MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)

Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

MKC

MUST KNOW CONCEPTS (MKC)

ECE **2021-2022**

Course Code & Course Name	:	19ECC11 & Microwave Engineering
Year/Sem/Sec	:	III/V/A,B&C

S.No	Term	Notation (Symbol)	Concept/Definition/Meaning/Units/ Equation/Expression	Units
			Unit I - Guided Waves	
1	Wave guide	-	It is a hollow conducting metallic tube of uniform cross section used for propagating electromagnetic waves.	-
2	TE wave or H wave	-	Transverse electric (TE) wave is a wave in which the electric field strength E is entirely transverse. It has a magnetic field strength in the direction of propagation and no component of electric field in the direction of propagation.	-
3	TM wave or E wave	-	Transverse magnetic (TM) wave is a wave in which the magnetic field strength H is entirely transverse. It has electric field strength in the direction of propagation and no component of magnetic field in the direction of propagation.	-
4	TEM wave	-	The TEM waves are Transverse Electro Magnetic waves in which both electric and magnetic fields are transverse entirely but have no components in the direction of propagation. It is also referred to as the principal wave.	-
5	Parallel plane wave	-	Parallel plane wave guide consists of two conducting sheets separated by a dielectric	-

	guide		material.	
6	Quality factor	-	The quality factor Q is a measure of frequency selectivity of the resonator. It is defined as Q = 2 π x Maximum energy stored / Energy dissipated per cycle	-
7	Free- space medium	-	Free-space medium is one in which there are no conduction currents and no charges.	-
8	Maxwell's equations	-	$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$	-
9	Phase velocity	Vp	Phase velocity is defined as the velocity of propagation of equiphasic surfaces along a guide. Vp = ω / β	Vp (m/sec)
10	Group velocity	Vg	Group velocity (vg) is defined as the velocity with which the energy propagates along a guide. Vg = dω / d β	m/s
11	Dominant mode	-	The modes that have the lowest cut off frequency is called the dominant mode.	-
12	Dominant mode for TE waves	-	Dominant mode: TE10	-
13	Dominant mode for TM waves	-	Dominant mode: TM01	-
14	Characteristics of TEM waves	-	It is a special type of TM wave It doesn't have either e or H component Its velocity is independent of frequency Its cut-off frequency is zero.	-
15	Attenuation factor	-	Attenuation factor = (Power lost/ unit length)/(2 x power transmitted)	-
16	Wave impedance	-	Wave impedance is defined as the ratio of electric to magnetic field strength Zxy= Ex/ Hy in the positive direction	-

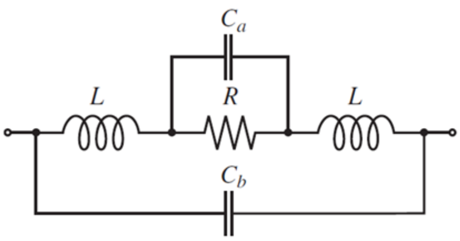
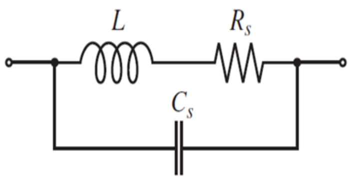
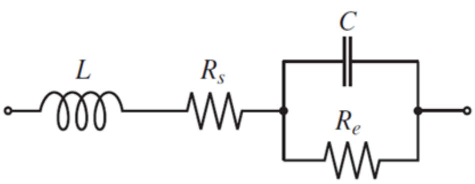
			Zxy= -Ex/ Hy in the negative direction	
17	Parallel plane wave guide	-	Parallel plane wave guide consists of two conducting sheets separated by a dielectric material.	-
18	Applications of wave guides	-	The wave guides are employed for transmission of energy at very high frequencies where the attenuation caused by wave guide is smaller. Waveguides are used in microwave transmission. Circular waveguides are used as attenuators and phase shifters.	-
19	Micro strip lines	-	A micro strip line consists of a single ground plane and a thin strip conductor on a low loss dielectric substrate above the ground plane.	-
20	Types of strip lines	-	• Parallel strip lines • Co-planar strip lines • Shielded strip lines.	-
21	Losses associated with micro strip line	-	• Dielectric loss in substrate • Ohmic loss in a strip conductor and the ground plane due to final conductivity. • Radiation loss.	-
22	Advantages of micro strip lines	-	• Small size and weight (ii) Increased reliability • Easy access for component mounting.	-
23	Disadvantages of micro strip lines	-	Micro strips cannot handle high power due to their smaller size. Radiation losses also occur in micro strip lines.	-
24	Relation between the attenuation factor for TE and TM waves	-	αTE =(fc/f)2	-
25	Minimum attenuation of TM mode	-	The attenuation of αTM reaches a minimum value at a frequency equal to √3 times the cut off frequency. f=√3 fc	-

Unit II - Waveguides				
26	Relation Between Vp & Vg	-	Relation Between Vp & Vg is Vp * Vg = C^2 Where C is free space velocity.	-
27	Impossible of TEM in rectangular waveguide	-	Since Transverse electromagnetic (TEM) wave do not have axial component of either E or H, it cannot propagate within a single conductor waveguide.	-
28	Wave Impedance for TE	ZTE	$Z = \frac{Z_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$	Ohms
29	Wave Impedance for TM	ZTM	$Z_{TM} = \eta\sqrt{1-\left(\frac{f_c}{f}\right)^2}$	Ohms
30	Wave Impedance for TEM	ZTEM	ZTEM = $\eta = \sqrt{\mu/\varepsilon}$ = 120π or 377 (for free space)	Ohms
31	Cut off frequency	fc	The frequency at which the wave motion ceases is called cut-off frequency of the waveguide.	Hertz
32	Evanescent mode	-	When the operating frequency is lower than the cut-off frequency, the propagation constant becomes real i.e., f0 < fc. The wave cannot be propagated. These non-propagating modes are known as evanescent mode.	-
33	Dominant mode	-	The modes that have the lowest cut off frequency are called as dominant mode.	-
34	Degenerate modes	-	Some of the higher order modes, having the same cutoff frequency are called as degenerate modes.	-
35	Dominant mode in Rectangular	-	The lowest mode for TE wave is TE10 (m=1 , n=0). The lowest mode for TM wave is	-

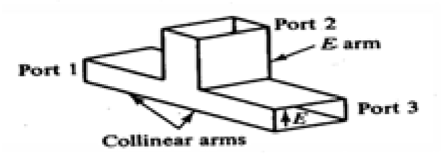
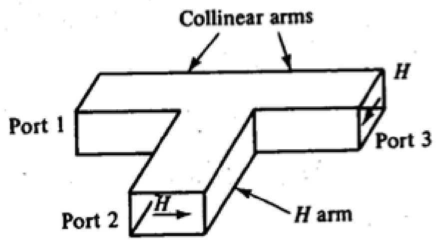
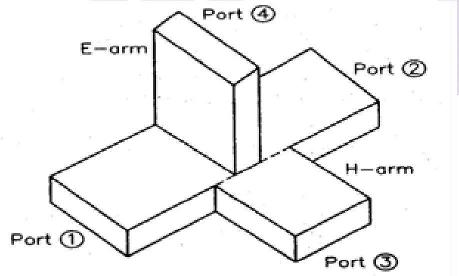
	wave guide		TM11 (m=1 , n=1)	
36	Rectangular waveguide	-	A rectangular waveguide is a conducting cylinder of rectangular cross section used to guide the propagation of waves.	-
37	Uses of Rectangular waveguide	-	Rectangular waveguide is commonly used for the transport of radio frequency signals at frequencies in the SHF band (3–30 GHz) and higher.	-
38	Transverse electromagnetic mode	-	In TEM mode, the electric and magnetic fields are transverse to the direction of wave propagation. EZ=0,HZ=0	-
39	Transverse electric mode	-	In TE mode, the electric field is transverse to the direction of wave propagation. EZ=0,HZ≠0	-
40	Transverse magnetic mode	-	In TM mode, the magnetic field is transverse to the direction of wave propagation. HZ=0, EZ≠0.	-
41	Hybrid mode	-	In HE mode, neither electric field nor magnetic field is transverse to the direction of wave propagation. EZ≠0, HZ≠0.	-
42	Cut off frequency	-	The operating frequency below which attenuation occurs and above which propagating takes place.	-
43	Cut off wavelength	-	Highest wavelength beyond which the wave is attenuated completely.	-
44	Dominant mode for the TE waves	-	The lowest mode for TE wave is TE10 (m=1 , n=0).	-
45	Dominant mode for the TM waves	-	The lowest mode for TM wave is TM11 (m=1 , n=1)	-
46	Phase velocity	-	The rate at which the wave changes its phase as the wave propagates inside waveguide.	-
47	Group velocity	-	The rate at which the wave actually propagate through the waveguide.	-
48	Velocity of light	-	The product of the phase and group velocity is square of velocity of light.	-
49	Guide wavelength	-	The distance travelled by the wave inside the waveguide to undergo a phase shift of 2pi radians.	-
50	Wave impedance	-	It is defined as the ration of electric field to the magnetic field strength.	-

Unit III - Two Port Network Theory				
51	Low frequency parameters	-	The parameters used to characterize the devices operating at low frequency are called as low frequency parameters.	-
52	List the Low frequency parameters	-	Z, Y, h and ABCD parameters are low frequency parameters.	-
53	S Parameter	-	It is Scattering (S) parameter and used to characterize the devices operating at high and RF frequencies.	-
54	Definition of S Parameter	-	It is defined as the ratio between normalized reflected wave (b) and normalized incident wave (a).	-
55	S matrix	-	It is a square matrix which gives all the possible combinations of power relationships between the various input and output ports of a Microwave junction.	-
56	Scattering Coefficients	-	The elements of S matrix are called as "Scattering Coefficients	-
57	Reciprocal Network	-	It is a network which satisfies reciprocity theorem.	-
58	Lossless Network	-	It is a network in which the output power is equal to input power and no loss occurs.	-
59	Two port Network	-	A network having only two ports is called as two port network.	-
60	S matrix of 'n'port network	-	$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ . \\ . \\ . \\ b_n \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & \dots & S_{1n} \\ S_{21} & S_{22} & S_{23} & \dots & S_{2n} \\ . & . & . & \dots & . \\ . & . & . & \dots & . \\ . & . & . & \dots & . \\ S_{n1} & S_{n2} & S_{n3} & \dots & S_{nn} \end{bmatrix} \times \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ . \\ . \\ . \\ a_n \end{bmatrix}$ **Column matrix** $[b]$ **Scattering matrix** $[S]$ **Matrix** $[a]$ [b] = [S] [a]	-

61	Properties of S parameter	-	Unitary property, Zero property and Symmetry property	-
62	Unitary property	-	For any lossless network the sum of the products of each term of any one row or of any column of the S matrix multiplied by its complex conjugate is unity	-
63	Zero property	-	For any lossless network the sum of the products of each term of any one row or of any column of the S matrix multiplied by the complex conjugate of any other row or any other column is zero.	-
64	Zero diagonal element	-	For an ideal N port network with matched terminations, there is no reflection from any port and the diagonal element of [S] are zero.	-
65	Need for S parameter	-	Non-availability of terminal voltage and current measuring equipments	-
66	Need for S parameter	-	Short circuit and open circuit are not easily achieved for wide range of frequencies.	-
67	Need for S parameter	-	Presence of active devices makes the circuit unstable for short or open	-
68	Q Factor	-	It is the measure of ability of an element to store energy and is equal to 2π times the average energy stored to that of the energy dissipated per cycle.	-
69	Types of Interconnection of networks	-	Serial, parallel and cascade connection	-
70	Symmetry of scattering matrix	-	|S| is a symmetric matrix when the microwave device has the same transmission characteristics in either direction of a pair of	-

			ports (Sij = Sji).	
71	Insertion loss	-	Insertion loss is a measure of the loss of the energy in transmission through a device compared to direct delivery of energy without the device.	-
72	Reciprocity theorem	-	This theorem states that when some amount of electromotive force (or voltage) is applied at one point (e.g., in branch k, Vk) in a passive linear network, that will produce a current at any other point (e.g., in branch m, Im). The same amount of current (in branch k, Vk) is produced when the same electromotive force (or voltage) is applied in the new location (in branch m, Im).	-
73	RF Equivalent circuit of resistor	-		-
74	RF Equivalent circuit of inductor	-		-
75	RF Equivalent circuit of capacitor	-		-
Unit IV - Microwave Devices and Generators				
76	Isolator	-	Isolator is a two port non-reciprocal device that provides low attenuation in the forward	

			direction and high attenuation in the reverse direction.	
77	Attenuator	-	Attenuator is a passive device which control or attenuate the amount of microwave power transferred from one port to another port.	
78	Phase shifter	-	A phase shifter is adevice that produces an adjustable change in the phase angle of the wave transmitted through it.	
79	Directional coupler	-	A directional coupler is a four-port device commonly used for coupling a known fraction of the microwave power to a port in the auxiliary line.	
80	Directivity of directional coupler	-	It is defined as the ratio of forward power Pf to the back power Pb and expressed in dB.	
81	Parameters of a directional coupler	-	Coupling co-efficient, Directivity, Insertion loss and Isolation.	
82	Types of directional coupler	-	• Two hole directional coupler • Four hole directional coupler • Reverse coupling directional coupler • Bethe hole directional coupler	
83	E plane Tee	-	It is a Tee junction in which the auxiliary arm extends from the main waveguide in the same direction as the E field of the waveguide.	

84	Structure of E plane Tee	-		-
85	H plane Tee	-	It is a Tee junction in which the auxiliary arm extends from the main waveguide in the same direction as the H field of the waveguide.	-
86	Structure of H plane Tee	-		-
87	Gunn effect	-	When the electric field is varied from zero to beyond a threshold value of 3000 V/cm, the carrier drift velocity is decreased and high frequency oscillations are generated in compound materials.	
88	Structure of Magic Tee	-		-
89	Materials exhibiting Gunn Effect	-	Gallium arsenide, Indium phosphide, Cadmium telluride and Indium arsenide	-
90	Klystron	-	A klystron is a vacuum that can be used either as a generator or as an amplifier of	

			power at microwave frequencies.	
91	Operating Principle of Klystron	-	Klystron tubes are operated by the principles of velocity or current modulation.	
92	Two-cavity klystron	-	It is a klystron amplifier which consists of two cavities called as buncher cavity and catcher cavity.	
93	Efficiency of two-cavity klystron	-	The efficiency of the two-cavity klystron amplifier is defined as the ratio of RF output power to the dc beam power.	
94	Reflex klystron	-	Reflex klystron is an oscillator with a built-in feedback mechanism.	
95	Travelling wave tube	-	Travelling wave tube (TWT) is a broad band microwave amplifier that uses a helix slow wave non-resonant microwave guiding structure.	-
96	Magnetron	-	A magnetron is a M-type microwave tube used to generate high microwave power.	-
97	Principle of operation of Magnetron	-	Magnetron is a high-powered vacuum tube that generates microwaves using interaction of a stream of electrons with a magnetic field in which the electrons emitted from cathode are moved in curved path between cathode and an anode	-
98	Coaxial magnetron	-	Coaxial magnetron is a magnetron composed of an anode resonator structure surrounded by an inner-single, high-Q cavity which is	-

			operating in the TE011 mode.	
99	Voltage-tunable magnetron	-	The voltage-tunable magnetron is a broadband oscillator in which the frequency is changed by varying the applied voltage between the anode and sole.	-
100	Applications of Reflex Klystron	-	• Radio receivers • Parametric amplifiers • Local oscillators of microwave receivers • As a signal source with variable frequency	-
Unit V - Microwave Measurements				
101	VSWR meter	-	A VSWR meter is a sensitive high gain, high Q, low voltage amplifier used to measure the VSWR.	-
102	Power meter	-	Power meter is an instrument that is designed to process the microwave input and to represent the power level on a calibrated scale.	-
103	Bolometer	-	Bolometer is a power sensor whose resistance changes with temperature as it absorbs microwave power.	-
104	Spectrum analyzer	-	A spectrum analyzer is a broadband super heterodyne receiver which provides a plot of amplitude versus frequency of the received signal.	-
105	Network analyzer	-	Network analyzer is an instrument which measures both amplitude and phase of a signal over a wide frequency range within a reasonable time.	-
106	Impedance measurement methods	-	Slotted line method and Reflectometer method.	-

107	Reflection coefficient	γ	The ratio of electric field strength of reflected and incident wave is called the reflection coefficient.	-
108	Loss tangent	δ	Loss tangent is the ratio of power dissipated to the power stored per cycle.	-
109	Direct microwave measuring instrument	-	Vector network analyzers, Spectrum analyzers and Power meters.	-
110	Measure of Loss tangent	-	It is a measure of energy loss in the form of heat when a wave is propagated through the material or medium.	-
111	Barretter	-	Barretter is a short thin metallic wire sensor which has a positive temperature coefficient of resistance.	-
112	Thermistor	-	Thermistor is a semiconductor sensor which has a negative temperature coefficient of resistance and can be easily mounted in microwave lines.	-
113	Wave meter or frequency meter	-	A typical wave meter is a cylindrical cavity with a variable short circuit termination which changes the resonance frequency of the cavity by changing the cavity length.	-
114	Power	P	Power is defined as the quantity of energy dissipated or stored per unit time.	W
115	Range of microwave power	-	✓ Low power (less than mW) ✓ Medium Power (from 10mW to 10W) ✓ High Power (greater than 10W)	-
116	Power sensors used in the power	-	Schottky barrier diode, Thermocouple, Bolometer	-

	meter			
117	Low VSWR	-	Values of VSWR not exceeding 10 are easily measured directly on the VSWR meter and are called as low VSWR.	-
118	Technique to find High VSWR	-	Double minimum method	-
119	Methods used to measure the dielectric constant	-	Waveguide method and Cavity perturbation method.	-
120	Causes of Insertion Loss	-	Mismatch loss at the input. Attenuation loss through the device. Mismatch loss at the output.	-
121	Attenuation	α	Attenuation is the gradual loss in intensity of power through a medium.	-
122	Various Forms of Q	-	Unloaded Q (Qu). Loaded Q (QL). External Q (QE)	-
123	Slotted line carriage	-	A slotted line carriage contains a coaxial E field probe which penetrates inside a rectangular waveguide slotted section or a coaxial slotted line section from the outer wall and is able to traverse a longitudinal narrow slot.	-
124	Thermocouple sensor	-	A thermocouple sensor is a junction of two dissimilar metals or semiconductors. It generates an emf when two ends are heated	-

			up differently	
125	Dielectric constant	k	Dielectric constant is defined as the ratio of permittivity of a substance to the permittivity of a free space	-
Placement Questions				
126	Range of frequencies in waveguides	-	The waveguides are operated in the Ghz range. In particular, the waveguides are active above 6 Ghz the range goes up to several tens of Ghz Beyond this range, the transmission is handled by optic fibre cables.	-
127	Cut off frequency in waveguides	-	The waveguides should be operated above the cut off frequency of 6 Ghz This will lead to effective power transmission. At a frequency below this, will lead to attenuation.	-
128	Range of frequencies in coaxial cable	-	Coaxial cables are operated in the MHz range. The main application includes television cable line transmission.	-
129	The phase velocity in wave guide	-	In air medium, the phase velocity is assumed to be the speed of light. For waveguides, the phase velocity is always greater than the speed of the light	-
130	Parameter of rectangular waveguide	-	In rectangular waveguide, a parameter is the broad wall dimension of the waveguide and the b parameter is the side wall dimension of -the waveguide. Always, a > b in a waveguide.	-
131	Rectangular hollow waveguide	-	a rectangular hollow waveguide can propagate both TE and TM modes of propagation. But due the presence of only one conductor, rectangular waveguide does not support the propagation of TEM mode.	-
132	Propagation in rectangular waveguide	-	Both TE and tm modes of propagation in rectangular waveguide have certain separate and specific cut off frequencies below which propagation is not possible. Hence propagation of signal occurs above the cut off frequency.	-
133	Lowest mode of TM wave	-	The field components for other lower modes of propagation in TM mode disappear for other lower modes of propagation. Hence, the lowest mode of propagation is TM11 mode.	-

134	Rectangular waveguide in TE_{00} mode	-	The field expressions for TE_{00} mode disappears or becomes zero theoretically. Hence, TE_{00} mode does not exist.	-
135	Cut off wavelength	-	Highest wavelength beyond which the wave is attenuated completely.	-
136	List the Low frequency parameters	-	Z, Y, h and ABCD parameters are low frequency parameters.	-
137	Definition of S Parameter	-	It is defined as the ratio between normalized reflected wave (b) and normalized incident wave (a).	-
138	Reciprocal Network	-	It is a network which satisfies reciprocity theorem.	-
139	Lossless Network	-	It is a network in which the output power is equal to input power and no loss occurs.	-
140	Transducer power gain	-	Transducer power gain is defined as the ratio of power delivered to the load to that of the power from the source.	-
141	Need for S parameter	-	✓ Non-availability of terminal voltage and current measuring equipments. ✓ Short circuit and open circuit are not easily achieved for wide range of frequencies. ✓ Presence of active devices makes the circuit unstable for short or open	-
142	E-H tee	-	It is a Tee junction constructed by E plane tee and H plane tee which are perpendicular to each other.	-
143	Directivity of directional coupler	-	It is defined as the ratio of forward power Pf to the back power Pb and expressed in dB.	-
144	Parameters of a	-	Coupling co-efficient, Directivity, Insertion loss and Isolation.	-

	directional coupler			
145	Applications of Reflex Klystron	-	• Radio receivers • Parametric amplifiers • Local oscillators of microwave receivers • As a signal source with variable frequency	-
146	Principle of operation of Magnetron	-	Magnetron is a high-powered vacuum tube that generates microwaves using interaction of a stream of electrons with a magnetic field in which the electrons emitted from cathode are moved in curved path between cathode and an anode	-
147	Spectrum analyzer	-	A spectrum analyzer is a broadband super heterodyne receiver which provides a plot of amplitude versus frequency of the received signal.	-
148	Network analyzer	-	Network analyzer is an instrument which measures both amplitude and phase of a signal over a wide frequency range within a reasonable time.	-
149	Low VSWR	-	Values of VSWR not exceeding 10 are easily measured directly on the VSWR meter and are called as low VSWR.	-
150	VSWR meter	-	A VSWR meter is a sensitive high gain, high Q, low voltage amplifier used to measure the VSWR.	-

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