M Tech
in
Electronics and Communication Engineering (Microwaves)

SYLLABUS

Department of Physics
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THE UNIVERSITY OF BURDWAN

Syllabus for M Tech in Electronics and Communication Engineering (Microwaves)

Course Structure

Semester	Topic	Marks	Credits
1st Sem (6 months)	Theoretical and Practical	450	22
2nd Sem (6 months)	-do-	450	22
3rd Sem (6 months)	Project I	200	16
	Term Paper/ Minor Elective from AICTE Approved Departments	50	02
	Research Methodology and IPR	50	02
4th Sem (6 months)	Project II	300	18
	Grand Viva Voce	100	04
Total (2 years)		**1600**	**86**

Distribution of Marks for the entire M Tech Programme

University Examination :	
Theory	650
Viva Voce on Laboratory works	100
Project Work	500
Term Paper/ Minor Elective from AICTE Approved Departments	50
Grand Viva Voce	100
Continuous Assessment :	
Theory	80
Practice	120
Total full marks for 2 years M Tech	**1600**

Comprehensive Course Structure

Semester	Topic	Marks	Credits
1st Sem (6 months)	Theoretical and Practical	360	18
	Seminar	40	02
	Viva Voce on Practical	50	02
2nd Sem (6 months)	Theoretical and Practical	360	18
	Seminar	40	02
	Viva Voce on Practical	50	02
3rd Sem (6 months)	Project I	200	16
	Term Paper/ Minor Elective from AICTE Approved Departments	50	02
	Research Methodology and IPR	50	02
4th Sem (6 months)	Project II	300	18
	Grand Viva Voce	100	04
Course duration – 2 years, Total		**1600**	**86**

Besides holding University examinations for the Semester-wise papers, students are assessed regularly by the teachers of the course during the Semesters I and II and marks are allotted in this regard under a head termed as "Continuous Assessment". The topic wise distribution of marks for the entire M Tech programme may be shown as under:

<u>Programme Outcome</u>

To produce skilled manpower for

- Research and Development sectors and industries related to Electronics & Telecommunication Engineering (Microwaves) and allied fields.
- Academic institutions and organizations.
- Entrepreneurship, startup programmes and consultancy.

Detailed Course Structure

Semester I

Paper Code	Paper	Credit	Marks			Total Marks
			Continuous Assessment		Univ. Exam	
			Theory	Practice		
MW 101	Advanced Electromagnetic Engineering (L=2, T=1, P=1)	03	05	05	50	60
MW 102	Microwave & mm Wave Circuits (L=2, T=1, P=1)	03	05	05	50	60
MW 103	Microwave & mm Wave Vacuum and Solid State Devices (L=2, T=1, P=1)	03	05	05	50	60
MW 104	Antenna and Radio Wave Propagation (L=2, T=1, P=1)	03	05	05	50	60
MW 105	Digital Signal Processing (L=2, T=1, P=1)	03	05	05	50	60
MW 106	Communication Theory (L=2, T=1, P=1)	03	05	05	50	60
MW 107	Seminar-I (L=0, T=0, P=2)	02	10	30	-	40
MW 108	Comprehensive Viva Voce on Practical's-I	02	-	-	50	50
	TOTAL	**22**	**40**	**60**	**350**	**450**

Semester II

Paper Code	Paper	Credit	Marks			Total Marks
			Continuous Assessment		Univ. Exam	
			Theory	Practice		
MW 201	Computational Electromagnetics (L=2, T=1, P=1)	03	05	05	50	60
MW 202	Microwave & mm Wave Measurements (L=2, T=1, P=1)	03	05	05	50	60
MW 203	Microwave & mm Wave Communication Systems (L=2, T=1, P=1)	03	05	05	50	60
MW 204	Radar, Remote Sensing and Navigational Technique (L=2, T=1, P=1)	03	05	05	50	60
(ANY ONE) MW 2051/ MW 2052/ MW 2053	Optional Elective-I (L=2, T=1, P=1) Microwave & mm Wave Device, Circuit and System Modeling/ Advanced Antenna Engineering/ Gyrotron Technology	03	05	05	50	60
(ANY ONE) MW 2061/ MW 2062	Optional Elective-II (L=2, T=1, P=1) Light Wave Technology/ Microwave Photonics	03	05	05	50	60
MW 207	Seminar-II (L=0, T=0, P=2)	02	10	30	-	40
MW 208	Comprehensive Viva Voce on Practical's-II	02	-	-	50	50
	TOTAL	**22**	**40**	**60**	**350**	**450**

Seminar (MW 107 and MW 207):

Each student in Semesters I and II is required to deliver one seminar per week on any of the topics suggested by the department having 15 minutes for presentation and 5 minutes for discussion. The internal teachers of the course will evaluate the performance of the students. Such evaluations will be termed as "Continuous Assessment".

Course Outcome for MW 107 and MW 207:

- To become able to design and prepare a presentation on assorted technical topics
- To gain the communication skill and confidence to present a topic before the audience
- To gain the skill on technical report writing

Comprehensive Viva Voce on Practical's (MW 108 and MW 208):

Students will be examined by a board of examiners on the practical training performed and the laboratory report during each of the semesters I and II.

Course Outcome for MW 108 and MW 208:

The skill and knowledge gained through practical training (includes design, simulation, fabrication and T&M) would be estimated.

Semester III

Paper Code	Paper	Credit	Marks	
			Univ. Exam	**Total**
MW 301	Project I	16	200	200
MW 302	Term Paper/ Minor Elective from AICTE Approved Departments	02	50	50
MW 303	Research Methodology and IPR ***May be opted from SWAYAM (https://swayam.gov.in/)***	02	50	50
	TOTAL	**20**	**300**	**300**

Semester IV

Paper Code	Paper	Credit	Marks	
			Univ. Exam	**Total**
MW 401	Project II	18	300	300
MW 402	Grand Viva-Voce	04	100	100
	TOTAL	**22**	**400**	**400**

MW 301 and MW 302: Project I and Term Paper/ Minor Elective from AICTE Approved Departments:

The entire third and fourth semesters of one year duration are assigned for the project works at different institutions and laboratories of repute within the country including Burdwan University.

Examinations for MW 301 will be held at the end of semester III. For Project I, a student has to submit a mid-term project report and to appear in a mid-term project viva voce. It would consist of a presentation and viva-voce examination.

For MW 302, the students would be assigned individual topics related to course curriculum. At the end of the semester, they have to submit a report on the topic and, to deliver and defend a presentation/ They have to select the Minor Elective Paper from other AICTE Approved Departments of this University.

MW 401 and MW 402: Project II and Grand Viva-Voce

Examinations for MW 401 will be held at the end of semester IV after the completion of the project work. In semester IV examination, a student has to submit the final dissertation based on the total project works carried out along with a presentation.

A student has to appear before a board of examiners at the end of Semester IV, for a grand viva-voce examination covering the entire course curriculum.

Course Outcome for MW 301 and MW 401:

- Students will have the experience of working in any one laboratories of repute in our country like CSIR-CEERI, Rajasthan, NPL, New Delhi; MTRDC, Bangalore, SAC, ISRO etc. including The University of Burdwan.
- Students will gain an experience on working on research topics/ application domain extensively of one-year duration

Course Outcome for MW 302:

- Students will have to undergo a self-study-based activity for the entire semester
- Would acquire knowledge on the allotted topic

Course Outcome for MW 402:

Students would gain an idea about how far he/ she has learned during the two-year study of M Tech in Electronics & Communication Engineering (Microwaves).

Detailed Syllabus (Theory Papers)

MW 101 (Advanced Electromagnetic Engineering)

Electromagnetic potentials; Poisson’s equations in scalar and vector potentials; propagation of electromagnetic waves in dielectric and conducting medium; Gauge transformation; Lorentz condition; Lorentz Gauge; rectangular and co-axial wave guides; application of Green function in electromagnetics, Liénard–Wiechert potential; Rayleigh scattering; relativistic electrodynamics: Gallilean and Lorentz transformations; Length contraction; time dilation; 4-D space; 4-D length; 4-D velocity and 4-D acceleration; basic electromagnetic equations in 4-D space; electromagnetic field tensor, Maxwell’s field equations in 4-D space using electromagnetic field tensors.

Electromagnetic theory and special theory of relativity.

Recommended Books:

1. J. Kraus and D. Fleisch, *Electromagnetics with Applications*, McGraw Hill Education
2. M. N. O. Sadiku and S. V. Kulkarni, *Principles of Electromagnetics,* Oxford University Press
3. C. A. Balanis, *Advanced Engineering Electromagnetics,* Wiley India Pvt Ltd
4. J. A. Stratton, *Electromagnetic Theory*, MGH
5. Panofsky and Philips, *Classical Electrodynamics*, Adison Wiesley Publishing Company Ltd
6. Jordan and Balmain, *Electromagnetic Waves and Radiating Systems*, PHI
7. R. F. Harrington, "*Time-Harmonic Electromagnetic Fields*", Wiley

Course Outcome:

- To gain the analytical skill on Electromagnetic Theory
- To become able to apply the knowledge in EM design problems

MW 102 (Microwave & mm Wave Circuits)

Network theorem at microwave frequencies; Foster's reactance theorem.
Transmission line theory: lumped element circuit model; the telegrapher equations; terminated lossless transmission line; generator and load mismatches; lossy transmission lines.

Microwave network analysis: the scattering matrix; the transmission matrix; ABCD matrix techniques; signal flow graph.

Smith chart: Impedance and admittance Smith chart; applications.

Waveguides; coaxial line; stripline; microstrip; wave velocities and dispersion; excitation of waveguides; coplanar waveguides; microstrip bends and discontinuities.

Impedance matching and tuning: matching with lumped elements; single-stub tuning; double stub tuning; the quarter wave transformer; theory of small reflections; binomial and Chebyshev matching transformer; tapered lines; the Bode-Fano criterion.

Microwave resonators: series and parallel resonant circuits; loaded, unloaded and external Q, transmission line resonators; waveguide cavities; dielectric resonators; stepped impedance resonators; excitation of resonators.

Elements of microstrip coupled lines: introduction; analysis methods; introduction to multi conductor transmission line.

Planner microwave components: power dividers and couplers; branch line coupler; rat race hybrid coupler.

Microwave filters synthesis and design.

RF behavior of passive components; microwave lumped elements: basic lumped elements; model extraction; scalable models.

Ferrite materials and non-reciprocal circuit components.

Recommended Books:

1. A. Das and S. K. Das, *Microwave Engineering*, McGraw Hill Education.
2. S. Das, *Microwave Engineering*, Oxford University Press.
3. K. C. Gupta, *Microwaves*, New Age International
4. N. Marcuvitz, *Waveguide Handbook*, McGraw-Hill Book Company Inc
5. K. Kurokawa, *An Introduction to the Theory of Microwave Circuits*, Academic Press

Course Outcome:

- Understanding on microwave & mm Wave passive circuits and systems
- Expertise on analysis, design, simulation, fabrication and measurement of passive microwave and mm-wave circuits

MW 103 (Microwave & mm Wave Vacuum and Solid State Devices)

RF and Microwave tubes:

Vacuum tube microwave device physics: Beam field interaction; power frequency limitation, device size limitations; special features of microwave tubes.

Non relativistic electron tubes: Parallel field type – Klystron, Reflex Klystron, Helix TWT, coupled cavity TWT, Twystrons; Crossed field type – magnetrons, FWCFA, carcinotron.

Relativistic electron tubes: gyrotrons; free electron LASER.

RF and Microwave Devices:

Diodes; high-frequency equivalent circuit; Schottky barrier diode; varactor diode; PIN diode; Applications.

Tunnel diodes; Impact ionization; IMPATT and other related diodes; small-signal analysis and model of IMPATT diode; TRAPATT; BARRITT.

Transferred electron devices; differential negative resistance and two-valley model of Gunn effect devices; modes of operation; waveguide cavity Gunn oscillator.

Three terminal devices; BJT, MESFET, MOSFET, HFET, HEMT – device physics, characteristics, model.

Recommended Books:

1. A. S. Gilmour, "*Microwave Tubes*", Artech House
2. A. S. Gilmour, "*Principle of Travelling Wave Tubes*", Aretch House
3. K. C. Gupta, *Microwaves*, New Age International
4. S. Y. Liao, *Microwave Devices and Circuits*, Pearson Education
5. R. E. Collin, *Foundations for Microwave Engineering, Wiley*
6. S. Das, *Microwave Engineering*, Oxford University Press
7. M. L. Sisodia, "*Microwave Active Devices: Vacuum and Solid State*, New Age Publishers

Course Outcome:

- Understanding on microwave & mm Wave vacuum tubes and solid-state devices
- To learn about the design issues of high frequency tube amplifiers and oscillators
- To learn about analysis and modelling of microwave solid-state devices

MW 104 (Antenna, Radio Wave Propagation and EMI/ EMC)

Antenna:

Antenna parameters; radiation from wires and loops; infinitesimal dipole; finite-length dipole; linear elements near conductors; small circular loop.

Aperture antenna: Huygens' principle; radiation from rectangular and circular apertures; design considerations; Babinet's principle; Fourier transform method in aperture antenna theory.

Horn and reflector antennas: radiation from sectoral and pyramidal horns; design techniques; parabolic reflector.

Printed antenna: basic characteristics; feeding methods; methods of analysis; design of rectangular and circular patch antennas; bandwidth enhancement techniques.

Antenna arrays and beam pattern: analysis and synthesis; dielectric resonator antennas; ultra wideband antennas; active antennas; antenna measurements.

Radio wave propagation:

Antenna located over flat and spherical earth; coverage diagram, it's application and interference formulas.

Modes of propagation: LOS and radio horizon; non-LOS propagation – indirect, tropospheric and ionospheric propagation; propagation effects as a function of frequency.

Need for modeling propagation; model selection and application.

Communication systems and link budget.

Atmospheric effects; fading and multipath characterization; indoor and outdoor propagation model; microwave and mm wave propagation and rain drop attenuation.

EMI/ EMC:

An overview of EMI/ EMC; EMI/ EMC requirements for electronic systems; source and characteristics of EMI; EMI control techniques; EMC applications; EMI/ EMC measurements.

Recommended Books:

1. C.A. Balanis, "*Antenna Theory: Analysis and Design*', Wiley
2. J.D Kraus, R. J. Marhefka and A. Khan, Antennas and Wave Propagation, MGH
3. R. S. Elliot, "*Antenna Theory and Design*", Wiley
4. S. R. Saunders and A. R. Zavala, "*Antennas and Propagation for Wireless Communication Systems*", Wiley
5. W. A. Stutzman and G. A Thiele, "*Antenna Theory and Design*"' Wiley
6. R. Garg, P.Bhartia, I. Bhal, A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House
7. R. E. Collin, "*Antenna and Radio Wave Propagation*", McGraw Hill
8. C. R. Paul, *Introduction to Electromagnetic Compatibility*, Wiley

Course Outcome:

- To learn about the basic analytical techniques in antenna engineering

- Expertise on analysis, design, simulation, fabrication and measurement of different microwave antenna
- To learn about different propagation model microwave signals
- To learn about EMI/ EMC and measurement

MW 105 (Digital Signal Processing)

Introduction to signals and signal processing; continuous time signals and systems; discrete time signals and systems – sampling process; transform domain representation of signals and systems – LT, FT, DTFT, DFT, Z-transform.

Infinite impulse response digital filter design: DF from continuous time domain filters; impulse invariant transformation; mapping techniques; bilinear transformation; stability consideration; frequency transformation.

Finite impulse response digital filter deign: frequency response of linear phase filters; windowing techniques; some common windows; issues with windowing.
Frequency sampling technique: convolution and correlation.

DSP hardware: special purpose hardware for digital filtering and signal generation.

Arithmetic circuits: Fast address; fast multipliers/ dividers; delay blocks; DSP chips.

Specialized DSP circuits: digital resonators; DDFS circuits; ADC/ DAC circuits.

Applications of DSP algorithms in speech analysis and radar signal analysis.

Recommended Books:

1. J. G. Proakis and D. G Manolakis, "*Digital Signal Processing: Principles, Algorithms, and Applications*", Pearson
2. A. V. Oppenheim and R. W. Schafer, "*Digital Signal Processing*", Pearson
3. S. K. Mitra, "*Digital Signal Processing: A Computer based Approach*", McGraw Hill
4. S. Salivhahanan, "*Digital Signal Processing*", McGraw Hill
5. L. R. Rabiner and B. Gold, "*Theory and Application of Digital Signal Processing*", PHI
6. M Hayes, "*Digital Signal Processing*", McGraw Hill
7. C. T. Chen, "*Digital Signal Processing: Spectral Computation and Filter Design*", Oxford University Press

Course Outcome:

- To learn the techniques involved in digital signal processing.
- Expertise on digital filter analysis and design
- To implement DSP algorithms through hardware and software

MW 106 (Communication Theory)

Random variables; probability distribution and probability densities; functions of random variables; statistical averages of random variables; some standard probability distributions; central limit theorem.

Random process; stationary process; mean, correlation, and covariance function; ergodic process; response of a linear time-invariant system to a random input signal; power density spectrum; Gaussian process.

Sampling theorem for bandlimited processes; discrete-time stochastic signal and systems; cyclostationary processes.

Representation of bandpass signals; Hilbert transform; linear bandpass systems; bandpass signals transmitted through bandpass systems; bandpass stationary stochastic process.

Noise: narrowband noise; narrowband noise in terms of in-phase and quadrature components; narrowband noise in terms of envelope and phase components; sine wave and narrowband noise.

Vector space; signal space; geometric representation of signals; orthogonal expansion of signals; representation of digitally modulated signal.

Continuous AWGN channel and vector channel; correlation detector; matched filter detector; the optimum detector; the maximum likelihood detection; MAP detection for signals with memory, probability of error.

Carrier recovery and symbol synchronization in demodulation; carrier phase estimation; joint estimation of carrier phase and symbol timing; performance of ML estimator.

Information theory; channel capacity and coding.

Recommended Books:

1. S. Haykin, *Communication Systems*, John Wiley & Sons
2. J. G. Proakis, *Digital Communications***,** McGraw-Hill
3. B. P. Lathi, Z. Ding, H. M. Gupta, "*Modern Digital and Analog Communication Systems*", Oxfor University Press
4. H. Taub, D. Schilling, and G. Saha, "*Principles of Communication Systems*", McGraw Hill
5. S. P. E. Xavier, "*Statistical Theory of Communication*", New Age International
6. S. M. Moser and P. N. Chen, "*A Students Guide to Coding and Information Theory*", Cambridge University Press.
7. R. M. Gray, "*Entropy and Information Theory*", Springer

Course Outcome:

- To learn about the theoretical background related to present day digital communication systems
- To become able to apply the knowledge in different digital transmission systems for analysis, design and performance estimate

MW 201 (Computational Electromagnetics)

Review of EM theory and EM problems: classification of solution regions; differential equations; boundary conditions; review of analytical methods – separation of variable, Laplace's equations and wave equation in different coordinate systems; useful orthogonal function.

Finite difference method: finite difference scheme; finite differencing of parabolic, hyperbolic and elliptic PDEs; application to partial boundary value problems.

Variational methods: element of calculus of variations; construction of functional from PDEs; Rayleigh Ritz method; weighted residual method – Galerkin method, practical application.

Moment methods: Element of integral equations; Greens function; application to quasi static problems, scattering problems, radiation problems etc.

Finite element method: basic scheme; application to standard EM problems.

Monte-Carlo method: random numbers and variables; evolution of error; numerical integration by Monte-Carlo method.

Transmission line matrix method: basic concepts.

Recommended Books:

1. M. N. O. Sadiku, "*Numerical Techniques in Electromagnetics with MATLAB*", CRC Press
2. D. B. Davidson, "*Computational Electromagnetics for RF and Microwave Engineering*", Cambridge University Press
3. R. Garg, "*Analytical and Computational Methods in Electromagnetics*", Artech House.
4. R. Mitra, "*Computational Electromagnetics: Recent Advance and Engineering Applications*", Springer
5. R. F. Harrington, "*Time-Harmonic Electromagnetic Fields*", IEEE Press

Course Outcome:

- Would acquire the knowledge on different computational techniques in electromagnetics
- Would be able to apply the knowledge in different application domain of microwave and antenna engineering

MW 202 (Microwave & mm Wave Measurements)

Review of scattering parameter and microwave network analysis.

Uncertainty and confidence in measurement; application of Smith chart in microwave networks; slotted line technique; measurement of unknown impedance using slotted line.
Coaxial connectors in measurement.

Vector network analysis and network analyzer; construction; calibration technique – SOLT and TRL calibration; measurement procedure; X-parameters and NVNA basics.

RF and microwave power measurement.

Time domain reflectometry.

Measurement of quality factor of resonators.

Noise figure measurement; measurement accuracy; mismatch effects.

Attenuation measurement.

Signal analysis basics; Spectrum analyzer measurement and applications; phase noise measurement techniques and frequency stability.

Measurement of dielectric properties of materials at RF and microwave frequencies; RFIC and MMIC measurement techniques; probe station.

Recommended Books:

1. D. M. Pozar, *Microwave Engineering*, Wiley
2. K. C. Gupta, *Microwaves*, New Age International
3. A. Das and S. K. Das, *Microwave Engineering*, McGraw Hill Education
4. S. Das, *Microwave Engineering*, Oxford University Press
5. N. V. Carvalho, "*Microwave and Wireless Measurement Technique*", Cambridge India
6. T. H. Lee, "*Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits*, Cambridge University Press
7. M. Sucher and J. Fox, "*Handbook of Microwave Measurements*", Vol.I, II, and III, John Wiley & Sons

Course Outcome:

- Understanding the principle and working of equipment used in microwave and mm-wave measurement
- Students would become familiarized with the issues associated with microwave and mm-wave T&M
- To gain the practical skill on microwave and mm-wave T&M

MW 203 (Microwave & mm Wave Communication Systems)

Modulation techniques:

Signal space analysis; binary digital modulation; M-ary digital modulation; error probabilities; effect of fading on bit error rates; spread spectrum modulation.

Wireless communication and network:

Evolution of wireless system; various impairments in wireless channels; modern wireless communication system; cellular concept; mobile radio signal propagation; modulation technique for wireless communication; equalization & diversity technique; coding technique for mobile communication; wireless network - WLAN, GSM, CDMA, GPRS, 3G & beyond.

Satellite communication:

Introduction; satellite orbit fundamentals; space segment and earth station; satellite links; multiple access schemes – FDMA, TDMA, CDMA, DAMA; packet radio – CSMA; ALOHA and slotted ALOHA.

Basic concepts:

OFDM, MIMO; software defined radio; cognitive radio; ultra wide band communication.

Recommended Books:

1. P. V. Sreekanth, *Course in Digital Microwave Communication Systems*, University Press
2. E. McCune, *Practical Digital Wireless Signals*, Cambridge University Press
3. J. G. Proakis, *Digital Communications*, McGraw-Hill
4. R. L. Peterson, R.E. Zeimer and D. E. Borth, *Introduction to Spread Spectrum Communications*, Pearson Education
5. A. F. Molisch, "*Wireless Communications*', Wiley
6. S. Haykin and M. Moher, "*Modern Wireless Communications*", Pearson
7. T. S. Rappaport, "*Wireless Communications: Principles and Practice*", Pearson Education

8. J. Schiller, “*Mobile Communications*”, Pearson
9. G. Maral, M. Bousquet, *Satellite Communications Systems*, Wiley
10. T. T. Ha, “*Digital Satellite Communication*”, McGraw Hill
11. P. Banerjee, “*Satellite Communication*”, PHI Learning Private Limited
12. C. Bostian, J. Allnutt and T. Pratt, “*Satellite Communications*”, Wiley
13. A. K. Maini and V Agarwal, “*Satellite Communications*”, Wiley India

Course Outcome:

- Understanding on different modulation techniques used in microwave communication systems
- Would acquire knowledge on various wireless communication systems
- Students would become able to understand the working of various satellite-based communication systems
- Students would familiarize with most current ideas like software defined radio and cognitive radio

MW 204 (Radar, Remote Sensing and Navigational Systems)

Radar:

Introduction; basic radar range equation and modification; CW, FM and pulsed radar; MTI and pulsed Doppler radars; scanning and tracking radars; receiver; duplexer; display systems; ambiguity diagram; pulse compression; radar antennas; ECM and ECCM .

Remote sensing:

Overview; earth’s atmosphere; land surface; oceans; land and sea ice; radiation budget; climate; radar altimeters; synthetic aperture radars (SAR); wind scatterometers; multispectral imaging; IR and microwave radiometers; concept of GIS.

Satellite based navigational systems:

Electronic navigation systems – global and regional; concepts of satellite based navigation systems – GPS, GLONASS, Galileo, Beidou, QZSS, NaVIC; code and carrier phase based measurement techniques; augmentation; relative positioning – DGPS, RTK; Precise Point Positioning (PPP); Satnav applications.

Recommended Books:

1. M. Skolnik, “*Introduction to Radar Systems*”, McGraw Hill
2. P. Z. Peebles, “*Radar Principles*”, Wiley
3. E. F. Nathanson, “*Radar Design Principles: Signal Processing and the Environment*”, PHI
4. M. A. Richards, “*Fundamentals of Radar Signal Processings*”, McGraw Hill
5. G. Joseph and C. Jeganathan, “*Fundamentals of Remote Sensing*”, Universities Press
6. B. C. Panda, “*Remote Sensing: Principle and Applications*”, Viva Books
7. I. H. Woodhouse, “*Introduction to Microwave Remote Sensing*”, CRC Press
8. P. J. G. Teunissen and O. Montenbruck (Eds) “*Springer handbook of global navigation satellite systems*”, Springer
9. P. Misra and P. Enge “*Global Positioning System: Signals, Measurements and Performance Revised*”, Ganga-Jamuna Press.
10. E. D. Kaplan and C. J. Hegarty, “*Understanding GPS: principles and applications*”, 2nd Edition, Artech house

11. G. Strang and K. Borre, "*Linear Algebra, Geodesy and GPS*", Wellesley – Cambridge Press

Course Outcome:

- Students would gain the skill on radar engineering
- Would have an idea of microwave and IR remote sensing and GIS
- Would have a knowledge of theoretical as well as practical expertise on satellite-based navigation systems

<u>Optional Elective-I: Any one from MW 2051, MW 2052, and MW 2053:</u>

MW 2051(Microwave & mm Wave Device, Circuit and System Modeling)

Noise and distortion in RF and microwave systems; noise in linear systems; noise figure and noise temperature; noise figure and temperature of cascaded network; basic threshold detection, nonlinear effects; dynamic range and intermodulation distortion.

Transistor scattering parameters; transistor noise models; review of impedance matching techniques; matching and biasing networks.

RF and microwave amplifier: two port power gain; stability; design for maximum and specified gain; low noise design; broad band design techniques; power amplifiers; theory of high-power load-pull characterization for RF and microwave transistors.

Transistor oscillators and related circuits: Radio frequency oscillators; microwave oscillators; voltage controlled oscillators; frequency synthesis methods; injection and phase locked loop analysis; oscillator phase noise.

Microwave mixers: mixer characteristics; diode mixers; FET mixers; mixer noise.

Time and frequency domain techniques in nonlinear microwave circuits and systems.

RF and microwave switches and attenuators.

Receiver design: Receiver architectures; dynamic range; frequency conversion and filtering; practical receiver examples; use of modern CAD for receiver front end circuit.

Recommended Books:

1. D. M. Pozar, *Microwave Engineering*, Wiley
2. D. M. Pozar, *Microwave and RF Design of Wireless Systems*, John Wiley and Sons
3. D. K. Mishra, *Radio-Frequency And Microwave Communication Circuits Analysis And Design*, CBSPD
4. A.M. Pavio, U. L. Rohde and G. D. Vendelin, *Microwave Circuit Design using Linear and Nonlinear Techniques*, Wiley
5. G. Gonzalez, *Microwave Transistor Amplifiers – Analysis and Design*, Prentice Hall Inc
6. I. Bhal and P. Bhartia, *Microwave Solid State Circuit Design*, 2nd Ed., Wiley Interscience
7. K. Kurokawa, *An Introduction to the Theory of Microwave Circuits*, Academic Press
8. K.Chang, *RF and Microwave Wireless Systems*, John Wiley and Sons

Course Outcome:

- Students would have an idea on microwave receiver design requirements

- Would have a skill on analysis, design and measurement of various microwave solid-state device-based systems

MW 2052 (Advanced Antenna Engineering)

Review of antenna parameters; theorems; and other fundamental issues

Miniaturization and bandwidth enhancement; Broad band dipole and matching technique; travelling wave and broad band antenna; frequency independent antenna; planar broad band antennas; UWB antenna

Compact antenna

Smart Antenna – benefits; types; fixed & switched beam antenna system; adaptive array system; analog and digital beamforming; multiple antenna design; combining techniques; diversity, multi beam formation; MIMO

Active antenna array

Recommended Books:

1. C.A. Balanis, "*Antenna Theory: Analysis and Design*', Wiley
2. J.D Kraus, R. J. Marhefka and A. Khan, Antennas and Wave Propagation, MGH
3. R. S. Elliot, "*Antenna Theory and Design*", Wiley
4. J. R. James and P. S. Hall, "*Handbook of Microstrip Antenna*", Peter Peregrinous Ltd
5. R. Garg, P.Bhartia, I. Bhal and A. Ittipiboon, "*Microstrip Antenna Design Handbook*", Artech House
6. G. Kumar and K.P. Ray, Broad Band Microstrip Antennas, Artech House
7. K. L. Wong, "*Compact and Broadband Microstrip Antennas*", Wiley
8. T. K. Sarkar, M. C. Wicks and M. S. Palma, "*Smart Antennas*" Wiley-Blackwell
9. B. Clerckx and C. Oestges, "*MIMO wireless Networks*", Elsevier

Course Outcome:

- Students would learn advanced techniques in microwave antenna design
- To become able to analyze, design, simulate, fabricate and measure the complicated microwave antenna like compact, broadband and multiband type
- Would learn the smart antenna and active antenna

MW 2053 (Gyrotron Technology)

Gyro devices

Gyrotron cavities

RF behavior

Gyrotron design principles

Output taper and quasi-optical launcher

RF window

Applications of gyrotron technologies

Recommended Books:

1. M. V. Kartikeyan, E Borie and M. Thumm, "*Gyrotrons: High-Power Microwave and Millimeter Wave Technology*", Springer
2. G. S. Nusinovich, "*Introduction to the Physics of Gyrotrons*", Johns Hopkins University Press
3. D. C Hai, "*Millimeter-Wave Gyrotron Traveling-Wave Tube Amplifiers*", Springer-Verlag Berlin and Heidelberg GmbH & Co. KG

Course Outcome:

- The students will learn about the modern gyrotron devices in details
- They will have an idea on design and fabrication of gyrotron tubes.

<u>Optional Elective-II: Any one from MW 2061 and MW 2062:</u>

MW 2061 (Light Wave Technology)

Introduction and fiber optics components: optical fiber; optical cables; splices and connectors; couplers and dividers.

Optical sources, detectors and displays for communication: LED; semiconductor LASER; PIN, APD; CCD; LCD.

Transmission and detection systems: intensity modulation; direct and coherent detection; S/N ratio; BER; WDM.

LIDAR and its applications.

Optical space communication.

Application of fiber optics systems.

Broadband technology: fiber optics links – design and systems; application of light wave technology to microwaves.

Recommended Books:

1. J. M. Senior, "*Optical Fiber Communications: Principles and Practice*", Pearson Education India
2. G. Keiser, "*Optical Fiber Communication*", McGraw Hill India
3. T. L. Singal, "*Optical Fiber Communications: Principles and Applications*", Cambridge University Press
4. M. Alhaider, "*Optical Fiber Communications*", Notion Press
5. C. K. Sarkar and D. C. Sarkar, "*Optoelectronics and Fiber Optic Communication*", New Age International
6. J. Franz and V. K. Jain, "*Optical Communication System*", Narosa Pub. House
7. M. Young, "*Optics and Lasers including Fibres and Optical Waveguides*", Springer

Course Outcome:

- The students would learn about the different active and passive components used in optical communications
- Would learn about different modulation techniques used in optical communication
- Would acquire knowledge on different standard optical communication system

MW 2062 (Microwave Photonics)

Microwave photonics basics.

Sources of noise and distortion in fiber optics links.

Propagation effects.

External intensity modulation with direct detection.

External phase modulation with interferometry detection.

Other optical modulation methods.

High current photo detectors.

Photonic oscillators for signal generation; THz sources.

Characterization of microwave photonic components.

Microwave photonics signal processing.
Application and trends.

Recommended Books:

1. V. J. Urick, K. J. Williams and J. D. McKinney, "*Fundamentals of Microwave Phiotonics*", Wiley
2. A. Vilcot, B. Cabon, and J, Chazelas, "*Microwave Photonics: From Components to Applications and Systems*", Springer
3. C. H. Lee, "*Microwave Photonics*", CRC Press
4. R. Oded, "*Photonic Processing of Microwave Signals*", Globeedit
5. R. Simons, "*Optical Control of Microwave Devices*", Artech House

***Course Outcome*:**

- Would gain the knowledge about how to integrate the microwave and optical technology to bring out the best of two subjects
- Would be able to understand the different techniques used in the subject
- Would learn the application of the course

MW 303 (Research Methodology and IPR)

May be opted from SWAYAM (https://swayam.gov.in/)

Unit 1:

Meaning of research problem; sources of research problem; criteria characteristics of a good research problem; errors in selecting a research problem; scope and objectives of research problem; approaches of investigation of solutions for research problem; data collection, analysis, and interpretation; necessary instrumentations.

Unit 2:

Effective literature studies approaches; analysis plagiarism, research ethics.

Unit 3:

Effective technical writing; how to write report; paper developing a research proposal; format of research proposal; a presentation and assessment by a review committee.

Unit 4:

Nature of intellectual property: patents; designs; trade and copyright; process of patenting and development - technological research, innovation, patenting, and development; international scenario: international cooperation on intellectual property; procedure for grants of patents, patenting under PCT.

Unit 5:

Patent rights: scope of patent rights; licensing and transfer of technology; patent information and databases; geographical indications.

Unit 6:

New developments in IPR; administration of patent System; new developments in IPR; IPR of biological systems, Computer Software etc.; traditional knowledge case studies.

Recommended Books:

1. S. Melvile and W Goddars, "*Research Methedology: An Introduction for Science & Engineering Students*"
2. W. Goddard and S. Melville, "*Research Methedology: An Itroduction*"
3. R. Kumar, "*Research Methodology: A Step by Step Guide for Beginers*"
4. Halbert, "*Resisting Intellectual Property*", Taylor & Francis Ltd.
5. Mayall, "*Industrial Design*", McGraw Hill
6. Asimov, "*Introduction to Design*", Prentice Hall
7. Niebel, "*Product Design*", Mcgraw Hill
8. R. P. Merges, P. S. Menell and M. A. Lemley, "*Intellectual Propertyin New Technological Age*".
9. T. Ramappa, "*Intellectual Property Rights under WTO*". S. Chand

Course Outcome:

- Would understand the different issues related with the research work
- Will have an idea about the IPR related matters associated with any research outcome/ product or technology development

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