JABALPUR ENGINEERING COLLEGE, JABALPUR (MP)
(An Autonomous Institute of Govt. of M.P.)
Affiliated to Rajiv Gandhi Technological University, Bhopal (MP)
Scheme of Study and Examination (w.e.f. July 2010)

M.E. II Sem. Branch : E & C Engg. Specialization : Microwave Engineering

Course Code	Subject	Periods			EVALUATION SCHEME					Credits
					SESSIONAL EXAM			ESE	SUB TOTAL	
		L	T	P	TA	CT	TOT			
EC-120	MIC and MMIC Design	3	1	-	10	20	30	70	100	4
EC-121	EMI and EMC Techniques	3	1	-	10	20	30	70	100	4
EC-122	Microwave Networks and Measurements	3	1	-	10	20	30	70	100	4
	Elective – I (Any One)									
EC-123A	Analytical and Computational Techniques in Electromagnetics	3	1	-	10	20	30	70	100	4
EC-123B	Microwave Communication & System									
	Elective - II (Any One)									
EC-124A	Radar Signature Analysis and Imaging	3	1	-	10	20	30	70	100	4
EC-124B	Phased Array Radar									
(PRACTICAL/DRAWING/DESIGN)										
EC-125L	Microwave Lab	-	-	2	60	-	60	90	150	6
EC-126L	Minor Project - II	-	-	2	60	-	60	90	150	6
	Total	**15**	**5**	**4**	**170**	**100**	**270**	**530**	**800**	**32**

T.A. Teachers Assessment, CT- Class Test, ESE - End Semester Examination, Total Marks 800
Total Periods : 24 Total Credits : 32

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	MIC & MMIC DESIGN	EC-120	Min "D"	Min "D"	5.0

MIC and MMIC Design

UNIT-I. Basic concepts of microwave integrated circuits: Wave propagation and circuit theory, transmission lines, planar circuits, Analytical methods associated with MIC theory, Passive elements, components and devices: Filters, couplers, circulators, isolators, antenna elements,

UNIT-II. Technology of hybrid MICs. Design of MIC components- transitions, couplers, filters Power dividers, oscillators, modulators, phase shifters & amplifiers .Analysis of basic transmission lines for millimeter wave frequencies-Integrated fin line , insulted image guide, trapped guide, non- radiative guide, groove guide.Transitions, bends and discontinuities at MM waves .Measurement techniques. Design of millimeter wave components, couplers, power dividers, filters, oscillators, switches, phase shifters and amplifiers

UNIT-III . Ferrimagnetic substrates and inserts, Microstrip circulators, Phase shifters, Microwave transistors, Parametric diodes and amplifiers, PIN diodes, Transferred electron devices, Avalanche diodes, IMPATT, BARITT devices. Introduction, Impedance transformers, Filters, High power circuits, Low power circuits, MICs in Radar and satellite.

UNIT-IV Fabrication process of MMIC, Hybrid MICs, Dielectric substances, Thick film and thin film technology and materials, Testing methods, Encapsulation and mounting of devices.**UNIT-V**.

UNIT- V. Measurement in MIC media, MIC test system, System applications of MICs: Radio system, satellite communication, Broadcast system, Future trend in MICs.

TEXT BOOKS

1. Hoffman R.K "Hand Book of Microwave Integrated Ciruits", Artech House, Boston, 1987
2. Gupta K.C and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975

REFERENCES

1. Ivan Kneppo, Kluwer , "Microwave Integrated Circuits".
2. Yoshihiro Konishi CRC press, "Microwave Integrated Circuits"

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	EMI & EMC TECHNIQUES	EC-121	Min "D"	Min "D"	5.0

EMI and EMC Techniques

UNIT- I BASIC CONCEPTS
Definition of EMI and EMC with examples, Classification of EMI/EMC - CE, RE, CS, RS, Units of Parameters, Sources of EMI, EMI coupling modes - CM and DM, ESD Phenomena and effects, Transient phenomena and suppression.EMP

UNIT- II EMI MEASUREMENTS
Basic principles of RE, CE, RS and CS measurements, EMI measuring instruments- Antennas, LISN, Feed through capacitor, current probe, EMC analyzer and detection t6echnique open area site, shielded anechoic chamber, TEM cell.

UNIT-III EMI CONTROL METHODS AND FIXES
Shielding, Grounding, Bonding, Filtering, EMI gasket, Isolation transformer, opto isolator.

UNIT-IV EMC STANDARD AND REGULATIONS
National and Intentional standardizing organizations- FCC, CISPR, ANSI, DOD, IEC, CENEEC, FCC CE and RE standards, CISPR, CE and RE Standards, IEC/EN, CS standards, Frequency assignment - spectrum conversation.

UNIT-V EMC DESIGN AND INTERCONNECTION TECHNIQUES
Cable routing and connection, Component selection and mounting, PCB design- Trace routing, Impedance control, decoupling, Zoning and grounding

TEXT BOOKS

1. Prasad Kodali.V–Engineering Electromagnetic Compatibility,S.Chand&Co –New Delhi – 2000
2. Clayton R.Paul – Introduction to Electromagnetic compatibility – Wiley & Sons – 1992

REFERENCES
1. Keiser – Principles of Electromagnetic Compatibility – Artech House – 3rd Edition – 1994
2. Donwhite Consultant Incorporate – Handbook of EMI / EMC – Vol I - 1985
3. EMC Analysis Methods & Computational Models-Frederick M Tesche, Michel V.lanoz, Torbjorn Karlsson(John Willey & Sons, Inc)
4. EMI/EMC Computational modeling Hand Book- by Archambelt.
5. Electrostatic Discharge In Electronics-Willian D.Greason(John Wiley & Sons, Inc).
6. The ARIAL RFI Book-Hare,WIRFI published by-The American Radio Relay League Newington.
7. Applied Electromagnetic Compatibility-Dipak L Sengupta & Valdis V Liepa(John Wiley & Sons Inc).

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	MICROWAVE NETWORKS AND MEASUREMENTS	EC-122	Min "D"	Min "D"	5.0

MICROWAVE NETWORKS AND MEASUREMENTS

Part I: Microwave Network

UNIT-I. Impedance and Equivalent Voltages and Currents, Foster's Reactance Theorem, Impedance and Admittance Matrices, Scattering Matrix, Transmission(ABCD\ Matrix.

UNIT-II. Signal Flow Graphs, Discontinuities and Modal Analysis, Excitation of Waveguides-Electric and Magnetic Currents, Excitation of Waveguides-Aperture Coupling.

Part II: Microwave Measurement.

UNIT-III. Power Measurement- High Power Measurement, calorimeter technique, Low power Measurement, bolometer technique, Very Low Power Measurement. Frequency Measurement - Different Technique to measure frequency, Slotted Line Technique, maxima & minima, wavelength & frequency measurement. Dielectric constant measurement of a solid using waveguide, Slotted line VSWR measurement, VSWR through return loss measurements

UNIT-I V. Impedance Measurement- Measurement of unknown load impedance of a transmission line, Slotted Line Technique to measure unknown impedance. Distortion & Frequency Translation Measurement- Different types of distortion occurred at microwave frequencies, Procedures for frequency translation. Detectors& Sensors: Definition of Detectors; Different type of microwave detectors functions and applications, Sensors: Definition & working principle, applications.

UNIT-V. Vector Network Analyzer (VNA): Concept of vector network analyzer, measurement of Scattering parameters, Basic block diagram of vector network analyzer (VNA), Application of vector network analyzers. Scalar Network Analyzer (SNA): Definition of network analyzer, Difference between SNA&VNA, Basic block diagram Scalar Network Analyzer.

Spectrum Analyzer: Basic block diagram of a spectrum analyzer, functions & applications of a spectrum analyzer. Time Domain Electrometer (TDR) & IC Technology: Introduction to Electrometer, Measurement of reflection coefficient using electrometer technique, Basic block diagram of a time domain electrometer.

References:

1. G.H.Bryant- Principles of Microwave Measurements- Peter Peregrinus Ltd.
2. D.Pozar- Microwave Engineering, 2nd Ed, John Wiley
3. T.S.Laverghetta- Hand book on Microwave Testing
4. S.F.Adam- Microwave Theory & Application- Prentice Hall, Inc
5. HP Application Notes
6. A.E. Bailey, Ed. Microwave Measurements- Peter Peregrinus Ltd
7. M. Engelson-Moder Spectrum Analyser: Theory & Applications Artech Hous
8. BOOKS:1. E.L. Giunzton, "Microwave Measurements", Mc Graw Hill Book Co. Inc. 1957.

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	ANALYTICAL AND COMPUTATIONAL TECHNIQUES IN ELECTROMAGNETIC	EC-123A	Min "D"	Min "D"	5.0

ANALYTICAL AND COMPUTATIONAL TECHNIQUES IN ELECTROMAGNETIC

UNIT-I. Basics of Scientific Computing and Overview of Computational Electromagnetics
Numerical error, convergence, interpolation, extrapolation, numerical integration, numerical differentiation, direct and iterative matrix equation solvers. CEM techniques, CEM modelling, CEM, the future.

UNIT-II. Finite Difference Method
Overview of finite differences, one dimensional FDTD, Obtaining wideband data using the FDTD, Numerical dispersion in FDTD simulations.
Finite Difference Time Domain Method in Two and Three Dimensions
2D FDTD algorithm, PML absorbing boundary condition, 3D FDTD algorithm, Commercial implementations.

UNIT-III. Finite Element Method
Variational and galerkin weighted residual formulations- Laplace equation, Simplex coordinates, high, frequency variational functional, Spurious modes, vector (edge) elements, application to waveguide eigenvalue analysis, three-dimensional Whitney element.

UNIT-IV. FDTD and Antenna Analysis

Antenna Characteristics: Antenna Fields and Radiation Patterns, Antenna Impedance. Motivation for Using FD-TD in Antenna Design. The Monopole Over a PEC Ground Plane: Modeling Considerations, Results. Waveguide and Horn Antennas: Two-Dimensional Horn Antenna, Three-Dimensional Waveguide Radiator. The Vivaldi Slotline Array:Background, The Planar Element, The Two-Element Vivaldi Pair, The Quad Element, The Linear Phased Array, Active Impedance of the Phased Array. Linear Superposition
UNIT-IV One-Dimensional Introduction to the Method of Moments
Electrostatic example, thin-wire electrodynamics and the methods of moments (MoM), more on basis functions, method of weighted residuals.

Text Book:
1. D. B. Davidson, "Computational Electromagnetics for RF and Microwave Engineering", Cambridge University Press, 2005.

References:
1. J. Jin, "The Finite Element Method in Electromagnetics", 2nd edition, Wiley, 2002.
2. Taflove and S. Hagness, "Computational Electrodynamics- The Finite Difference Method", Artech House, Third Edition, 2005.
3. F. Peterson, S. L. Ray, and R. Mittra,"Computational Methods for Electromagnetics", Wiley,IEEE Press, 1997.
4.Electromagnetic Simulation Using the FDTD Method, by Dennis M. Sullivan.Published by IEEE.
5. Weng Cho Chew, Mei Song Tong, Bin Hu "Integral Equation Methods for Electromagnetic and Elastic Waves" A Publication in the Morgan & Claypool Publishers series,2009

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	MICROWAVE COMMUNICATION & SYSTEMS	EC-123B	Min "D"	Min "D"	5.0

MICROWAVE COMMUNICATION & SYSTEMS

UNIT-I. Introduction to Microwave Communication:
Basic Concepts of Digital Microwave: Microwave Development, Microwave Evolution in the World, Characteristics of Digital Radio Communication System, Challenges and Opportunities for Digital Microwave Communication, Microwave Frequency Band Choice and RF Channel Arrangements, Digital Microwave Communication System Model, Digital Microwave Frame Structure.

UNIT-II. Digital Microwave Equipment:
Digital Microwave Equipment Classification, Microwave antenna and feeder, Outdoor unit (ODU), Indoor Unit, Installation and Adjustment of Split Microwave System.
Microwave System Networking and Application- Microwave System Typical Networking Modes and Station Types, Relay Station, Digital Microwave Application .

UNIT-III. Microwave Propagation Theory:
Electric Wave Propagation in Free Space, Influence of Ground Reflection on the Electric Wave Propagation, Influence of Troposphere on Electric Wave, Fading caused by Several Atmospheric and Earth Effects, Frequency Selective Fading, Statistic Feature of Fading.

UNIT-IV. Anti-Fading Technology in Digital Microwave Equipment:
Anti-Fading Measurements, Adaptive Equalization, Cross-Polarization Interference Counteracter (XPIC) Automatic Transmit Power Control (ATPC), Diversity Reception, Microwave Equipment Protection Mode, Interference and Main Methods against Interference.
Digital Microwave Engineering Calculation: Microwave Path Parameter Calculation, Calculation of Microwave Circuit Index.

UNIT-V. Microwave Engineering Design-
Requirement: Basic Requirement of Microwave Path and Cross-section Design, Selecting Microwave Band and Configuring Polarization, Technical Requirement of Digital Microwave Relay Communication Engineering Design.
Design: Route, Site and Antenna Height, Frequency Selection and Polarization Arrangement, Circuit Performance Estimate. SDH Microwave Circuit, SDH Microwave Site Type and Polarization Configuration, Calculation of PDH Microwave Circuit Indexes.
Precautions: Equipment Layout, Installation of Microwave Antenna, Process Requirement for the Tower.

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	RADAR SIGNATURE ANALYSIS & IMAGING	EC-124A	Min "D"	Min "D"	5.0

RADAR SIGNATURE ANALYSIS & IMAGING

UNIT –I Basics: Basic radar equation, range delay, velocity delay, Doppler effect, accuracy, resolution and ambiguity, Tradeoffs and penalties in waveform design, significance of matched filter in radar signal analysis-complex representation of band-pass signal, matched filter response to Doppler shifted signal.

UNIT – II : Basic radar signals- constant frequency pulse, linear frequency modulated pulse, costas frequency modulated pulse, nonlinear frequency modulation, phase coded pulse- barker code, chirp-like phase code, asymptotically perfect codes, Huffman code, bandwidth considerations in phase-coded ignals, multi carrier phase coded signal in radar signals. Diverse pulse repetition interval (PRI) pulse trains- introduction to moving target indication (MTI) radar, blind speed, MTI radar performance analysis, optimal MTI weights, diversifying the PRI.

UNIT – III Time & frequency Transforms :

Time-Frequency Transforms Linear Time-Frequency Transforms , Bilinear Time-Frequency Transforms.**Detection and Extraction of Signal in Noise** Time-Varying Frequency Filtering , SNR Improvement in the Time-Frequency, Domain, CFAR Detection in the Joint Time-Frequency Domain, Signal Extraction in the Joint Time-Frequency Domain.**Time-Frequency Analysis of Radar Range Profiles:** Electromagnetic Phenomenology Embedded in Back-Scattered Data , Time-Frequency Representation of Range Profiles, Application of High-Resolution Time- Frequency Techniques to Scattering Data , Extraction of Dispersive Scattering Features, from Radar Imagery Using Time-Frequency Processing.**Time-Frequency-Based Radar Image Formation:** Radar Imaging of Moving Targets, Standard Motion Compensation and Fourier-Based Image Formation, Time-Frequency-Based Image Formation, Radar Imaging of Maneuvering Targets, Radar Imaging of Multiple Targets.

Trends in Time-Frequency Transforms for Radar Applications: Applications of Adaptive Time-Frequency Transforms, Back-Scattering Feature Extraction, Image Formation, Motion Compensation, Moving Target Detection, Micro-Doppler Analysis.

UNIT IV-Radar Imaging: Wave Propagation in Two and Three Dimensions : ScalarWave Propagation, Basic Facts about theWave Equation . Introduction to Scattering Theory, The Born Approximation, The Incident Field, Model for the Scattered Field The Effect of Matched Filtering. **Synthetic-Aperture Radar :** Spotlight SAR, Stripmap SAR, Understanding SAR Images, The Effects of Discrete Slow Time Other Imaging Algorithms. **Inverse Synthetic-Aperture Radar:** The Far-Field Approximation, The Far-Field Expansion in the ScalarWave Born Approximation, Inverse Synthetic-Aperture Imaging. **Antennas:** Array Steering, Antenna Properties, Antennas in Imaging.

UNIT-V Radar Signal Processing: System fundamentals & Definitions as applied to radars, Signal integration,Correlation,Convolution,Spectrum Analysis,Fast Algorithms,Processing Errors Windows,Resolution,Digital Filter fundamentals,Doppler & MTI fundamentals & methods,Blind Doppler shifts & Staggering,De-staggering and Processing , CW,High PRF and Medium PRF Doppler Processing

References:

1. Byron Edde- RADAR-Priciples,Technology & Applications
2. M. Cheney, B. Borden.Fundamentals of Radar Imaging. The Society for Industrial and Applied Mathematics. (SIAM) 2009.
3. Victor C. Chen, Hao Ling Time-Frequency Transforms for Radar Imaging and Signal AnalysisArtech House2002

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	PHASED ARRAY RADAR	EC-124B	Min "D"	Min "D"	5.0

PHASED ARRAY RADAR

UNIT-I. Phased Arrays in Radar and Communication Systems : System requirements for radar and communication antennas, Array characterization for radar and communication systems, Fundamental results from array theory, Array size determination, Time-delay compression.

UNIT-II. Pattern characteristics of Linear and Planar Arrays : Array analysis, characteristics of linear and planer arrays, Scanning to endfire, Thinned arrays. **Pattern Synthesis for Linear and Planar Arrays** : Linear arrays and planar arrays with separable distributions, circular planar arrays and adaptive arrays.

UNIT-III. Electronic Scanning Radar Systems : Frequency and phase scanning, Phase design techniques.

UNIT-IV. : **Introduction to Stealth Systems:** Introduction, Introduction to low probability of intercept systems, A little history of stealth systems, Basic LPI equations, Introduction to radar cross-section, Introduction to signature balance.

Interceptability Parameters and Analysis- Interceptability parameters, Interceptability analysis, Example mode interceptability, Footprint calculation.

Stealth Waveforms-Waveform criteria, Frequency diversity, Power management, Pulse compression, Discrete phase codes, Hybrid waveforms, Noise propagation in pulse compressors

UNIT-V. Stealth Antennas and Radomes: Introduction, Antenna parameters, Single radiators, Antenna arrays, Electronically scanned arrays, Antenna scattering, Low RCS radomes

Signal Processing for Stealth: Introduction to stealth signal processing, Air target search, acquisition, track, Terrain following/terrain avoidance, Doppler beam sharpening, Synthetic aperture radar (SAR) mapping, Ground MTI and MTT

Text Books :

1. Phased Array Antenna Hand Book – Robert J. Mailloux, Artech House, Boston, London,1994.
2. Radar Engineering Hand Book – Skolnic, McGraw Hill, 1970
3. Introduction to RF Stealth by David Lynch, Jr., Scitech Publishing Inc., 2003.,www.scitechpub.com

Reference Books :

1. Electronic Scanning Radar Systems Design Hand Book – Peter J. Kahrilas, Artech House, 1976

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COURSE CONTENT & GRADE (w.e.f. July 2010)

Branch	Subject Title	Subject Code	Grade for End Sem		CGPA at the end of every even semester
			T	P	
	MICROWAVE LAB	EC-125L	Min "D"	Min "D"	5.0

MICROWAVE LAB

The exercises in this component shall be designed to demonstrate the basic principles outlined in different units of the theory paper. After completing the exercises the student should have developed a good grasp of the practical utilities of the theory content.

(Suggested Exercise)

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COURSE CONTENT & GRADE (w.e.f. July 2010)

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			T	P	
	MINOR PROJECT - II	EC-126L	Min "D"	Min "D"	5.0

MINOR PROJECT – II

The exercises in this component shall be designed to demonstrate the basic principles outlined in different units of the theory paper. After completing the exercises the student should have developed a good grasp of the practical utilities of the theory content.

(Suggested Exercise)