Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NECC509	Microwave Measurements	3	1	0	4

Course Objective

The course aims to present the different techniques for measurement and characterization of circuits and antennas for applications in the microwave frequency bands. The student will basically learn how to select the most appropriate instruments and components to organize a measurement setup for a given circuit/microwave property. Moreover, he/she will be able to conduct autonomously some standard measures.

Learning Outcomes

Upon successful completion of this course, students will:

- Understanding of setup the basic and some advanced microwave measurement setup for the characterization of active and passive devices.
- have idea to find the permittivity and permeability of unknown materials.
- be able to understand the working of different instruments like Vector Network Analyzer, Spectrum Analyzer, Power Meter, etc.
- be able to measure the different antenna parameters.

Module No.	Topics to be Covered	Contact Hours	Learning Outcome
1	Review of measurement and instrumentation basics, Permittivity measurement (two-point method, cavity perturbation method, etc.), Permeability measurement, Measurement of Q factor (Loaded, unloaded and External Q factor), transmission line methods and resonance methods).	12+4T	Understanding of microwave test bench setup and measurements of different material parameters such as permittivity and permeability. Idea to find out the Q-factor and its mathematical analysis.
2	Impedance (Double minima method, Smith Chart, Byrne Bridge, directional coupler method, Probe method), frequency and phase measurement, VSWR and power measurement	10L+4T	This unit will help student in understanding the Impedance calculation through Smith Chart. Furthermore, student will also learn the frequency, power and phase measurements.
3	Antenna measurement (Far Field measurement, Gain measurement, return loss and VSWR measurement).	8L+2T	Students will familiarize with different parameters of antenna and also learn the measurement setup to measure these parameters.
4	Vector network analyzer (VNA), Calibration techniques, passive and active circuit characterization using network analyzer, Spectrum analyzers, characteristic of spectrum analyzer.	12L+4T	Student will familiarize the working mechanism through internal structure of different state of art instruments. Understanding of relevant mathematical modelling with respect to these instruments.
	Total	**42L+14T**	

Text Books:

1. Handbook of Microwave Measurements, by Max Sucher, Jerome Fox, Volume: I, II, III, 1963.

Reference Books:

1. Electronics Measurements by Terman & Pettit, 2nd edition, 1952.
2. Dielectric Materials and Applications by A. R. Von Hippell, 1995.
3. Practical Radio frequency test and Measurement by Joseph J. Carr, 1st edition, 2002.
4. David Pozar, Microwave Engineering, 3rd edition, (Wiley, 2005).
5. Technical Notes/Application Notes of various devices