Department of Electronics & Communication Engineering
राष्ट्रीय प्रौद्योगिकी संस्थान,मणिपुर
NATIONAL INSTITUTE OF TECHNOLOGY MANIPUR
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(An Autonomous Institute under MHRD, Govt. of India)

M.TECH. (ELECTRONICS AND COMMUNICATION ENGINEERING)

SEMESTER-I

Course Code	Course Title	L	T	P	C
EC 501	Analog and Digital CMOS IC Design	3	0	0	6
EC 503	Embedded Systems Design	3	0	0	6
EC 505	Modern Wireless Communication	3	0	0	6
EC 507	Signal Processing Algorithms	3	0	0	6
EC 5xx	Elective-I	3	0	0	6
EC 51x	Elective-II (Laboratory Course)	0	0	3	3
		Total:			33

SEMESTER-II

Course Code	Course Title	L	T	P	C
EC 502	Semiconductor IC technology	3	0	0	6
EC 504	Advanced Digital Communication	3	0	0	6
EC 506	Advance Microwave Engineering	3	0	0	6
EC 5xx	Elective-III	3	0	0	6
EC 51x	Elective-IV(Laboratory Course)	0	0	3	3
		Total:			27

SEMESTER-III

Course Code	Course Title	L	T	P	C
EC 611	Project-I	0	0	24	24
		Total:			24

SEMESTER-IV

Course Code	Course Title	L	T	P	C
EC 612	Project-II	0	0	24	24
		Total:			24

Students can select subjects either from Elective A or B.

List of Electives A

Electives-I

Course Code	Course Title	L	T	P	C
EC 521	Digital System Design	3	0	0	6
EC 523	Signal Processing for Embedded Systems	3	0	0	6
EC 525	Real Time Operating Systems	3	0	0	6
EC 527	Microcontroller for Embedded Systems	3	0	0	6
EC 529	Embedded Networking	3	0	0	6

EC 531	FPGA Design	3	0	0	6
EC 535	VLSIDSP	3	0	0	6
EC 537	Digital IC Design	3	0	0	6
EC 539	MEMS and Microsystem Technology	3	0	0	6
EC 541	Biomedical Signal and Systems	3	0	0	6

Electives-II

Course Code	Course Title	L	T	P	C
EC 511	VLSI and Embedded Lab-I	0	0	3	3
EC 513	Signal and Image Processing Lab	0	0	3	3

Electives-III

Course Code	Course Title	L	T	P	C
EC 524	Modeling of Semiconductor Devices	3	0	0	6
EC 526	ASIC Design and Modeling	3	0	0	6
EC 528	Embedded Computing	3	0	0	6
EC 530	Low Power VLSI	3	0	0	6
EC 532	VLSI System Design	3	0	0	6
EC 534	VLSI EDA Tools	3	0	0	6
EC 536	Reconfigurable Computing	3	0	0	6
EC 538	Memory Technologies	3	0	0	6
EC 540	Filter Design	3	0	0	6
EC 542	CPLD & FPGA Architecture	3	0	0	6

Electives-IV

Course Code	Course Title	L	T	P	C
EC 512	VLSI and Embedded Lab-II	0	0	3	3
EC 514	System Simulation Lab-A	0	0	3	3

List of Electives B

Elective-I

Course Code	Course Title	L	T	P	C
EC 551	Advance Digital Signal Processing	3	0	0	6
EC 553	Mobile Communication	3	0	0	6
EC 557	Fiber Optics Communication	3	0	0	6
EC 569	Software Defined Radio	3	0	0	6
EC 563	Advance Electromagnetic	3	0	0	6
EC 565	Antenna for Mobile Applications	3	0	0	6
EC 567	Electromagnetic Interference	3	0	0	6
EC 569	Advanced Antenna Design	3	0	0	6
EC 571	Principle of Microwave solid state devices	3	0	0	6

Elective-II

Course Code	Course Title	L	T	P	C
EC 515	Advanced Microwave and Antenna Lab	0	0	3	3
EC 517	Communication System Lab	0	0	3	3

Elective-III

Course Code	Course Title	L	T	P	C
EC 552	Information Theory and Coding	3	0	0	6
EC 554	Data Communication	3	0	0	6
EC 556	Satellite Communication	3	0	0	6
EC 558	Advance Radio Communication	3	0	0	6
EC 560	System-on-Chip (SoC)	3	0	0	6
EC 562	Microwave Devices and Circuits	3	0	0	6
EC 564	RF Component & Circuit Design	3	0	0	6
EC 568	Radar Engineering	3	0	0	6
EC 570	Advance EM Wave Propagation and Antenna	3	0	0	6
EC 572	Microwave Filter Design	3	0	0	6
EC 574	Image Processing Techniques	3	0	0	6

Elective-IV

Course Code	Course Title	L	T	P	C
EC 514	Advanced Communication Lab	0	0	3	3
EC 516	Image Processing Lab	0	0	3	3

EC 501	Analog and Digital CMOS IC Design	3	0	0	6
	MOS Switch, MOS Diode/ Active Resistor, Current Sinks & Sources, Current Mirror, Current & Voltage Reference, Band gap References. Inverters, Differential Amplifiers, Cascode Amplifiers, Current Amplifiers, Output Amplifiers, High Gain Amplifier Architectures. Buffered Opamp, High Speed/Frequency Opamps, Differential Output Opamps, Micro power Op amps, Low Noise Opamp. Low Voltage Opamp, Macro models for Opamps. Sequential Ckts. Design of FSM, Moore & Mealy machines, Metastability, Solutions to metastability, Synchronization methods, VHDL codes for complex sequential machines, Hazards, Types of hazards, Method to eliminate hazards, case studies. CMOS parasitic, Technology scaling, Lambda parameter, Design calculations for different logic ckts, Calculations for Area on chip, Power dissipation, PDP, Transmission gate, Domino logic, NORA logic, CMOS layout techniques, Transient response, Advance trends of elements & Alloys for ultra fast logic ckts. **Texts :** 1. J.M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits- A Design Perspective, 2nd ed., PHI, 2003 2. N.H.E. Weste and K. Eshraghian, Principles of CMOS VLSI Design – a System Perspective, 2nd ed., Pearson Education Asia, 2002 3. S.M. Kang and Y. Leblevici, CMOS Digital Integrated Circuits Analysis and Design, 3rd ed., McGraw Hill, 2003 4. J. P. Uyemura, Introduction to VLSI Circuits and Systems, John Wiley & Sons (Asia) Pte Ltd, 2002 5. R. Jacob Baker, CMOS Circuit Design, Layout, and Simulation, IEEE Press, 1997.				

6. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill 2001
7. P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, 2nd edition, Oxford University Press, 1997
8. B. Razavi, RF Microelectronics, Prentice-Hall, 1998.
9. P. R. Gray and R. G. Meyer, Analysis and design of Analog Integrated circuits 4th Edition, Wiley Student Edition, 2001.
10. D. A. Johns and K. Martin, Analog Integrated Circuit Design, Wiley Student Edition, 2002.

EC 502	Semiconductor IC technology	3	0	0	6

Historical perspective, processing overview, crystal growth, wafer fabrication and basic properties of Silicon Wafers, Clean Rooms, Wafer Cleaning, Epitaxy, Thermal Oxidation of Silicon, Lithography, Wet and Dry Etching, Thin film deposition, Diffusion, Ion Implantation, Metallization, Process Integration: Passive components, Bipolar Technology, MOSFET Technology, MESFET Technology, MEMS Technology, IC Manufacturing: Electrical Testing, Packaging, Yield, Future trends and Challenges: Challenges for integration, system on chip.

Texts:

1. G. S. May and S. M. Sze, Fundamentals of Semiconductor Fabrication, Wiley India, 2004.
2. J. D. Plummer, M. D. Deal and P. B. Griffin, Silicon VLSI Technology, Fundamentals, Practice and Modeling, Pearson education, 2000.
3. S. M. Sze, VLSI Technology, 2nd Edn., TMH, 2004.
4. S. M. Sze, Semiconductor Devices: Physics and Technology, 2nd Edn., Wiley India, 2011.
5. W. R. Runyan and K. E. Bean, Semiconductor Integrated Circuit Processing Technology, Addison Wesley Publishing Company, 1990.
6. S. A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford University Press, 1996.
7. M. J. Madou, Fundamentals of Micro fabrication, 2nd Edition, CRC Press, 2011.

EC 503	Embedded Systems Design	3	1	0	6

Digital Systems and Embedded Systems, Design Methodology, Design Metrics, Specialties, Concepts & types of Memory, Cache Memory, Cache mapping techniques, replacement policies, Cache wire Techniques, Cache Impact on system Performance, Integrated Circuits Technologies- Full custom/VLSI, Logic Families, ASICs , PLDs, PALs, CPLDs , FPGA, Packaging and Circuit Boards, Interconnection and Signal Integrity , Differential Signaling. General Purpose Processor, System On chip, Embedded Computer Organization, ARM 7/ARM 9 architecture, ARM Microcontrollers and Processor Cores, Instructions and Data handling, interfacing with Memory, Interrupts, Timers, ARM Bus. I/O Devices, Controllers, Simple & Autonomous I/O Controllers, Parallel, Multiplexed, Tristate, and Open-Drain Buses, Bus Protocols, Serial Transmission Techniques & Standards, Wireless protocols, CAN & advanced Buses. Design Methodology, Design Flow, Architecture Exploration, Functional Design, Functional Verification, Synthesis, Physical Design, Design Optimization, Area Optimization, Timing Optimization, Power Optimization, Design for Test , Fault Models and Fault Simulation, Scan Design and Boundary Scan, Built-In Self Test (BIST), Nontechnical Issues.

Texts/References:

1. Digital Design: An Embedded Systems Approach Using Verilog, Peter J. Ashenden ELSEVIER, Morgan Kaufmann Publication, 2008.
2. Data books of ARM7/ARM9 J. Staunstrup and W. Wolf, editors, Hardware/Software Co-Design: Principles and Practice, Kluwer Academic Publishers, 1997.
3. G. DeMicheli, R. Ernst, and W. Wolf, editors, Readings in Hardware/Software Co-Design, Academic Press, 2002.

EC 504	Advanced Digital Communication	3	0	0	6

Analog-to-Digital Conversion: Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth for PAM signal, Natural sampling, Flat top sampling, Quantization of signals, Quantization error, Pulse- code modulation (PCM), Electrical representation of binary digits, The PCM system, Companding, Multiplexing PCM signals, Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.
Digital Modulation Techniques: Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying, Differentially-Encoded PSK (DEPSK), Quadrature Phase-Shift Keying (QPSK), Quadrature Amplitude Shift Keying (QASK), Binary Frequency-Shift Keying (BFSK), Similarity of BPSK and BFSK, M-ary FSK, Minimum Shift Keying (MSK).

Data Transmission: A base band signal receiver, Probability of error, The Optimum Filter, Matched Filter, Probability of error in Matched filter, Coherent reception, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK, Calculation of error probability of BPSK and BFSK, Error probability for QPSK] Bit-by-bit encoding versus Symbol-by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate and comparison of modulation systems.

Information Theory and Coding: Discrete messages, The concept of amount of information, Entropy, Information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of a Gaussian channel, Bandwidth-S/N tradeoff, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding for error detection, Coding for error detection and error correction, Block codes (coding and decoding), Convolution codes (coding and decoding).

Text/References:
1. Wayne Tomasi, "Electronic communications systems" 5th edition Pearson Educaion Asia, 2006
2. Taub and Schilling, "Principles of Communication Systems", TMH, 2nd Edition, 2006
3. S. Haykin, "Digital Communication", Wiley, 2006.
4. S. Haykin, "Analog and Digital Communication", Wiley.

EC 505	Modern Wireless Communication	3	0	0	6

Cellular concepts, frequency reuse, co channel interference, Cell splitting. Radio propagation characteristics; models for path loss, shadowing and multipath fading (delay spread, coherence bandwidth coherence time. Doppler spread). Jakes' channel model. Digital modulation for mobile radio; analysis under fading channels; diversity techniques and Rake demodulator. Introduction to spread spectrum communication. Multiple access techniques used in mobile wireless communications: FDMA/TDMA, CDMA. The cellular concept: Frequency reuse; the basic theory of hexagonal cell layout; spectrum efficiency. FDM/TDM Cellular systems; channel allocation schemes. Handover analysis. Cellular CDMA; soft capacity. Erring capacity comparison of FDM/TDM systems and cellular CDMA. Discussion of GSM standards; signaling and call control; mobility management; location tracing. Wireless data networking; packet error modeling on fading channels, performance analysis of link and transport layer protocols over wireless channels; mobile data networking (mobile IP); wireless data in GSM, IS-95, and GPRS.

Texts/Rferences:
1. Jochen Schiller, "Mobile Communications", Second Edition, Pearson Education, 2003.
2. William Stallings, "Wireless Communications and Networks", Pearson Education, 2002.
3. KavehPahlavan, PrasanthKrishnamoorthy, "Principles of Wireless Networks", First Edition, Pearson Education, 2003.
4. Uwe Hansmann, LotharMerk, Martin S. Nicklons and Thomas Stober, "Principles of Mobile Computing", Springer, 2003.
5. C.K.Toh, "AdHoc Mobile Wireless Networks", First Edition, Pearson Education, 2002.

EC 506	Advance Microwave Engineering	3	0	0	6
	Significance of Maxwell Equations, Theory of Transmission line, Principles of microwave circuits, Wave guides and boundary conditions, Cavity resonators, Directional couplers, Phase shifter, microstrip line, Various types of antennas and feed systems, Antenna measurement principles, MICs, antenna, stub matching, smith chart, Noise and None linear distortion: Noise in Microwave Circuits, Noise Figure, Nonlinear Distortion, Dynamic Range. **Text/References:** 1. B. Razavi, IEEE Press 1995. 2. D. M. Pozar, "Microwave Engineering," 4th Edition, Wiley, 2012. 3. Elements of Electromagnetics, 4th Edition – Matthew N O Sadiku Oxford University Press 4. Engineering Electromagnetics, 2ed Edition - Nathan Ida Springer India				
EC 507	Signal Processing Algorithms	3	0	0	6
	Orthogonal transforms: DFT, DCT and HAAR; Properties of DFT; Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency; Linear convolution using DFT; Digital filter structures: Basic FIR/IIR filter structures, FIR/IIR Cascaded lattice structures, Parallel all pass realization of IIR transfer functions, Sine cosine generator; Computational complexity of filter structures; Multirate signal processing: Basic structures for sampling rate conversion, Decimators and Interpolators; Multistage design of interpolators and decimators; Polyphase decomposition and FIR structures; Computationally efficient sampling rate converters; Arbitrary sampling rate converters based on interpolation algorithms: Lagrange interpolation, Spline interpolation; Quadrature mirror filter banks; Conditions for perfect reconstruction; Applications in sub-band coding. **Texts:** 1. R. Chassaing and D. Reay, Digital signal processing and applications with TMS320C6713 and TMS320C6416, Wiley, 2008. 2. S. K. Mitra, Digital Signal Processing: A Computer Based Approach,3rd Edn., TMH, 2008. 3. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson Prentice Hall, 2007.				

EC 521	Modern Digital System Design	3	0	0	6
	Principles of Sequential logic design: Concept of FSM - Metastability, State machine structures: Moore machine - Mealy machine, Analysis of state machine with D and J-K Flip-flops, Clocked synchronous state machine design, Designing state machine using state diagrams, State machine synthesis using transition list, Clock skew, Overview of PLDs, CPLDs and FPGAs, RT level combinational circuit, Regular sequential circuit, Design examples with VHDL. **Texts:**1. J. F. Wakerly: Digital Design-Principles and Practices, 4th Edition, Pearson, 2008. 2. Pong P. Chu: FPGA Prototyping by VHDL Examples: Xilinx Spartan-3 Version, 1st Edition, WileyInterscience, 2008.				
EC 523	Signal Processing for Embedded Systems	3	0	0	6
	Digital Signal Processing Overview, Convolution, Correlation, Digital filters, DFT, STFT, DCT, wavelets and filter banks, FFT algorithms and Implementation, Representations of the DSP algorithms, Block diagrams, Signal flow graph, Data-flow graph, Dependence graph, iteration bounds, Pipelining and Parallel processing of FIR filters, Algorithm transformation: Retiming , Folding, Unfolding, Algorithmic strength reduction in Filters and Transforms, Parallel FIR filters, Fast FIR algorithms, Discrete cosine transform and Inverse DCT, Parallel processing for IIR filters, Pipelined adaptive digital filters. Introduction to Digital signal processing systems, MAC, Barrel shifter, ALU, Multipliers, Dividers, DSP processor architecture, Software developments, Selections of DSP processors, real time implementation considerations, Hardware interfacing, DSP processor architectures: TMS 320C54XX, TMS 320C67XX, Blackfin processor: Architecture				

	overview, memory management, I/O management, On chip resources, programming considerations, Real time implementations, Applications of DSP systems: FIR filters, IIR filters, DTMF generation and detection, FFT algorithms, wavelet algorithms, Adaptive algorithms: system identification, inverse modeling, noise cancellation, prediction. **Texts:** 1. Sen M. Kuo and Woon-Seng Gan, "Digital Signal Processors, architectures, implementations, and applications", Prentice-Hall, 1999. 2. V. Madisetti, " The Digital Signal Processing Handbook", IEEE press, 2000 3. K. K. Parhi, "VLSI Digital Signal Processing Systems- Design and Implementation", John Wiley & Sons, Inc, 2008. 4. Sanjit K. Mitra, " Digital Signal Processing: A Computer based approach", McCraw Hill, 1998. 5. Lawrence R. Rabiner and Bernard Gold, "Theory and application of Digital signal Processing", Prentice-Hall of India, 2006.				
EC 524	Modeling of Semiconductor Devices	3	0	0	6
	p-n Junctions: equilibrium conditions, forward and reverse-biased junctions, reverse-bias breakdown, transient and a-c conditions, recombination and generation in the transition, semiconductor hetero-junctions, Metalsemiconductor junctions: Schottky barriers, rectifying and Ohmic contacts, Bipolar junction transistors: minority carrier distribution and terminal currents, generalized biasing, switching, secondary effects, frequency limitations of transistors, hetero-junction bipolar transistors, Field-Effect Transistors: JFETcurrent-voltage characteristics, effects in real devices, high-frequency and high-speed issues, Metal Insulator Semiconductor FET, MOSFETbasic operation and fabrication; ideal MOS capacitor; effects of real surfaces; threshold voltages; output and transfer characteristics of MOSFET, short channel and Narrow width effects, MOSFET scaling, Optoelectronics Devices: Light emitting diodes, Lasers, Photoconductors, Junction Photodiodes, Avalanche Photodiodes, Solar Cells, SPICE Models for Semiconductor Devices: MOSFET Level 1, Level 2 and level 3 model, Model parameters; SPICE models of p-n diode and BJT. **Texts:** 1. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, 6th Edition, PHI Private Limited, 2011. 2. P. Bhattacharya, Semiconductor Optoelectronics Devices, 2nd Edition, PHI, 2009. 3. G. Massobrio and P. Antognetti, Semiconductor Device Modeling withSPICE, 2nd Edition, TMH, 2010. 4. C. C. Hu, Modern Semiconductor Devices for Integrated Circuits, Pearson Education, 2010. 5. R. S. Muller and T. I. Kamins, Device Electronics for Integrated Circuits, 3rd Edition, Wiley India, 2009. 6. S. M. Sze and K. K. Ng, Physics of Semiconductor Devices, 3rd Edition, Wiley India, 2010. 7. Y. Tsividis, Operation and Modeling of the MOS transistor, 2nd Edition, TMH, 1999. 8. S. A. Neamen and D. Biswas, Semiconductor Physics and Devices, 4th Edition, TMH, 2012.				
EC 525	Real Time Operating Systems	3	0	0	6
	Software Architectures, Software Developments Tools, Programming Concepts, Embedded Programming in C and C++, Queues, Stacks, Optimization of Memory needs, Program Modeling Concepts, Software Development Process Life Cycle and its Model, Software Analysis, Design and Maintenance, Operating System Concepts, Processes, Deadlocks, Memory Management, Input /Output, Files, Security, the Shell, Recycling of Concepts. Operating system structure Monolithic Systems: Layered Systems, Virtual Machines, Exo-kernels, Client-Server Model,Real Time Operating Systems (µC/OS):Real-Time Software Concepts, Kernel Structure, Task Management, Time Management, Inter task Communication & Synchronization, Memory Management, and Porting µCos-II. Linux/RT Linux: Features of Linux, Linux commands, File Manipulations, Directory, Pipes and				

	Filters, File Protections, Shell Programming, System Programming, RT Linux Modules, POSIX Threads, Mutex Management, Semaphore Management. **Texts:** 1. µC/OS-II, The real time Kernel, Jean J. Labrossy, Lawrence: R & D Publications, 2000. 2. Embedded Real Time Systems: Concepts, Design & Programming, Dr.K.V.K.K. Prasad, Dreamtech Publication, 2007. 3. An Embedded Software Primer, David E. Simon, Pearson Education Publication, 2005. 4. Modern Operating Systems, Second Edition, Andrew S. Tanenbaum, Prentice Hall Publication, 2001. 5. Embedded Systems Architecture, Programming and design, Raj Kamal, Tata MCgraw-Hill Publication, 1999.				
EC 526	ASIC Design and Modeling	3	0	0	6
	Types of ASICs - Design flow - CMOS transistors - Combinational Logic Cell – Sequential logic cell - Data path logic cell - Transistors as Resistors - Transistor Parasitic Capacitance- Logical effort. PROGRAMMABLE ASICS, PROGRAMMABLE ASIC LOGIC CELLSAND PROGRAMMABLE ASIC I/O CELLS 9 Anti fuse - static RAM - EPROM and EEPROM technology - Actel ACT - Xilinx LCA –Altera FLEX - Altera MAX DC & AC inputs and outputs - Clock & Power inputs - Xilinx I/O blocks. PROGRAMMABLE ASIC ARCHITECUTREArchitecture and configuration of Spartan / Cyclone and Virtex / Stratix FPGAs – Micro-Blaze / Nios based embedded systems – Signal probing techniques. LOGIC SYNTHESIS, PLACEMENT AND ROUTINGLogic synthesis - ASIC floor planning- placement and routing – power and clocking strategies.				
EC 527	Microcontroller for Embedded Systems	3	0	0	6
	ARM Design Philosophy, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families. Instruction Set: Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions. Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instructions, Single-Register and Multi Register Load-Store Instructions, Stack, Software Interrupt Instructions. Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops. Cache Architecture, Polices, Flushing and Caches, MMU, Page Tables, Translation, Access Permissions, Context Switch. **Texts/References**: 1. ARM Systems Developer's Guides- Designing & Optimizing System Software – Andrew N. Sloss, Dominic Symes, Chris Wright, 2008, Elsevier. 2. Embedded Microcomputer Systems, Real Time Interfacing – Jonathan W. Valvano – Brookes / Cole, 1999, Thomas Learning.				
EC 528	Embedded Computing	3	0	0	6
	System Calls, Scheduling, Memory Allocation, Timers, Embedded Linux, Root File System, Busy Box. Tasks, Threads, Multi-Threading, Semaphore, Message Queue. GNU GCC, make, gdb, static and dynamic linking, C libraries, compiler options, code optimization switches, lint, code profiling tools. Sensor and actuator interface, data transfer and control, GPS, GSM module interfacing with dataprocessing and display, OpenCV for machine vision, Audio signal processing. Sockets, ports, UDP, TCP/IP, client server model, socket programming, 802.11, Bluetooth, ZigBee, SSH, firewalls, network security. Application binary interface, exception and interrupt handling, interrupt latency, assemblers, assembler directives, macros, simulation and debugging tools.				

	Texts/References: 1. Modern Embedded Computing - Peter Barry and Patrick Crowley, 1st Ed., Elsevier/Morgan Kaufmann, 2012. 2. Linux Application Development - Michael K. Johnson, Erik W. Troan, Adission Wesley, 1998. 3. Assembly Language for x86 Processors by Kip R. Irvine 4. Intel® 64 and IA-32 Architectures Software Developer Manuals 4. Operating System Concepts by Abraham Silberschatz, Peter B. Galvin and Greg Gagne. 5. The Design of the UNIX Operating System by Maurice J. Bach Prentice-Hall 6. UNIX Network Programming by W. Richard Stevens				
EC 529	Embedded Networking	3	0	0	6
	Embedded Networking: Introduction – Serial/Parallel Communication – Serial communication protocols RS232 standard – RS485 – Synchronous Serial Protocols -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) – PC Parallel port programming - ISA/PCI Bus protocols – Firewire. USB bus – Introduction – Speed Identification on the bus – USB States – USB bus communication: Packets –Data flow types – Enumeration – Descriptors –PIC 18 Microcontroller USB Interface – C Programs –CAN Bus – Introduction Frames –Bit stuffing –Types of errors –Nominal Bit Timing – PIC microcontroller CAN Interface –A simple application with CAN. Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components –Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol. Exchanging messages using UDP and TCP – Serving web pages with Dynamic Data – Serving web pages that respond to user Input – Email for Embedded Systems – Using FTP – Keeping Devices and Network secure. Wireless sensor networks – Introduction – Applications – Network Topology – Localization –Time Synchronization - Energy efficient MAC protocols –SMAC – Energy efficient and robust routing – Data Centric routing. **Texts/ References:** 1. Embedded Systems Design: A Unified Hardware/Software Introduction - Frank Vahid, Tony Givargis, John & Wiley Publications, 2002 2. Parallel Port Complete: Programming, interfacing and using the PCs parallel printer port - Jan Axelson, Penram Publications, 1996. 3. Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F series - Dogan Ibrahim, Elsevier 2008. 2. Embedded Ethernet and Internet Complete - Jan Axelson, Penram publications, 2003. 3. Networking Wireless Sensors - BhaskarKrishnamachari, Cambridge press 2005.				
EC 530	Low Power VLSI	3	0	0	6
	Introduction: Power dissipation analysis, Physics of Power Dissipation in CMOS FET Devices, Dynamic power, Static power Low-power circuit techniques –Voltage scaling and threshold-voltage hurdle in low-power design, Low power design Using Energy Recovery Technique. Advanced Techniques - Low Power CMOS VLSI Design, Low-power circuit level and device level approach. Low-power Analog and digital design issues in weak inversion and strong inversion regions of operation. Power Estimation - Synthesis for Low Power - Design and Test of Low Voltages - CMOS Circuits. **Text/Reference:** 1. Gary Yeap " Practical Low Power Digital VLSI Design",1997. 2. Kaushik Roy, Sharat Prasad, "Low Power CMOS VLSI Circuit Design", 2000.				
EC 531	FPGA Design	3	0	0	6
	Architecture vs organization, Design styles, Implementation styles, Design Examples using programmable logic devices, Design of Universal block. Design of memory, Floating point				

	multiplier, Barrel shifter, Special purposeProcessors - Xilinx Vertex and Spartan - II; Altera FLEX 10k and other architectures. Design of parameterized library cells, Implementation and Testing- Xilinx,Actel and Altera FPGA based systems. Design - Case study. **Texts:** 1. John V.Old Field, RichradC.Dorf, Field Programmable Gate Arrays, John Wiley1995. 2. Michel John Sebastian Smith: Application Specific Integrated Circuits, Pearson, 1997.				
EC 532	VLSI System Design	3	0	0	6
	Basics of system hardware design: Hierarchical design using top-down and bottom-up methodology, System partitioning techniques, interfacing between system components, Handling multiple clock domains, Synchronous and asynchronous design styles; Design of finite state machines: state assignment strategies; The Processor: Data path and Control, Enhancing performance with Pipelining, exploiting of Memory hierarchy. **Texts / References:** 1. G. De. Micheli, Synthesis and Optimization of Digital Circuits, Tata McGraw-Hill, 2004. 2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, 2nd Edition, Morgan Kaufmann Publishers, Inc, 1998. 3. J. Rabaey, Digital Integrated Circuits, A Design Perspective, 2nd Edition, Pearson Education, 2003. 4. H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Eight Indian Reprint, Pearson Education, 2002. 5. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.				
EC 534	VLSI EDA Tools	3	0	0	6
	ASIC design flow, various design entries, IP cores, cross compilers, cell design, stick diagrams, synthesis, place and route, floor planning, power estimation, static timing analysis, dynamic timing analysis, antenna rules, design rule check, electric rule check, schematic rule check, Clock domain crossing check, layout verses schematic, layout techniques, verification, manufacturing tests. Xilinx ISE, Actel libero, Active HDL, Sinplify pro, Leonardo spectrum, Quartus, Boole Dozer, Model Simdesign entries, various simulation, synthesis, place and route, timing verification. Cadence, IC station – design entries, simulations, various tools in the suit, GDS files. Microwind, Spice, Magic – layout techniques, simulations, DRCs, tools available in the suit. **Texts:** 1. Michael Smith, “Application Specific Integrated Circuits”, Pearson Education Asia, 2000. 2. Reference manuals of the respective tools.				
EC 535	VLSI DSP	3	0	0	6
	Introduction to DSP systems: Representation of DSP algorithms; Iteration Bound: Definition, Examples, Algorithms for computing Iteration bound; Pipelining and Parallel Processing: Definitions, Pipelining and parallel processing of FIR filters, Pipelining and parallel processing for low power; Retiming: Definitions and Properties, Solving system of Inequalities, Retiming techniques; Unfolding: Definition, An algorithm for unfolding, Applications of unfolding; Folding: Definition, Folding transformations, Register minimization techniques, Register minimization in folded architectures; Systolic Architecture Design: Introduction, Systolic array design methodology, FIR systolic arrays, Selection of scheduling vector, Matrix-Matrix multiplication and 2D systolic array design; CORDIC based Implementations: Architecture, Implementation of FIR filter and FFT algorithm; Bit-Level arithmetic architectures: Parallel multipliers, Bit-serial multipliers, Bit-Serial FIR filter design and Implementation; Redundant arithmetic: Redundant number representation, Carry-free radix-2 addition and subtraction, radix-2 hybrid redundant multiplication architectures; Low-power design: Theoretical background, Scaling versus power consumption, Power analysis, Power reduction techniques, Power estimation approaches. **Texts:**				

1. U. Meyer-Baese, DSP with FPGA, Springer, 2004.
2. K. K. Parhi, VLSI DSP Systems, Wiley, 2003.
3. R.G. Lyons, Understanding Digital Signal Processing, Pearson Education, 2004.

EC 536	Reconfigurable Computing	3	0	0	6

Computing requirements, Area, Technology scaling, Instructions, Custom Computing Machine, Overview, Comparison of Computing Machines. Interconnects, Requirements, Delays in VLSI Structures; Partitioning and Placement, Routing; Computing Elements, LUT's, LUT Mapping, ALU and CLB's, Retiming, Fine-grained & Coarse-grained structures; Multicontext; Comparison of different architectures viz. PDSPs, RALU, VLIW, Vector Processors, Memories, Arrays for fast computations, CPLDs, FPGAs, Multicontext, Partial Reconfigurable Devices; TSFPGA, DPGA, Mattrix; Best suitable approach for RD; Case study. Control Logic, Binding Time and Programming Styles, Overheads, Data Density, Data BW, Function density, Function diversity, Interconnect methods, Best suitable methods for RD; Contexts, Context switching; Area calculations for PE; Efficiency, ISP, Hot Reconfiguration; Case study. Architectures for existing multi FPGA systems, Compilation Techniques for mapping applications described in a HDL to reconfigurable hardware, Study of existing reconfigurable computing systems to identify existing system limitations and to highlight opportunities for research; Software challenges in System on chip; Testability challenges; Case studies. Modelling , Temporal portioning algorithms, Online temporal placement, Device space management, Direct communication, Third party communication, Bus based communication, Ckt switching, Network on chip, Dynamic network on chip, Partial reconfigurable design.

Texts:

1. IEEE Journal papers on Reconfigurable Architectures.
2. "High Performance Computing Architectures" (HPCA) Society papers.
3. Christophe Bobda, "Introduction to Reconfigurable Computing", Springer Publication, 2009.
4. Maya Gokhale, Paul Ghaham, "Reconfigurable Computing", Springer Publication, 2011.

EC 537	Digital IC Design	3	0	0	6

Introduction; Metrics; Switch Logic; Process; Gates; MOS Transistor; Inverter VTC,MOS Capacitor; Inverter Delay; Power Buffer Sizing; Wires; CMOS Logic; Logical Effort; Process variation Effects, Introduction to VLSI fabrication.

Memory; Decoders; Pass Transitor; Dynamic and Static Logic; Domino Logic; Scaling; Adders; Multipiers; Latches; Timing; Clock; SRAM; Design for Performance; Power Performance Tradeoff.

Analysis and Design of Digital Integrated Circuits. Circuit analysis of piecewise linear single energy storage element networks. Rules for determining states of diodes and transistors. Bipolar junction and field effect transistors as switches.

Basic digital logic gates. Integrated circuit logic and building blocks (TTL, MOS, CMOS, ECL, Integrated Injection Logic). Sweep circuits (constant current, Miller, bootstrap), Monostable, Astable, and Bistable (Schmitt Trigger) switching circuits, Applications (pulse width modulator, triangle wave generator, FM function generator design).

Text/References:

1. Ivan Sutherlnd, Robert F Sroull, David Harris, Logical Effort: Designing Fast CMOS Circuits
2. N. Weste and K. Eshranghian, Principles of CMOS VLSI Design, Addison Wesley. 1985
3. L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985
4. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.

	5. J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India, 1997				
EC 538	Memory Technologies	3	0	0	6
	Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, MOS SRAM Cell and Peripheral Circuit, Bipolar SRAM, SOl, Advanced SRAM Architectures, Application Specific SRAMs; DRAMs, MOS DRAM Cell, BiCMOS DRAM, Error Failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAM, High Density ROMs, PROMs, Bipolar & CMOS PROM, EEPROMs, Floating Gate EPROM Cell, OTP EPROM, EEPROMs, Nonvolatile SRAM, Flash Memories. RAM Fault Modeling, Electrical Testing, Pseudo Random Testing-Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing-Application Specific Memory Testing. General Reliability Issues, RAM Failure Modes and Mechanism, Nonvolatile Memory, Reliability Modeling and Failure Rate Prediction, Reliability Screening and Qualification. Radiation Effects, SEP, Radiation Hardening Techniques. Process and Design Issues, Radiation Hardened Memory Characteristics, Radiation Hardness Assurance and Testing, Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog Memories, Magneto Resistive Random Access Memories (MRAMs), Experimental Memory Devices. Memory Hybrids (2D & 3D), Memory Stacks, Memory Testing and Reliability Issues, Memory Cards, High Density Memory Packaging, Future Directions, Introduction to digital tablet PC, LCD, DVD player etc. **Texts:** 1. Ashok K.Sharma, " Semiconductor Memories Technology, Testing and Reliability ",Prentice- Hall of India Private Limited, New Delhi, 1997. 2. Memories", Springer Publication. 3. Wen C. Lin, "Handbook of Digital System Design", CRC Press.				
EC 539	MEMS and Microsystem Technology	3	0	0	6
	Historical Background: Silicon Pressure sensors, Micromachining, MicroElectro Mechanical Systems Microfabrication and Micromachining : Integrated Circuit Processes, Bulk Micromachining : Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA) Physical Microsensors : Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors Microactuators : Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors-Microactuator systems : Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems : Success Stories, Micromotors, Gear trains, Mechanisms Application Areas: All-mechanical miniature devices, 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays RF/Electronics device/system, Optical/Photonic device/system, Medical device e.g. DNA-chip, micro-arrays **Text/References:** 1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001. 2. Marc Madou, "Fundamentals of Microfabrication" by, CRC Press, 1997.Gregory Kovacs, "Micromachined Transducers Sourcebook" WCB McGraw-Hill, Boston, 1998. 3. M.-H. Bao, "Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes" by Elsevier, New York, 2000.				
EC 540	Filter Design	3	0	0	6

	Signals, Noise and Information, Signal Processing Methods, Transform-Based Signal Processing, Source-Filter Model-Based Signal Processing. Bayesian Statistical Model-Based Signal Processing. Different classes of noises and distortion, Linear prediction models, forward and backward models, Eigenvalue and PCA, power spectrum analysis. Impulse noise modelling, detection and removal. Impulse noise using linear prediction models. **Text/References:** 1. S.V. Vaseghi, Advance signal processing and noise reduction, Wiley, 2008.				
EC 541	Biomedical Signal and Systems	3	0	0	6
	Introduction to Biomedical Signals, Nature of Biomedical Signals, Examples of Biomedical Signals – EMG, ECG, EEG, ERPs, PCG, VMG, VAG, Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Concurrent, Coupled, and Correlated Processes- Illustration of the Problem with Case-Studies. Filtering for Removal of Artifacts- Illustration of the Problem with Case-Studies, Time-Domain Filters, Frequency-Domain Filters, Optimal Filtering, The Wiener Filter, Adaptive Filters for Removal of Interference, Selecting an Appropriate Filter Application: Removal of Artifacts in the ECG, Event Detection, Detection of Events and Waves, Correlation Analysis of EEG channels, Cross-spectral Techniques. The Matched Filter, Detection of the P Wave, Homomorphic Filtering, Application- ECG Rhythm Analysis, Identification of Heart Sounds, Wave shape and waveform Complexity, Analysis of Event-related Potentials, Morphological Analysis of ECG Waves, Envelope Extraction and Analysis of Activity, Application- Normal and Ectopic ECG Beats, Analysis of Exercise ECG. Frequency-domain Characterization The Fourier Spectrum, Estimation of the Power Spectral Density Function, Measures Derived form PSDs. Modeling Biomedical Systems, Point Processes Parametric System Modeling Autoregressive of All pole Modeling, Pole-Zero Modeling, Electromechanical Models of Signal Generation, Application- Heart-rate Variability, Spectral Modeling and Analysis of PCG. Analysis of Non stationary Signals, Time-Variant Systems, Fixed Segmentation, Adaptive Segmentation, Use of Adaptive Filters for Segmentation, Application- Adaptive Segmentation of EEG Signals, Adaptive Segmentation of PCG Signals. Pattern Classification and Diagnostic Decision , Pattern Classification, Supervised Pattern Classification, Unsupervised Pattern Classification, Probabilistic Models and Statistical Decision , Logistic regression Analysis The Training and Test Steps, Neural Networks, Measures of Diagnostic Accuracy and Cost, Reliability of Classifier and Decisions **Texts:** 1. R. M. Rangayyan “Biomedical Signal Analysis- A case study approach”, Wiley Publications, 2006. 2. Eugene N Bruce “Biomedical signal processing and signal modeling”, Wiley publications, 2007.				
EC 542	CPLD and FPGA Architecture	3	0	0	6
	Introduction, Simple Programmable Logic Devices – Read Only Memories, Programmable Logic Arrays, Programmable Array Logic, Programmable Logic Devices/Generic Array Logic; Complex Programmable Logic Devices –Architecture of Xilinx Cool Runner XCR3064XL CPLD, CPLD Implementation of a Parallel Adder with Accumulation. Organization of FPGAs, FPGA Programming Technologies, Programmable Logic Block Architectures, Programmable Interconnects, Programmable I/O blocks in FPGAs, Dedicated Specialized Components of FPGAs, Applications of FPGAs. Introduction, Programming Technology, Device Architecture, The Xilinx XC2000, XC3000 and XC4000 Architectures. Introduction, Programming Technology, Device Architecture, The Actel ACT1, ACT2 and ACT3 Architectures. General Design Issues, Counter Examples, A Fast Video Controller, A Position Tracker for a Robot Manipulator, A Fast DMA Controller, Designing Counters with ACT devices, Designing Adders and Accumulators with the ACT Architecture. **Text/References:** 2. Field Programmable Gate Array Technology - Stephen M. Trimberger, Springer International Edition.				

3. Digital Systems Design - Charles H. Roth Jr, Lizy Kurian John, Cengage Learning.
4. Field Programmable Gate Arrays - John V. Oldfield, Richard C. Dorf, Wiley India.
5. Digital Design Using Field Programmable Gate Arrays - Pak K. Chan/SamihaMourad, Pearson Low Price Edition.
6. Digital Systems Design with FPGAs and CPLDs - Ian Grout, Elsevier, Newnes.
7. FPGA based System Design - Wayne Wolf, Prentice Hall Modern Semiconductor Design Series.

EC 551	Advance Digital Signal Processing	3	0	0	6

Parametric methods for power spectrum estimation: Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order

Adaptive signal processing :FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares.

Multirate signal processing: Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.

Linear prediction and optimum linear filters: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Levinson-Durbin Algorithm, Schiir Algorithm, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction

Wavelet transforms :Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.

Text/References:

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, Third edition, (2000) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2002.
3. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, Pearson Education(1979).
4. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
5. Raghuveer. M. Rao, AjitS.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000

EC 552	Information Theory and Coding	3	0	0	6

Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan's Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word-Length, Shannon-Fano Coding, Shannon's First Theorem, Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon's First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary Symmetric Channel, Hamming Distance, Shannon's Second (Fundamental) Theorem, Converse of Shannon's Theorems.

Review: Algebra, Krawtchouk Polynomials, Combinatorial Theory, Probability Theory. Linear Codes: Block Codes, Linear Codes, Hamming Codes, Majority Logic Coding, Weight Enumerators, The Lee Metric, Hadamard Codes, Golay Codes (Binary and

	Ternary), Reed Muller Codes, And KerdockCodes.Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming's Sphere –Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes. Cyclic Codes: Generator Matrix, Check polynomial, Zeros of Cyclic Codes, BCH Codes, Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed-Muller Codes. Perfect Codes and Uniformly Packed Codes: Lloyd's Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems. Quaternary Codes, Binary Codes Derived from codes over Z4, Galois Rings over Z4, Cyclic Codes over Z4. Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes. **Text/References:** 1. G. A. Jones and J. M. Jones, "Information and Coding Theory", Springer, 2000. 2. J. H. van Lint, "Introduction to Coding Theory", Springer, 1999. 3. Cover Thomas, "Elements of Information Theory", and Wiley 2006. 4. R. W. Hamming, "Coding and Information Theory", Prentice Hall, 1986. 5. T. M. Cover and J. A. Thomas, "Elements of Information Theory", Wiley, 1991. 6. R. E. Blahut, "Principles and Practice of Information Theory," AWL, 1987.				
EC 553	Mobile Communication	3	0	0	6
	Introduction to Cellular Mobile Systems: A basic cellular system, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, planning a cellular system, overview of generations of cellular systems. Elements of Cellular Radio Systems Design and interference: General description of the problem, concept of frequency reuse channels, co-channel interference reduction factor, desired C/I from a normal case in an omni directional antenna system, cell splitting, consideration of the components of cellular systems. Introduction to co-channel interference, co-channel measurement design of antenna system, antenna parameter and their effects. Cell Coverage for Signal & antenna structures: General introduction, obtaining the mobile point to point mode, propagation over water or flat open area, foliage loss, propagation near in distance, long distance propagation, point to point prediction model- characteristics, cell site, antenna heights and signal coverage cells, mobile to mobile propagation. Characteristics of basic antenna structures, antenna at cell site, mobile antennas. Frequency Management & Channel Assignment, Hand Off & Dropped Calls: Frequency management, fixed channel assignment, non- fixed channel assignment, traffic & channel assignment. Why hand off, types of handoff and their characteristics, dropped call rates & their evaluation. Modulation methods and coding for error detection and correction: Introduction to Digital modulation techniques, modulation methods in cellular wireless systems, OFDM. Block coding, convolution coding and Turbo coding. Multiple access techniques: FDMA, TDMA, CDMA; Time-division multiple access (TDMA), code division multiple access (CDMA), CDMA capacity, probability of bit error considerations, CDMA compared with TDMA Second generation, digital, wireless systems, GSM, IS_136 (D-AMPS), IS-95, mobile management, voice signal processing and coding. **Text/References:** 1. Mobile Cellular Telecommunications; 2nd ed.; William, C Y Lee McGraw Hill 2. Mobile wireless communications; Mischa Schwartz, Cambridge University press, UK, 2005 3. Mobile Communication Hand Book; 2nd Ed.; IEEE Press 4. Wireless communication principles and practice, 2nd Ed, Theodore S Rappaport, Pearson Education.				

	5. 3G wireless Demystified; Lawrence Harte, Mc. Graw Hill pub				
EC 554	Data Communication	3	0	0	6
	Concept of CCN/DCN, characteristics of data – Users' sub-network, topological design etc. Accessing techniques, Data Modeling – M/M/1 analysis, Circuit switching, message switching, Packet switching, and ATM cell switching, Protocols, ISO, OSI. Networking objectives, classification of networks – LAN, MAN, WAN, ISDN. Techniques and theories of CSMA/CD Bus, Token Ring, Token passing bus- throughput analysis, Modeling (Stalling Models, IEEE Model etc.). Introduction to wireless networks, GSM, TDMA & CDMA-design and analysis, PCS concepts, Network operation and maintenance, NetworkDelay analysis, Routing, Flow Control, Congestion Control. **Text/Reference:** 1. Behrouz A. Forouzan, "TCP/IP Protocol Suit", TMH, 2000 2. Wayne Tomasi, "Introduction to Data communications and Networking", Pearson Ed. 2007 3. Tananbaum A. S., "Computer Networks", 3rd Ed., PHI, 1999 4. Black U, "Computer Networks-Protocols, Standards and Interfaces", PHI, 1996 5. Stallings W., "Data and Computer Communications", 6th Ed., PHI, 2002. 6. Stallings W., "SNMP, SNMPv2, SNMPv3, RMON 1 & 2", 3rd Ed., Addison Wesley, 1999 7. Laurra Chappell (Ed), "Introduction to Cisco Router Configuration", Techmedia				
EC 556	Satellite Communication	3	0	0	6
	Introduction: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital theory:Orbital mechanics, locating the satellite in the orbit w.r.t. earth look angle determination. Azimuth & elevation calculations. Spacecraft systems: Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. Satellite link design: Basic transmission theory, noise figure and noise temperature, C/N ratio, satellite down link design, satellite uplink design Modulation, Multiplexing, Multiple access Techniques: Analog telephone transmission, Fm theory, FM Detector theory, analog TV transmission, S/N ratio Calculation for satellite TV linking, Digital transmission, base band and band pass transmission of digital data, BPSK, QPSK , FDM, TDM, Access techniques: FDMA, TDMA, CDMA Encoding & FEC for Digital satellite links: Channel capacity, error detection coding, linear block, binary cyclic codes, and convolution codes. Satellite Systems: Satellite Earth station Technology, satellite mobile communication, VSAT technology, Direct Broadcast by satellite (DBS) **Text/Reference:** 1. Timothy Pratt, Charles W. Bostian, "Satellite communication", John Wiley & sons, Publication, 2003 2. J.J. Spilker, "Digital Communication by satellite, PHI Publication, 1997 3. J. Martin, "Communication satellite systems", PHI publication, 2001				
EC 557	Fiber Optics Communication	3	0	0	6
	Overview of Optical Communications, Optical Fibers, Signal Degradation, International standards, Review of Optical Sources, Review of Photo detectors, structures for InGaAs APDs, Temperature effect on avalanche gain, Optical receiver, Introduction to optical amplifiers (EDFA), Overview of WDM, Passive optical couplers, Isolators and Circulators.				

	Texts: 1. G.Keiser, Optical Fiber Communications, TMH, 4th Edition, 2008. 2. J. Gowar, Optical Communication Systems, PHI, 2nd Edition, 1993.				
EC 558	Advance Radio Communication	3	0	0	6
	Elements of a Communication Systems, FM Modulators, FET Phase Modulator, Foster-Seeley FM Discriminator, Ratio Detector, AM Transmitter, FM Transmitter, SSB Transmitter, TRF Radio Receiver, Super heterodyne Receiver, Image Frequency, AGC, SSB Transceiver, Special Features in Communication Receiver, Digital Radio, Television Broadcasting, TV Channels, TV Scanning, Indian TV Standards, composite video Signal, Functional blocks and operational aspects of each block of TV transmitter and receiver, CCD cameras, color TV display systems, Digital TV technology, HDTV systems. **Texts:** 1. Louis E Frenzil, Communication Electronics: Principles and Applications, 3rd Edition, MGH, 2001. 2. George Kennedy and Bernard Davis, Electronic Communication Systems, TMH, 4th Edition, 2000. 3. BernardGrob, Basic Television and Video Systems, 6th Edition, MGH, Singapore, 2000.				
EC 560	System-on-Chip (SoC)	3	0	0	6
	IC Technology, Economics, CMOS Technology overview, Power consumption, Hierarchical design, Design Abstraction, EDA tools. MOSFET model, parasitics, latch up, advanced transistor structures; Wire parasitics; Design rules, Scalable design rules, process parameters; stick diagrams, Layout design tools; Layout synthesis, layout analysis. CMOS gate delays, transmission time, speed power product, low power gates; Delay by RC trees, cross talk, RLC delay, cell based layout, Logic & interconnect design, delay modeling, wire sizing; Power optimization, Switch logic networks. Pipelining, Data paths, Adders, ALUs, Multipliers, High density memories; Metastability, Multiphase clocking; Power optimization, Design validation, Sequential testing; Architecture for low power. Floor planning methods, global routing, switch box routing, clock distribution; off chip connections, packages, I/O architectures, pad design. Complete chip design including architecture, logic and layout for Kitchen timer chip OR Microwave oven chip. **Texts:** 1. Wayne Wolf, “Modern VLSI Design”, Pearson Education, 1998. 2. KamaranEshraghian, “Principles of CMOS VLSI Design”, Pearson Education, 2007 3. Rabey, Chandrakasan, “Digital IC Design”, Preason Publication, 2009.				
EC 561	Software Defined Radio	3	0	0	6
	SDR concepts & history, Benefits of SDR, SDR Forum, Ideal SDR architecture, SDR Based End-to-End Communication, Worldwide frequency band plans, Aim and requirements of the SCA, Architecture Overview, Functional View, Networking Overview, Core Framework, Real Time Operating Systems, Common Object Request Broker Architecture (CORBA), SCA and JTRS compliance, Radio Frequency design, Baseband Signal Processing, Radios with intelligence, Smart antennas, Adaptive techniques, Phased array antennas, Applying SDR principles to antenna systems, Smart antenna architectures, Low Cost SDR Platform, Requirements and system architecture, Convergence between military and commercial systems, The Future For Software Defined Radio **Texts/References:** 1. Dillinger, Madani, Alonistioti (Eds.): Software Defined Radio, Architectures, Systems and Functions, Wiley 2003 2. Reed: Software Radio, Pearson, 1997. 3. Software Defined Radio for 3G, 2002, by Paul Burns. 4.Tafazolli (Ed.): Technologies for the Wireless Future, Wiley 2005. 5. Bard, Kovarik: Software Defined Radio, The Software Communications Architecture,				

	Wiley, 2007.				
EC 562	Microwave Devices and Circuits	3	0	0	6
	Microwave frequencies, Interactions between electrons and fields, Electromagnetic plane waves, Electric and magnetic wave equations, Poynting theorem, Uniform plane waves and reflection, Plane wave propagation in free space and lossless dielectric, Plane wave propagation in lossy media, Plane wave propagation in metallic film coating on plastic substrate,Transmission line equations and solutions, Reflection coefficient and transmission coefficient, Standing wave and standing wave ratio, Line impedance and admittance, Smith chart, Microwave waveguides and components, Rectangular waveguides, Microwave cavities, Directional couplers, Circulators and isolators, Microwave transistors and tunnel diodes, Microwave bipolar transistors, Heterojunction transistors, Microwave tunnel diodes, Microwave field effect transistors, Junctionfield effect transistors, Metal semiconductor field effect transistors Text/References: 1. Samuel Y.Liao, " Microwave Devices and Circuits" Third edition,PHI 2. SK Roy, M Mitra, "Microwave semiconductor devices", PHI 2003 3. David M. Pozar, "Microwave Engineering" Wiley				
EC 563	Advance Electromagnetic	3	0	0	6
	Wave Equation, Waves in perfect dielectrics, Intrinsic wave constants, waves in lossy matter, reflection of waves, transmission line concepts, waveguide concepts, resonator concepts, radiation, and antenna concepts. Transmission line theory, Wave functions, Plane waves, rectangular waveguides, alternative mode sets, Rectangular cavity, partially filled wave guide, dielectric- slab guide, surface guided waves, modal Expansions of fields, currents in waveguides, Apertures in ground planes. **Text/References:** 1. R. F Harrington., "Time Harmonic Electromagnetics", McGraw Hill, 1961. 2. RF Harrington, "Field Computation by Moment Methods", New York: MacMillan, 1968. 3. E.C Jordan & K.G. Balmain, "Electromagnetic Waves and Radiating Systems", 2nd Edition, Prentice Hall India, Pvt. Ltd., New Delhi.				
EC 564	RF Component & Circuit Design	3	0	0	6
	Transmission lines , Broadband Mactching, Scattering Parameters, microwave transistorsPassive Components: Inductors, Inductor Model, Analytical model, Printed Inductors, Inductors on Si substrate and GaAs substrate. Thick film inductors,Thin film inductors, LTCC inductors. Wire Inductors.Capacitors, Monolithic capacitors, interdigital capacitors. Resistors, chip resistor ,MCM resistor, Monolithic resistors, Microwave Resonators and Narrowband Filters, Broadband Filters Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design, Broadband Amplifier Design Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design Microwave Oscillators: One Port negative resistance oscillators, Two Port negative resistance oscillators, Oscillator configurations **Text/References:** 1. Lumped Elements for RF and Microwave Circuits " I. J. Bahl ,Artech House 2. Microwave Transistor Amplifier: Analysis and Design, Gonzalez G. Prentice Hall 1984. 3. Microwave Semiconductor Circuit Design, Davis W. Alan, Van NostrandReinhold, 1984. 4. Microwave Circuit Analysis and Amplifier Design, Samuel Y. Liao, Prentice Hall 1987. 5. High Frequency Amplifier, Ralph S. Carson, Wiley Interscience, 1982				
EC 565	Antenna for Mobile Applications	3	0	0	6

	Radiation fields of wire antennas: Concept of vector potential. Modification for time varying retarded case. Fields associated with Hertzian dipole. Radiation resistance of elementary dipole with linear current distribution. Radiation from half-wave dipole and quarter – wave monopole. Use of capacity hat and loading coil for short antennas. Antenna Fundamentals and Antenna Arrays: Definitions: Radiation intensity, Directives gain, Directivity, Power gain, Beam Width, Band Width, Gain and radiation resistance of current element. Half-wave dipole and folded dipole. Reciprocity principle, Effective length and Effective area. Relation between gain effective length and radiation resistance. Loop Antennas: Radiation from small loop and its radiation resistance. Antenna Arrays: Expression for electric field from two and three element arrays. Uniform linear array. Method of pattern multiplication. Binomial array. Use of method of images for antennas above ground. Traveling wave (wideband) antennas: Radiation from a traveling wave on a wire. Analysis and design of Rhombic antenna. Coupled Antennas: Self and mutual impedance of antennas. Two and Three element Yagi antennas, Log periodic antenna. Aperture and Lens Antennas: Radiation from an elemental area of a plane wave (Huygen's Source). Radiation from the open end of a coaxial line. Radiation from a rectangular aperture treated as an array of Huygen's sources. Relation between dipole and slot impedances. Method of feeding slot antennas. **Text/References:** 1. E.C. Jordan and Balmain, "Electro Magnetic Waves and Radiating Systems", PHI, 1968, Reprint 2003 2. John D. Kraus and RonalatoryMarkefka, "Antennas", Tata McGraw-Hill Book Company, 2002 3. R.E. Collins, "antennas and Radio Propagation", McGraw-Hill, 1987 4. Ballany, "Antenna Theory", John Wiley & Sons, Second Edition, 2003				
EC 567	Electromagnetic Interference	3	0	0	6
	Introduction to Electromagnetic Compatibility (EMC), EMC Requirements for Electronic Systems, Radiated Emissions, Conducted Emissions ,Spectra of Digital Waveforms, The Spectrum of Trapezoidal (Clock) Waveforms, spectral Bounds for Trapezoidal Waveforms, Effect of Rise/Fall-time on Spectral Content, Bandwidth of Digital Waveforms, Effect of Repetition Rate and Duty Cycle, Effect of Ringing (Undershoot/Overshoot) Transmission Lines and Signal Integrity: The Transmission-Line Equations, Printed Circuit Board (PCB) Structures, High-Speed Digital Interconnects and Signal Integrity Sinusoidal Excitation of the Line and the Phasor Solution. Conducted Emissions and Susceptibility: Measurement of Conducted Emissions,1 The Line Impedance Stabilization Network (LISN),Common- and Differential-Mode Currents Again, Power Supply Filters, Basic Properties of Filters, A Generic Power Supply Filter Topology, Effect of Filter Elements on Common. Differential-Mode Currents, Separation of Conducted Emissions into Common and Differential-Mode Components for Diagnostic Purposes, Power Supplies, Linear Power Supplies, Switched-Mode Power Supplies (SMPS), Effect of Power Supply Components on Conducted Emissions, Power Supply and Filter Placement, Conducted Susceptibility **Text/References:** 1. Clayton R Paul: Introduction to Electromagnetic Compatibility Wiley 2nd Edition 2. V.P. Kodali, "Engineering Electromagnetic Compatibility",S. Chand & Co. Ltd., New Delhi, 2000. 3. "Electromagnetic Interference and Compatibility", IMPACT series, IIT-Delhi, Modules1-9.				

	4. Keiser, "Principles of Electromagnetic Compatibility", 3rd ed., , Artech House 5. Henry W.Ott.,"Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 1988				
EC 568	Radar Engineering	3	0	0	6
	Radar and Radar Equation, Doppler Effect, CW Radar, FM - CW radar, altimeter, Multiple Frequency Radar, Pulse Radar, Pulse Doppler Radar, Tracking Radar, RADAR System Design, Matched Filter, Detector Characteristics, Phased Arrays, Advantages and Limitations Navigational Aids. **Text/References:** 1. M.I. Skolnik, Introduction Radar Systems, McGraw Hill Book Co., Fourth Edition, 2001. 2. G.S.N. Raju, Radar Engineering and Fundamentals and Navigational Aids, I.K. International, 2008. 3. Simon Kingsley and Shaun Quegan, Understanding Radar Systems, SciTech Publishing, 1999. 4. Introduction to Radar Systems – Merrill I. Skolnik, TMH Special Indian Edition, 2nd Edition, 2007.				
EC 569	Advanced Antenna Design	3	0	0	6
	Basic of the Antenna, Different radiation zones, Mechanism of radiation, Scattering parameters, dipole antennas and arrays, horn antenna, slot antenna, SIW antenna, dielectric resonator antenna, Helical antenna, Log periodic antenna, Microstrip antenna design: structure, feeding techniques, field distribution, surface wave propagation, radiation mechanism, microstrip array antenna. **Text/References:** 1. C. A. Balanis, "Antenna Theory: Analysis and Design," John Wiley & Sons, 2009. 2. R. J. Marhefka, A. S. Khan and J. D. Kraus, "Antennas and Wave Propagation", Tata McGraw - Hill Education 2010. 3. M. Sachidananda and A. R. Harish "Antennas and Wave Propagation" Oxford University Press, USA 2007.				
EC 570	Advance EM Wave Propagation and Antenna	3	0	0	6
	Review of Maxwell's Equation and boundary conditions; time harmonic electromagnetic fields; vector potentials; electromagnetic theorems and concepts, Impedance matching and tuning, dipole antennas and arrays, horn antennas, parabolic antennas, slot antennas and arrays, microstrip antennas, Ground wave propagation, sky wave propagation, space wave propagation. **Texts / References:** 1. C. A. Balanis, "Advanced Engineering Electromagnetics," John Wiley & Sons, 2009. 2. R. F. Harrington, "Time Harmonic Electromagnetic Fields," McGraw Hill, 2001. 3. C. A. Balanis, "Advanced Engineering Electromagnetics," John Wiley & Sons, 1989. 4. R. E. Collin, "Antenna and radio wave propagation," McGraw Hills, 1985. 5. C. A. Balanis, "Antenna Theory: Analysis and Design," John Wiley & Sons, 2009. 6. R. J. Marhefka, A. S. Khan and J. D. Kraus, "Antennas and Wave Propagation", Tata McGraw - Hill Education 2010. 7. M. Sachidananda and A. R. Harish "Antennas and Wave Propagation" Oxford University Press, USA 2007.				
EC 571	Principle of Microwave solid state devices	3	0	0	6
	Microwave devices and applications, Transferred electron devices, Gunn – effect diodes – GaAs diode, Ridley- watkins-Hilsum (RWH) theory, Modes of operation, LSA diodes, InP diodes, Avalanche transit time devices, Read diode, IMPATT diode, TRAPATT diodes, BARITT diodes, Microwave linear beam tubes (O Type), Conventional vacuum triodes, Tetrodes and pentodes, klystrons, Multicavity klystron amplifiers, Reflex klystrons, Helix traveling wave tubes (TWT), Coupled cavity traveling wave tubes, Microwave				

	crossed filed tubes (M Type), Magnetron oscillators, Forward wave crossed field amplifier (FWCFA OR CFA), Strip lines, Microstrip lines, Parallel strip lines, Coplanar strip lines, Shielded strip lines, Monolithic microwave integrated circuits, Materials, Monolithic microwave integrated circuit growth, MOSFET fabrication. **Text/References:** 1. Samuel Y.Liao, " Microwave Devices and Circuits" Third edition,PHI 2. SK Roy, M Mitra, "Microwave semiconductor devices", PHI 2003 3. David M. Pozar, "Microwave Engineering" Wiley				
EC 572	Microwave Filter Design	3	0	0	6
	Introduction, General procedure for filter design, Active and passive filters, Periodic Structures, Filter Design by the Image Parameter Method, Filter Transformations, Insertion Loss Methode, Type of Low Pass Filter, Maximally Flat, Butterworth, Binomial Filter, Equal Ripple or Chebyshev Filter, Elliptic Filter, Linear Phase Filter, Types of Scaling for Low Pass Prototype, Filters implementation in microwave circuits, Stepped Impedance Low Pass Filters, Filter Implementation, Stepped-Impedance Low-Pass Filters, Coupled Line Filters, Filters Using Coupled Resonators. **Text/References:** 1. Devid M. Pozer, " Microwave Engineering" 4th edition, Wiley. 2. Samuel Y.Liao, " Microwave Devices and Circuits" Third edition,PHI. 3. C. A. Balanis, "Advanced Engineering Electromagnetics," John Wiley & Sons, 2009.				
EC 574	Image Processing Techniques	3	0	0	6
	Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT, KLT, SVD. Image Enhancement - Histogram equalization and specification techniques, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contraharmonic mean filters, Homomorphic filtering, Color image enhancement. Image restoration - Degradation model, Unconstrained restoration - Lagrange multiplier and Constrained restoration, Inverse filtering-removal of blur caused by uniform linear motion, Wiener filtering, Geometric transformations-spatial transformations. Image segmentation - Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and Merging – Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm-Segmentation by K-Means Algorithm. Digit Recognition using Convolutional Neural network. Compression - Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Vector Quantization, Transform coding, JPEG standard, MPEG. Image. Morphology - Preliminaries, dilation, erosion, open and closing, hit or miss transformation, basic morphologic algorithms. **Texts/ References:** 1. Digital Image Processing, Rafael C. Gonzalez, Richard E. Woods, Second Edition, Pearson Education/PHI, 2000. 2. W.K.Pratt, Digital Image Processing , 3/e Edn., John Wiley & sons, Inc. 2006. 3. K. R. Castleman, Digital Image Processing, Pearson, 2006. 4. Anil K. Jain, Fundamental of image processing, Pearson, 2002. 5. Image Processing, Analysis, and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Second Edition, Thomson Learning, 2008. 6. Introduction to Digital Image Processing with Matlab, Alasdair McAndrew, Thomson Course Technology,2001. 7. Computer Vision and Image Processing, Adrian Low, Second Edition, B.S. Publications, 2005. 8. Digital Image Processing using Matlab, Rafael C.Gonzalez, Richard E.Woods, Steven L. Eddins, Pearson Education, 2007.				