Department of Electrical Engineering

Curriculum for M.Tech (Electronics Systems & Communication)

FIRST SEMESTER

Sl. No	Sub. Code.	Subject	L-T-P	Credits
1	EE 641	Digital Communication	3-1-0	4
2	EE 643	Microwave & Antenna Systems	3-1-0	4
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Professional Elective – III	3-1-0	4
6	EE 671	Microwave & Antenna Lab	0-0-3	2
7	EE 673	Simulation & Computing Lab	0-0-3	2
8	EE 685	Seminar & Technical Writing – I	0-0-3	2
TOTAL				**26**

SECOND SEMESTER

Sl. No	Sub. Code.	Subject	L-T-P	Credits
1	EE 642	Wireless Communication	3-1-0	4
2	EE 654	Satellite Communication	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Professional Elective – V	3-1-0	4
5		Professional Elective – VI	3-1-0	4
6	EE 672	Advanced Communication Laboratory	0-0-3	2
7	EE 674	Embedded System Laboratory	0-0-3	2
8	EE 686	Seminar & Technical Writing – II	0-0-3	2
TOTAL				**26**

THIRD SEMESTER

Sl. No	Sub. Code.	Subject	L-T-P	Credits
1	EE 687	Seminar & Technical Writing – III		2
2	EE 691	Summer Research / Industrial Project		4
3	EE 693	Research Project Work – I		8
4	EE 695	Research Project Review – I		8
TOTAL				**22**

FOURTH SEMESTER

Sl. No	Sub. Code.	Subject	L-T-P	Credits
1	EE 688	Seminar & Technical Writing – IV	0-0-3	2
2	EE 692	Comprehensive Viva-Voce		4
3	EE 694	Research Project Work – II		8
4	EE 696	Research Project Review – II		4
5	EE 699	Dissertation		8
TOTAL				**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T-P	Credits
9.	EE 627	State Space & Digital Control	3-1-0	4
1.	EE 634	Robotics & Automation	3-1-0	4
2.	EE 635	System Identification and Adaptive Control	3-1-0	4
3.	EE 636	Intelligent Control	3-1-0	4
4.	EE 637	Soft Computing Techniques	3-1-0	4
5.	EE 653	Digital Image Processing	3-1-0	4
6.	EE 645	Adaptive Signal Processing	3-1-0	4
7.	EE 646	Estimation of Signals & Systems	3-1-0	4
8.	EE 647	Information Theory & Coding	3-1-0	4
10.	EE 655	VLSI Signal Processing	3-1-0	4
11.	EE 656	Computer Communication Networks	3-1-0	4
12.	EE 657	Optical communication	3-1-0	4
13.	EE 664	Embedded Computing Systems	3-1-0	4
14.	EE 665	Digital Speech Processing	3-1-0	4
15.	EE 666	Evolutionary Computing Techniques	3-1-0	4
16.	EE 667	Digital VLSI Design	3-1-0	4
17.	EE 668	Instrumentation and Sensors	3-1-0	4
18.	EE 669	Nanoelectronic Devices Modeling & Simulation	3-1-0	4
19.	EE 681	Special Topics in Electrical Engineering – I		3/4
20.	EE 682	Special Topics in Electrical Engineering – II		3/4
21.	EE 683	Special Laboratory in Electrical Engineering – I	0-0-3	2
22.	EE 684	Special Laboratory in Electrical Engineering – II	0-0-3	2

LIST OF PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T-P	Credits
1.	CH 668	Evolutionary Computation	3-1-0	4
2.	CR 645	Nanomaterials	3-1-0	4
3.	CS 613	Wireless Network Security	3-1-0	4
4.	CS 614	Combinatorial Optimization	3-1-0	4
5.	CS 623	Real Time Systems	3-1-0	4
6.	CS 624	Network Security	3-1-0	4
7.	CS 625	Ad hoc and Wireless Networks	3-1-0	4
8.	CS 632	Distributed Operating Systems	3-1-0	4
9.	CS 633	Bioinformatics	3-1-0	4
10.	CS 634	Biometric Security	3-1-0	4
11.	CS 643	Embedded Systems	3-1-0	4
12.	CS 649	VLSI System Design	3-1-0	4
13.	EC 600	Architecture of DSP	3-1-0	4
14.	EC 620	Modeling and circuit Simulators for VLSI Systems	3-1-0	4
15.	EC 621	Digital VLSI Design	3-1-0	4
16.	EC 622	Analog and Mixed mode VLSI	3-1-0	4
17.	EC 623	HDL and High Level VLSI	3-1-0	4
18.	EC 624	Embedded Computing System	3-1-0	4
19.	EC 626	Low Power VLSI	3-1-0	4
20.	EC 628	VLSI Signal Processing	3-1-0	4
21.	EC 640	Pattern Recognition Application	3-1-0	4
22.	MA 522	Operation Research		
23.	MA 523	Discrete Mathematics		
24.	MA 524	Statistical Methods		
25.	MA 527	Fractals		
26.	MA 551	Numerical Analysis		
27.	MA 552	Fuzzy logic and Set Theory		
28.	MA 553	Optimization Techniques		
29.	PH 645	Non-linear dynamics, Chaos and its recent applications	3-1-0	4
30.	PH 646	Synchronization and its recent applications in Chaotic systems	3-1-0	4

SUMMARY OF COURSES

Sub Discipline: Control, Power Electronics and Drives

EE 627	State Space & Digital Control	3-1-0	4
EE 634	Robotics & Automation	3-1-0	4
EE 635	System Identification and Adaptive Control	3-1-0	4
EE 636	Intelligent Control	3-1-0	4
EE 637	Soft Computing Techniques	3-1-0	4

Sub Discipline: Electronics, Signal Processing and Communication

EE 641	Digital Communication	3-1-0	4
EE 642	Wireless Communication	3-1-0	4
EE 643	Microwave & Antenna Systems	3-1-0	4
EE 653	Digital Image Processing	3-1-0	4
EE 645	Adaptive Signal Processing	3-1-0	4
EE 646	Estimation of Signals & Systems	3-1-0	4
EE 647	Information Theory & Coding	3-1-0	4
EE 654	Satellite Communication	3-1-0	4
EE 655	VLSI Signal Processing	3-1-0	4
EE 656	Computer Communication Networks	3-1-0	4
EE 657	Optical communication	3-1-0	4
EE 664	Embedded Computing Systems	3-1-0	4
EE 665	Digital Speech Processing	3-1-0	4
EE 666	Evolutionary Computing Techniques	3-1-0	4
EE 667	Digital VLSI Design	3-1-0	4
EE 668	Instrumentation and Sensors	3-1-0	4
EE 669	Nanoelectronic Devices Modeling & Simulation	3-1-0	4

Sub Discipline: Laboratory Courses

EE 671	Microwave & Antenna Lab	0-0-3	2
EE 673	Simulation & Computing Lab	0-0-3	2
EE 672	Advanced Communication Laboratory	0-0-3	2
EE 674	Embedded System Lab	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

EE 681	Special Topics in Electrical Engineering – I		3/4
EE 682	Special Topics in Electrical Engineering – II		3/4
EE 683	Special Laboratory in Electrical Engineering – I	0-0-3	2
EE 684	Special Laboratory in Electrical Engineering – II	0-0-3	2
EE 685	Seminar & Technical Writing – I	0-0-3	2
EE 686	Seminar & Technical Writing – II	0-0-3	2

EE 687	Seminar & Technical Writing – III		2
EE 688	Seminar & Technical Writing – IV	0-0-3	2
EE 691	Summer Research / Industrial Project		4
EE 692	Comprehensive Viva-Voce		4
EE 693	Research Project Work – I		8
EE 694	Research Project Work – II		8
EE 695	Research Project Review – I		8
EE 696	Research Project Review – II		4
EE 697	Special Topics in Signal Processing		
EE 698	Special Topics in Communication		
EE 699	Dissertation		8

DETAILED SYLLABI OF COURSES

Sl. No	Sub. Code	Subject	L-T-P	Credits
1.	EE 634	Robotics & Automation	3-1-0	4
2.	EE 635	System Identification and Adaptive Control	3-1-0	4
3.	EE 636	Intelligent Control	3-1-0	4
4.	EE 637	Soft Computing Techniques	3-1-0	4
5.	EE 641	Digital Communication	3-1-0	4
6.	EE 642	Wireless Communication	3-1-0	4
7.	EE 643	Microwave & Antenna Systems	3-1-0	4
8.	EE 653	Digital Image Processing	3-1-0	4
9.	EE 645	Adaptive Signal Processing	3-1-0	4
10.	EE 646	Estimation of Signals & Systems	3-1-0	4
11.	EE 647	Information Theory & Coding	3-1-0	4
12.	EE 654	Satellite Communication	3-1-0	4
13.	EE 655	VLSI Signal Processing	3-1-0	4
14.	EE 656	Computer Communication Networks	3-1-0	4
15.	EE 657	Optical communication	3-1-0	4
16.	EE 664	Embedded Computing Systems	3-1-0	4
17.	EE 665	Digital Speech Processing	3-1-0	4
18.	EE 666	Evolutionary Computing Techniques	3-1-0	4
19.	EE 667	Digital VLSI Design	3-1-0	4
20.	EE 668	Instrumentation and Sensors	3-1-0	4
21.	EE 669	Nanoelectronic Devices Modeling & Simulation	3-1-0	4
22.	EE 671	Microwave & Antenna Lab	0-0-3	2
23.	EE 672	Advanced Communication Laboratory	0-0-3	2
24.	EE 673	Soft computing Laboratory	0-0-3	2
25.	EE 681	Special Topics in Electrical Engineering – I		3/4
26.	EE 682	Special Topics in Electrical Engineering – II		3/4
27.	EE 683	Special Laboratory in Electrical Engineering – I	0-0-3	2
28.	EE 684	Special Laboratory in Electrical Engineering – II	0-0-3	2
29.	EE 685	Seminar & Technical Writing – I	0-0-3	2
30.	EE 686	Seminar & Technical Writing – II	0-0-3	2
31.	EE 687	Seminar & Technical Writing – III		2
32.	EE 688	Seminar & Technical Writing – IV	0-0-3	2
33.	EE 691	Summer Research / Industrial Project		4
34.	EE 692	Comprehensive Viva-Voce		4
35.	EE 674	Embedded System Lab	0-0-3	2
36.	EE 693	Research Project Work – I		8
37.	EE 694	Research Project Work – II		8
38.	EE 695	Research Project Review – I		8
39.	EE 696	Research Project Review – II		4
40.	EE 697	Special Topics in Signal Processing		
41.	EE 698	Special Topics in Communication		
42.	EE 699	Dissertation		8

EE 634 ROBOTICS AND AUTOMATION 4 credits [3-1-0]

Transformations and Kinematics of Position: Homogeneous transformations; Rotation matrices; Three and four parameter representations for orientation; Mathematical Singularities; Robot kinematic modeling; Forward kinematics; Inverse kinematics problem: closed-form and numerical solutions; Concept of decoupling. Kinematics of Velocity and Robot Statics: Translational and rotational velocities; Velocity transformations; Jacobian transformations; Derivatives of homegeneous transformation matrices; Forward kinematics; Inverse kinematics of velocity; Static force/torque transformations; Recursive equations of motion and static force/torque relationships. Trajectory Planning and Kinematic Control: Point-to-point vs Continuous motion. Polynomials. Linear functions with parabolic blends. Via points. Cartesian paths. Kinematic control. Robot Dynamics: Euler-Lagrange equations; Lagrangian approach to robot dynamics; Actuator dynamics; Properties of the robot dynamic model: inertial coefficients, centrifugal and coriolis coefficients, and gravity terms. Newton-Euler formulation of robot dynamics; Computational considerations. Robot Positional Control: Independent joint control: based on PD and PID compensators, based on feed forward control; State-space modelling and analysis; Lyapunov stability analysis; Multivariable PD control; Computed-Torque control; Implementaion and robustness issues; Cartesian based control schemes; Robust control methods; Adaptive control methods. Robot Compliance and Force Control: Compliance and stiffness; Force control in a single DOF system; Impedance control; Hybrid force and position control; Stability issues and other problems; Simultaneous force / position; control of constrained robots. Discrete geometry and quantization, length estimation, automated visual inspection, object recognition and matching, depth perception problems, stereo geometry and correspondences, motion analysis, optical flow, multi-resolution processing of images, application of computer vision, remote sensing, target tracking.

Essential Reading:

1. L. Sciavicco and B. Siciliano, *Modeling and Control of Robot Manipulators*. Springer, 2007
2. F.L. Lewis, D.M. Dawson and C.T. Abdallah, *Robot Manipulator Control: Theory and Practice,* Revised and Expanded, Marcel Dekker, New York, 2004.
3. K.S. Fu, R.C. Gonzalez, and C.S.G. Lee, *Robotics: Control, Sensing, Vision, and Intelligence*, McGraw Hill, NY, 1987.

Supplementary Reading:

1. J. J. Craig, *Introduction to Robotics, Mechanics and Control*, 2nd edition, Addison Wesley, MA. Digitized Dec 4, 2007
2. R. J. Schilling, *Fundamentals of Robotics Analysis and Control*, Prentice Hall, NJ, Digitized Dec 5, 2007

EE 635 SYSTEM IDENTIFICATION & ADAPTIVE CONTROL 4 credits [3-1-0]

Introduction and overview of Systems Identification, Adaptive Control and applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators, Nonlinear Least Squares. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, convergence analysis, Time varying parameters. Nonlinear System Identification. Adaptive schemes. Adaptive control theory. Applications; Situations when constant Gain feedback is insufficient; Robust control. The adaptive control problem. The model following problem. MRAS based on

stability theory.Model following when the full state is measurable. Direct MRAS for general linear systems. Prior knowledge in MRAS. MRAS forpartially known systems. Use of robust estimation methods in MRAS. The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear quadratic STR. Adaptive Predictive control. Prior knowledge in STR. Linear-in-the-parameters model. Least squares estimation. Experimental conditions. Recursive estimators. Extended leastsquares. Robust estimation methods (dead zone, projection).Implementation issues.

Essential Reading:

1. K.J. Astrom and B. Wittenmark, *Adaptive Control*, Addison, Pearson 2006.
2. L. Ljung, *System Identificaiton Theory for the user*, Prentice-Hall, 2007.

Supplementary Reading:

1. K.S. Narendra & A.M. Annaswamy, *Stable Adaptive Systems*, Prentice-Hall, 1989.
2. Landau & Zito, *Digital Control Systems: Design, Identification and Implementation*, Springer, 2006.

EE 636 INTELLIGENT CONTROL 4 credits [3-1-0]

MATLAB and SIMULINK: Introduction, Control Toolbox, System Identification Toolbox, Fuzzy Logic Toolbox, Neural Network Toolbox, Genetic Algorithm Toolbox. System Identification and Adaptive Control: Discrete-time models, least squares estimation, recursive least squares estimation, self-tuning regulator. Artificial Neural Networks Applications to System Identification & Control: Introduction, learning with ANNs, single-layer networks, multi-layer perceptrons, ANNs for identification, ANNs for control. Fuzzy Logic Control: Introduction, fuzzy sets, fuzzy logic, fuzzy logic controller design, Fuzzy Modelling & identification, Adaptive Fuzzy Control Design. Evolutionary Computation for Control & identification: Applications of EC methods to system identification and control. Combination of Soft Computation Approaches Control & Identification: Neuro-fuzzy, evolutionary neuro and evolutionary fuzzy systems.

Essential Reading:

1. D. Driankov, H. Hellendoorn, M Reinfrank, *An Introduction to Fuzzy Control*, Springer-Verlag, Reprint 2001
2. Li-Xin Wang, *A Course in Fuzzy Systems and Control*, Prentice Hall, Digitized 2007
3. K.F. Man, K.S.Tang, S.Kwong and W.A.Halang, *Genetic Algorithms for Control*, Springer, Digitized in 2007.

Supplementary Readings:

1. Li-Xin Wang, *Adaptive Fuzzy Systems and Control: Design and Stability Analysis*, 2007, Prentice-Hall, Intl.
2. S.H. Zak, *Systems and Control*, Oxford Univ. Press, 2003.

EE 637 SOFT COMPUTING TECHNIQUES 4 credits [3-1-0]

Introduction: What is SC? Why is it useful? Fuzzy Sets, Fuzzy Set operations, Fuzzy Rules and Fuzzy Reasoning, Extension Principle and fuzzy relations, fuzzy compositions, Fuzzy Reasoning, Fuzzy Inference Systems Extension principle, Fuzzy Inference Systems (Mamdani Fuzzy Models, defuzzification methods, Sugeno Fuzzy Models), Fuzzy Modeling, Biological

Neural Networks and simple models; The Artificial Neuron Model; Hopfield Nets; Energy Functions and Optimization; Perceptrons & Threshold Logic machines; Multilayer Networks their variants and Applications; Capacity of Multilayer Networks; Back propagation; Recurrent Nets; Tree Structured Networks; Unsupervised Learning; Hebbian Learning, Principal Component Analysis; Competitive Learning, Feature Mapping, Self Organizing Maps, Adaptive Resonance Theory. Evolutionary Computation: Different variants, Genetic Algorithm, Hybrid Systems: ANFIS, Fuzzy Filtered NN & Neural Fuzzy Systems, GA tuned Fuzzy System, Adaptive Fuzzy Clustering, etc., Summary Remarks

Essential Reading:

1. S. Haykin, *Neural Networks: A Comprehensive Foundation*, Pearson, 2006
2. T.J. Ross, *Fuzzy Logic with Engineering Application,* John Wiley and Sons, 2004.
3. D.B. Fogel, *Evolutionary Computation*, IEEE Press, 2003.

Supplementary Reading:

1. A.Konar, *Computational Intelligence: Principles, Techniques and Applications*, Spinger Verlag, 2005.
2. V. Kecman, *Learning & Soft Computing*, Pearson, 2006.

EE 641 DIGITAL COMMUNICATION 4 credits [3-1-0]

Digital modulation techniques: BPSK, BFSK and DPSK, QPSK, M-ary PSK, MSK, M-ary FSK, GMSK. Optimum receivers for AWGN channel: Optimum receiver for signals corrupted by AWGN, performance of optimum receiver for memoryless modulation, optimum receiver for CPM signals, optimum receiver for signals with random phase in AWGN channel. CARRIER AND SYMBOL SYNCHRONIZATION: Signal Parameter estimation, carrier phase estimation, symbol timing estimation, Joint estimation. Channel capacity and coding: Channel models and channel capacity, Block codes – coding and decoding, cyclic codes, algebraic codes, Reed-Solomon Code, Convolutional codes; Spread spectrum signals for digital communication: Direct sequence (DS) spread spectrum and its applications, frequency hopping (FH) spread spectrum, synchronization of spread spectrum systems.

Essential Reading:

1. H. Taub, D.L. Schilling and G. Sinha, *Principle of Communication Systems*, 3rd Ed., Tata McGraw Hill, 2008.
2. J.G. Proakis, *Digital Communication,* McGraw-Hill, 2000.

Supplementary Reading:

1. B. Sklar, *Digital Communications*, Pearson Education, India, 2001
2. J.G. Proakis and M. Salehi, *Communication Systems Engineering*, Pearson Education International, 2002
3. J.R. Barry, E.A. Lee and D.G. Messerschmitt, *Digital Communication,* Springer, 2004.

EE 642 WIRELESS COMMUNICATION 4 credits [3-1-0]

Evolution and example of mobile radio systems, recent trends, Frequency reuse, Channel assignment, hand off process, Interference. Path less:– Radio wave propagation, diffraction, Scattering, link budget; Outdoor and indoor propagation models; Principle of multi path propagation, Impulse response model of channels, parameters for mobile multi path channels, concept of fading, Rayleigh and Ricean fading; simulation of fading channels. Modulations

techniques for mobile communication:- Linear Modulation techniques, constant envelop modulation, QPSK, MSK, GMSK, spread spectrum modulation techniques. Equalization:- Fundamentals, General adaptive equalizer, Linear and non-linear equalizers, diversity techniques, RAKE receivers. Basic concept of coding. Multiple access techniques: - Introduction, FDMA, TDMA, CDMA, Space division multiple access, capacity of cellular systems. Introduction to OFDM and Wireless LAN.

Essential Reading:

1. T.S. Rappaport, *Wireless Communications – Principles and Practice*, Prentice Hall of India, 2002.
2. W C Y Lee; *Mobile Communication Engineering*, Tata McGraw Hill, India, 2008

Supplementary Reading:

1. W.C.Y. Lee, *Digital Cellular Systems*, Mc Graw Hill, 2000.
2. G. Stuber; *Principles of Mobile Communication*, 2001, Springer

EE 643 MICROWAVE & ANTENNA SYSTEMS 4 credits [3-1-0]

Circuit Concepts, Transmission lines, Micro-strip lines, Wave guides, Microwave networks, Microwave resonator, Electromagnetic wave Generation Process, Microwave Amplifiers and oscillators, Scattering of electromagnetic waves; Retarded potential, radiation from a dipole, antenna properties, types of antennas, Frequency independent antennas, antenna arrays, Design of log periodic antennas, Slot, Horn and complementary antennas, electromagnetic propagation: Ground wave, Space wave, Sky wave Propagation.

Essential Reading:

1. D.M. Pozar, *Microwave Engineering*, John-Wiley, 2004.
2. R. Chatterjee, *Antenna Theory and Practice*, New Age Publishers, 2nd Edition, 2008.

Supplementary Reading:

1. G.P. Srivastava, V.L. Gupta, *Microwave Devices and Circuit Design,* Prentice Hall of India, 2006.
2. R.S. Elliott, *Antenna Theory & Design*, Wiley-IEEE Press, 2003.
3. V. Fusco**,** *Foundations of Antenna Theory and Techniques*, Prentice Hall, 2005.

EE 653 DIGITAL IMAGE PROCESSING 4 credits [3-1-0]

Digital Image Fundamentals, Image Transforms: Fourier, Hadamard, Walsh, Discrete cosine and Hotelling Transforms; Image Enhancement: Histogram modification, Histogram equalisation, Smoothing, Filtering, Sharpening, Homomorphic filtering. ; Image restoration, Segmentation: Pixel classification, Bi-level thresholding, Multi-level thresholding, P-tile method, Adaptive thresholding, Spectral & spatial classification, Edge detection, Hough transform, Region growing. Matching and Registration: Image modeling, Stereo mapping, Landmark matching, Rectification in geometric transformations, Match measurement, Matching of binary pattern, Distortion tolerant matching; Digital geometry and its applications: Neighborhood, Path, Connectedness, Holes and Surroundness, Borders, Distances, Medial Axis Transform (MAT), Shrinking and Expanding, Thinning. Introduction to Mathematical morphology and its application, Morphological Operations, Dilation, Erosion, Opening, Closing, Smoothing, Extraction of connected components, Thinning.

Essential Reading:

1. R.C. Gonzalez, R.E. Woods, *Digital Image Processing,* Pearson Prentice Hall, 2007.
2. B. Chanda, D.D. Majumder, *Digital Image Processing and Analysis,* Prentice Hall, 2007.

Supplementary Reading:

1. W.K. Pratt**,** *Digital Image Processing (Fourth Edition)***,** John Wiley & Sons, Inc., 2007
2. A.K. Jain, *Fundamentals of Digital Image Processing*, Prentice Hall, 1988.

EE 645 ADAPTIVE SIGNAL PROCESSING 4 credits [3-1-0]

Adaptive systems: Examples and applications. Adaptive linear combiner : the performance function, gradient and minimum mean square error, alternative expression of gradient, LMS, NLMS, sign-error, sign-data and FXLMS algorithms, transform domain LMS, Recursive least square algorithm, windowed RLS, computational complexity, Block adaptive filter(time and DFT domains), adaptive lattice filters, IIR adaptive filter : equation error form. Adaptive filtering, Adaptive channel equalization, Adaptive line enhancement and adaptive system identification. Hardware implementation of digital adaptive filter. Applications of adaptive filter : 50Hz interference in electrocardiography, cancellation of donor-heart interference, cancellation of maternal ECG in electrocardiography, cancellation noise in speech signals, adaptive echo cancellation in long distance telephone line, self tunning filter. Adaptive control systems: model inverse and model reference controls. Introduction of adaptive array and adaptive beam forming. Recent advances in adaptive filtering.

Essential readings:

1. B. Widrow and S. D. Sterns, *Adaptive Signal Processing*, Pearson Education, 2nd Indian reprint, 2002.
2. D. G. Manolakis, V.K. Ingle, S.M. Kogon, *Adaptive Signal Processing*, McGraw-Hill, 2000.

Supplementary Reading:

1. J. Benesty, Y. Huang, *Adaptive Signal processing: Applications to Real World Problems*, Springer, 2003.
2. S. Haykin and T. Kailath, *Adaptive Filter Theory*, Pearson Education, 2005.

EE 646 ESTIMATION OF SIGNALS & SYSTEMS 4 credits [3-1-0]

Introduction to probability theory and statistics. Static state estimation, recursive least squares (RLS). Statistically consistent estimation. Weighted L.S. Dynamic state estimation, Kalman filter and square root Kalman filter. System Identification, parametric models. L.S estimation, bais. Generalized least square (GLS) and instrumental variable (IV). Persistently exciting input signals. Likely functions and maximum likelihood estimation (MLE).Cramer Rao lower bound, Singular value decomposition (SVD). Stochastic approximation algorithm (STA) and convergence. Non-parametric estimation. Order and structure determination. PMM and PMM; rank collapse condition, Yule-Walker equation. Multivariable system representation. Controllability and observability indices, Guidorzi's formulation. Volterra series representation of non-linear systems. Introduction to time-series analysis, Auto-correlation function (ACF) and partial ACF, their use. Non-stationary time series model, ARIMA and SARIMA. ; Introduction to linear least square estimation: a geometric approach. Wiener filter, Levinson filter, updating QR filter and the Kalman filter. Filter implementation structures: lattice, ladder and the systolic QR. Stochastic realization theory (modelling given the covariance). Modelling given the raw data.

Spectral estimation. Recursive least squares identification algorithms: Levinson-type, Kalman-type and the QR-type. Nonlinear System Identification Techniques

Essential Reading:

1. M.S.Grewal and A.P. Andrews, *Kalman Filtering Theory and Practice using Matlab*, Wiley, 2001
2. F.L. Lewis, L. Xie, and D. Popa, *Optimal & Robust Estimation: With an Introduction to Stochastic Control Theory*, John Wiley and Sons, New York, 2007. Second Edition.

Supplementary Reading:

1. O.Nells, *Nonlinear System Identification*, Springer, 2007.

EE 647 INFORMATION THEORY & CODING 4 credits [3-1-0]

Sources-memoryless and Markov; Information; Entropy; Extended sources; Shanon's noiseless coding theorem; Source coding; Mutual information; Channel capacity; BSC and other channels; Shanon's channel capacity theorem; Continuous channels; Comparison of communication systems based on Information Theory; Channel Coding-block and convolutional block codes- majority logic decoding; Viterbi decoding algorithm; Coding gains and performance.

Essential Reading:

1. R. Bose, *Information Theory Coding and Cryptography*, Tata Mc-Graw Hill, 2008.
2. G. A. Jones, Josephine Mary Jones, *Information and Coding Theory*, Springer, 2000.

Supplementary Reading:

1. D.R. Hankerson, G. Hoffman, D.A. Leonard, C.C. Lindner, K.T. Phelps, C. A. Rodger, J.R. Wall, *Coding Theory and Cryptography: The Essentials*, CRC Press, 2000.
2. R. Togneri, C. J. S. DeSilva, *Fundamentals of Information Theory and Coding Design,* CRC Press, 2003.

EE 652 AD HOC NETWORKS 4 credits [3-1-0]

Mobile ad hoc networking; imperatives, challenges and characteristics. Bluetooth networks; Routing approaches. Proactive and reactive protocols. Clustering and hierarchical routing. Multipath routing. Security aware routing; Energy efficient communication in ad hoc networks. Measuring energy consumption. Power save protocols. Maximum life time routing; Secure routing protocols. Intrusion detection. Security considerations in ad hoc sensor networks. Key management; Characterization of IP traffic. QOS classification. Self similar processes. Statistical analysis of non – real time traffic and real – time services.

Essential Reading:

1. C.S. Murthy & B.S. Manoj, *AdHoc Wireless Networks*, Pearson, 2004.
2. T.Janevski, *Traffic Analysis and Design of Wireless IP Networks,* Artech House, 2003

Supplementary Reading:

1. S.Basagni & M.Conti, *Mobile Ad Hoc Networking*, Wiley, 2004
2. C.Perkins, *Ad Hoc Networking*, Addison Wesley, 2000.

EE 654 SATELLITE COMMUNICATION 3 credits [3-0-0]

Original Satellite Communications, History, Current State, Overview of Satellite System Engineering; Orbital Aspects of Satellite Communication**:** Orbital mechanism, look angle determination, orbit determination, orbit effects on Communication, System performance; Satellite Link Budget**:** Basic transmission theory, system noise and G/T ratio, down link design, satellite system using small earth station, up-link design; Modulation Multiplexing Techniques**:** Analog telephone transmission, Television transmission, Digital transmission, Digital TV and bandwidth Compression, time division multiplexing; Multiple Access Techniques**:** Frequency division multiple access, time division multiple access, code division multiple access, practical demand access systems, random access, multiple access with on-board processing; Satellite Earth Solution Techniques: Earth solution design, tracking, small earth station antennas, Equipment for the Earth station.

Essential Reading:

1. T.Pratt and W.Boston, *Satellite Communications,* John Wiley & Sons, 2004
2. W.W. Wu, *Elements of Digital Satellite Communication*, Vol. 1, Computer Science Press 2006.

Supplementary Reading:

1. T.T. Ha, *Digital Satellite Communications,* McGraw Hill, U.S.A., 2004
2. G.D.Gordon, W.L.Morgan, *Principles of Communication Satellite,* John Wiley & Sons, U.S.A., 2005.

EE 655 VLSI SIGNAL PROCESSING 4 credits [3-1-0]

Overview of VLSI Architectures, Typical Signal Processing Algorithms, representation of DSP algorithms; Iterative bound: data-flow graph representation, loop bound and iterative bound; Pipelining and parallel processing: pipelining of FIR filters, pipelining and parallel processing for low-power; Retiming: definition and properties, retiming techniques; Unfolding: properties of unfolding, critical path, unfolding and retiming; Folding: folding transformations, register minimization techniques; Systolic architecture design methodology, FIR systolic arrays; Fast convolution: Cook-Toom algorithm, Winograd algorithm, cyclic convolution; Algorithm strength reduction in filters and transforms: parallel FIR filters, DCT and IDCT, rank-order filters; Pipelined and parallel recursive and adaptive filters: pipeline inverting in digital filters, pipelining in first-order IIR filter, parallel processing for IIR filter; DSP Processors for Mobile and Wireless Communications, Processors for Multidimensional Signal Processing;

Essential Reading:

1. K. K. Parhi, *"VLSI Digital Signal Processing Systems, Design and Implementation"*, John Wiley, 2003

Supplementary Reading:

1. S.Y.Kung, "VLSI Array Processors", Prentice-Hall, 1988

EE656 COMPUTER COMMUNICATION NETWORKS 4 credits [3-1-0]

Communication Model, Data Communications, Computer Communication Architecture, Standard Making Organisations.Concepts and Terminology, Asynchronous and Synchronous Data Communications, Multiplexing Techniques. Communication Networking Techniques, Circuit Switching, Packet Switching, Local Area Networks. Protocols, Layered Approach, TCP / IP Protocol Suite, System Network Architecture. The Bridge and Routing, Connectionless internetworking, Connection oriented internetworking. Transport and Network Services TCP / UDP. Session Characteristics, OSI Session and Service Protocol. Presentation Concepts, Encryption and Authentication Codes, Virtual Terminal Protocols. Network Management, File Transfer and Electronic Mail. Communication Switching Techniques, Frame-mode Bearer Service, Frame Relay Congestion Control, Synchronous Transfer Mode.

Essential Reading:

1. W.Stallings, *Data and Computer Communications*, Prentice Hall of India, 2006
2. A.Godbole, *Data Communications and Networks,* 1st Edition, Tata Mc-Graw Hill, 2002.

Supplementary Reading:

1. A.S.Tanenbaum, *Computer Networks*, 2nd Ed.; PHI, New Delhi, 2002.
2. F.Halsall, *Data Communications, Computer Networks and Open Systems*, Pearson Education, 2003
3. U.D. Black, *Computer Networks: Protocols, Standards, and Interfaces,* Prentice Hall, 2007

EE 657 OPTICAL COMMUNICATION 4 credits [3-1-0]

Introduction to optical communication: Characteristics of optical transmission media, optical fibres- preparation and transmission characteristics, loss and dispersion mechanisms; Optical sources**:** principles of operation, modulation characteristics and driver circuits, LED, laser diodes, light source linearity, modal, and partition and reflection noise**;** Power Launching and Coupling**:** Source to fibre power launching, lensing schemes for coupling improvement, fibre to fibre joints, couplers, multiplexers and splices; Photo detectors: principles of operation, circuits and performance, preamplifiers and post-detection amplifiers; Optical Fiber systems: intensity modulation/direct detection system, link budget using direct detection, coherent system, wavelength converters, coherent and WDM systems, Photonic switching.

Essential Reading:

1. G.Keiser, *Optical Fibre Communications*, McGraw Hill, 2008.
2. J.M. Senior, *Optical Fiber Communications: Principles and Practice*, PHI, 2008.

Supplementary Reading:

1. Jones, W.B. Jones, *Introduction to Optical Fiber Communications Systems*, Oxford University Press, 1995.
2. A.J. Rogers, *Understanding Optical Fiber Communications*, Artech House, 2001.
3. J.C. Palais, *Fiber optic communication*, 5th edition, Prentice Hall, 2004.

EE 662 COMPUTER VISION 4 credits [3-1-0]

Discrete Geometry and Quantization, Length Estimations, Automated Visual Inspection, Object reorganization and matching, Depth perception problems, Stereo Geometry and correspondence, Motion analysis, Optical flow, Multiresolution Processing of Images,

Applications of Computer Vision, Remote Sensing, Biomedical Imaging, Document Processing, Target tracking.

Essential Reading:

1. D.A. Forsyth, J. Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2003.
2. L.G. Shapiro, G. C. Stockman, *Computer Vision*, Prentice Hall, 2001.

Supplementary Reading:

1. M. Sonka, V. Hlavac, R. Boyle, *Image Processing, Analysis, and Machine Vision*, Cengage Learning, 2008.
2. T. Morris, *Computer Vision and Image Processing*, Palgrave McMillan, 2003.

EE 664 EMBEDDED COMPUTING SYSTEMS 4 credits [3-1-0]

Microcomputer-based Systems, Software Development, Interfacing Methods, Interrupt Synchronization, Threads, Timing Generation and Measurements Serial I/O Devices, Parallel Port Interfaces, Memory Interfacing, High Speed I/O Interfacing Analog Interfacing Data Acquisition Systems, Microcomputer-based Control Systems Simple Networks, Digital Filters. ; Circuits and DSP Architectures**:** Circuit design basics, deep submicron issues, low architectures for embedded systems. ; Architecture Design: Embedded processor architectures, Architectural techniques for low power, Design methods for core based ASICs. ; Compiler and OS**:** Introduction to compiler optimizations, Power models for compiler optimizations, Code size vs. performance / power tradeoffs. ; DSP Algorithm Design**:** A/D conversion and finite precision analysis, Algorithms for embedded systems: source and channel processing, Portable embedded code. **; Networking:** Networking basics (addressing and routing), Wireless vs. wire-line networking, Distributed OS for networked embedded systems: Case study of JINI. ;

Essential Reading:

1. W. Wolf, *Computers as Components: Principles of Embedded Computer System Design*, Second Edition, Elsevier/MK, 2005
2. F. Vahid and T. Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, Wiley, 2002.

Supplementary Reading:

1. P. Marwedel, *Embedded System Design*, Springer, 2006.

EE 665 DIGITAL SPEECH PROCESSING 4 credits [3-1-0]

Signal processing tools, digital filters, Fourier series and transforms, DFT, FFT ,Short-Term Fourier Transform (STFT), Filter banks, Speech acquisition and digitization, Speech analysis and parameter extraction, Short-term analysis, frames and windows, Time-domain analysis: energy, zero-crossings, statistic parameters, autocorrelation, Frequency-domain analysis: spectra and spectrograms, Cepstral analysis, Linear prediction analysis, Pitch and formant estimation Static and dynamic features, Speech signal synthesis, Speech coding, Speech enhancement.

Essential Reading:

1. T.F. Quatieri, *Discrete-Time Speech Signal Processing: Principles and Practice*, Prentice-Hall, 2001.
2. L.R. Rabiner, and R.W. Schafer, *Digital Processing of Speech Signals,* Prentice-hall, 2007.

Supplementary Reading:

1. S. Furui, *Digital speech processing, synthesis, and recognition*, CRC Press, 2001
2. R. Deller, J. H. L. Hansen, and J. G. Proakis, *Discrete-Time Processing of Speech Signals,* 2nd edition, IEEE Press, 2000.

EE 666 EVOLUTIONARY COMPUTING TECHNIQUES 4 credits [3-1-0]

Genetic Algorithm: Basic concepts, Search space, working principle. Encoding: binary, Octal, Hexadecimal, permutation, Value and Tree. Decoding, fitness function, Selection: Roulette-wheel, Boltzmann, Tournament, Rank and Steady-state. Elitism, Crossover: single-pint, two-point, multi-point, uniform, matrix and cross over rate, Mutation: mutation, mutation rate. Variations of GA: Adaptive GA and Real coded GA (SR.; Ant colony optimization: Ant foraging behaviour, combinatorial optimization, Routing in communication network, traveling sales man problem, graph portioning, nest building. ; Particle swarm Optimization: basic principle, algorithm, flowchart. Variations of PSO: weighted, repulsive, stretched, comprehensive learning, combined effect PSO and clonal PSO. ; Bacterial Foraging Optimization: Forging theory, social foraging, foraging behaviour of E. coli bacteria, BFO algorithm, chemotatic, swarming, reproduction and elimination and dispersal. Variations of BFO: fuzzy BFO and Adaptive BFO. Artificial Immune System: overview, central and peripheral immune systems, immune network : clonal selection and its mathematical modeling, beyond clonal selection, danger theory, negative selection. Applications: function optimization, adaptive system identification, channel equalization and financial forecasting.

Essential readings:

1. D.E. Goldberg, *Genetic Algorithms in search, Optimization and machine learning*, 1989.
2. R.C. Eberhart, Y. Sai and J. Kennedy, *Swarm Intelligence* , The Morgan Kaufmann Series in artificial Intelligence, 2001.
3. D. Dasgupta, *Artificial Immune Systems and their applications*, 1998.

Supplementary Reading:

1. K.M. Passino, *Biomimicry for optimization, control and automation*, 2004.

EE 667 DIGITAL VLSI DESIGN 4 credits [3-1-0]

Introduction to VLSI Design, Levels of abstraction and the complexity of design, Challenges of VLSI design: power, timing, area, noise, testability, reliability and yield ; CAD tools: simulation, layout, synthesis, test; MOS modeling, MOS device models, Short-channel effects and velocity saturation, Scaling of MOS circuits; VLSI fabrication technology, Layout design, Design rules, Stick diagrams; The CMOS inverter, VTC, Switching behavior, Noise margins and power dissipation; Static and dynamic CMOS combinational logic gate, Transistor sizing in static CMOS, logical effort , Pass-transistor logic, sizing issues , Domino logic gates , estimating load

capacitance , Simple delay models (RC) for CMOS gates , Power consumption; Latches and clocking, Flip-flops, Set-up and hold tests, Static and dynamic latch and flip-flop, Clock design; Datapath units, Adders, Shifters, Multipliers; Control logic strategies, PLAs , Multi-level logic, Synthesis and place-and-route CAD; MOS memories , Register, SRAM , DRAM; Global interconnect modeling, Capacitance, resistance and inductance of interconnect; Signal and power-supply integrity issues, Electromigration, RC interconnect modeling Driving large capacitive load, reducing RC delays; Layout design, Standard-cell layout, Chip layout and floor planning, Array layout; Implementation issues, Design for testability, Packaging technology, I/O issues: ESD protection, boundary scan, inductance, synchronization

Essential Reading:

1. J.M. Rabaey, A. Chandrakasan and B. Nikolic, *Digital Integrated Circuits: A Design Perspective*, Second Edition, Pearson/PH, 2003. (Cheap Edition)

Supplementary Reading:

1. J.P. Uyemura, *Introduction to VLSI Circuits and Systems*, Wiley, 2001.
2. W.Wolf, *Modern VLSI Design: Systems-on-Chip Design*, Third Edition, Pearson/PH, 2002. (Cheap Edition)
3. R. L. Geiger, P. E. Allen and N. R. Strader, *VLSI Design Techniques for Analog and Digital Circuits*, McGraw-Hill, 1990.

EE 668 INSTRUMENTATION AND SENSORS 4 credits [3-1-0]

Measurement error and uncertainty. Accuracy, confidence limits, confidence level. Measuring methods. Characteristics of measuring instruments. Voltage and current measurement. Frequency measurement. Signals and noise. Signal conditioning: instrumentation amplifiers, sample and hold circuits, filters, current to voltage conversion analog multiplexers, isolation amplifiers. A/D and/a conversion: parallel, successive approximation and dual slope A/D converters. Data acquisition systems. Virtual instrumentation. Sensors and transducers: temperature, geometric displacement, force, torque, vibration. Microprocessor and PC based Instrumentation system Design. Introduction to computer control of processes.

Essential Reading:

1. D.V. Murty, *Transducers and Instrumentation*, PHI, 2008
2. C. S. Rangan, G. R. Sarma, V. S. V. Mani, *Instrumentation: Devices and Systems*, TMH, 2008

Supplementary Reading:

1. A.S. Morris, *Principles of Measurement and Instrumentation*, Prentice Hall, 2007
2. A.J. Bouwens, *Digital Instrumentation*, TMH, 2002

EE 669 NANOELECTRONIC DEVICES MODELING & SIMULATION 4 credits [3-1-0]

Band theory of solids, carrier transport mechanism, superconductor, Dielectrics, semiconductor diode, MOS capacitor, MOSFET device physics, EKV Model, circuit simulation techniques, SPICE, CMOS Scaling, Moore's Law, Advance CMOS (NanoCMOS) and beyond, ITRS, Problems with short channel devices, CMOS Scaling limit, Emerging Nanotechnologies, SET,QCA, RSQF, RTD. Device Fabrication and Characterization: Material requirement, MOS

capacitor as a building block of FET, Physical Vapour Deposition(PVD), Metal Organic Chemical Vapor Deposition(MOCVD), Nanopatterening (OPLG,MBE,ALD)

Essential Reading:

1. W. Ranier, *Nanoelectronics and Information Technology*, Wiley-VCH, 2003.
2. J.H. Davis, *The Physics of Low Dimensional Structure*, Cambridge University Press, 1998.
3. A.M. Lonescu and S. Mahapatra, *Hybrid CMOS Single Electron Transistor Device and Circuit Design*, Artech House Publication, ISBN 1-59693-069-1, 2006

Suggested Reading:

1. International Technology Roadmap for Semiconductor (ITRS)

Remarks:

Course code to be used:

1.	EE 685	Seminar & Technical Writing - I		
2.	EE 686	Seminar & Technical Writing – II		
3.	EE 687	Seminar & Technical Writing - III	0-0-3	2
4.	EE 688	Seminar & Technical Writing - IV	0-0-3	2
5.	EE 691	Summer Research / Industrial Project		4
6.	EE 692	Comprehensive Viva Voce		4
7.	EE 693	Research Project Work – I		8
8.	EE 694	Research Project Work – II		8
9.	EE 695	Research Project Review – I		8
10.	EE 696	Research Project Review – II		4
11.	EE 699	Dissertation		8

Course codes provided by the Department:

1.	EE 681	Seminar & Technical Writing - I	0-0-3	2
2.	EE 682	Seminar & Technical Writing – II	0-0-3	2
3.	EE 683	Seminar & Technical Writing – III		4
4.	EE 684	Seminar & Technical Writing – IV	0-0-3	2
5.	EE 685	Summer Research / Industrial Project		4
6.	EE 690	Research Project Work – II		8
7.	EE 691	Research Project Work – I		8
8.	EE 692	Research Project Review – II (Clashed)		4
9.	EE 693	Research Project Review – I		6
10.	EE 694	Dissertation		8
11.	EE 695	Comprehensive Viva-Voce		4

EE 692 - Comprehensive Viva-Voce in (4^{th} Semester Curriculum) and Embedded Systems Laboratory (in Summary of Courses, etc.)
EE 652 – Ad Hoc Networks (No description in Curriculum)
EE 662 – Computer Vision (No description in Curriculum)

EE 636 – (SR) 2.Adaptive Fuzzy Systems and Control Design and Stability Analysis (Publisher missing).

EE 666 - (SR) 2.Biomimicry for optimization, control and automation (Publisher missing).
EE 669 – International Technology Roadmap for Semiconductor (Publisher, etc missing)