Course Curriculum

B.Sc. Engineering Honors Degree
Electronic and Telecommunication Specialization

Including Syllabi for Course Modules
Conducted by
Department of Electronic and Telecommunication Engineering
University of Moratuwa
September 2009

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1. Course Curriculum Outline

The information given below outlines the course curriculum for the Department of Electronic and Telecommunication Engineering specialization.

The course unit selections indicated for a particular semester/level is for guidance of students and academic advisors only. All units shown may not be offered in a particular year. The syllabi of course units offered by other departments are available with the curriculum for that particular department.

The following descriptors are used:

C – Core Modules
E – Elective Modules
O – Optional Modules

Summary of Normal Minimum Credit Requirements

Overall GPA credits	= 135	credits
Overall Non-GPA credits	= (15)	credits

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 1									
CE1022	Fluid Mechanics	C	2	3/4	2.0				
CS1032	Programming Fundamentals	C	2	3/1	3.0				
EE1012	Electrical Engineering	C	2	3/4	2.0				
EL1012	Language Skills Enhancement I	C	-	3/1	1.0				
MA1012	Mathematics	C	3	1/1	3.0				
ME1032	Mechanics	C	2	3/4	2.0				
MT1022	Properties of Materials	C	2	3/4	2.0		15.0		15.0
						Total for Semester 1	15.0	-	15.0
***Term A1* (before field selection) *& Term A2* (after field selection)**									
MN1012	Engineering in Context	C	2	-		1.0			
EL1020	Language Skills Enhancement II	C	-	6/1	1.0				
EN1952	Engineering Design	C	2	3/1		1.5			
EN1962	Engineering Skills Development	C	1	6/1		1.5	1.0	4.0	
DE1xx2	Non-Technical Option I	E	2	6/1	2.0				
DE1xx2	Non-Technical Option II	E	2	6/1	2.0		2.0		
						Total for Term A	3.0	4.0	7.0

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 2									
EL1030	Language Skills Enhancement III	C	2			2.0			
MA1021	Methods of Mathematics	C	3	1/1	3.0				
EN1012	Electronic Devices and Circuits	C	2	-	2.0				
EN2042	Electronic Product Manufacturing Processes	C	2	-	2.0				
EN1052	Introduction to Telecommunications	C	2	-	2.0				
EN1102	Introduction to Computer Systems	C	2	-	2.0				
EN1092	Laboratory Practice	C	-	6/1	2.0				
EN2972	Communication Skills	C	1	-		1.0	13.0	3.0	
						Total for Semester 2	13.0	3.0	16.0

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 3									
MA2012	Differential Equations	C	2	-	2.0				
MA2022	Calculus	C	2	-	2.0				
EN2012	Analog Electronics	C	2	3/2	2.5				
EN2022	Digital Electronics	C	2	3/2	2.5				
EN2052	Communication Systems	C	2	3/2	2.5				
EN2062	Signals and Systems	C	2	3/2	2.5				
EE2092	Theory of Electricity	C	2	3/2	2.5		16.5		
EN2452	Computer Organization	E	2	3/2	2.5				
EN2532	Robotics Design and Competition	E	2	3/2	2.5		2.5		
ME1852	Basic Engineering Thermodynamics	E	1.5	3/2	2.0				
ME2122	Engineering Drawing and Computer Aided Modeling	E	2.0	3/1	3.0				
CE1812	Mechanics of Materials	E	2	-	2.0		2.0		
					Total for Semester 3		21.0	-	21.0

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 4									
MA2032	Linear Algebra	C	2	-	2.0				
MA2042	Discrete Mathematics	C	2	-	2.0				
EN3022	Electronic Design and Realization	C	2	3/2	2.5				
EN2072	Communications I	C	2	3/2	2.5				
EN2082	Electromagnetics	C	2	3/2	2.5				
EN2142	Electronic Control Systems	C	2	3/2	2.5		14.0		
CS2022	Data Structures and Algorithms	E	2	3/2	2.5				
CS2832	Modular Software Development	E	1	6/1	3.0				
CS2042	Operating Systems	E	2	3/2	2.5		2.5		
EN2542	Introduction to Biomedical Engineering	E	2	-	2.0				
EE2022	Electrical Machines & Drives I	E	2	-	2.0				
EE2062	Electrical Installation I	E	2	-	2.0		2.0		
EN2962	Presentation Skills	C	1			1.0			
EN2902	Field Visit					1.0		2.0	
						Total for Semester 4	18.5	2.0	20.5

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 5									
EN3012	Analog Circuit Design	C	2	3/2	2.5				
EN3052	Communications II	C	2	3/2	2.5				
EN3322	Digital Signal Processing	C	2	3/2	2.5				
EN3542	Digital Systems Design	C	2	3/2	2.5				
CS3022	Computer Networks	C	2	3/1	3.0		13.0		
EN3312	Antennas and Propagation	E	2	3/2	2.5				
EN3532	Electronic Instrumentation	E	2	3/2	2.5				
EN3552	Fundamentals of Machine Vision & Image Processing	E	2	3/2	2.5				
EN3562	Robotics	E	2	3/1	3.0				
EN3572	Biomedical Signal Processing	E	2	3/2	2.5		5.0		
MA3012	Applied Statistics	E	2		2.0				
MA3022	Numerical Methods	E	2		2.0		2.0		
MN3042	Business Economics & Financial Accounting	E	3	-	3.0				
MN3052	Industrial Management & Marketing	E	3	-	3.0		3.0		
						Total for Semester 5	23.0	-	23.0
Semester 6 + Term B									
EN3992	Industrial Training	C				6.0	-	6.0	6.0

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 7									
EN4012	Advanced Electronics	C	2	3/2	2.5				
EN4052	Communication III	C	2	3/2	2.5				
EN4202	Project***	C			2.5		7.5		
EN4212	Power Electronics	E	2	3/2	2.5				
EN4222	Electronic Manufacturing Systems	E	2	3/2	2.5				
EN4232	Industrial Electronics	E	2	3/2	2.5		2.5**		
EN4312	Telecommunication Core Networks	E	2	3/2	2.5				
EN4322	Optical Fiber Communications	E	2	3/2	2.5				
EN4332	Microwave Engineering	E	2	3/2	2.5		2.5**		
CS3612	Intelligent Systems	E	2	3/2	2.5				
EN4532	Advance Digital System Laboratory	E	1	3/1	2.0				
EN4542	Medical Electronics and Instrumentation	E	2	3/2	2.5		2.0**		
EN4922	Research Project**	O			5.0				
EN4932	Technical and Scientific Writing	O				1.0			
MA4022	Operational Research	E	3	-	3.0				
MA4042	Neural Network and Fuzzy Logic	E	3	-	3.0		3.0		
MN 3042	Business Economics & Financial Accounting	E	3	-	3.0				
MN 3052	Industrial Management & Marketing	E	3	-	3.0				
MN 4062	Organizational Behavior and Management	E	2	-	2.0				
MN4132	Consumer and Industrial Marketing	E	2	-	2.0				
MN4122	Human Resource Management and Industrial Relations*	E	2	-	2.0				
MN4042	Technology Management*	E	2	-	2.0				
MN4022	Engineering Economics*	E	2	-	2.0		2.0^{+}		
					Total for Semester 7		19.5	-	20.0

Code	Module Name	Category	Lectures hrs/week	Lab/ Assignments hrs/week	Credits		Norm		
					GPA	NGPA	GPA	NGPA	Total
Semester 8									
EN4202	Project***	C			5.0		5.5		
EN4242	Consumer Electronics	E	2	3/2	2.5				
EN4252	Industrial Motor Control	E	2	3/2	2.5				
EN4262	Automobile Electronics	E	2	3/2	2.5				
EN4272	Agricultural Electronics	E	2	3/2	2.5				
EN4282	Electronic Applications in Renewable Energy	E	2	3/2	2.5				
EN4292	Industrial Automation	E	2	3/2	2.5		2.5**		
EN4342	Broadcast Technologies	E	2	3/2	2.5				
EN4352	Radar and Navigation	E	2	3/2	2.5				
EN4362	Microwave Communications	E	2	3/2	2.5				
EN4372	Teletraffic Theory and Switching	E	2	3/2	2.5				
EN4382	Wireless and Mobile Communications	E	2	3/2	2.5				
EN4392	Information Theory	E	2	3/2	2.5				
EN4402	Mobile Computing	E	2	3/2	2.5		2.5**		
EN4552	Nanotechnology for ICT	E	2	3/2	2.5				
EN4562	Autonomous Systems	E	2	3/2	2.5				
EN4572	Pattern Recognition and Machine Intelligence	E	2	3/2	2.5				
EN4582	Advances in Machine Vision	E	2	3/2	2.5				
EN4592	Medical Imaging and Image Processing	E	2	3/2	2.5		2.5**		
MN4122	Human Resource Management and Industrial Relations*	E	2	-	2.0				
MN4042	Technology Management*	E	2	-	2.0				
MN4082	Small Business Management and Entrepreneurship	E	2	-	2.0				

MN4022	Engineering Economics*	E	2	-	2.0				
MN4092	Management Skills Development	E	2	-	2.0				
MN4112	Production and Operations Management	E	2	-	2.0		2.0+		
MA4012	Linear Models and Multivariate Statistics	E	3	-	3.0				
MA4032	Time Series and Stochastic Processes	E	3	-	3.0		3.0		
						Total for Semester 8	18.0		17.5

Term C									
EN4202	Project***	C			2.0		2.0		
DE4xx2	Non-Technical Option						2.0		
						Total for Term C	4.0		4.0
						Total Graduation Requirement	135.0	15.0	150.0

Notes

*	Offered in both Semester 7 & Semester 8
**	If “Research Project” is taken, 2.5 credits each from Semester 7 and Semester 8 is considered to be covered.
***	A total of 10 credits are distributed in Semester 7, Semester 8 and Term C.
+	A total of 4 credits from Semester 7 and Semester 8
‡	2.5 credits from Semester 7 or 8

2. Term A Module Information

The following lists the graduation requirements for Term A.
GPA credits for Term A = 3.0 credits
NGPA credits for Term A = (4.0) credits

2.1

<table>
<tr><td>Module Code</td><td>EN1952</td><td>Module Title</td><td colspan="4">Engineering Design</td></tr>
<tr><td>Credits</td><td>1.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1962</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>6/1</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify basic engineering design concepts
2. Simulate the dynamics of a small design group
3. Apply the knowledge gained to a design project resulting in a working prototype.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Design Principles (12 hrs): Introduction to Engineering Design, life cycles of engineering products and processes, design processes and design tools, concurrent engineering, creativity and reasoning, analysis and synthesis, simulation, evaluation and decision making

2. Case Studies (12 hrs): Several simple but comprehensive design case studies selected from different disciplines of engineering addressing the topics (a) Design for manufacturing, (b) Mechanical and material aspects in design, (c) Electrical, electronic and IT aspects in design

3. Design Assignments (18 hrs): Group based design assignments (topics to be selected by Engineering Design Center in consultation with the department or proposed by the student groups). The project will include (a) gathering of data and information from various sources as a preliminary to the design, (b) preparing a work plan and delegating duties, (c) working with others and to produce results by given deadlines and within given costs, (d) learning the basic procedures required for conceptual, preliminary and detailed designs, (e) learning the importance of the cost component in the manufacturing process, (f) preparing a report and making a presentation on the work done, (g) demonstrating the working of the prototype</td></tr>
</table>

2.2

<table>
<tr><td>Module Code</td><td>EN1962</td><td>Module Title</td><td colspan="5">Engineering Skills Development</td></tr>
<tr><td>Credits</td><td>1.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1952</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>6/1</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Use software for engineering design
2. Develop skills related to electronic prototyping
3. Produce product documentation.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Basic Software Tools Needed for Electronic Design and Manufacturing (3 hrs): Electronic circuit simulation using software, solid modeling using software
2. Equipment Used for Manufacturing (3 hrs): Basic workshop practice (introduced during Level 1 Semester 2), soldering, PCB manufacture, casing design and construction
3. Documenting and Reporting (3 hrs): Design documentation, presenting of product, marketing and other skills</td></tr>
</table>

3. Semester 2 Module Information

The following lists the graduation requirements for Semester 2.
GPA credits for Semester 2 = 13 credits
NGPA credits for Semester 2 = (3) credits

3.1

Module Code	EN1012	**Module Title**	Electronic Devices and Circuits			
Credits	2.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	-		

Learning Outcomes

At the end of the module the student will be able to:

1. Identify “electrons” and “photons”, the two particles which are important in semiconductor electronics and optoelectronics
2. Design a simple dc power supply
3. Design a single stage amplifier and estimate the voltage & current gains and input & output impedances of the amplifier
4. Simulate a simple amplifier operation using suitable software
5. Construct a digital combinational circuits to perform a simple logical operation.

Outline Syllabus

1. Wave-particle duality of light and matter **(1 hr)**
2. Energy levels and stimulated emission of radiation **(2 hrs)**
3. Schrödinger wave equation: Band theory of solids, E-k diagram, Fermi-Dirac statistics and Fermi Level **(4 hrs)**
4. Conduction in metals, Conduction in p-n junction devices, diffusion and junction capacitance of a p-n junction **(3 hrs)**
5. Diodes and their applications **(4 hrs)**
6. Transistor Amplifier; BJT and FET **(6 hrs)**
7. Logic circuits **(6 hrs)**
8. Logic families: DL, DTL, TTL **(2 hrs)**

3.2

Module Code	EN2042	Module Title	Electronic Product Manufacturing Processes			
Credits	2.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	-		

Learning Outcomes

At the end of the module the student will be able to:

1. Identify various manufacturing processes involved in electronic product manufacturing
2. Explain printed circuit board (PCB) manufacturing processes
3. Discuss different methods used for electronic component mounting
4. Identify different soldering methods
5. Describe manufacture of product enclosures.

Outline Syllabus

1. **Introduction (2 hrs)**
2. **Product Dissection (2 hrs):** Disassembly and identification of manufacturing processes
3. **PCB Manufacturing (6 hrs):** Schematic design, layout design, design rules, photo-tool creation, drilling, planting, etching, solder masking
4. **Component Mounting (6 hrs):** Through-hole component forming, component insertion, surface mounting
5. **Soldering Methods (6 hrs):** Hand soldering, wave soldering, reflow soldering
6. **Enclosures (6 hrs):** Injection molding, metal forming, metal punching

3.3

Module Code	EN1052	Module Title	Introduction to Telecommunications			
Credits	2.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Tutorials**	-		

Learning Outcomes

At the end of the module the student will be able to:

1. Explain basic concepts related to communication systems
2. Differentiate between analog and digital communications principles
3. Describe basic aspects of a computer network
4. Differentiate between network topologies and types of networks
5. Discuss the operation of end user equipment in communications.

Outline Syllabus

1. **Introduction to Telecommunication Systems (2 hrs):** Historical developments and current trends
2. **Elementary Concepts in Telecommunications (6 hrs):** Digital and analog signals, Types of communication channels, Bandwidth and filtering, The effect of bandwidth and noise on signals, The radio spectrum and wave propagation, Modulation
3. **Transmission (4 hrs):** Guided and unguided transmission, multiplexing, Transmission networks, Multiplexing hierarchies for high speed communication networks
4. **Access Networks (5 hrs):** PSTN, DSL, Wireless local loop, Mobile
5. **Switching and Signaling (2 hrs):** Hierarchical networks, teletraffic concepts
6. **Networking Principles (5 hrs):** Topologies, Types of networks, layered architecture, Internetworking, Security including Public Key Encryption
7. **Telecommunication Devices (4 hrs):** The telephone instrument, The radio receiver, The TV receiver, Modems, cellular phones etc.

3.4

<table>
<tr><td>Module Code</td><td>EN1092</td><td>Module Title</td><td colspan="4">Laboratory Practice</td></tr>
<tr><td>Credits</td><td>2.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>-</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>6/1</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Handle instruments properly
2. Implement circuits meeting with good practices
3. Test basic analog electronic circuit correctly
4. Handle basic communication equipment with care
5. Observe performance of basic communication systems
7. Test computer systems for errors.

Outline Syllabus

1.
   i. Semiconductor diode and its applications. (**1 session**)
   ii. Building up a regulated DC power supply. (**2 sessions**)
   iii. Investigation of the behavior of the passive circuit elements. (**1 session**)
   iv. Single stage transistor amplifier (BJT). (**1 session**)
   v. Single stage transistor amplifier (FET). (**1 session**)

2.
   i. Study of characteristics of a communication channel. (**1 session**)
   ii. Simulating the effect of Signal to Noise Ratio. (**2 sessions**)
   iii. Simulating basic operation of computer networks. (**2 sessions**)
   iv. FM receiver (**1 session**)
   v. Study of Pulse Code Modulation. (**1 session**)
   vi. Study of modulation schemes. (**2 sessions**)

3.
   i. Basic logic circuit blocks used in a computer - using the logic trainer modules **(1 session)**
   ii. BIOS set up and hardware troubleshooting (**1 session**)
   iii. Shell programming (**1 session**)
   iv. Inter-Process Communication (IPC) programming (**1 session**)
   v. Programming with system calls (**1 session**)
   vi. Consuming services (**1 session**)
   vii. Basic network and security tools (ping, traceroute, nslookup, whois, port scanner) (**1 session**)

3.5

Module Code	EN1102	Module Title	Introduction to Computer Systems			
Credits	2.0	Hours/Week	Lectures	2	Pre/Co – requisites	
GPA/NGPA	GPA		Lab/Assignments	-		

Learning Outcomes

At the end of the module the student will be able to:

1. Have a broad understanding of different topics in computer science & engineering.

Outline Syllabus

1. **Data Processing (2 hrs):** Concepts of data processing, ability to use devices to process data and interfering with the process via instructions, abstraction, modeling & representation, history of using different devices to process data, using electricity as a representation of information, transistors and microprocessors, outline of information technology
2. **Computer Number Formats & Arithmetic (2 hrs):** Numerical representation of data, number systems & conversions, addition, subtraction, complements, floating point notation, multiplying, division
3. **Basic Computer Architecture (4 hrs):** Von Neumann architecture and other architectures, Flynn's taxonomy, CPU, memory, instruction sets and instruction execution, computing devices (PCs, servers, embedded systems, smartphones, video game consoles, motes, etc.), semiconductor technology, FPGAs & reconfigurable computing
4. **Operating System Structure & Services (2 hrs):** operating-system services, operating system structure, hardware abstraction layer, operating system design & implementation, system calls, user interface, shell programming
5. **System Software (2 hrs):** Operating systems, compilers, linkers, assemblers, loaders, utility software, shell, virtualization, hypervisor, virtual machine
6. **Management of Processes, Memory & Storage (2 hrs):** Processes, inter-process communication, threads, multithreading models, CPU scheduling, process synchronization, deadlocks, main memory, virtual memory, swapping, paging, structure of the page table, segmentation, file-system interface, file-system implementation, mass-storage structure
7. **Programming Language Concepts (4 hrs):**evolution of languages, levels of abstraction, Lambda calculus, regular expressions, operator precedence, recursion, data types, syntax, semantics, programming paradigms, multi-paradigm programming languages,
8. **System Programming (4 hrs):** Optimizing C programs with Assembly code, how a program becomes a process, threads and thread of execution, layout of a programming image, library function calls, function return values and errors, Linux kernel programming, device driver programming
9. **Distributed Systems and Real Time Systems (4 hrs):** Distributed computing, grid computing, cloud computing, utility computing, cluster computing & high-performance computing, embedded operating systems, features of real-time kernels, implementing real-time operating systems, sensor networks, sentient computing, ubiquitous computing, Internet of things, ambient intelligence, software agents
10. **Security (2 hrs):** Number theory, cryptography, PAIN (privacy, authentication, integrity, non-repudiation), public-key algorithms, digital signatures, communication security, information systems security, authentication protocols, capability & access control lists

3.6

<table>
<tr><td>Module Code</td><td>EN2972</td><td>Module Title</td><td colspan="4">Communication Skills</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Appreciate the importance of creative writing skills
2. Learn effective public speaking skills
3. Develop interpersonal communication and critical thinking necessary for small group communication.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Creative Writing (4 hrs): Writing in an engineering career context, electronic communication, applying constructive feedback to the rewrite process, composition principles, applied writing and common report formats, audience analysis.

2. Public Speaking (12 hrs): Elements of effective public speaking. Organization, language, delivery and nonverbal communication.

3. Interpersonal Communications (12 hrs): Analysis of divergent audiences, verbal and nonverbal people interactions. Principles of interpersonal communications including perception, self-concept, persuasive communication, and communication barriers. Small group communication in organization and academic environment. Group roles, conflict management and decision making within a group.</td></tr>
</table>

4. Semester 3 Module Information

The following lists the graduation requirements for Semester 3.

GPA credits for Semester 3	= 21.0	credits
NGPA credits for Semester 3	= (0)	credits

4.1

<table>
<tr><td>Module Code</td><td>EN2012</td><td>Module Title</td><td colspan="4">Analog Electronics</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Examine the behavior of BJT and FET amplifiers in low, mid and high frequency ranges
2. Design transistor amplifiers to meet given specifications
3. Explain the differential amplifying concepts
4. Identify the functionality and applications of operational amplifier circuits
5. Identify different power amplifier classes and their characteristics
6. Perform power calculations for power amplifiers
7. Identify power electronic devices, their construction, operation and applications.

Outline Syllabus

1. **Analysis of Transistor Circuits (12 hrs):** Analysis of transistor circuits at DC, biasing circuits for BJTs and FETs, transistor as an amplifier, single-stage BJT/FET amplifier configurations, small-signal models, small signal mid-frequency equivalent circuits and analysis, low frequency and high frequency equivalent circuits of BJT/FET circuits, h-parameter model, pole zero analysis, Bode plots, frequency response of amplifiers, multistage amplifiers

2. **Differential Amplifiers (2 hrs):** The BJT differential pair, small-signal operation of the BJT differential amplifier, characteristics of a differential amplifier, differential amplifier with active load

3. **Operational Amplifiers (6 hrs):** Ideal opamp, negative feedback in opamp circuits, operational amplifier specifications, opamp applications, practical behavior of opamps, instrumentation amplifiers

4. **Power Amplifiers (4 hrs):** Definitions, applications and types of power amplifiers, power transistors, transistor power dissipation, amplifier classes and their efficiency, push-pull amplifiers, harmonic distortion and feedback, heat generation of power transistors and heat sinks

5. **Power Electronic Devices and Circuits (4 hrs):** Properties and applications of thyristors, triacs, diacs, uni-junction transistors, power MOSFETs, IGBTs and GTOs, power electronic circuits such as power controllers, CDi, protection and switching circuits

4.2

<table>
<tr><td>Module Code</td><td>EN2022</td><td>Module Title</td><td colspan="4">Digital Electronics</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Design combinational and sequential digital circuits
2. Differentiate characteristics of logic families
3. Compare usage of different logic families
4. Use programmable devices in digital circuits
5. Compare different types of analog-to-digital and digital-to-analog converters.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Combinational and Sequential Logic Circuits (12 hrs) Five variable Karnaugh maps, Quine–McCluskey method, flip-flops, latches, counters, registers and other MSI devices, design of finite state machines

2. Logic Families (6 hrs) Ideal logic gates, logic levels and noise margins, dynamic response of logic gates, Analysis of logic families (fan-in, fan-out), diode logic, logic families (DTL, TTL, ECL, CMOS)

3. Programmable Devices (8 hrs) Programmable logic devices, PLAs, PALs, GALs, RAM and ROM chips, microcontrollers

4. Conversion Circuits (2 hrs) ADC, DAC, types dual slope, successive approximation etc., common chips available</td></tr>
</table>

4.3

<table>
<tr><td>Module Code</td><td>EN2052</td><td>Module Title</td><td colspan="4">Communication Systems</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Assignments/Demos</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Explain different signal propagation methods and their relevance in communications
2. Describe the key types of communication systems
3. Identify the suitability of different telecommunication systems for a given scenario
4. Discuss current trends in the telecommunication sector.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Signal Propagation (4 hrs): Guided and un-guided propagation methods, reflection, refraction, diffraction & absorption effects, transmission lines, twin lines and the coaxial lines
2. Satellite Communication and Terrestrial Microwave Communication (4 hrs): Free space and tropospheric wave propagation, satellite services, applications of terrestrial microwave communication
3. Wireless Networks (4 hrs): Wireless LANs, mobile networks, sensor networks
4. Optical Communication (4 hrs): Introduction to optical fiber communication systems, comparison with microwave and coaxial systems, characteristics of silica optical fiber, optical fiber types
5. Broadcasting Systems (4 hrs): Basic concepts of broadcasting, television and radio broadcasting networks
6. Radar and Navigation (4 hrs): Introduction and early history, classification of Radar systems, basic concepts and measurements, the Radar equation
7. Core Networks (4 hrs): Introduction to the concept of core networks and convergence, high speed transmission and switching technologies</td></tr>
</table>

4.4

Module Code	EN2062	Module Title	Signals and Systems			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Formulate time and frequency domain descriptions for basic continuous and discrete time signals
2. Analyze linear time invariant continuous and discrete time systems based on system characteristics
3. Analyze simple systems to determine their stability and response to various input signals
4. Use software as an analysis tool to investigate the operation of LTI systems.

Outline Syllabus

1. **Introduction to Signals and Systems (4 hrs):** Continuous and discrete signal models, building block signals (eg. pulse, impulse etc), energy and power signals, use of software tools to represent signals, continuous and discrete system modeling using block diagrams, continuous and discrete system classification (eg. causal/non causal, linear/nonlinear)

2. **Linear Time Invariant Systems (6 hrs):** Continuous and discrete time impulse, impulse response and convolution, differential and difference equation system representations, software tools for discrete and continuous time system analysis.

3. **Frequency Domain Analysis Methods (14 hrs):** Continuous and discrete time frequency response characteristics, Fourier series representation of periodic signals, properties of continuous and discrete time Fourier series, applications of Fourier series for power supply design, continuous time Fourier transform, discrete time Fourier transform, properties and applications of Fourier transforms, sampling and reconstruction, Laplace transforms and z-transforms.

4. **Stability Analysis (4 hrs):** Stability analysis of discrete and continuous time systems, pole-zero analysis of systems, BIBO stability.

4.5

<table>
<tr><td>Module Code</td><td>EN2452</td><td>Module Title</td><td colspan="4">Computer Organization</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Describe how digital hardware can facilitate interpreting a given set of instructions and process data accordingly
2. Explain the abstract image of a computing system from the point of view of the Assembly language programmer
3. Appreciate how hardware architecture can facilitate parallel competing
4. Develop assembly language programmes for the x86 platform and become proficient in good programming practices.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Hardware Implementation of ALU (2 hrs): Adders, multipliers, design of arithmetic unit, logic unit & ALU
2. Internal Organization of CPU (4 hrs): Internal organization of CPU consisting of ALU, internal registers, internal buses & control unit
3. Microprocessor Based System (2 hrs): Assembly of processing, memory & I/O subsystems to make a system, memory mapped I/O, isolated I/O, interrupts and DMA
4. Interface Standards (2 hrs): PCI Express, SATA, USB, IEEE 1394 (FireWire), RS-232 (serial port)
5. Memory Subsystem (4 hrs): Memory requirement of a system, properties and implementation of memory, types of memory ICs, memory hierarchy, memory organization, address mapping
6. Performance Improvement (6 hrs): Clock speed, register width, instruction set, reducing the execution path length, design with pre fetching, pipelined design, caching, branch prediction, out of order execution & register renaming, speculative execution
7. Parallel Computer Architectures (4 hrs): On chip parallelism (instruction level parallelism, on chip multithreading, single chip multiprocessors), coprocessors (network processors, media processors, crypto-processors), shared memory multiprocessors, message passing multi computers, grid computing.
8. Introduction to Assembly Language Programming (4 hrs): 8086 assembly language, interrupt handling, subroutine calls, segments in memory, command line arguments, string manipulation, introduction to multi-core programming</td></tr>
</table>

4.6

<table>
<tr><td>Module Code</td><td>EN2532</td><td>Module Title</td><td colspan="4">Robot Design and Competition</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Design a robot to perform a simple task
2. Identify what sensors and actuators are most appropriate for a simple robot
3. Design an acceptable control algorithm for a small mobile robot.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Introduction to Autonomous Mobile Robots (4 hrs): Sense, think and act cycle of autonomous mobile robots is discussed, basic mobile platforms are also discussed
2. Motors (4 hrs): Basics of DC, Step, and servo motors are discussed with their control techniques such as PWM and H-bridge, how these motors are interfaced to and controlled by a robot control board
3. Sensors (4 hrs): Basics of robot sensors such as IR, switch, and sonar, how these sensors are interfaced to a robot control board
4. Robot Control Board (4 hrs): Robot control board designed by the ENTC Department, soldering and step-by-step assembly/test process of the PCB
5. Programming (4 hrs): Programming of the robot control board from a PC through serial port
6. System Integration and Testing (4 hrs): Integration of sensors and actuators to the robot control board, simple feedback control for sense-think-act cycle
7. Robot Competition (4 hrs): Nature of the robot competition, rules and scoring method</td></tr>
</table>

5. Semester 4 Module Information

The following lists the graduation requirements for Semester 4.

GPA credits for Semester 4	= 18.5	credits
NGPA credits for Semester 4	= (2)	credits

5.1

Module Code	EN3022	**Module Title**	Electronic Design and Realization			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Identify various stages in an electronic design
2. Discuss circuit design and prototyping
3. Identify the importance of testing
4. Illustrate enclosure design and prototyping
5. Prepare proper documentation for electronic designs.

Outline Syllabus

1. **Introduction (2 hrs)**
2. **Design Flow (2 hrs):** Need identification, conceptual design, detail design, design iteration
3. **Circuit Design and Prototyping (8 hrs):** Top-down / bottom-up approaches, schematic design, HDL design, simulation and verification, PCB prototyping
4. **Testing (6 hrs):** Test coverage, boundary scanning, test vector generation, prototype testing and design verification, product testing and quality assurance
5. **Enclosure Design and Prototyping (8 hrs):** Solid modeling and visualization, rapid prototyping, mould design, tool design
6. **Documentation (2 hrs)**

5.2

Module Code	EN2072	Module Title	Communications I			
Credits	2.5	Hours/Week	Lectures	2	Pre/Co – requisites	
GPA/NGPA	GPA		Lab/Assignments	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Analyze characteristics of random signals and stochastic processes
2. Discriminate between different analog modulation schemes using theoretical analysis
3. Choose the most appropriate modulation scheme for a given application
4. Design communication links
5. Describe the implications of practical sampling versus ideal sampling
6. Identify and compare the distinctive features and relative advantages of PCM, delta modulation, and differential PCM.

Outline Syllabus

1. **Random Signals and Noise (6 hrs):** Random processes: classification, mean, correlation and covariance functions, and spectral characteristics, Noise: thermal noise, white noise, filtered noise, and noise equivalent bandwidth, baseband signal transmission with noise, and matched filtering

2. **Analog Modulation Schemes and their Performance in Noise (8 hrs):** Amplitude modulation, angle and frequency modulation, receivers for analog modulation schemes, performance analysis in noise, and multiplexing

3. **Communication Link Analysis (6 hrs):** Received signal power and noise power, noise figure, noise temperature, and link budget analysis

4. **Sampling and PCM (8 hrs):** Sampling: chopper sampling, ideal sampling and reconstruction, practical sampling and aliasing, pulse amplitude modulation, quantization, pulse code modulation, noise considerations in PCM, differential PCM, delta modulation and predictive coding

5.3

Module Code	EN2082	Module Title	Electromagnetics			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Estimate inductance and capacitance of a twin line and a coaxial line
2. Explain the electric field and potential distributions within the semiconductor diode
3. Apply Maxwell's equations to electromagnetic wave propagation scenarios
4. Analyze the propagation characteristics and power flow of electromagnetic waves in free space and through metal waveguides when signals are transmitted through these media.

Outline Syllabus

1. **Static Electric & Magnetic Fields (6 hrs):** Poisson's and Laplace's equations and their applications to examine a static electric field, integral and differential forms of Gauss's law, Ampere's law, Faraday's law as applied to static electric and magnetic fields, capacitance and inductance of twin lines and coaxial lines, boundary conditions, effect of earth on transmission line properties
2. **Dynamic Fields (2 hrs):** Maxwell's equations and their uses in communications
3. **Plane Wave Propagation (6 hrs):** Concept of an electromagnetic wave and free space propagation, near field and far field from a electromagnetic point source, uniform plane wave propagation in a dielectric medium, intrinsic impedance of a medium, speed of propagation, propagation constant, power flow, Poynting theorem, UPW propagation in a low loss dielectric and a good conductor, skin depth
4. **Polarization (2 hrs):** Linear, circular and elliptic polarization of electromagnetic waves, application of polarization in telecommunications
5. **Reflection of EM Waves (6 hrs):** Boundary conditions, reflection and transmission coefficients of electromagnetic waves at normal incidence and at oblique incidence at an interface, Brewster angle, critical angle and their relevance in communications
6. **Guided Wave Propagation (6 hrs):** Introduction to metal waveguides, wave propagation through a rectangular and circular metal waveguide, TE and TM modes, power flow through a waveguide, cavity resonators

5.4

<table>
<tr><td>Module Code</td><td>EN2142</td><td>Module Title</td><td colspan="4">Electronic Control Systems</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Design a controller for a given plant using computer based tools
2. Analyze physical systems using control theories
3. Implement analog and digital controllers.

Outline Syllabus

1. **History of Control Engineering (2 hrs):** Outlines briefly the history of the field presenting some classical control examples that explain the control principles

2. **Classical Control Theory (6 hrs):** System modeling using ODEs, transformation to Laplace(frequency) domain, regulator design, stability analysis, root locus design using simulation software

3. **Second Order Systems (4 hrs):** rise time, peak overshoot, settling time, damping

4. **Designing Servo Systems (4 hrs)** Bode analysis, stability analysis, compensator design using simulation software

5. **Introduction to Modern Control (4 hrs):** Time-domain modeling, state transition, controllability, observability, observer based controller, Full state feedback and pole placement

6. **Introduction to Optimal Control (4 hrs):** Linear quadratic regulator, linear algebraic riccatti equation

7. **Controllers Implementation (4 hrs):** Analog controllers (OPAMP), digital controllers (microcontroller)

5.5

<table>
<tr><td>Module Code</td><td>EN2542</td><td>Module Title</td><td colspan="4">Introduction to Biomedical Engineering</td></tr>
<tr><td>Credits</td><td>2.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify different biological systems and their functions
2. Construct simple engineering models for physiological systems
3. Analyze engineering solutions to physiological phenomena.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Overview of Biomedical Engineering (2 hrs): Divisions of biomedical engineering, activities of biomedical engineers, ethical issues in biomedical engineering.
2. Overview of the Human Body (8 hrs): Brief description of anatomical and physiological divisions of the human body.
3. Basic Principles and Concepts in Biomedical Engineering (4 hrs): Review of linear systems, time and frequency domain techniques.
4. Respiratory Mechanics and Mechanical Ventilation (6 hrs): Models for respiratory mechanics, method of identifying abnormalities respiration, ventilators.
5. Models of Cardiovascular System and Related Medical Equipment (8 hrs): Chemoreflex regulation of respiration, cardiovascular mechanics, heart-rate variability, cardiac electrophysiology, pacemakers, defibrillators.</td></tr>
</table>

5.6

<table>
<tr><td>Module Code</td><td>EN2902</td><td>Module Title</td><td colspan="4">Field Visit</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>-</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Appreciate Electronic and Telecommunication engineering as practiced in the industry.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. The course will be in the form of one or more field visits to places of interest to Electronic and Telecommunication graduates. These will include, but not limited to, communication towers, mobile providers, telecommunication infrastructure etc.</td></tr>
</table>

5.7

<table>
<tr><td>Module Code</td><td>EN2962</td><td>Module Title</td><td colspan="4">Presentation Skills</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>-</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the importance of identifying the target audience
2. Describe the writing process
3. Discuss plagiarism and the need to acknowledge the work of others
4. Demonstrate the importance of report organization, introduction and conclusion strategies
5. Differentiate the different skills required for presentation in oral and written communications
6. Prepare the correct type of document to suit the target audience
7. Present to a selected public audience
8. Handle a moc interview.

Outline Syllabus

1. **Writing skills (8 hrs):** Writing process, common writing styles, formats and types of writing (letters, memos, proposals, reports, manuals etc.,), writing to different target audiences, report organization methods, introduction and conclusion strategies, planning, reviewing and revised writing, plagiarism, word processing techniques for report writing

2. **Introduction to Presentations (4 hrs):** Preparation of presentation speeches, presentation delivery skills, planning the presentation, presentation practice, influencing your audience

3. **Interview Skills (2 hrs):** Preparation for interviews, answering interview question, behavioral interview questions, practicing interview skills

6. Semester 5 Module Information

The following lists the graduation requirements for Semester 5.

GPA credits for Semester 5	= 23.0	credits
NGPA credits for Semester 5	= (0)	credits

6.1

<table>
<tr><td>Module Code</td><td>EN3012</td><td>Module Title</td><td colspan="4">Analog Circuit Design</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2012</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the effects of positive and negative feedback on the performance of electronic circuits
2. Examine the operation of different types of sinusoidal and non sinusoidal oscillator circuits
3. Identify types of filters, filter approximations and filter topologies
4. Design passive and active filters
5. Identify linear power supply circuits and protections circuits
6. Design a linear power supply
7. Perform noise analysis of analog electronic circuits.

Outline Syllabus

1. **Feedback (6 hrs):** The general feedback structure, negative feedback, feedback topologies, loop gain and stability, effect of feedback on amplifier poles, stability study using Bode plots, frequency compensation of amplifiers

2. **Analog Filter Design (4 hrs):** Passive and active filter design: LP, HP, BP filter design, Butterworth, Chebyshev approximations, second order active filter topologies

3. **Oscillators (6 hrs):** Principle of operation, frequency determination, common oscillator circuits, crystal oscillators, stability, non-sinusoidal waveform generators: multivibrators and Schmitt triggers

4. **Phase Locked Loops (4 hrs):** Operating principles, classifications of PLL types, theory of liner PLL, theory of digital PLL, designing PLL circuits, practical circuits, frequency synthesis

5. **Linear Power Supplies (4 hrs):** Regulators, stabilization and protection circuits

6. **Noise in Electronic Circuits (4 hrs):** Types of noise, analysis of noise in amplifiers, noise figure, noise temperature

6.2

<table>
<tr><td>Module Code</td><td>EN3052</td><td>Module Title</td><td colspan="4">Communications II</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Apply the knowledge of the mathematical and geometrical representation of baseband and modulated signals for analysis and design of communication systems
2. Discriminate between different digital modulation techniques using theoretical analyses
3. Design optimum receivers for various linear modulation schemes in AWGN channel
4. Evaluate the performance of discrete multicarrier communication (OFDM) systems
5. Compare and contrast spread spectrum communications to conventional modulation schemes in terms of bandwidth usage, performance, and as a multiple access technique
6. Analyze the error performances of DS-SS and FH-SS systems under jamming and broadband noise.

Outline Syllabus

1. **Digital Modulation Techniques (8 hrs):** Baseband pulse transmission: digital PAM signals, and power spectra of digital PAM, band-pass signals and systems, signal-space representation, linear memoryless modulation methods: ASK, PSK, FSK, and QAM, digital subscriber lines and modems

2. **Receiver Design for AWGN Channel (8 hrs**): Coherent detection of signals in noise: correlation detector, matched-filter detector, and maximum likelihood decoding, performance of optimum receivers for linear modulation schemes

3. **Multi-carrier Modulation (6 hrs):** Principles of multicarrier modulation, mitigation of subcarrier fading, discrete implementation (OFDM), and challenges in multicarrier transmission

4. **Spread Spectrum Systems (6 hrs):** Spread-spectrum principles, direct-sequence spread spectrum (DSSS), spreading sequences, RAKE receivers, and frequency-hopping spread spectrum (FHSS)

6.3

<table>
<tr><td>Module Code</td><td>EN3322</td><td>Module Title</td><td colspan="4">Digital Signal Processing</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Identify in the issues relevant to implementing continuous signal processing in digital domain
2. Demonstrate the applicability of Digital Signal Processing beyond the traditional application areas involving electrical signals
3. Choose the correct filter implementation based on evaluation of different choices
4. Design filters to meet a given set of specifications
5. Demonstrate the effects of finite word lengths on implementation of filters
6. Analyze digital systems to extract their behavioural characteristics.

Outline Syllabus

1. **Discrete Time Signals and Systems (4 hrs):** Discrete-time signals, discrete-time systems, linear shift invariant systems, frequency response, difference equations, discrete convolution
2. **Z Transform (2 hrs):** Bilateral z transform, properties, inverse transform, stability analysis
3. **Fourier Analysis of Discrete Time Signals and Systems (4 hrs):** Discrete time Fourier Transform, Fast Fourier Transform
4. **Structures for Discrete-Time Systems (6 hrs):** Direct form, parallel, lattice, cascade, signal flow graphs
5. **Digital Filter Design Methods (6 hrs):** FIR filters, window method, frequency sampling method, Minimax method, etc., IIR filters, impulse invariant method, bilinear transform method, minimum mean square error method, etc.
6. **Finite Length Register Effects and Hardware for DSP (3 hrs):** Quantization noise, limit cycles, overflow oscillations, round off noise, scaling of digital filters
7. **Adaptive Signal Processing (3 hrs):** Effect of noise on signal processing, adaptive algorithms: LMS, RLS

6.4

<table>
<tr><td>Module Code</td><td>EN3542</td><td>Module Title</td><td colspan="4">Digital Systems Design</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2022</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Demonstrate the required skills in Hardware Description Language that facilitate rapid prototyping of digital systems
2. Design sequential systems using RTL based approach
3. Describe different approaches available for processor design
4. Identify the key stages in designing a processor
5. Analyze the requirements of a system to decide whether a custom-made processor is required
6. Design a custom-made processor
7. Describe the requirements to use asynchronous sequential based approaches.

Outline Syllabus

1. **Hardware Description Languages (4 hrs):** Introduction to reconfigurable computing , circuit specification using hardware description languages, use of HDL packages
2. **RTL based System Design (4 hrs):** Introduction to RTL based design, data paths and controllers
3. **RISC Architecture (4 hrs):** Features of RISC architecture, pipelining, register windows, register renaming
4. **Processor Design (8 hrs):** Instruction set architecture, hardwired and microprogramming approaches to processor design
5. **Memory Design (4 hrs):** RAM, ROM, EPROM, SRAM, DRAM, memory cells and memory organization, cache memory design, memory interfacing
6. **Asynchronous Sequential System Design (4 hrs):** Introduction to asynchronous sequential systems, race conditions, stability issues, state reduction techniques

6.5

<table>
<tr><td>Module Code</td><td>EN3312</td><td>Module Title</td><td colspan="4">Antennas and Propagation</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2082</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Discuss basic definitions of terms related to antenna design
2. Analyze simple antenna structures
3. Illustrate electromagnetic wave propagation mechanisms and related terminology
4. Design an antenna for a given specification.

Outline Syllabus

1. **Transmission Lines (8 hrs):** Transmission lines as distributed components, characteristic impedance, propagation characteristics, reflection, voltage standing waves, the Smith chart, methods of impedance matching, practical transmission lines (twisted pair, coaxial cable, substrate transmission lines)
2. **Antenna Basics (2 hrs):** Isotropic and anisotropic radiators, antenna radiation patterns, directivity, gain, antenna aperture, vector and scalar potentials, retarded potentials, radiation, near field and far field, Friis formula
3. **Wire Antennas (4 hrs):** Dipoles, monopoles, standing wave antennas (longwire, v-antenna and rhombic antenna), loop antennas, helical antennas, log-periodic antennas
4. **Aperture Antennas (6 hrs):** Stutzman principle, Babinet's principle, Booker's Law, slot antennas, horn antennas, patch antennas, reflector antennas, lens antennas
5. **Antenna Arrays (2 hrs):** Antenna array basics, linear uniform arrays, binomial arrays, coupled arrays, self and mutual impedance, Yagi-Uda array
6. **Radio Wave Propagation (4 hrs):** Ground wave propagation, the ionosphere and sky wave propagation, space wave propagation, tropospheric effects (refraction, reflection, diffraction and absorption)
7. **State of the Art Topics in Antennas and Propagation (2 hrs)**

6.6

Module Code	EN3532	Module Title	Electronic Instrumentation			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN1012
GPA/NGPA	GPA		**Lab/Assignments**	3/2		
Learning Outcomes						

At the end of the module the student will be able to:

1. Differentiate static and dynamic characteristics of electronic instruments
2. Explain the operational principles of basic analog and digital test instruments
3. Analyze measurement errors and how to improve accuracy of measurements
4. Discuss instrumentation circuits and its relevance to measurement accuracy.

Outline Syllabus

1. **General Measurement Theory (2 hrs):** The foundations of electronic measurement theory, measurement errors and error reduction techniques, factors influencing measurement errors, Signals and noise in measurement systems
2. **Generalized Performance Characteristics of Instruments (3 hrs):** Static characteristics, dynamic characteristics
3. **Fundamental Operational Principles of Instruments (8 hrs):** Voltmeters and ammeters (analog and digital), signal sources and function generators, oscilloscopes and their measurements, electronic counters power supplies, spectrum and network analyzers, logic analyzers
4. **Instrumentation Circuits (4 hrs):** Signal conditioning, instrumentation amplifiers, data acquisition and transmission circuits
5. **Instrument Usage (4 hrs):** Probes and other attachments, grounding and shielding design, choosing instruments for a given instrumentation environment
6. **Control in Electronic Instruments (7 hrs):** Use of embedded control in instrumentation

6.7

Module Code	EN3552	**Module Title**	Fundamentals of Machine Vision and Image Processing			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN2062
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Represent images using 2-dimensional discrete signals and systems
2. Analyze images using 2-dimensional discrete Fourier transform and FFT
3. Compare the spatial and frequency domain image processing operations
4. Illustrate the basis for image compression
5. Evaluate the issues relevant to processing of 2-dimensional signals
6. Develops simple image processing and computer vision algorithms to general vision-related problems
7. Choose the correct image processing technique based on proper requirement analysis
8. Choose the correct vision based techniques for a given application.

Outline Syllabus

1. **Image Processing Fundamentals (2 hrs):** Matrix representation, neighbors, distance measures, representation/descriptors, image processing using simulation software
2. **2-dimensional Discrete Time Signals and Systems (4 hrs):** Discrete-time signals, discrete-time systems, linear shift invariant systems, frequency response, discrete convolution, spatial-domain transformations/filtering, Fourier analysis in 2D
3. **Image Enhancement, Restoration and Conversion (4 hrs):** of the image degradation / restoration process, noise models, filtering
4. **Image Segmentation (4 hrs):** Point, line and edge detection, region-based segmentation
5. **Fundamentals of Computer Vision and Human Vision System (2 hrs)**
6. **Binary Image Processing for Vision Applications (4 hrs)**
7. **Video Image Processing (4 hrs):** Time varying image analysis, optical flow, object tracking
8. **Color, Photometric Stereo, Shape from X (4 hrs):** Introduction to the topics

6.8

Module Code	EN3562	Module Title	Robotics			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	Preferred EN2062 EN2142
GPA/NGPA	GPA		**Lab/Assignments**	3/1		

Learning Outcomes

At the end of the module the student will be able to:

1. Analyze the motion of a robot manipulator
2. Use software tools to simulate robot manipulator kinematics
3. Design a compliant joint controller for robot manipulators
4. Design an appropriate trajectory planner for robot manipulators
5. Discuss future directions of robotics in the society and industry.

Outline Syllabus

1. **Introduction (2hrs):** The history and background of robotics, technical aspect of robots
2. **Mathematics of Robot Manipulators (4hrs):** Kinematics and inverse kinematics of robot manipulators is discussed, co-ordinate transformation between frames and how it is applied to calculate end-effector's position and velocity (homogeneous transformation matrix, DH parameters)
3. **Differential Motion (2 hrs):** Manipulator Jacobeans, and static equilibrium
4. **Trajectory Planning (2 hrs):** Cartesian space and joint space trajectory planning and their pros and cons are discussed, trajectory planning in industrial manipulators are specifically discussed
5. **Robot Sensors (2 hrs):** Internal and external sensors and sensor fusion for robot control, position encoders, force-torque sensors, and ultrasonic sensors
6. **Drive Systems for Robot (4 hrs):** DC servo drive systems with speed and direction control, feedback and feed forward control
7. **Compliant Motion (2 hrs):** Force control with a robot hand
8. **Application Oriented Robot System Design (4 hrs):** Designing a robot system for a given application (with case studies), type of the robot, type of sensor and actuators used, and trajectory planning method to be used
9. **Autonomous Mobile Robots and Robot Intelligence (4 hrs):** Issues in autonomous mobile robots such as self-localization, and navigation, introduction to behavior-based control subsumption architecture for advanced mobile robots
10. **Current and Future Trends in Robotics (2 hrs):** Computer vision techniques, image acquisition and processing techniques, vision based control of robot manipulators, robotics in industry, military application in robotics

6.9

<table>
<tr><td>Module Code</td><td>EN3572</td><td>Module Title</td><td colspan="4">Biomedical Signal Processing</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2062</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Identify and describe the sources of key bio-medical signals
2. Demonstrate the understanding of signal representation techniques and their applicability to the analysis of biomedical signals
3. Describe and quantify the effects of noise on biomedical signals
4. Analyze different type of biomedical signals to get a deeper contextual understanding.

Outline Syllabus

1. **Physiology and Characteristics of Biomedical Signals (2hrs):** Introduction
2. **ECG (6 hrs):** Cardiac electrophysiology, relation of electrocardiogram (ECG) components to cardiac events, clinical applications, ECG filtering and frequency analysis of the electrogram, QRS detection, P & T wave detection, heart rate variability
3. **EEG (6 hrs):** Source of EEG signals, measurement of EEG signals, frequency domain analysis of EEG, modeling of EEG signals, EEG artifacts, use of software tools to analyze EEG
4. **Signal Representation by Basis Functions (4 hrs):** Principal component analysis (PCA), independent component analysis (ICA)
5. **Effect of Noise on Medical Signal Processing (6 hrs):** Noise characteristics, noise reduction techniques, adaptive signal processing, LMS, RLS
6. **Blind Source Separation (2 hrs):** Separate fetal and maternal ECG signals using techniques based on second- and higher-order statistical methods
7. **Speech Signals (2 hrs):** The source-filter model of speech production, spectrographic analysis of speech

7. Semester 6 and Term B Module Information

The following lists the graduation requirements for Semester 6 and Term B.

GPA credits for Semester 6 and Term B = 0 credits
NGPA credits for Semester 6 and Term B= (6.0) credits

7.1

Module Code	EN3992	**Module Title**	Industrial Training			
Credits	6.0	**Hours/Week**	**Lectures**	-	**Pre-requisites**	
GPA/NGPA	NGPA		**Lab/Assignments**	-	**Co-requisites**	

Learning Outcomes

At the end of the module the student will be able to:

1. Appreciate the differences between academic and industrial environments
2. Value the training institutions relevance to engineering and engineering management
3. Relate the knowledge gained via training to the project which will be assigned and bring it to completion
4. Adhere to engineering ethics, industrial safety standards and processes
5. Present the findings in a training report.

Outline Syllabus

1. **Induction:** This is an initial period to help the student in the transition from academic to industrial life. The students should meet his/her Mentor to discuss the contents and the objectives of training. He/She should also receive information about the training organization, its products or services and the terms and conditions of employment.

2. **Practical Skills:** During this period the student should receive instructions in the practical skills essential for his/her future employment. It should also include an appreciation of the work of others in converting an engineering design into a final product (if appropriate).

3. **General Engineering Training:** In a large organization this should include an introduction to the work done in a number of departments. Under these circumstances, the student may eventually be working as a member of a team in the organization. The student should be made aware of the management and administration sectors of the organization.

4. **Directed Objective Training:** The major part of the training should have directed application to the activity which the student intends to follow after the training program (activities should be relevant to the major in which the student will be graduating in). At this stage the student should be encouraged to work on a real project and be given increasing responsibility for independent work to establish interest and confidence in his/her work. *Most of the training time will cover Design and Development, Documentation and Data preparation, and commissioning. The student should also have a thorough understanding of the operations of the training place in the Electronics and Telecommunication Engineering context.*

8. Semester 7 Module Information

The following lists the graduation requirements for Semester 7.

GPA credits for Semester 7 = 20.0 credits
NGPA credits for Semester 7 = (0.0) credits

8.1

Module Code	EN4012	Module Title	Advanced Electronics			
Credits	2.5	Hours/Week	Lectures	2	Pre/Co – requisites	
GPA/NGPA	GPA		Lab/Assignments	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Recognize EMC and EMI issues
2. Describe VSLI design concepts and fabrication issues
3. Explain new developments related to materials, production process
4. Discuss regulatory issues related to electronic devices
5. Discover different types of applications and new trends in electronic applications.

Outline Syllabus

1. **Electromagnetic Compliance and Immunity (4 hrs):** Electromagnetic compliance and immunity
2. **VLSI Design and Semiconductor Fabrication (6 hrs):** VLSI design flow, design hierarchy, design rules, full custom and semi custom design, application examples
3. **Advance Electronic Materials and Devices (4 hrs):** Wide band gap materials and devices, special transistor structures
4. **Current Trends in Electronics (2 hrs):** Regulatory issues, recycling, miniaturization, packaging
5. **Applications in Industrial Electronics (2 hrs):** Basic introduction to the industrial electronics, sensors and systems
6. **Introduction to Nanotechnology for ICT (2 hrs):** Basic introduction to nanotechnology for ICT
7. **Applications in Automobile Electronics (2 hrs):** Introduction to the applications of electronics in automobile industry, usage and considerations
8. **Consumer Electronic Applications (2 hrs):** Types of consumer electronic applications
9. **Applications in Renewable Energy (2 hrs):** The renewable energy sources, applications in the renewable electronics and main considerations
10. **Agricultural Electronics (2 hrs):**

8.2

Module Code	EN4052	**Module Title**	Communications III			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Choose an appropriate source coding technique to suit a given application
2. Describe the basic concepts of data secret-key and public-key encryption systems
3. Relate the improvement in the error performance to the concepts of error control coding, Hamming distance and coding gain
4. Use matrix or polynomial operations to perform encoding and decoding operations of a given block code
5. Apply the Viterbi algorithm to perform maximum likelihood decoding of convolutional codes
6. Design of signals for band-limited channels
7. Apply optimum and suboptimum receiver techniques for channels with ISI and AWGN.

Outline Syllabus

1. **Source Coding (4 hrs):** Information measure: entropy and mutual information, coding for discrete memoryless sources: Huffman coding and run-length codes, coding for analog sources: optimum quantization, block and transform coding, and examples of source coding: audio compression and video compression.

2. **Data Encryption and Decryption (4 hrs):** Introduction to cryptosystems, secrecy of a cipher system, practical security, stream encryption, public key cryptosystems, and pretty good privacy.

3. **Channel Coding (8 hrs):** Error detection and correction, linear block codes: matrix representation of block codes, syndrome decoding, error detection and correction capabilities, and cyclic codes, convolutional codes: convolutional encoding, maximum likelihood decoding, and Viterbi decoding algorithm

4. **Digital Signaling Over Bandwidth Constrained AWGN Channels (6 hrs):** Characterization of band-limited channels, signal design for band-limited channels: band-limited signals for no ISI, Nyquist criterion, band-limited signals with controlled ISI, and data detection for controlled ISI: symbol-by-symbol detection and maximum-likelihood sequence detection

5. **Communication Through Band-limited Channels (6 hrs):** Optimum receivers for channels with ISI and AWGN: optimum maximum-likelihood receiver, discrete-time model for a channel with ISI, Implementation of MLSE using Viterbi algorithm, linear equalization: peak distortion and minimum mean square error criteria, and decision feedback equalization

8.3

Module Code	EN4202	Module Title	Project			
Credits	10.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Identify a real-world problem of sufficient complexity that can be solved using the technologies learnt during the undergraduate career within a given time frame
2. Appreciate the need for group work in solving real-world problems and the role of the individual
3. Demonstrate the skills required for writing a project proposal and associated business plan for the problem identified
4. Defend the proposal drafted for solving a real-world problem
5. Apply the knowledge gained to determine alternative approaches to solving the problem
6. Analyze different approaches to solve the identified problem
7. Evaluate the different approaches to find the most suitable one
8. Design and develop the solution using the selected approach
9. Evaluate the effectiveness of the solution
10. Justify the methods adopted in the solution
11. Compile a comprehensive document detailing all aspects related to the project.

Outline Syllabus

1. **Investigation Stage**: The student should be capable of independently referring to books, papers, academic literature and electronic resources to justify their choice of project. Conduct a literature survey in order to academically support any claims, technologies and methods used in your project. This phase should also be used to determine if there are other methods that have been used to address the same or similar implementation aspects of your project. As a consequence of this activity, the student should now have a number of sources of information upon which to base the work that is to follow. Identifying or estimating the hardware and software components required for the successful implementation of the proposed project is also carried out within the scope of this phase.

2. **Implementation Stage:** Once the preliminary investigation is carried out and a project of appropriate complexity is chosen, the next stage is to design and implement the prototype. Identifying the proper approach of implementation is also key to completing the project successfully. Use design software, simulationd to support your design strategies. The implementation phase includes construction and testing of the prototype. A major portion of the time should be spent with this phase. At the implementation stage, the student is allowed to alter or modify the methodologies proposed in the previous phase depending on any new information available at this stage.

3. **Presentation Phase**: Placing the work in context and presenting it effectively is also an important part of the project. Effective presentation of the project material and a well structured report is expected for the satisfactory completion of the final year project. The documentation and knowledge presevation includes a presentation, report, DVD with structured information as well as a viva.

8.4

Module Code	EN4212	Module Title	Power Electronics			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Describe the fundamental principles of different power electronic devices
2. Identify different applications in power electronics
3. Apply the knowledge of power electronic devices and controllers to analyze power electronic circuits
4. Design and implement various power electronics devices and circuits
5. Troubleshoot power electronics devices and circuits.

Outline Syllabus

1. **Fundamentals of Power Electronics (2 hrs):** Introduction to power electronics, fundamentals of power electronics, devices and considerations
2. **AC Power Handling (4 hrs):** Diode and thyristor controlled rectifiers, ac power controlling
3. **Simulation of Power Electronic Circuits (2 hrs):** Simulation of power electronic circuits using appropriate software
4. **Thermal Management of Power Devices (2 hrs):** Thermal management, heat sink calculation and power devices selection on thermal aspects
5. **Drive and Protection Circuits (4 hrs):** Drive circuits of power semiconductor devices, high side drivers and operation, protection circuits and measures, snubber circuits, over voltage and over current protection, EMI aspects
6. **DC / DC Converters (4 hrs):** Design of buck, boost and buck-boost converters, characteristics and practical aspects
7. **Inverters (2 hrs):** Voltage source and current source inverters, PWM, hysteresis and resonance pulse inverters, applications and control methods
8. **Advanced Power Supplies (6 hrs):** Switching regulators, switch mode power supplies, uninterrupted power supplies
9. **Motor Controlling (2 hrs):** AC, DC and BLDC motor controlling methods and design

8.5

Module Code	EN4222	Module Title	Electronic Manufacturing Systems			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN2042, EN3022
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Describe manufacturing process design
2. Explain production planning
3. Discuss methods used for raw material control
4. Describe methods used for production control
5. Appraise productivity improvement techniques and manufacturing information management techniques.

Outline Syllabus

1. Introduction **(2 hrs)**
2. Process design and engineering, translation of product design information to manufacturing information **(6 hrs)**
3. Production planning, scheduling, production strategies: make-to-order, make-to-stock **(6 hrs)**
4. Incoming raw material control, material ordering and stocking, Cumban system **(4 hrs)**
5. Product fabrication, assembly, testing, repair, quality control **(6 hrs)**
6. Productivity improvement, manufacturing information management **(4hrs)**

8.6

<table>
<tr><td>Module Code</td><td>EN4232</td><td>Module Title</td><td colspan="4">Industrial Electronics</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Identify the sensors and actuators used in industrial applications
2. Use sensors and actuators in automation applications
3. Identify the controllers used in industrial application
4. Use industrial controllers in automation applications
5. Identify electronics in machinery used in industrial applications
6. Design protection systems for structures and automation systems.

Outline Syllabus

1. **Industrial Sensors and Actuators (6 hrs):** Pressure sensors, temperature sensors, humidity sensors, viscosity sensors, flow sensors, load cells, etc., electric actuators, pneumatic actuators, hydraulic actuators, etc.
2. **Electronics in Industrial Machines (6 hrs):** CNC machines, industrial robots, molding machines, EDM machines, welding machines, heat treatment machines, printing machines, packeting machines, conveyors, etc.
3. **Industrial Controllers (6 hrs):** Analog and digital controllers, programmable controllers, fuzzy logic controllers, fuzzy neural controllers, embedded controllers, etc.
4. **Industrial Automation (6 hrs):** Overview, industrial networks, automation software
5. **Protection (4 hrs):** Lightning protection, vibration protection

8.7

<table>
<tr><td>Module Code</td><td>EN4312</td><td>Module Title</td><td colspan="4">Telecommunication Core Networks</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Discuss signaling and its relevance in a given application
2. Discriminate between different digital transmission and multiplexing technologies
3. Differentiate between different data transmission technologies
4. Justify the reasons for convergence of different technologies.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Signaling (4 hrs): Evolution of signaling systems, The CCITT no. 7 signaling system
2. Transmission (8 hrs): Multiplexing hierarchies V PCM and time division multiplexing, SONET, SDH and WDM techniques and networks
3. Data Transmission Technologies (10 hrs): X.25, frame relay, asynchronous transfer mode (ATM), congestion control in data transmission, IP based networks, transmission in WANs
4. Convergence of Technologies (6 hrs): Voice and video over packet switching networks, integrated networks, applications in multimedia communications, MPLS</td></tr>
</table>

8.8

Module Code	EN4322	Module Title	Optical Fiber Communications			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Investigate and evaluate the capabilities of optical devices and fiber types
2. Identify the underlying innovations behind emerging technologies in fiber optic communications
3. Recommend a cost effective solution for real world optical link design problems.

Outline Syllabus

1. **Introduction (2 hrs):** Introduction to optical communication systems, history of optical fiber and optical communication systems, comparison with other wired and wireless media
2. **Optical Fiber (6 hrs):** Optical fiber as a dielectric waveguide, optical fiber construction and types (glass fibers, plastic fibers, graded index fibers etc.), mechanisms of attenuation and dispersion, mulitmode and single mode fibers, modal and chromatic dispersion, dispersion compensation
3. **Optical Sources (6 hrs):** Light emitting diodes (LED's), laser diodes, VCSEL and DFB lasers
4. **Optical Detectors and Receivers (4 hrs):** PIN photodiode, avalanche photodiode, noise in optical receivers, bit error rate calculation
5. **Modulation, Amplification and Multiplexing (6 hrs):** Direct modulation bandwidth of LED's and semiconductor lasers, fiber amplifiers, wavelength division multiplexing and fiber components
6. **Optical Link Design and Practice (4 hrs):** Link budget calculations and selection of optical components

8.9

Module Code	EN4332	**Module Title**	Microwave Engineering			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN2082
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Apply basic principles of electromagnetic to understand the behavior of microwaves and their propagation
2. Discriminate the operating principles of basic microwave devices such as waveguides, thermionic, semiconductor and ferrite microwave devices
3. Use basic microwave devices effectively, observing safety precautions.

Outline Syllabus

1. **Microwave Circuit Theory (8 hrs):** Scatter parameters, signal flow graphs (for source, load and transducer), Smith chart based solutions, circuit simulation software
2. **Transmission Lines and Substrate Components (3 hrs):** Coaxial lines, microstrips and slot lines, filters, bends, quarter wave transformers, couplers, junctions, lumped components
3. **Passive Components (6 hrs):** Terminations, attenuators, reactive stubs, cavity resonators, bends, T junctions, magic T junction, hybrid ring, directional couplers, slotted lines, ferrite filters, isolators, circulators, phase shifters
4. **Microwave Tubes (4 hrs):** Magnetron, klystron, reflex klystron, traveling wave tube
5. **Semiconductor Devices (5 hrs):** Gunn diode, PIN diode, varactor diode, tunnel diode, backward diode, Schottky diode, point contact diode, IMPATT diode, bipolar junction transistors, hetero junction transistors, field effect transistors (MESFET, HMET), introduction to monolithic microwave integrated circuits
6. **Microwave Antennas (2 hrs):** Horn antenna, helical antenna, phased arrays, slot antennas, reflector antennas, lens antennas, patch antennas

8.10

<table>
<tr><td>Module Code</td><td>EN4532</td><td>Module Title</td><td colspan="4">Advanced Digital System Laboratory</td></tr>
<tr><td>Credits</td><td>2.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN3542</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/1</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify the reasons to implement a specific system on reconfigurable hardware
2. Describe the System-on-Chip (SoC) concept and its advantages
3. Demonstrate the modeling for digital systems for implementation in system on a chip
4. Demonstrate the skills required for optimizing of FPGA resources and troubleshooting critical issues on reconfigurable hardware such as timing
5. Evaluate the performance of the systems implemented.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Complex Digital Systems (4 hrs): System specification, design, implementation and performance evaluation on reconfigurable hardware (FPGA)
2. Implementation of SoC (System on a Chip) on FPGAs (4 hrs): SoC concept, real world examples, timing and synchronization, power and energy
3. Role of Software in SoC (4 hrs): Hardware/software co-design, implementing real-time operating systems on reconfigurable hardware
4. SoC Troubleshooting Techniques (2 hrs): Use of industry standard tools for trouble shooting SoCs – e.g. chip scope</td></tr>
</table>

8.11

<table>
<tr><td>Module Code</td><td>EN4542</td><td>Module Title</td><td colspan="4">Medical Electronics and Instrumentation</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Discuss the operational principle of transducers and electrodes used in medical instrumentation
2. Use elements of a biotelemetry system
3. Explain the application of biomedical devices
4. Discuss interactions between instruments and biological systems.

Outline Syllabus

1. **Basic Transducers and Principles (4 hrs):** Volume and flow transducers, catheter and diaphragm based transducers, force and motion transducers, temperature, heat flow and humidity sensors
2. **Biopotential Electrodes (4 hrs):** Biopotential amplifiers and cardiac measurements, electrode-electrolyte interfaces and inductance plethysmography
3. **Chemical Measurement Systems (8 hrs):** Enzyme based sensors, immunosensors, mass spectrometry, chromatography, electrophoresis, magnetic resonance, IR spectrometry and pulse oximetry
4. **Biotelemetry (4 hrs):** Antenna design, frequency modulation, pulsed RF, phase locked loops in medical instrumentation, distributed networks and telemedicine
5. **Electrosurgical Devices (4 hrs):** Theory of operation, monopolar and bipolar modes, ESU design, active and dispersive electrodes, and ESU hazards
6. **Biomedical Lasers (4 hrs):** Interaction and effects of different laser radiation on biological tissues, laser beam delivery systems

8.12

Module Code	EN4922	**Module Title**	Research Project				
Credits	5.0	**Hours/Week**	**Lectures**	-	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	-		
Learning Outcomes						

At the end of the module the student will be able to:

1. Explain specific issues related to the chosen research topic based on how concepts have been built up through cross referencing of related research material
2. Demonstrate skills of critical comparison with similar research topics
3. Demonstrate specific skills related to research methodologies
4. Demonstrate programming/analytical skills required for advanced research
5. Write a research paper of acceptable quality.

Outline Syllabus

1. Research methodologies, significance of literature survey, search methodologies, formulating research ideas, referencing research
2. Reading and reviewing research articles, formalized methods of conducting a research, developing and implementing algorithms
3. Writing research reports, preparing a paper for publication based on research outcomes

8.13

<table>
<tr><td>Module Code</td><td>EN4932</td><td>Module Title</td><td colspan="4">Technical and Scientific Writing</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignments</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify the importance of the target audience in technical and scientific writing
2. Differentiate between different types of technical reports, its elements and organization
3. Explain the need for comprehensive literature survey
4. Explain the need for templates in technical documents
5. Use of citations, cross references, bibliography styles and indexes
6. Write a review or critique for a given article.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Technical Writing (8 hrs): Common technical writing styles, formats and types of writing., use of templates, bibliographies, introduction and conclusion strategies, planning, reviewing and revised writing
2. Word Processing Techniques (4 hrs): Using Tex for technical writing
3. Reviews and Critiques (2 hrs): Elements of a good review/critique</td></tr>
</table>

9. Semester 8 Module Information

The following lists the graduation requirements for Semester 8.

GPA credits for Semester 8	= 17.5	credits
NGPA credits for Semester 8	= (0)	credits

9.1

Module Code	EN4242	Module Title	Consumer Electronics			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		
Learning Outcomes						
At the end of the module the student will be able to: 1. Explain the operation principles of commonly used consumer electronic devices 2. Identify and isolate common faults in electronic systems 3. Repair and configure selected electronic devices.						
Outline Syllabus						
1. **Television (6 hrs):** Basic operation, troubleshoot, common faults of televisions, LCD & plasma televisions 2. **Electronics in Display Devices (2 hrs)**: Operating principle and troubleshooting of CRT, LCD, and plasma screens 3. **Record and Playback Devices (2 hrs):** Construction, operation, common brands and repair procedures of VCD, DVD, Blu-Ray, etc. 4. **Printing Machines (2 hrs):** Operation of the printers, common faults of dot matrix printers, ink-jet printers, bubble-jet printers and laser printers 5. **Photocopy Machines and Scanners (2 hrs):** Operation, troubleshooting and optional features 6. **Multimedia Projectors (2 hrs):** Operation, sensing technologies (TFT, DLP), common faults and troubleshoot 7. **Telephone and Related Devices (4 hrs):** Construction, fault identification, repair and configuration of telephones, mobile phones, wireless handsets, fax machines and modems. 8. **Devices with Fuzzy Logic (4 hrs):** Usage and implementation of fuzzy logic in consumer electronic devices (such as washing machines, air conditioners) 9. **Other Consumer Electronic Devices (4 hrs):** Construction and operation of combo box, digital cameras, camcorders, etc.						

9.2

<table>
<tr><td>Module Code</td><td>EN4252</td><td>Module Title</td><td colspan="4">Industrial Motor Control</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN4212</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Differentiate types of motors and their characteristics
2. Identify the different controlling strategies used in motor controlling
3. Apply the knowledge of power electronics for designing high power motor controllers
4. Optimize the motor controller designs in terms of efficiency, torque output, power density and stability with advance motor control concepts and methods
5. Troubleshoot motor control circuits and systems.

Outline Syllabus

1. **Fundamentals of Motor Control (2 hrs):** Introduction to motor control electronics, different aspects and considerations
2. **Servo Motor Control (2 hrs):** Different types of servo motors and characteristics, controlling theories and strategies of servo motors
3. **Different Switching Techniques (4 hrs):** Sine PWM, space vector PWM and hysteresis loop PWM techniques used for motor power / current control
4. **DC Motor Control (4 hrs):** DC motor classification, types of DC motors, basic equations, controlling DC motors in four quadrant operations
5. **Induction and Synchronous Motor Control and Inverter Design (4 hrs):** Variable speed drives design, implementation and optimization
6. **Brushless DC and Permanent Magnet Synchronous Motor Design (4 hrs):** BLDC motors and PMSM design concepts, controlling methods, controller design and position sensor design
7. **Optimization of Output Parameters (Torque, Efficiency and Ripple Ractor) (4 hrs):** Optimization of motor output parameters (torque, efficiency and ripple factor) using different controller methods, selective harmonic elimination method and other high order harmonic elimination techniques
8. **Applications (4 hrs):** Robotics, electric/hybrid vehicles, conveyors, elevators, etc.

9.3

Module Code	EN4262	Module Title	Automobile Electronics			
Credits	2.5	Hours/Week	Lectures	2	Pre/Co – requisites	EN1012
GPA/NGPA	GPA		Lab/Assignments	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Describe the basic operation of the automobile control systems
2. Identify the different parts of automobile control systems
3. Explain how to troubleshoot electronic / electrical elements in automobiles
4. Identify features in automobile control and electronic systems that can be modified to improve the performance.

Outline Syllabus

1. **Operation of the Internal Combustion Engine (2 hrs):** Two stroke gasoline engine, four stroke gasoline engine and four stroke diesel engine, turbo charger
2. **Fuel Metering and Delivery (2 hrs):** Conventional carburetor, EFI system (single point fuel injection, multi point fuel injection, gasoline direct injection), diesel direct and indirect injection
3. **Ignition Control (2 hrs):** Conventional ignition, transistor control ignition, capacitor discharge ignition, distributor less ignition
4. **Emission Control (1 hr):** Emission control methods such as catalytic converter
5. **Engine Control Unit (4 hrs):** Sensors and actuators, engine control techniques, vehicle fault diagnosing
6. **Safety and Security (4 hrs):** ABS systems, intelligent traction control, airbag systems, vehicle security systems
7. **Air Conditioning and Automatic Climate Control (2 hrs):** Intelligent air conditioning systems and climate control systems
8. **Automotive Navigation Systems (2 hrs):** Automatic navigation systems available in vehicles, sensors and algorithms
9. **Intra Vehicle Communication (4 hrs):** I^2C, CAN networking, local interconnect network, FlexRay
10. **Emerging Technologies in Automobiles (3 hrs):** Electric and hybrid vehicles, fuel cell powered vehicles, fuel enhancing techniques
11. **Electronic Device Fabrication for Automobiles (1 hrs):** The special considerations in automobile grade semiconductor device manufacturing
12. **Cruise Control (1 hrs):** Cruise control systems in vehicles

9.4

<table>
<tr><td>Module Code</td><td>EN4272</td><td>Module Title</td><td colspan="4">Agricultural Electronics</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Describe properties & functions of soil and suitable electronic instrumentations for soil property & function measurements
2. Discuss soil fertility & plant nutrition and suitable electronic instrumentation for fertility & plant nutrition management
3. Explain plant physiology and electronic instrumentation related to plant physiology
4. Discuss physical properties of agricultural produce, produce quality and electronic instrumentation for quality measurements
5. Explain principles of preservation of agricultural produce and suitable electronic instrumentation for agricultural produce preservation.

Outline Syllabus

1. **Introduction (3 hrs)**
2. **Properties and Functions of Soil (5 hrs):** Physical and chemical properties effecting crop growth, soil water retention, instrumentations for soil property and function measurements
3. **Soil Fertility and Plant Nutrition (5 hrs):** Nutrient dynamics, functions of plant nutrients, deficiency and toxicity symptoms, soil fertility and productivity, fertility management, instrumentation for fertility management
4. **Plant Physiology (5 hrs):** Principle physiological aspects, effect of environmental factors, optimization of plant yield, instrumentation related to plant physiology
5. **Agricultural Product Quality and Processing (5 hrs):** harvest maturity, measurement of quality, sensory properties, instrumentation for product quality and processing
6. **Processing of Agricultural Produce (5 hrs):** Psychrometry and moisture dynamics, introduction to principles of presevation, physicochemical changes, instrumentation for quality assessment and process control

9.5

<table>
<tr><td>Module Code</td><td>EN4282</td><td>Module Title</td><td colspan="4">Electronic Applications in Renewable Energy</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Compare different types of renewable energy sources and their characteristics
2. Apply the knowledge of power electronics for designing and analyzing power controlling, storage, distribution and interconnection circuitry related to renewable energy applications.
3. Optimize the power output and efficiency of the renewable energy extraction system.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Renewable Energy Sources and Characteristics (4 hrs): Different types of renewable energy sources (solar, wind, micro hydro, Sterling thermal), characteristics, feasibility and availability.
2. Variable Input Voltage, Variable Input Frequency Power Controlling Circuitry (4 hrs): The design and characteristics of variable input voltage and variable input frequency controllers, optimization techniques of the controllers in terms of power extraction
3. Energy Storage Mechanisms (2 hrs): Variation of renewable energy input and storage mechanisms of energy, design of high power energy storage and retrieving mechanisms, managing multiple renewable energy systems
4. High Voltage Electronics, Power Converters (4 hrs): High voltage electronics devices and protection mechanisms, deign of high voltage power converters
5. HVDC Transmission (4 hrs): Design and analysis of HVDC transmission systems and back to back converters
6. Grid Interconnection (6 hrs): Interconnection of the power sources with national grid, controlling methods and circuit design
7. Applications (4 hrs): Wind mill controllers, photo voltaic controllers, micro hydro controllers</td></tr>
</table>

9.6

Module Code	EN4292	Module Title	Industrial Automation			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Evaluate a given industrial automation system and suggest on possible improvements
2. Design and implement a complete solution for a full industrial automation system
3. Troubleshoot an existing industrial automation system.

Outline Syllabus

1. **Sensors (4 hrs):** Limit switches, photo sensors, magnetic sensors, inductive sensors, ultrasonic sensors, process control sensors used for humidity, pressure, temperature, load and flow measurements
2. **Actuators (4 hrs):** Motors and electrical linear drives, pneumatic and hydraulic cylinders and linear drives, pneumatic and hydraulic rotary drives and motors
3. **Pneumatic and Hydraulic Control Systems (4 hrs):** Pneumatic generation, purification and flow control, control valves, pure pneumatic/hydraulic control systems, electro-pneumatic/hydraulic control systems, relay circuits, ladder logic, simulation of pneumatic / hydraulic systems
4. **Programmable Logic Controllers (6 hrs):** Operation and construction of switching modules and PLCs, high end PLCs, PLC programming, other add-ons, PLC standards
5. **Human Machine Interfaces (4 hrs):** HMI software, display and touch panels interfacing and programming
6. **Industrial Networks (2 hrs):** CAN-open, profibus, Modbus, pndustrial Ethernet, configuration and interconnection
7. **Motor Controlling in Industrial Automation (2 hrs):** Motor controlling using inverters and encoders, etc. Servo motors and controllers
8. **Industrial Printers (2 hrs):** Usage, interfacing and features of industrial inkjet printers, pad printer, etc.

9.7

<table>
<tr><td>Module Code</td><td>EN4342</td><td>Module Title</td><td colspan="4">Broadcast Technologies</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Assess different broadcast technologies
2. Design TV and radio broadcast networks.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Analog and Digital Sound Broadcasting (4 hrs): Conventional FM broadcasting and DAB standards
2. Fundamentals of Terrestrial Analog TV Broadcasting (6 hrs): Encoders and dcoders in PAL and NTSC systems, characteristics of composite video signal, modulation of CVS and spectrum utilization, TV transmitters, and network planning
3. Terrestrial Digital TV Broadcasting (4 hrs): Motivation for digital TV, need for compression, predictive encoding and transform coding, motion estimation and compensation
4. MPEG Video Compression Standards (2 hrs)
5. Digital TV Broadcasting Standards (6 hrs): DVB- T, ATSC, and ISDB standards, and network planning
6. Transmitters for Digital TV Broadcasting (4 hrs): Operational principals and test and measurement for DTV transmitters
7. Introduction to IPTV, Cable TV and Satellite TV (2 hrs)</td></tr>
</table>

9.8

<table>
<tr><td>Module Code</td><td>EN4352</td><td>Module Title</td><td colspan="4">Radar and Navigation</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Explain block diagrams and the operation of different types of RADAR and selected navigation systems
2. Apply the fundamental engineering concepts found in electromagnetic, electronics, signal processing, antennas and propagation in the design of practical RADAR systems and navigation systems
3. Design pulsed RADAR and selected navigation systems by optimizing various design parameters
4. Use RADAR and navigational equipment effectively with safe operating precautions.

Outline Syllabus

1. **Radar Systems (8 hrs):** Introduction and early history, classification of Radars, basic concepts and measurements, the Radar equation, propagation effects of atmospheric refraction, properties of radar targets, Radar detection in the presence of noise, Introduction to Radar signal processing, Radar antennas CW Radar, frequency-modulated CW Radar, MTI and pulse Doppler Radar, tracking Radar, introduction to secondary surveillance Radar (SSR)

2. **En-Route Navigational Aids (6 hrs):** Rho-Theta navigation, VHF Omni-range (VOR), distance measuring equipment (DME), Radio altimeter, introduction to Doppler navigation and satellite based navigation

3. **Navigational Aids for Landing (6 hrs):** Instrument landing system (ILS), approach and terminal Radars, use of precision approach path indicators (PAPI)

4. **Satellite Based Navigation System (8 hrs):** Global positioning system, satellite constellation, principle of triangulation, navigational messages, frame format, errors in position fixing, GPS receivers, automatic dependant surveillance (ADS) systems, future air navigation systems (FANS)

9.9

Module Code	EN4362	**Module Title**	Microwave Communication			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the use of microwave communication systems in providing broadband solutions
2. Design the RF links in terrestrial and satellite microwave communication systems
3. Plan and propose microwave link solutions to the communication problems in the industry.

Outline Syllabus

1. **Principles of Terrestrial Microwave Communication (4 hrs):** Principles of tropospheric wave propagation: reflection, refraction, diffraction & absorption effects
2. **RF Link Design for Terrestrial Microwave Communication (6 hrs):** Path design, fading & fade margin, link power budget
3. **Reliability Measures (4 hrs):** Protection methods & link configurations
4. **Introduction to Satellite Systems (4 hrs):** Concept, history, orbits, footprints, frequency bands, constellations, applications
5. **Satellite Communication Link Design and Analysis (4 hrs):** Satellite RF link path design, fading & fade margin, satellite link power budget, antennas
6. **Digital Modem Design (2 hrs):** Subsystems in a satellite, satellite payload, digital modem
7. **Error Control for Digital Satellite Links (2 hrs):** Use of modern error control codes in satellite communication links
8. **Codec design (2 hrs):** Basic principles of speech/video coding and their usage in satellite communication systems

9.10

<table>
<tr><td>Module Code</td><td>EN4372</td><td>Module Title</td><td colspan="4">Teletraffic Theory and Switching</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Justify the importance of traffic theory for communication networks
2. Evaluate different switching technologies
3. Design an end-to-end multimedia over IP network application
4. Analyze the performance of standard routing algorithms and MPLS.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Teletraffic Theory (8 hrs): Statistical characterization of telecommunications traffic, the Erlang B formula and its applications, circuit efficiency, grade of service and measurement of congested circuits, dimensioning of telephone circuits and switches
2. Switching (8 hrs): Space switching, time switching, and stored program control (SPC) switching, blocking and non-blocking switches, packet switching with comparison to circuit switching
3. Multimedia Over IP Networks (4 hrs): VOIP, H323, H264, RTP/RTCP, SIP
4. Multiprotocol Label Switching (8 hrs): Basic principles of MPLS, LDP, MPLS with traffic engineering</td></tr>
</table>

9.11

Module Code	EN4382	Module Title	Wireless and Mobile Communications			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Explain relative merits and demerits of wireless communication technologies
2. Select a wireless technology or a combination of technologies to suit a given application
3. Plan a wireless communications system for a given environment in which it is to be deployed.

Outline Syllabus

1. **Introduction (1 hrs):** Introduction to wireless communication systems: evolution, fixed wireless access, cellular, paging, and trunked mobile systems
2. **Propagation and System Planning (6 hrs):** Radio wave propagation in the mobile environment: large scale and small scale fading, Interference, mobile radio link design and network planning
3. **Wireless Access (7 hrs):** Overview of wireless access networks, base and subscriber stations, frequency planning, multiple access technologies, Noise and interference in wireless communication systems, diversity reception, and MIMO communication
4. **Cellular Systems (6 hrs):** Evolution of cellular systems, principles and operation, capacity considerations, and standards
5. **Wireless Network Standards (4 hrs):** Wireless LANs, wireless MANs, short range wireless networks, standards, capabilities and applications, broadband wireless networks, and integration of different types of wireless networks
6. **Wireless Sensor Networks (4 hrs):** Introduction to sensor networks and applications, issues in sensor networks in comparison to conventional wireless networks, special design considerations in energy conservation, routing etc.

9.12

Module Code	EN4392	**Module Title**	Information Theory			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Determine the amount of information per symbol and information rate of a discrete memoryless source
2. Design lossless source codes for discrete memoryless source to improve the efficiency of information transmission.
3. Evaluate the information capacity of discrete memoryless channels and determine possible code rates to achievable on such channels.
4. Apply Shannon-Hartley theorem for information transmission on Gaussian channels to determine the capacity
5. Select a suitable lossy data compression technique for a given situation
6. Appreciate information theoretic results as fundamental limits on performance of communication systems

Outline Syllabus

1. **Introduction to Information Theory (1 hr):** Introduction to information theory and its applications
2. **Information and Sources (6 hrs):** Definition of information, Information sources: memoryless and Markov sources, information measures: self information, entropy, relative information, and mutual information, Jensen's inequality and information rate
3. **Source Coding (6 hrs):** Classes of codes, average length, Kraft’s inequality, Huffman codes, conditions for existence Huffman codes, optimality of Huffman codes, Shannon-Fano-Elias coding, and Lempel-Ziv coding
4. **Channel Capacity (8 hrs):** Capacity of discrete memoryless channels**:** examples of channel capacity, symmetric channels, Jointly typical sequences, channel coding theorem, and zero error coding, capacity of Gaussian channel: Gaussian channel, converse to the coding theorem, band limited channels, and parallel channels
5. **Source Coding with a Fidelity Criterion (7 hrs):** Optimal quantization: rate distortion theorem, calculation of rate distortion function, converse to rate distortion theorem, and Introduction to audio and video coding standards and characteristics

9.13

<table>
<tr><td>Module Code</td><td>EN4402</td><td>Module Title</td><td colspan="4">Mobile Computing</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Discuss the different requirements and issues of user mobility in networks
2. Analyze different mobile application architectures
3. Evaluate security mechanisms in mobile networks.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Protocols Supporting Mobility (6 hrs): Mobile network layer protocols, mobile-IP, dynamic host configuration protocol (DHCP), mobile transport layer protocols, mobile-TCP, indirect-TCP, wireless application protocol (WAP)
2. Mobile Applications Architecture (8 hrs): Extended client-server model, peer-to-peer model, mobile agent model, wireless internet, smart client, messaging, mobile data management, mobile OS, WAP, WML, J2ME
3. Location Awareness (3 hrs): Handoff and location management concepts, mobility management in PLMN, mobility management in mobile internet, mobility management in mobile agent systems, adaptive location management methods
4. Security in Mobile Environment (4 hrs): Wireless and mobile network security threats, encryption, integrity protection, intrusion detection systems, authentication and access control, security for mobile agents
5. HCI Issues (4 hrs)
6. Resource Management (3 hrs)</td></tr>
</table>

9.14

<table>
<tr><td>Module Code</td><td>EN4552</td><td>Module Title</td><td colspan="4">Nanotechnology for ICT</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Explain the basic principles of Nanotechnology
2. Describe machinery used for nanofabrication
3. Identify nano materials and their applications
4. Identify pros and cons of Nanotechnology.

Outline Syllabus

1. **Introduction (2 hrs):** Nano scale, quantum dynamics, reaction cross section, top-down and bottom-up approaches
2. **History and Background (2 hrs):** History of nanotechnology, origin of the concepts
3. **Carbon Nanotubes – CNT (4 hrs):** Generation, properties and applications of CNT
4. **Equipment and Processes of Nanotechnology (8 hrs):** Scanning tunneling microscope, atomic force microscope, electron beam lithography, molecular beam lithography
5. **Nanofactory (2 hrs):** The concept of molecular manufacturing
6. **Nano Materials and Applications (6 hrs):** Light weight substances, high efficient solar cells, anti-dust materials, fuel catalysts, etc.
7. **Future Nano Applications (2 hrs):** Space ladder, nano-robots, etc.
8. **Biological and Environmental Hazards of Nanotechnology (2 hrs)**

9.15

<table>
<tr><td>Module Code</td><td>EN4562</td><td>Module Title</td><td colspan="4">Autonomous Systems</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">Preferred EN2532, EN3562</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify methods of controlling autonomous systems
2. Analyze autonomous system applications
3. Discuss manufacturing and automation of autonomous system components.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Autonomous Systems and Machine Learning (6hrs): Introduction to autonomous systems, supervised, unsupervised, and reinforcement learning
2. Mobile Robot Localization and Navigation(4hrs): Sensor fusion, Kalman filter, occupancy grid, water-flow algorithm for micromouse
3. Adaptive and Intelligent Control (6hrs): Behaviour-based control, controller fusion, neural networks and fuzzy Logic based control techniques, control under modelling errors and uncertainties
4. Multi Agent Systems (4hrs): Cooperative control, swarm intelligence, flock behaviour
5. Human-Machine Interface (4hrs): EEG, EOG interfaces, welfare and rehabilitation robotics, supervisory control, task-resolved motion control, teleoperation, wave parameters
6. Intelligent Manufacturing and Soft Automation (4hrs): Robotics devices for manufacturing industry, automation using soft agents</td></tr>
</table>

9.16

<table>
<tr><td>Module Code</td><td>EN4572</td><td>Module Title</td><td colspan="4">Pattern Recognition and Machine Intelligence</td></tr>
<tr><td>Credits</td><td>2.5</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1. Investigate the capabilities of classifiers and learning algorithms
2. Recommend the best classifier to tackle real life pattern recognition problems
3. Relate the state-of-the-art of pattern recognition research to need driven applications, such as medical diagnosis and industrial quality control.

Outline Syllabus

1. **Introduction to Pattern Recognition (2 hr):** Concept of pattern recognition, history and applications of pattern recognition in biomedical engineering, data mining, computer vision, signal processing, computer security, natural language processing etc.
2. **Classifiers and Machine Learning (8 hrs):** The feature space, the perceptron, non-linear classifiers, multiclass classifiers, learning methods, overfitting, and classifier confidence.
3. **Decision Trees (6 hrs):** Discrete attribute decision trees, continuous attribute decision trees, learning algorithms (ID3, C4.5, CART, random forest), cut point selection.
4. **Nearest Neighbor Classifiers (4 hrs):** Voronoi maps, *k*NN classifiers, distance metrics.
5. **Support Vector Machines (4 hrs):** Support vectors, the kernel trick, SVM kernel types.
6. **Statistical Learning (4 hrs):** Bayesian learning, Naive Bayes classifiers.

9.17

Module Code	EN4582	**Module Title**	Advances in Machine Vision			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Apply image processing knowledge to solve real world problems
2. Use theoretical knowledge to implement recent vision applications
3. Comprehend a significant part of the vision literature.

Outline Syllabus

1. **Image Segmentation (6 hr):** Thresholding, region growing, k-means, EM, mean-shift, active contours, dynamic programming, level-set methods, and graph cuts for segmentation

2. **3-D Reconstruction (6 hrs):** Epipolar geometry, camera models, camera calibration, stereo correspondence, optic flows, fundamental matrix, two-view reconstruction, structure from motion, visual SLAM

3. **Object Recognition (6 hrs):** Bayesian recognition, Markov random fields, detection of objects and object classes, invariance to illumination, scaling and rotation, machine learning techniques for selection, popular detectors for faces, cars etc.

4. **Feature Detection and Tracking (6 hrs):** Corner detection, interest point detection, less-distinctive and distinctive features, feature descriptors, scale space, SIFT features and current distinctive feature detectors, feature tracking, Kalman filter, particle filter, appearance-model-based tracking

5. **Vision for Graphics (4 hrs):** Warping, mosaicing, dense 3-D reconstruction, image-based rendering

9.18

Module Code	EN4592	**Module Title**	Medical Imaging and Image Processing			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Identify methods of visualizing anatomical and physiological information
2. Analyze the biological aspects of medical imaging
3. Compare and contrast imaging modalities
4. Implement and test existing post-processing and visualization techniques.

Outline Syllabus

1. **Overview of Medical Imaging (2 hrs):** Imaging modalities, ionizing radiations, structural and functional imaging
2. **X-ray (4 hrs):** Projection X-ray principles and equipment, dose and exposure, attenuation coefficient, clinical X-ray procedures.
3. **Computed Tomography (4 hrs):** Basic principles, sonograms, reconstruction principles, Hounsfield units, scanner designs, dose considerations, artifacts.
4. **Magnetic Resonance Imaging (4 hrs):** Nuclear magnetic resonance (NMR), magnets and coils, spatial encoding, k-space, image quality, contrast manipulation, pulse sequences.
5. **Ultrasound (4 hrs):** US principle, transducer, ultrasound-tissue interactions, acoustic impedance, A-mode imaging, time gain compensation (TGC), beam steering, B-mode imaging, resolution and penetration, Doppler ultrasound.
6. **Nuclear Medicine (4 hrs):** Radiopharmaceuticals, gamma camera, single photon emission computed tomography (SPECT), positron-emission tomography (PET).
7. **Post Processing and Analysis (6 hrs):** Image perception, image quality, image enhancement and visualization, image segmentation and registration.

10. Courses Offered to Other Departments

Module	**Semester**	**Department(s)**
EN1012	S2	Computer Science & Eng.
EN1052	S2	Electrical Eng.
EN2012	S3	Electrical Eng.
EN2022	S3	Computer Science & Eng.
EN2022	S2	Electrical Eng.
EN2062	S4	Computer Science & Eng.
Service Cources		
EN1802	S2	Chemical & Process Eng., Material Science & Eng., Mechanical Eng., Textile & Clothing Technology
EN2852	S3	Chemical & Process Eng., Material Science & Eng., Mechanical Eng.

11. Service Courses

11.1

Module Code	EN1802	**Module Title**	Basic Electronics			
Credits	2.0	**Hours/Week**	**Lectures**	1.5	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	3/2		

Learning Outcomes

At the end of the module the student will be able to:

1. Describe basic principles of operation of semiconductor devices
2. Use diodes and transistors in simple electronic circuits
3. Use operational amplifiers in simple amplifier applications
4. Use logic gates to design simple combinational logic circuits.

Outline Syllabus

1. **Introduction (2 hrs):** Historical aspects, practical electronic systems, electronic industry, practical aspects of passive components, manufacturing electronic products, software tools
2. **Materials Used in Electronics (2 hrs):** Introduction to semiconductors and their basic properties, modern electronic materials
3. **Diodes, Diode Circuits and Applications (4 hrs):** Operation and characteristics of junction diode, zener diode, varactor diode and light emitting diode, rectification, clamping and limiting circuits, thyristors and controlled rectification
4. **Bipolar Junction Transistors (BJTs) and Circuits (4 hrs):** Operation and characteristics of BJT, use as a switch and as an amplifier, biasing schemes, amplifier configurations and parameters
5. **Field Effect Transistors (FETs) and Circuits (4 hrs):** Operation and characteristics of JFET, use as a switch and as an amplifier, comparison with BJTs.
6. **Integrated Circuit Amplifiers (4 hrs):** The need for integration, operational amplifiers, inverting amplifier configuration of op amp, monolithic audio IC amplifiers
7. **Logic Gates and Circuits (8 hrs):** Logic gates and Boolean algebra, minimization of logic expressions, combinational logic circuits, introduction to sequential logic circuits, design of simple logic circuits

11.2

<table>
<tr><td>Module Code</td><td>EN2852</td><td>Module Title</td><td colspan="4">Applied Electronics</td></tr>
<tr><td>Credits</td><td>2.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1.5</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:
1. Identify characteristics of operational amplifiers
2. Use operational amplifiers in simple applications
3. Identify different types of sensors and their operation
4. Use sensors in simple applications
5. Use data converters in simple applications.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td colspan="7">1. Operational Amplifiers (8 hrs): Operation and characteristics, non-inverting and inverting configuration, applications: inverter, comparator, voltage follower (buffer), adder, subtractor, integrator, differentiator, oscillator
2. Sensors and Transducers (8 hrs): Performance characteristics of transducers: dynamic range, sensitivity, resolution, input/output impedance, useful frequency range, resistance transducers, opto-conductive transducers, capacitive transducers, inductive transducers, thermocouples, piezoelectric transducers
3. Electronic Instrumentation Systems (8 hrs): Analog-to-digital and digital-to-analog conversion, frequency ranges and bandwidth, signal reflection in cables, noise and interference, noise reduction methods
4. Microcontrollers (4 hrs): introduction, programming and applications of microcontrollers</td></tr>
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