# Curriculum and Syllabus for M.Tech.

Electronics and Communication Engineering With Specialization in Communication Systems

From The Academic Year 2021

(Approved in Senate 44)


Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram

Chennai-600 127

| Semester 1 | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Name | Category | L | T | P | C |
| 1 | EC5000 | Random Processes | PCC | 3 | 1 | 0 | 4 |
| 2 | EC5001 | Digital Communication | PCC | 3 | 1 | 0 | 4 |
| 3 | EC5002 | Wave Propagation in Communication | PCC | 3 | 1 | 0 | 4 |
| 4 | EC5003 | Digital Signal Processing | PCC | 3 | 1 | 0 | 4 |
| 5 | EC5004 | RF System Design | PCC | 3 | 1 | 0 | 4 |
| 6 | EC5005 | Digital Communication Practice | PCC | 0 | 0 | 3 | 1.5 |
| 7 | EC5006 | RF System Design Practice | PCC | 0 | 0 | 3 | 1.5 |
| | | | | | | | 23 |
| | | | | | | | |
| Semester 2 | | | | | | | |
| S.No | Course Code | Course Name | Category | L | T | P | C |
| 1 | EC5007 | Wireless Communication | PCC | 3 | 1 | 0 | 4 |
| 2 | EC5008 | Advanced Digital Signal Processing | PCC | 3 | 1 | 0 | 4 |
| 3 | | Professional Elective Course 1 | PEC | 3 | 1 | 0 | 4 |
| 4 | | Professional Elective Course 2 | PEC | 3 | 1 | 0 | 4 |
| 5 | | Professional Elective Course 3 | PEC | 3 | 1 | 0 | 4 |
| 6 | | Professional Elective Course 4 | PEC | 3 | 1 | 0 | 4 |
| | | | | | | | 24 |
| Semester 3 | | | | | | | |
| S.No | Course Code | Course Name | Category | L | T | P | C |
| 1 | EC6000 | MT-EC-CS-Project I (May-July) (Summer Internship) | PCD | 0 | 0 | 20 | 10 |
| 2 | EC6001 | MT-EC-CS-Project II (Aug-Nov) | PCD | 0 | 0 | 32 | 16 |
| | | | | | | | 26 |
| Semester 4 | | | | | | | |
| S.No | Course Code | Course Name | Category | L | T | P | C |
| 1 | EC6002 | MT-EC-CS-Project III (Dec-April) | PCD | 0 | 0 | 32 | 16 |
| | | | | | | | 16 |

1. Professional Elective Course is an elective course offered or prescribed by the parent department.
2. 3 Months internship is mandatory, however, the curriculum offers the flexibility to carry out 3-12 Months internship with the approval of the parent department.
3. In line with the guidelines approved by the Senate (Senate 46-07), an M.Tech student can earn a maximum of 6 credits from NPTEL Courses. For all successfully completed NPTEL Courses, the letter grade “H” (Pass) will be awarded and credits of such courses will not be accounted for CGPA calculation.

Semester wise Credit Distribution

| Semester | | | | | | |
|---|---|---|---|---|---|---|
| Category | S1 | S2 | S3 | S4 | Total | % |
| Professional Core Course (PCC) | 23 | 8 | 0 | 0 | 31 | 34.8 |
| Professional Elective Course (PEC) | 0 | 16 | 0 | 0 | 16 | 18.0 |
| Professional Career Development (PCD) | 0 | 0 | 26 | 16 | 42 | 47.2 |
| Total | 23.0 | 24.0 | 26.0 | 16.0 | 89.0 | 100.0 |
| | 23.0 | 47.0 | 73.0 | 89.0 | | |

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|---|---|---|---|---|---|---|
| Course Name | Random Processes | Course Code | EC5000 | | | |
| Offered by Department | Electronics and Communication Engineering | Structure(LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | NIL | Approved In | Senate-44 | | | |
| Learning Objectives | • To introduce various tools needed to analyse randomness, and concepts of likelihood (that arises in communications).<br>• To introduce modelling of various engineering systems using processes like Markov chains, Poisson processes, etc.<br>• To analyse systems for performance metrics. | | | | | |
| Learning Outcomes | Students are expected to<br>• Understand various concepts and tools in Random Processes<br>• Analyse various performance metrics (like throughput) using the concepts covered<br>• Model various engineering systems using the tools studied. | | | | | |
| Course Contents (with approximate breakup of hours for lecture/ tutorial/practice) | • Introduction to Probability: Sets, Events, Axioms of Probability, Conditional Probability and Independence, Bayes Theorem and MAP Decision Rule (9L + 2T)<br>• Random Variables: Definitions, Cumulative Distribution Functions, mass and density functions, joint and conditional distributions, Functions of Random Variables (8L + 3T)<br>• Expectations: Mean, Variance, Moments, Correlation, Chebychev and Schwarz Inequalities, Moment-generating and Characteristic Functions, Chernoff Bounds, Conditional Expectations (8L + 3T)<br>• Random Vectors: Jointly Gaussian random variables, Covariance Matrices, Linear Transformations, Diagonalization of Covariance Matrices (8L + 3T)<br>• Random Sequences: Sequences of independent random variables, correlation functions, wide-sense stationary sequences, LTI filtering of sequences Law of Large Numbers, Central Limit Theorem (9L + 3T) | | | | | |
| Essential Reading | 1. Scott L. Miller and Donald G. Childers, Probability and Random Processes: With Applications to Signal Processing and Communications, Academic Press; 2nd edition, 2012, ISBN: 9780123869814.<br>2. Stark and Woods, Probability and Random Processes with Applications to Signal Processing, Pearson Education, 3rd edition, 2002, ISBN: 9780130200716. | | | | | |
| Supplementary Reading | 1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, Athena Scientific, 2nd edition, 2008, ISBN: 9781886529236.<br>2. Geoffrey Grimmett and David Stirzaker, Probability and Random Processes, Oxford; 3rd edition, 2001, ISBN: 9780198572220.<br>3. Bruce Hajek, Random Processes for Engineers, Cambridge University Press, 2014, ISBN: 9781107100121. | | | | | |

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|---|---|---|---|---|---|---|
| Course Name | Digital Communication | Course Code | EC5001 | | | |
| Offered by Department | Electronics and Communication Engineering | Structure(LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | NIL | Approved In | Senate-44 | | | |
| Learning Objectives | • To introduce the concepts of digital communication.<br>• To study various modulation schemes and their performance.<br>• To study and understand basic channel coding techniques. | | | | | |
| Learning Outcomes | The students are able to<br>• understand any digital communication system<br>• design a digital communication system<br>• analyze various channel coding techniques | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/practice) | • Introduction to digital communications, review of sampling theorem, and representation of band-pass signals (6L + 2T)<br>• Digital communications through AWGN channel – Signal representation, PAM, PSK, and QAM signals, multi-dimensional signals, optimum receiver for AWGN, probability of error for symbol detection, approximations using Union bound, Chertoff bound (12L+4T)<br>• Digital communications through band-limited channels – Power spectrum of random digital signal, signal design for band-limited channels - Nyquist criterion, partial response signals, Timing and frequency synchronization for linearly modulated digital signals. (6L+2T)<br>• Digital communications through dispersive channels – Channel equalization, maximum likelihood sequence detection and the Viterbi algorithm, and practical (fractionally-spaced, adaptive) receivers for ISI channels, MAP sequence estimation and symbol detection (6L+2T)<br>• Block codes and syndrome decoding, convolutional codes and MLSE, Trellis coded modulation, Turbo codes (12L+4T) | | | | | |
| Essential Reading | 1. J. G. Proakis and M. Salehi, Communication Systems Engineering, Pearson, 2nd edition, 2018, ISBN: 9780130617934. | | | | | |
| Supplementary Reading | 1. U. Madhow, Introduction to Communication Systems, Cambridge University Press, 1st edition, 2014, ISBN: 9781107022775.<br>2. B. P. Lathi and Z. Ding, Modern Digital and Analog Communication Systems, 5th edition, Oxford University Press, 2018, ISBN: 9780190686840. | | | | | |

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|---|---|---|---|---|---|---|
| Course Name | Wave Propagation in Communication | Course Code | EC5002 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure (LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | Undergraduate level Electromagnetics | Approved In | Senate-44 | | | |
| Learning Objectives | This course is designed as a graduate course to provide a conceptual understanding of the basics of electromagnetism and its application to the principles of wave propagation for communication. | | | | | |
| Learning Outcomes | At the end of the course, the learners are expected to do the following:<br>• Understand the properties of electromagnetic (EM) waves<br>• Analyse the propagation of plane EM waves in free space, media and at interfaces<br>• Determine the characteristics of EM waves in bounded media<br>• Apply the EM wave theory to transmission lines, antennas, guided wave and fiber-optic communication | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/ practice) | • **Transmission Lines**: TEM mode – transmission line equivalence -Distributed capacitance and inductance - Digital transmission lines (10 L+3T)<br>• **Plane Electromagnetic Waves:** Review of Maxwell's equations (integral and differential form) – Plane waves in lossless media – Plane waves in lossy media – dielectrics and conductors – Poynting theorem - Plane waves at boundaries – Wave reflection and transmission (12L+4T)<br>• **Wave propagation in bounded media:** Parallel plate waveguide - TEM modes - Rectangular waveguides – Resonators - Lossy waveguides -Dielectric waveguides – optical fibers - Dispersion and group velocity (10L+4T)<br>• **Antennas:** Basics of radiation theory - Types of antennas – Antenna arrays (10L+3T) | | | | | |
| Essential Reading | 1. David K. Cheng, Field and Wave Electromagnetics, 2nd Edition, Pearson Education, ISBN: 9781292026565 2014.<br>2. C. A. Balanis, Antenna Theory and Design, 3rd Edition, John Wiley & Sons, ISBN-047166782X, 2005. | | | | | |
| Supplementary Reading | 1. Nannapaneni Narayana Rao, Elements of Engineering Electromagnetics, 6th Edition, Pearson Education, ISBN: 978 0131139619, 2013.<br>2. Fawwaz T. Ulaby Eric Michielssen and Umberto Ravaioli, Fundamentals of Applied Electromagnetics, 7th Edition, Pearson Education, ISBN: 9781292082486, 2015.<br>3. David. M. Pozar, Microwave Engineering, 4th Edition, John Wiley, ISBN: 9781118298138, 2011.<br>4. J. D. Kraus and R. J. Marhefka, Antennas for All Applications, 3rd Edition, Tata McGraw Hill,ISBN:978-0071122405 , 2002. | | | | | |

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|---|---|---|---|---|---|---|
| Course Name | Digital Signal Processing | Course Code | EC5003 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure (LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | Signal and Systems | Approved In | Senate-44 | | | |
| Learning Objectives | • To make students familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.<br>• To make students aware about the meaning and implications of the properties of systems and signals. | | | | | |
| Learning Outcomes | • Students will learn the essential primary topics in DSP that are necessary for successful Postgraduate level research.<br>• Students will have the ability to solve various types of practical problems in DSP. | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/ practice) | • **Review of signals and systems**: Basic discrete time signals, classifications and operations, convolution and correlation. (6L+2T)<br>• **Fourier Domain Analysis of LTI Systems**: Frequency domain characteristics of LTI systems, Frequency response of LTI system, Magnitude and phase response, Extension to higher order systems, filters, principle phase and phase responses, all pass systems, minimum phase systems, group delay, linear phase systems, (11L+5T)<br>• **Discrete time Fourier transform (DTFT):** Definition of DTFT, Inverse formula, properties and relationship with continuous time Fourier series (CTFS). (6L+2T)<br>• **Sampling**: Sampling, aliasing and oversampling effects. (3L+1T)<br>• **Discrete Fourier Transform**: Definition of DFT and Inverse DFT, Relationship with DTFT, Circular convolution, windowing methods, Introduction to Fast Fourier Transform, Decimation in time and Decimation in Frequency algorithm (8L+2T)<br>• **z Transform**: Definition of z transform, Inverse z transform, Region of convergence, Pole zero plots, properties of ROC and z (8L+2T) | | | | | |
| Essential Reading | 1. V. Oppenheium, R. W. Schafer, Discrete-time signal processing, 2nd edition, Prentice Hall, 2010.<br>2. S. K. Mitra, Digital Signal Processing: A computer base approach, 3rd edition, Mc Graw Hill Higher Education, 2016.<br>3. J. G. Proakis and D. G. Manolakis, Introduction to Digital Signal Processing, 4th edition, Prentice Hall, 2012. | | | | | |
| Supplementary Reading | 1. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley-India, 2008.<br>2. Simon Haykin, Adaptive Filter Theory, Pearson Education, Fourth Edition, 2011.<br>3. Manolakis, D., Ingle, M., Kogon, S., Statistical and Adaptive Signal Processing, McGraw-Hill, 2000. | | | | | |

<table>
<tr><td>Course Title</td><td>RF System Design</td><td>Course No</td><td colspan="4">EC5004</td></tr>
<tr><td>Offered by Department</td><td>Electronics & Communication Engineering</td><td>Structure (LTPC)</td><td>3</td><td>1</td><td>0</td><td>4</td></tr>
<tr><td>To be offered for</td><td>M.Tech</td><td>Course Type</td><td colspan="4">Core</td></tr>
<tr><td>Prerequisite</td><td>Basic knowledge of electromagnetics at undergraduate level (Engineering Electromagnetics/Electromagnetic Waves/Any equivalent course)</td><td>Approved In</td><td colspan="4">Senate-44</td></tr>
<tr><td>Learning Objectives</td><td colspan="6">The key objective of this course is to provide a comprehensive understanding of high frequency circuit design principles, and the analysis and design of passive and active RF circuits for communication systems.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="6">At the end of the course, the students are expected to be able to:<ul><li>Understand the principles and behavior of high frequency circuits.</li><li>Use the Smith Chart to perform impedance matching and other RF system design.</li><li>Design and analyze various RF front end systems such as power dividers/combiners, couplers, filters, attenuators, switches, phase shifters, amplifiers, mixers, oscillators, etc.</li></ul></td></tr>
<tr><td>Course Contents (with approximate breakup of hours for lecture/tutorial/ practice)</td><td colspan="6"><ul><li>Review of transmission line theory, lumped and distributed approach, network analysis, Scattering parameters, the Smith Chart and its applications. (8L+3T)</li><li>Impedance matching circuits: Lumped and distributed element approaches. (3L+1T)</li><li>Design of power dividers/combiners, couplers. (6L+2T)</li><li>RF Filter design: lumped and distributed element realizations. (6L+2T)</li><li>Design of microwave attenuators, RF switches, phase shifters, isolators. (5L+1T)</li><li>Amplifier design, gain and stability analysis, design for maximum gain and specific gain, low noise amplifier design. (8L+3T)</li><li>Design of mixers and oscillators. (6L+2T)</li></ul></td></tr>
<tr><td>Essential Reading</td><td colspan="6"><ol><li>David M. Pozar, Microwave Engineering, 4th edition, John Wiley & Sons, ISBN: 9781118298138, 2011.</li><li>R. Ludwig, P. Bretchko, RF Circuit Design: Theory and Applications, 2nd edition, Prentice-Hall, ISBN: 9780130953230, 2000.</li></ol></td></tr>
<tr><td>Supplementary Reading</td><td colspan="6"><ol><li>C. Bowick, RF Circuit Design, 2nd edition, Newnes, ISBN: 9780750685184, 2007.</li></ol></td></tr>
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|---|---|---|---|---|---|---|
| Course Name | Digital Communication Practice | Course Code | EC5005 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure(LTPC) | 0 | 0 | 3 | 1.5 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | NIL | Approved In | Senate-44 | | | |
| Learning Objectives | • To introduce the concepts of digital communication.<br>• To study various modulation schemes and their performance.<br>• To study and understand basic channel coding techniques. | | | | | |
| Learning Outcomes | The students are able to<br>• understand any digital communication system<br>• design a digital communication system<br>• analyze various channel coding techniques | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/practice) | The experiments are numerical evaluations done in a programming environment like MATLAB/GNU Octave or Python. Experiments include<br>• BER/SER performance of Digital communications through AWGN channels – PAM, PSK, QAM, multi-dimensional constellation<br>• Channel equalization: MLSE, Viterbi algorithm, MAP sequence estimation<br>• Block codes and convolutional codes | | | | | |
| Essential Reading | 1. J. G. Proakis and M. Salehi, Communication Systems Engineering, Pearson, 2nd edition, 2015, ISBN: 9780130617934. | | | | | |
| Supplementary Reading | 1. U. Madhow, Introduction to Communication Systems, Cambridge University Press, 1st edition, 2014, ISBN: 9781107022775.<br>2. B. P. Lathi and Z. Ding, Modern Digital and Analog Communication Systems, 5th edition, Oxford University Press, 2018, ISBN: 9780190686840. | | | | | |

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| Course Name | RF System Design Practice | Course Code | EC5006 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure (LTPC) | 0 | 0 | 3 | 1.5 |
| To be offered for | M.Tech. | Course Type | Core | | | |
| Prerequisite | Basic knowledge of electromagnetics at undergraduate level (Engineering Electromagnetics/Electromagnetic Waves/Any equivalent course) | Approved In | Senate-44 | | | |
| Learning Objectives | The key objectives of this course are to:<br>• Equip the students to design RF circuits and integrate these components to build an RF system.<br>• Build proficiency in using CAD tools such as RF circuit simulator and full wave simulator.<br>• Provide a hands-on experience in characterization and measurement of RF circuits and components. | | | | | |
| Learning Outcomes | At the end of this course, the students should be able to:<br>• Design passive and active RF circuits such as filters, power dividers, couplers, attenuators, switches, phase shifters, amplifiers, mixers, oscillators, etc.<br>• Design RF circuits and integrate them together to build the RF front-end for communication systems.<br>• Become proficient with RF circuit characterization and measurements. | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/ practice) | • Analysis and design of various RF circuits: impedance matching circuits, low pass, high pass, band pass and bands top filters, stepped impedance low pass filter, power dividers and combiners, couplers, attenuators, switches, phase shifters, amplifiers, mixers and oscillators.<br>• Characterization and measurement of RF components using Vector Network Analyzer. | | | | | |
| Essential Reading | 1. David M. Pozar, Microwave Engineering, 4th edition, John Wiley & Sons, ISBN: 9781118298138, 2011.<br>2. 2. R. Ludwig, P. Bretchko, RF Circuit Design: Theory and Applications, 2nd edition, Prentice-Hall, ISBN: 9780130953230, 2000. | | | | | |
| Supplementary Reading | 1. C. Bowick, RF Circuit Design, 2nd edition, Newnes, ISBN: 9780750685184, 2007. | | | | | |

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|---|---|---|---|---|---|---|
| Course Name | Wireless Communication | Course Code | EC5007 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure (LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | Random Processes, Digital Communication | Approved In | Senate-44 | | | |
| Learning Objectives | The course objectives are as follows:<br>• To provide a thorough understanding of the wireless channel and related impairments<br>• To understand various multiple access technologies, antenna diversity and MIMO system<br>• To get an exposure to the current and emerging wireless systems (LTE, 802.11 etc.) | | | | | |
| Learning Outcomes | At the end of the course, the learners are expected to do the following:<br>• Describe the fading natures of a wireless channel and various impairments<br>• Analyze the BER performance over fading channels including diversity<br>• Analyze the performance parameters of various wireless technologies like CDMA, OFDM and MIMO | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/ practice) | • **Wireless Communications and Diversity**: Review of basic concepts, Multipath Propagation, Path Loss models, Wireless Channel Modeling – Fading, BER Performance (8L+3T)<br>• **Wireless Channel Modeling**: Power delay profile- Delay Spread, Inter Symbol Interference, Coherence Bandwidth – flat, frequency selective Fading, Mobility - Doppler Shift and Coherence Time, Slow, Fast fading (6L+2T)<br>• **Diversity in Wireless Systems**: Multiple Antenna Wireless Systems, System Model, Diversity Combining: Maximal Ratio Combining, Equal Gain Combining, Selection Combining (6L+2T)<br>• **CDMA:** Introduction to CDMA, Features of CDMA2000 and WCDMA, Rake Receiver for CDMA systems, Multiuser CDMA performance (4L+1T)<br>• **OFDM and OFDMA Technologies**: Multicarrier Modulation (MCM) and OFDM, OFDM System Model, IFFT/ FFT Transceiver Model, BER performance, Successive Interference Cancellation (9L+3T)□**Multiple Input Multiple Output (MIMO) Technology**: MIMO System Model, MIMO Zero-Forcing and Minimum Mean Square Error (MMSE) Receivers, MIMO Channel Capacity, Optimal Power Allocation, Alamouti Coding, MIMO Beamforming (9L+3T) | | | | | |
| Essential Reading | 1. Goldsmith, Wireless Communication, 1st edition, Cambridge University Press, 2009, ISBN: 9780521704168<br>2. Simon Haykin and Michael Moher, Modern Wireless Communications, 1st edition, Pearson, ISBN:978-81-317-0443-1, 2011. | | | | | |
| Supplementary Reading | 1. Tse, David, and Pramod Viswanath, Fundamentals of Wireless Communication. Cambridge, UK: Cambridge University Press, 2005. ISBN: 0521845270. Online version.<br>2. T.S. Rappaport, Wireless Communications, Principles and Practice, 2nd Ed., Pearson Education, 2010.<br>3. Aditya K Jagannatham, Principles of Modern Wireless Communication Systems, 1st edition, Mc Graw Hill, ISBN: 978-1-259-02957-8, 2016. | | | | | |

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|---|---|---|---|---|---|---|
| Course Name | Advanced Digital Signal Processing | Course Code | EC5008 | | | |
| Offered by Department | Electronics & Communication Engineering | Structure (LTPC) | 3 | 1 | 0 | 4 |
| To be offered for | M.Tech | Course Type | Core | | | |
| Prerequisite | Digital Signal Processing | Approved In | Senate-44 | | | |
| Learning Objectives | This course covers the techniques and gain proficiency of modern signal processing that are fundamental to a wide variety of application areas. In this course various aspects of advanced signal processing along with applications in filter design and modern communication systems will be comprehensively discussed which are prime focus of signal processing industries all over the world. | | | | | |
| Learning Outcomes | • Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research.<br>• Students will have the ability to solve various types of practical problems in DSP. | | | | | |
| Course Contents (with approximate breakup of hours for lecture/tutorial/ practice) | **Introduction to the course**: Review of transforms, Sampling theorem, Quantization, AD and DA conversion. (8L+3T)<br>**Implementation of Discrete-time Systems:** Structures of FIR, IIR systems, Representation of numbers, State-space Representation-Quantization of filter coefficients, Round-off effects in digital filters (15L+5T)<br>**Multirate Digital Signal Processing**: Mathematical description of change of sampling rate, Interpolation and Decimation, Implementation of sampling rate conversion, Polyphase decomposition, digital filter banks (15L+5T)<br>**Applications**: Spectrum analysis using DFT, Power spectral estimation (4L+1T) | | | | | |
| Essential Reading | 1. J. G. Proakis and D. G. Manolakis, Introduction to Digital Signal Processing, 4th edition, Prentice Hall, 2012.<br>2. S. K. Mitra, Digital Signal Processing: A computer base approach, 3rd edition, Mc Graw Hill Higher Education, 2016.<br>3. V. Oppenheium, R. W. Schafer, Discrete-time signal processing, 2nd edition, Prentice Hall, 2010. | | | | | |
| Supplementary Reading | 1. Simon Haykin, Adaptive Filter Theory, Pearson Education, Fourth Edition, 2011.<br>2. Manolakis, D., Ingle, M., Kogon, S., Statistical and Adaptive Signal Processing, McGraw-Hill, 2000.<br>3. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley-India, 2008. | | | | | |