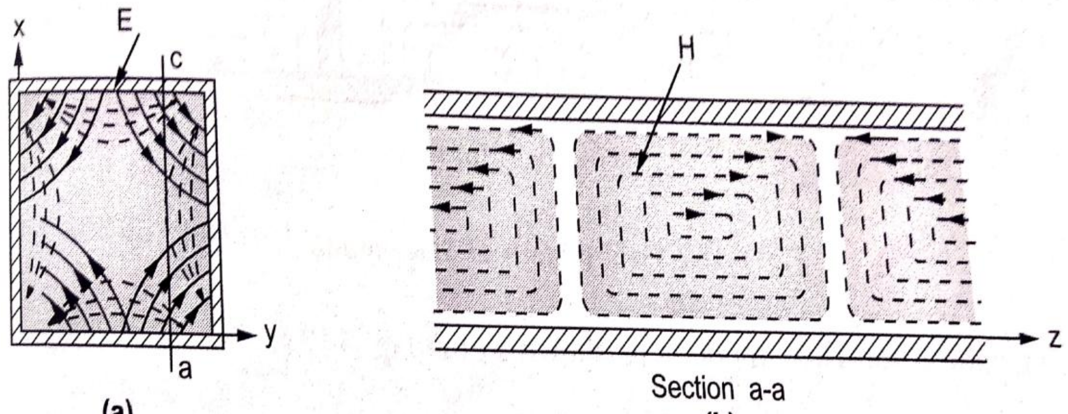
7.	(i) Explain the operation of quarter wave transformer and mention its important applications. (ii) A single stub is to match a load 400Ω line to a load of 200 - j100Ω. The wave length is 3m. Determine the position and length of the short circuited stub. (**A/M 2019)**
8.	A 75Ω lossless transmission line is to be matched with a (100-j80)Ω using single stub. Calculate the stub length and its distance from the load corresponding to the frequency of 30MHz using smith chart. (**A/M 2019)**
9.	A 300Ω transmission line is connected to a load impedance of 450-j600Ω at 10MHz. Find the position and length of a short circuited stub required to match the line using smith chart. (**A/M 2017)**
10.	(i) A load impedance of 90 -j50Ω is to be matched to a line of 50Ω using single stub matching. Find the length and position of the stub. (ii) Design a quarter wave transformer to match a load of 200Ω to a source resistance of 500Ω. The operating frequency is 200 MHz. (**A/M 2017)**
	PART – C Question
1.	With neat diagram, explain the single stub and double stub matching network. Also explain the design procedure. (**A/M 2018)**
2.	i) Discuss the application of quarter wave line in impedance matching and copper insulator. ii) A 30 m long lossless transmission line with characteristic impedance Z_0 of 50Ω is terminated by a load impedance ZL=60 + j 40Ω The operating wavelength is 90 m. Find the reflection coefficient, standing wave ration and input impedance using SMITH chart.
3.	A 50 Ω transmission line is connected to a load impedance ZL= 60+j80Ω. The operating frequency is 300MHz A double stub matching an eight of a wave length apart is used to match the load to the line find the required lengths of the short circuited stubs using SMITH chart.
4.	i) A 75 Ω lossless transmission line is to be matched to a resistive load impedance of Z_L=100Ω via a quarter wave section find the characteristic impedance of the quarter wave transformer. ii) A 50Ω lossless transmission line is terminated in a load impedance of ZL=(25+j50)Ω Use the SMITH chart to find (1) Voltage reflection coefficient (2) VSWR (3)Input impedance of the line given that the line is 3.3 wavelength long and (4) Input admittance of the line
5.	(i) Draw and explain the principle of double stub matching. (ii) A UHF lossless transmission line working at 1 GHz is connected to an unmatched line producing a voltage reflection coefficient of 0.5(0.866 + j 0.5). Calculate the length and position of the stub to match the line.

UNIT -4 WAVEGUIDES

	PART – A Question & Answer
1.	**What is dominant mode? (A/M 2018, N/D 2017)** The mode which has lowest cut off frequency or highest cut of wavelength is called dominant mode.
2.	**Write the expression for cut off wavelength of the wave which is propagated in between two parallel planes. (N/D 2017)** The cutoff wavelength $\lambda c = 2a/m$
3.	**Justify why TM01 and TM10 modes in a rectangular waveguide do not exist. (A/M 2019, N/D 2016)** $E_x = \frac{-j\beta}{h^2} C \frac{m\pi}{a} \cos\left(\frac{m\pi}{a}x\right) \sin\left(\frac{n\pi}{b}y\right)$; $H_y = \frac{-j\omega\varepsilon}{h^2} C \frac{m\pi}{a} \cos\left(\frac{m\pi}{a}x\right) \sin\left(\frac{n\pi}{b}y\right)$ TM_{01} mode: By substituting m and n values in above equations , all the field components become zero inside guide . So TM01 mode cannot exist inside the rectangular waveguide. TM_{10} mode: By substituting m and n values in above equations , all the field components become zero inside guide . So TM10 mode cannot exist inside the rectangular waveguide.
4.	**Calculate the cut off frequency of a rectangular waveguide whose inner dimensions are a = 2.5cm and b = 1.5cm operating at TE_{10} mode. (A/M 2017)** For TE10 mode, a=2.5 cm = $2.5X10^{-2}$ m ; b=1.5 cm = $1.5X10^{-2}$ m Assume free space as dielectric, $f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} = \frac{3\times10^8}{2}\sqrt{\left(\frac{1}{2.5\times10^{-2}}\right)^2 + \left(\frac{0}{1.5\times10^{-2}}\right)^2} = 6GHz$
5.	**What is meant by guided waves?** The electromagnetic waves that are guided along or over conducting or dielectric surface are called guided waves. Examples of guided waves are parallel wires and transmission lines.
6.	**Define TEM wave.** The Transverse Electromagnetic (TEM) waves are waves in which both electric and magnetic fields are transverse entirely but have no components of E_z and H_z. It is also called the principal wave.
7.	**What is transverse magnetic wave?** Transverse magnetic (TM) wave is a wave in which the magnetic field strength H is entirely

	transverse. It has a electric field strength E_z in the direction of wave propagation and no component of magnetic field H_z in the direction of wave propagation.
8.	**An air filled rectangular waveguide of inner dimensions 2.286*1.016 in centimeters operates in the dominant TE_{10} modes. Calculate the cut off frequency and phase velocity of a wave in the guide at a frequency of 7 GHz. (N/D 2016)** The free space wavelength is given by $\lambda_0 = \frac{c}{f} = \frac{3\times10^8}{7\times10^9} = 0.0428m$ The cut off wavelength is given by $f_c = \frac{c}{\lambda_c}$ for TE_{10} mode , $\lambda_c = 2a = 2\times0.02286 = 0.04572m$ $f_c = \frac{3\times10^8}{0.04572} = 6.5616\,\text{GHz}$ The phase velocity is given by $\upsilon_p = \frac{c}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}} = \frac{3\times10^8}{\sqrt{1-\left(\frac{0.0428}{0.04572}\right)^2}} = 0.8531\times10^9\,m/\sec$
9.	**Define the cut off frequency of a guide.** The frequency at which the wave motion ceases is called cutoff frequency of the waveguide.
10.	**Define guide wavelength.** The wavelength is defined as the distance travelled for the phase shift through 2Π radius. Thus wavelength is given by $\lambda = 2\Pi/\beta = \lambda_g$.
11.	**What is principal wave?** The principal wave is nothing but a transverse electromagnetic (TEM) wave. It is the special case of guided wave propagation.
12.	**What are the characteristics of TEM waves?** The characteristics of TEM waves are: i. The amplitude of field component is constant ii. The velocity of propagation and the wave impedance are independent of frequency of the wave iii.TEM waves cannot exist in a single conductor hollow waveguide iv. The cut – off frequency of TEM wave is zero v. The ratio of amplitudes of E to H is intrinsic impedance. vi. It doesn't have either Ez or Hz component.

13.	**Define free space velocity.** It is the velocity of propagation of an EM wave in the free space. It is denoted by v_0 and its value is $v_0 = c = 3*10^8$ m/sec
14.	**Define phase velocity.** The phase velocity is defined as the rate at which wave changes its phase as the wave propagates inside the region between parallel planes. it is denoted by v_p.
15.	**Define group velocity.** The group velocity is defined as the actual velocity with which the wave propagates inside the region between two parallel planes. It is denoted by v_g.
16.	**Give the reason for impossibility of TEM waves in waveguides.** The TEM wave cannot propagate through the waveguide. Because it needs either axial conductor for axial current or an axial displacement current to support transverse magnetic field. Both these conditions are not possible in waveguide.
17.	**What is degenerate mode in rectangular waveguide?** The higher order modes which are having the same cut off frequency are called degenerate modes. In a rectangular waveguide, TEm,n and TMm,n modes (both m = 0 and n = 0) are always degenerate mode.
18.	**What are the advantages and applications of cylindrical waveguide?** The cylindrical waveguide has an equivalent of TE_{on} mode which is not possible in rectangular waveguide. The cylindrical waveguides are used as attenuators and phase shifters. The cylindrical waveguides are advantageous when we use optical fiber using dielectrics such as glass or plastic because it is easy to manufacture these dielectrics in cylindrical shapes.
19.	**What is the need for guide termination?** To avoid reflection at the receiving end, the transmission lines are properly terminated at the receiving end. Now waveguide is a form of transmission line. Hence to avoid reflection losses, the waveguide must be properly terminated.
20.	**What is Bessel function?** The analysis of field components within the hollow, perfectly conducting cylinder with uniform cross section is carried out using the cylindrical co ordinate system. The resulting differential equation is called Bessel's equation. the solution of such equation is callled Bessel function.
21.	**What is an evanescent mode?** When the operating frequency is lower than the cut-off frequency, the propagation constant becomes real. So the wave cannot be propagated for that frequency. This non- propagating mode is known as evanescent mode.

22.	**What is the dominant mode in circular waveguide?** For the circular waveguide, the mode for which value of the λ_{cmn} is highest is called the dominant mode of a wave.
23.	**Draw the field pattern of TM waves in dominant mode.**  (a) The TE_{11} field in the cylindrical guide (b) The Tm_{01} field in the cylindrical guide
24.	**Draw field pattern of TE_{11} mode.**  (a) (b)
25.	**What is waveguide?** A hollow conducting metallic tube of uniform cross section which is used for propagating electromagnetic wave is called wave guide.

PART – B Question

1.	Write Bessel's differential equation and Bessel function and TM and TE waves in circular wave guides. (**N/D 2018)**
2.	Derive the solution for TE and TM mode in rectangular waveguide. (**N/D 2018)**
3.	Derive an expression for the transmission of TM waves between parallel perfectly conducting planes for the field components. (**A/M 2018)**
4.	An air filled circular waveguide having an inner radius of 1 cm is excited in dominant mode at 10 GHz. Find (a) the cut off frequency of the dominant mode at 10 GHz. (b) the guide wavelength and (c) wave impedance. Also find the bandwidth for operation in the dominant mode only. (**A/M 2018)**

5.	Derive the field equations of TE waves travelling in Z direction in a rectangular waveguide. (**N/D 2017, A/M 2017)**
6.	Derive an expression for the TE waves between parallel perfectly conducting planes for the field components. (**A/M 2019)**
7.	For a frequency of 10GHz and planes separation of 5cm in air, find the cut off frequency, cut off wavelength, phase velocity and group velocity of the wave. (**A/M 2019**
8.	When dominant mode is transmitted through a circular waveguide, the wavelength measured is to be 13.33cm. The frequency of the microwave signal is 3.75 GHz. Calculate the cut off frequency, inner radius of guide, phase velocity, group velocity, phase constant, wave impedance, bandwidth from operation in dominant mode only. (**A/M 2017)**
9.	Explain the propagation of electromagnetic waves in a cylindrical waveguide with suitable expressions.
10.	Using Bessel function derive the TE wave components in circular waveguides.
	PART – C Question
1.	A TE 10 wave at 10 GHz propagates in a brass $\sigma_C = 1.57 * 10^7$(S/m) rectangular waveguide with inner dimensions a = 1.5 cm and b = 0.6 cm, which is filled with $\varepsilon_r = 2.25$, $\mu_r = 1$, loss tangent = $4*10^{-4}$. Determine (i) the phase constant (ii) the guide wavelength, (iii) the phase velocity, (iv) the wave impedance, (v) the attenuation constant due to loss in the dielectric, and (vi) the attenuation constant due to loss in the guide walls. (**N/D 2018)**
2.	(i) Explain the wave behaviour in a guiding structures. (ii) Explain why TEM waves does not exist in waveguides. (**A/M 2018)**
3.	Examine the effectiveness of Bessel's differential equation and Bessel function with reference to waveguides. (**N/D 2017)**
4.	Discuss the characteristics of TM waves in circular waveguides.
5.	Derive the expressions for TM wave components in circular waveguide using Bessel function.

UNIT -5 RF SYSTEM DESIGN CONCEPTS

	PART – A Question & Answer
1.	**Define S matrix.** Scattering matrix is a square matrix which gives all the combination of power relationships between the various input and output port of a microwave junction.
2.	**Why is S matrix used in RF / Microwave analysis?** 1. Equipment is not readily available to measure total voltage &total current at the ports of the network. 2. Short and open circuits are difficult to achieve over a broad band of frequencies. 3. Active devices, such as power transistor &tunnel diodes, frequently won’t have stability for a short or open circuit.
3.	**List the reasons for using RF/Microwaves.** ✓ Wider bandwidth due to higher frequency ✓ Smaller component size leading to smaller systems ✓ More available and less crowded frequency spectrum ✓ Better resolution for radars due to smaller wavelengths ✓ lower interference due to lower signal crowding ✓ Higher speed of operation ✓ Higher antenna gain possible in a smaller space
4.	**List RF/Microwave applications.** ✓ Communication - TV and Radio Broadcast, Optical Communications ✓ Radar ✓ Navigation- microwave landing system (MLS), Global Positioning System (GPS) ✓ Remote sensing ✓ Domestic and Industrial applications ✓ Medical applications
5.	**Define transition frequency f_T.** The transition frequency f_T (also known as the cut off frequency) of a BJT determines the operating frequency at which the common emitter, short circuit current gain h_{fe} decreases to unity. The transition frequency f_T is related to the transit time τ that is required for carriers to travel through the emitter collector structure. $f_T = 1/\tau$
6.	**How are FETs classified?** FETs are classified according to how the gate is connected to the conducting channel. ✓ Metal Insulator Semiconductor FET (MISFET)

	✓ Junction FET (JFET) ✓ MEtal Semiconductor FET (MESFET) ✓ Hetero FET
7.	**What is a Hetero FET?** The hetero structures utilize abrupt transitions between layers of different semiconductor materials. Examples are GaAIAs to GaAs or GalnAs to GaAIAs interface; The High Electron Mobility Transistor (HEMT) belongs to this class.
8.	**What is HEMT?** HEMT also known as modulation doped FET (MODFET), exploits the differences in band gap energy between dissimilar semiconductor materials such as GaAIAs and GaAs in an effort to substantially surpass the upper frequency limit of the MESFET while maintaining low noise performance and high power rating.
9.	**How is an HEMT constructed?** The basic hetero structure consists of a GaAIAs n doped semiconductor layer followed by an undoped GaAIAs spacer layer, and a highly resistive semi insulating GaAs substrate.
10.	**What are the advantages of S parameter at high RF/microwave frequencies?** ✓ S parameters provide a complete characterization of a network, as seen at its two ports. ✓ S parameters make the use of short or open completely unnecessary at higher frequencies. ✓ S parameters require the use of the matched loads for termination and because the loads absorb all the incident energy, the possibility of serious reflections back to the device or source is eliminated.
11.	**Why amplifier design at RF differ significantly from the conventional low frequency approach?** Amplifier designs at RF differ significantly from the conventional low frequency circuit approaches and consequently require special considerations because the voltage and current waves impinge upon the active device necessiates appropriate matching to reduce the VSWR and avoid undesirable confusions.
12.	**List the key parameters of the amplifiers.** ✓ Gain and gain flatness (in dB) ✓ Operating frequency and bandwidth (in Hz) ✓ Output power (in dBm) ✓ Power supply requirements (in V and A) ✓ Input and output reflection coefficients (VSWR) ✓ Noise figure (in dB)

13. What are the parameters that affect the performance of the amplifiers?

Intermodulation distortion (IMD) products, harmonics, feedback and heating effects.

14. Write the formula for transducer gain.

$$G_T = \frac{\text{power delivered to the load}}{\text{available power from the source}} = \frac{P_L}{P_A}$$

$$G_T = \frac{\left(1-|\Gamma_L|^2\right)|S_{21}|^2\left(1-|\Gamma_S|^2\right)}{|1-\Gamma_L\Gamma_{\text{out}}|^2|1-S_{11}\Gamma_S|^2}$$

15. Write the formula for unilateral transducer power gain.

An approximation for the transducer power gain is the so-called unilateral power gain, Gru which neglects the feedback effect of the amplifier ($S_{12} = 0$)

$$G_{TU} = \frac{\left(1-|\Gamma_L|^2\right)|S_{21}|^2\left(1-|\Gamma_S|^2\right)}{\left(1-|\Gamma_L S_{22}|^2\right)|1-S_{11}\Gamma_S|^2}$$

16. Write the additional power relations equations.

Additional power gain :

$$G_A = G_T\Big|_{\Gamma_L=\Gamma_{\text{out}}} = \frac{\text{Power available from the amplifier}}{\text{Power available from the source}}$$

$$G_A = \frac{|S_{21}|^2\left(1-|\Gamma_s|^2\right)}{\left|1-|\Gamma_{\text{out}}|^2\right||1-S_{11}\Gamma_S|^2}$$

Operating power gain :

$$G = \frac{\text{power delivered to the load}}{\text{power supplied to the amplifier}} = \frac{P_L}{P_{in}} = \frac{P_L}{P_A}\cdot\frac{P_A}{P_{in}} = G_T\frac{P_A}{P_{in}}$$

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

17. Define stability.

It is the stability of an amplifier to maintain effectiveness in its normal operating characteristics inspite of large changes in the environment such as physical temperature, signal frequency, source or load condition etc.

18. Write the equations for unconditional stability.

A network is to be "unconditionally stable" in a frequency range if, and only if

	$\|\Gamma_{IN}\| < 1$ and $\|\Gamma_{OUT}\| < 1$ For all $\|\Gamma_S\| < 1$ and $\|\Gamma_L\| < 1$
19.	**Write the equations for conditional stability.** A network is said to be "conditionally stable" or potentially unstable in a frequency range if $\|\Gamma_{IN}\| < 1$ and $\|\Gamma_{OUT}\| < 1$ Only for a limited range of values of passive source and load impedances but not for all values $\Gamma_{IN} = S_{11} + (S_{12} S_{21} \Gamma_L / 1 - S_{22} \Gamma_L)$ $\Gamma_{OUT} = S_{22} + (S_{12} S_{21} \Gamma_S / I - S_{11} \Gamma_S)$
20.	**Write the stability or Rollet factor.** $k = \frac{1 - \|S_{11}\|^2 - \|S_{22}\|^2 + \|\Delta\|^2}{2\|S_{12}\|\|S_{21}\|} > 1$
21.	**What is the function of matching networks?** Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.
22.	**Define Noise figure.** Noise Figure F is defined as the ratio of the input SNR to the output SNR. F = Input SNR/ Output SNR
23.	**List the two types of stability.** i) Conditional stability ii) Unconditional stability
24.	**Define diffusion current.** The physical contact of a p type with an n type semiconductor leads to the pn junction. Because of the difference in the carrier concentrations between the two types of semiconductors, a current flow will be initiated across the interface. This current is commonly known as a diffusion current an is composed of electrons and holes.
25.	**Define SOAR.** The safe operating area (SOAR) is defined as a set of biasing points where the transistor can be operated without risk of unrecoverable damage to the device.

PART – B Question

1.	Discuss the properties and reasons for using RF with its applications.
2.	Briefly explain about active RF components.
3.	Explain about the energy band diagram of schottky contact.
4.	Discuss about the forward and reverse active mode of BJT.

5.	Discuss about the frequency response of BJT.
6.	Explain the construction of field effect transistors. Sketch its transfer and output characteristics.
7.	Briefly explain about HEMT with its frequency response.
8.	List the high frequency parameters. Discuss about the formulation of S parameters.
9.	Explain about the up conversion and down conversion of mixer.
10.	What is negative resistance device? State the oscillation conditions for RF oscillator.
	PART – C Question
1.	An RF amplifier has the following S parameters. $S_{11} = 0.3\angle -70°$, $S_{12} = 0.2\angle -10°$, $S_{21} = 3.5\angle 85°$, $S_{22} = 0.4\angle -45°$. Furthermore, the input side of the amplifier is connected to a voltage source with $V_S = 5V\angle 0°$ and source impedance $Z_S = 40\Omega$. The output is utilized to drive an antenna, which has an impedance of $Z_L = 73\Omega$. Assuming that the S parameters of the amplifier are measured with reference to a $Z_0 = 50\Omega$ characteristic impedance, find the following quantities. a) Find the Γ_L, Γ_S, Γ_{in}, Γ_{out}, b_S b) Transducer gain G_T, Unilateral transducer gain G_{TU}, Available gain G_A, Operating Power gain G Power delivered to the load P_L, available power from the source P_A, actual input power P_{in}, and incident power to the amplifier P_{inc}.
2.	(i) A MESFET operated at 5.7GHz has the following S parameters: $S11 = 0.5\angle -60°$, $S12 = 0.02\angle 0°$, $S21 = 6.5\angle 115°$, $S22 = 0.6\angle -35°$. Verify the circuit whether it is unconditionally stable or not? (ii) Write brief notes on: Operating power gain Available power gain Noise figure
3.	Investigate the stability region of a transistor whose S parameters are recorded as follows: $S_{12} = 0.2\angle -10°$, $S_{11} = 0.7\angle -70°$, $S_{21} = 5.5\angle 85°$, $S_{22} = 0.7\angle -45°$ at 750MHz
4.	Derive the equation for power gain, available power gain, transducer power gain.
5.	Briefly discuss about the graphical solution of stability criteria both input and output stability circles.