Syllabus and Rules and Regulations

for

B. Tech Minor Degree

(in addition to existing Major Degree)

in

Electronics and Communication Engineering

2022-2023 onwards

In the ECE Department

NATIONAL INSTITUTE OF TECHNOLOGY DELHI

(An autonomous Institute under the aegis of Ministry of Education, Govt. of India)

Rules and Regulations for the Proposed Minor Degree Programme

1. Other department's (CSE, EEE, ME etc.) B. Tech students may opt for the minor degree in the ECE department as per their interest. Parent department students will not be eligible for the minor degree.
2. ECE department is providing minor degree through three different **bouquet of specializations**. Their names and detailed curriculum are attached herewith in the Annexures.
3. The above bouquet of specialization will contain completely different courses/ newly innovative courses with a completely new course code, in comparison to our existing ongoing curriculum (major degree).
4. Students have to opt for a minimum of 4 theory courses and 1 project course for a minor degree i.e. minimum 18 credits to opt for a minor degree in ECE discipline.
5. All such above theory courses for the minor degree will be of (L-T-P = 3-0-2 = 4 credits i.e. theory + lab courses.
6. The SGPA and CGPA calculation will also be completely different for a major and minor degree, with no mapping or no correlation.
7. Separate grade sheets for the minor degrees will be issued like the existing major degree.
8. To commence with the provision of Major and Minor Degrees will be applicable for the students studying in the 5th Semester only from the Academic Year 2022-23. Upcoming 3dr year/ 5th semester Students, while registering for the 5th semester can choose this option.
9. Students studying in the 7th Semester in the Academic Year 2022-23 are not eligible for Major and Minor Degrees.
10. Minor Degree is not mandatory for the students. It is optional for only those students who are willing to do it.
11. The students can opt for the courses for Minor Degree from the 5th semester to the 8th semester with not more than 2 courses in a semester.
12. For a Minor degree, the students can opt for a maximum of two courses through online modes such as MOOC/ NPTEL, etc.
13. In case, the student opts for online courses (as mentioned in the previous point), the Department as per the academic calendar and prevailing norms will do the evaluation.
14. Subjects, listed in the 8th semester will be purely online modes such as MOOC/ NPTEL, etc. However, the Department as per the academic calendar and prevailing norms will do the evaluation.

Credit Requirement

SI. No.	Category of Courses	Credits offered in the Present Major Degree	Minimum Credits to be Earned through Minor Degree (in addition to the major degree)
1.	Basic Sciences	---	---
2.	Departmental Core	---	---
3.	Other Engineering	---	---
4.	Humanities and Social Sciences	---	---
5.	Elective	24	16
6.	Open Elective	---	---
7.	Project	02	02
8.	Mandatory Courses	---	---

Minimum Credits Required for Award of Minor Degree = 18 (in addition to their Major degree)

Bouquet of Specializations

Specialization in MEMS and Nano-electronics:

Course Code	Course Name	L	T	P	Credit
ECB 601	Introduction to MEMS Technology	3	0	2	4
ECB 602	NEMS and Nano-electronics	3	0	2	4
ECB 603	Fabrication and Micromachining	3	0	2	4
ECB 604	Analog/ RF applications of MEMS	3	0	2	4
ECB 605	Advanced Nano-electronics	3	0	2	4
ECP 601	Project	0	0	0	2

Specialization in Computational Information Processing:

Course Code	Course Name	L	T	P	Credit
ECB 606	Digital Information Processing System	3	0	2	4
ECB 607	Digital Visual Processing	3	0	2	4
ECB 608	Statistical Analysis and Computing	3	0	2	4
ECB 609	Applied Game Theory	3	0	2	4
ECB 610	Block chain and It's Application	3	0	2	4
ECP 601	Project	0	0	0	2

Specialization in SoC Design & IOT:

Course Code	Course Name	L	T	P	Credit
ECB 611	Real Time Embedded System	3	0	2	4
ECB 612	Digital IC Design	3	0	2	4
ECB 613	System on Programmable Chip Design	3	0	2	4
ECB 614	Cloud Computing & Machine Learning	3	0	2	4
ECB 615	Introduction to IoT System Design	3	0	2	4
ECB 616	Digital Signal and Image Processing	3	0	2	4
ECB 617	Real Time Signal Processing	3	0	2	4
ECP 601	Project	0	0	0	2

Curriculum in Detail

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 601					
Type of Course	Theory				
Course Title	**Introduction to MEMS Technology**				
Course Coordinator					
Course Objectives:	This course introduced the basic concept of MEMS technology along with various structures and applications.				
POs	1. Introduction to MEMS Technology their basic concepts 2. Interpret the basic meaning of sensors and actuators 3. Understanding of MEMS material other than silicon. 4. MEMS structures with their different applications				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				

Text Books:		
1.	Title	MEMS and NEMS systems devices and structures
	Author	E. S. Lyshevski
	Publisher	CRC press
	Edition	2001
2.	Title	MEMS and Microsystems: Design and Manufacture http://www.morganclaypoolpublishers.com/catalog_Orig/product_info.php?products_id=898
	Author	Tai-ran Hsu
	Publisher	Tata McGraw-Hill
	Edition	2008
3.	Title	Microsystem Design
	Author	S. Senturia
	Publisher	Kluwer Academic Publishers
	Edition	2005
	Title	An Introduction to Microelectromechanical Systems Engineering
4.	Author	Nadim Maluf, K. Williams
	Publisher	Artech House
	Edition	2004

Contents	**Unit I:** **Introduction:** Classical scaling in CMOS, Moore's Law - Clean room concept, Evolution of Micro sensors & MEMS, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration, Micro machined Micro sensors& MEMS applications: Mechanical, Inertial, Biological, Chemical, Acoustic, Integrated Smart Sensors
	Unit II: MEMS Materials, Properties of MEMS Materials, Silicon-Compatible Material System, Other Materials and Substrates Important Material Properties and Physical Effects, Applications and Markets,
	Unit III: Devices: Sensors and Actuators, Introduction to Electrostatic Sensors and Actuators, MEMS Transducers
	Unit IV: MEM Structures, Microactuators:- Piezoelectric, chemical, Thermopneumatic, electrostatic and electromagnetic microactuators, MEMS Simulators and different FEA tools,, MEMS Applications in Life Sciences
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 602					
Type of Course	Theory				
Course Title	**NEMS and Nano-electronics**				
Course Coordinator					
Course Objectives:	The Nano-electronics shows the technology issues beyond 65 nm with new proposed structures. The studies also helps to understand the pro's and con's of different materials while using for new nano devices.				
POs	1. Introduction to NEMS Technology and nanoelectronics with their scaling challenges. 2. The non-classical MOS transistor provides the insight into different structure of MOSFETs with improved performance 3. Demonstrates the usage of germanium in MOS devices 4. Analyse the difference between NEMS and MEMS.				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				

Text Books:		
1.	Title	MEMS and NEMS systems devices and structures
	Author	E. S. Lyshevski
	Publisher	CRC press
	Edition	2001
2.	Title	Fundamentals of Modern VLSI devices http://www.morganclaypoolpublishers.com/catalog_Orig/product_info.php?products_id=898
	Author	Y. Taur and T. Ning
	Publisher	Cambridge University
	Edition	2008
3.	Title	MOS (Metal Oxide Semiconductor) Physics and Technology
	Author	Nicollian and J. R. Brews
	Publisher	Wiley Publishers
	Edition	2005
Contents	**Unit I:** **Issues in scaling MOS transistors**: Short channel effects, Description of a typical 65 nm CMOS technology, Role of interface quality and related process	

	techniques, Gate oxide thickness, scaling trend, SiO2 vs High-k gate dielectrics, Integration issues of high-k, Interface states, bulk charge, band offset, stability, reliability - Qbd high field, possible candidates, CV and IV techniques, Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot, Metal gate transistor : Motivation, requirements, Integration Issues.
	Unit II **Non classical MOS transistor:** Requirements, and Novel devices SOI - PDSOI and FDSOI, Ultrathin body SOI - double gate transistors, integration issues. Vertical transistors - FinFET and Cylindrical gate FET. Novel devices: Tunnel FET, Negative-Capacitance (NC) FET. Metal source/drain junctions - Properties of schotky junctions on Silicon, Germanium and compound semiconductors – Work function pinning.
	Unit III Germanium Nano MOSFETs: strain, quantization , Advantages of Germanium over Silicon, PMOS versus NMOS. Compound semiconductors: Compound semiconductors MOSFETs in the context of channel quantization and strain, Hetero structure MOSFETs, exploiting novel materials, strain, quantization. Emerging nano materials: CNT, Graphene, Nanotubes, nanorods and other nano-structures
	Unit IV Microelectromechanical Systems, Devices, and Structures, NEMS Architectures, Nano-systems, Quantum Mechanics, and Mathematical Model. Modeling of Micro- and Nanoscale Electromechanical Systems, Devices, and Structures
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 603					
Type of Course	Theory				
Course Title	**Fabrication and Micromachining**				
Course Coordinator					
Course Objectives:	This course gives the insight into the fabrication of MEMS techniques. This course also provides the knowledge about the bulk micromachining of MEMS and packaging.				
POs	1. Interaction with Fabrication technology of MEMS 2. Also provides the insight of bulk micromachining 3. Demonstrates the packaging of NEMS and MEMS				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				
Text Books:					
1.	Title	Introductory MEMS, Fabrication and Applications			
	Author	Thomas M. Adams, Richard A. Layton			
	Publisher	Springer			
	Edition	2010			
2.	Title	Fundamentals of MICROFABRICATION: The Science of Miniaturization http://www.morganclaypoolpublishers.com/catalog_Orig/product_info.php?products_id=898			
	Author	Marc J. Madou			
	Publisher	CRC press			
	Edition	2001			
Contents	**Unit I** Silicon growth, Miller indices, Oxidation, Oxidation kinetics, PVD: vacuum fundamentals, thermal evaporation, sputtering, Other additive techniques: CVD, Electrodeposition, Spin coating, wafer bonding, Silicon Ingot manufacturing,				
	Unit II Photoresists: positive and negative, Working with resist: applying photoresist, exposure and pattern transfer, development and post-treatment, Masks, Resolution in contact, proximity and projection printing, Sensitivity and resist profiles, Mask alignment, Permanent resistes.				
	Unit III: Bulk micromachining: Wet chemical etching, Dry etching, Surface				

	micromachining: Surface micromachining processes, Problems with surface micromachining, Lift off, Process integration: a surface micromaching example, designing a good MEMS process flow.
	Unit IV Function of packaging, Packaging levels, Packaging requirements particular to MEMS
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 604					
Type of Course	Theory				
Course Title	**Analog/RF Applications of MEMS**				
Course Coordinator					
Course Objectives:	This course offers the in-depth knowledge of Analog /RF MEMS along with their application. The course also provide insight into wireless RF MEMS and Mechanical transducers.				
POs	1. Demonstrates the application of MEMS in analog circuits 2. Integration of circuits and MEMs are well studied 3. The concept of Mechanical and electrostatics are well understood				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				
Text Books:					
1.	Title	RF MEMS: Theory, Design, and Technology			
	Author	GABRIEL M. REBEIZ			
	Publisher	Wiley, 2003			
	Edition	2003			
2.	Title	RF MEMS Circuit Design for Wireless Communications Héctor http://www.morganclaypoolpublishers.com/catalog_Orig/product_info.php?products_id=898			
	Author	J. De Los Santos			
	Publisher	Artech House			
	Edition	London (2002)			
3.	Title	MEMS and NEMS Systems, Devices, and Structures			
	Author	Sergey Edward Lyshevski			
	Publisher	CRC Press			
	Edition	2001			
Contents	**Unit I** RF MEMS Configurations, Comparison of MEMS Switches with GaAs PIN Diode and Transistor Switches, Application Areas of RF MEMS, Integration of RF MEMS with Silicon and GaAs, Electronics, Linearity and Intermodulation Products, Power Handling and Reliability				
	Unit II Introduction: Wireless Standards, Systems, and Architectures, Power- and				

	Bandwidth-Efficient Wireless Systems Challenges, MEMS-Based Wireless Appliances Enable Ubiquitous Connectivity
	Unit III The Resonant MEMS Switch, Capacitors, Inductors, MEMS Microswitch Arrays, Reconfigurable Antennas, Tunable Dipole Antennas, Filters
	Unit IV Mechanical Transducers, Radiation transducers, Thermal transducers, magnetic transducers, chemical and biological transducers, microfluidic devices
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

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Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 605					
Type of Course	Theory				
Course Title	**Advanced Nano-electronics**				
Course Coordinator					
Course Objectives:	This course introduces the concept of 3D technology with the already implemented FinFET devices. This course provides the knowledge of different efficient architectures for improved CMOS performance.				
POs	1. Demonstrates the 3D technology for CMOS 2. Integration of different materials with MOS transistors 3. The novel architectures like carbon nanotubes, silicon nanotube and Junction less FET has been well explained.				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				
Text Books:					
1.	Title	Advanced Nanoelectronics: Post silicon Materials and devices			
	Author	M. M. Hussain			
	Publisher	Wiley-VCH			
	Edition	2019			
2.	Title	Junctionless Field Effect transistors Simulationshttp://www.morganclaypoolpublishers.com/catalog_Orig/product_info.php?products_id=898			
	Author	S. Sahay, M.K Jagdish,			
	Publisher	Wiley-VCH			
	Edition	2019			
Contents	**Unit I** FinFET Technology, 3D Integrated Circuit Technology, Neuromorphic Computing Technology, Quantum Computing Technology, Nanowire Field-Effect Transistors, General Scaling Laws Leading to Nanowire Architectures, Nanowire Growth and Device Fabrication Approaches, State-of-the-Art Nanowire Devices				
	Unit II 2D Materials Transistor and Device Technology, Graphene Electronics for Radiofrequency Applications, MoS2 Devices for Digital Application				
	Unit III				

	Introduction, Process Integration for Ge MOS Devices, State-of-the-Art Ge CMOS with Recessed Channel and S/D, Carbon Nanotube Logic Technology, Fundamentals of Carbon Nanotube, Perspective of CNT-Based Logic Technology. Tunnel Field-Effect Transistors: The Fundamentals, Modelling of TFETs, Beyond Low-Power Computation
	Unit IV Energy-Efficient Computing with Negative Capacitance, Experimental Demonstration of Negative Capacitance FETs, How a Negative Capacitance Gate Oxide Leads to Sub-60-Millivolt/Decade Switching, Direct Measurement of Negative Capacitance in Ferroelectric, How a Ferroelectric Material Acts as a Negative Capacitor, Spin-Based Devices for Logic, Memory, and Non-Boolean, Architectures, Spin-Based Devices, Nano-magnetic Devices
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 606	**No**	**No**	**Yes**	**No**	
Type of Course	Theory				
Course Title	**Digital Information Processing System**				
Course Coordinator					
Course Objectives:	To introduce students basic techniques in designing and implementing digital signal processing systems. Introduce efficient computation method of discrete Fourier transform. To study the advanced signal processing techniques and application. Apply the signal processing algorithms for a wide range of applications.				
POs	Understand basic concepts of digital signal processing, its practical applications. Ability to develop systems for various applications of digital signal processing				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				

Text Books:		
1.	Title	Digital Signal Processing: A Computer-Based Approach
	Author	S. K. Mitra
	Publisher	McGraw-Hill
	Edition	Third edition, 2006
2.	Title	Discrete-Time Signal Processing
	Author	A.Oppenheim and R. Schafer
	Publisher	Prentice Hall
	Edition	Second edition, 1999
3.	Title	Digital Signal Processing: Principles, Algorithms and Applications
	Author	J. Proakis, D. Manolakis
	Publisher	Prentice-Hall
	Edition	Fourth edition, 2006
Reference Book		
1.	Title	Theory and Application of Digital Signal Processing
	Author	L.R. Rabiner and B. Gold
	Publisher	Phi Learning

	Edition	First edition, 2008
Contents	**Unit 1: Introduction to DSP** Introduction to Digital signal processing, Discrete time signals and sequence operations, properties. Discrete time signals and systems, their properties, Quantization, sampling, Nyquist–Shannon sampling theorem.	
	Unit 2: Z-Transform Z-transforms by summation of left, right, and two-sided sequences, Regions of convergence and Z-transform properties, Inverse Z-transform, Stability and causality, Solution of Difference Equations UsingZ-transform.	
	Unit 3: Discrete and fast Fourier Transforms Definition of Discrete Fourier Transform (DFT) and relation to Z-transform, Properties of the DFT, Matrix Formulation of the DFT and IDFT, Linear and periodic convolution using the DFT, Zero padding, spectral leakage, resolution and windowing in the DFT. Efficient computation of DFT, FFT algorithms, Decimation in time domain and decimation in frequency domain algorithms.	
	Unit 4: FIR and IIR Filter Structures StructuresandpropertiesofFIRandIIRfilters,IIR-Direct,parallelandcascadedrealizations,FIR–Directandcascadedrealizations,Coefficientquantizationeffects in digital filters.	
	Unit 5: Design of FIR and IIR filters Digitalfilterdesign,Finiteimpulseresponse(FIR)filters-Windowdesigntechniques,KaiserWindowdesigntechnique,Equi-rippleapproximations,Infiniteimpulseresponse(IIR)filters-Bilineartransformmethod,Examplesofbilinear transform method.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

Course No.:	**Open Course**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	

	(Yes/No)				
ECB 607	**No**	**No**	**Yes**	**No**	
Type of Course	Theory				
Course Title	**Digital Visual Processing**				
Course Coordinator					
Course Objectives:	Overview of digital visual processing (DVP) field; understand the fundamental DVP algorithms and implementation; gain experience in applying image processing algorithms to real problems.				
POs	Student will understand basics of visual processing.				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				
Text Books:					
1.	Publisher	McGraw-Hill			
	Edition	Third edition, 2006			
2.	Author	J. Proakis, D. Manolakis			
	Publisher	Prentice-Hall			
Reference Books:					
1.	Author				
	Publisher	Phi Learning			
Contents	**UNIT I:** Digital image fundamentals: Visual perception, Visual sensing and acquisition, sampling and quantization, basic relationship between pixels and theirneighbour hood properties; Image enhancement in spatial domain: Gray-level transformations, histogram equalization				
	UNIT II: Visual filtering Spatial filters- averaging, order statistics; Edge detection first and second derivative filters, Sobel, Canny, Laplacian and Laplacian-of Gaussion masks. Filtering in frequency domain: One and two-dimensional DFT, properties of 2-D DFT, periodicity properties, convolution and correlation theorems, Fast Fourier Transforms, Smoothing and sharpening filtering in frequency domain, ideal and Butterworth filters, homomorphic filtering.				
	UNIT III: Visual Information restoration Degradation/ restoration, process, noise models, restoration in presence of noise-only spatial filtering, linear position-invariant degradations, estimating				

	the degradation function, inverse filtering, Wiener filtering, constrained least squares filtering, geometric transformations. **Color image processing**: Color models RGB, HSI, YUV, pseudo-color image processing, full-colorimage, processing, color transformation, color segmentation, noise in, color images.
	UNIT IV: Morphological mage Processing Basic operations- dilation, erosion, opening, closing, Hit-Miss transformations, Basic morphological algorithms- boundary extraction, region filling, connected components, convex hull, thinning, thickening, skeletons, pruning, extensions to gray-scale morphology.
	UNIT V: Image segmentation Edge linking and boundary detection, Hough transforms, graph-theoretic techniques, global and adaptive thresholding, Region based segmentation, Segmentation by morphological watersheds, motion base segmentation; Texture Analysis: Co-occurrence matrix, Gabor filter.motion base segmentation; Texture Analysis: Co-occurrence matrix, Gabor filter. motion base segmentation; Texture Analysis: Co-occurrence matrix, Gabor filter.
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course no:	**Open course**	**HM Course**	**DC (Y/N)**	**DE (Y/N)**	**Course no:**

	(YES/NO)	**(Y/N)**			
ECB 608	No	No	No	No	ECB 509
Type of Course	Theory				**Type of Course**
Course Title	**Statistical Analysis and Computing**				
Course Coordinator					**Course Coordinator**
Course objectives:	This course aims to familiarize several algorithms for processing and estimation of random signals. This course teaches filtering methods for stochastic processes and covers the spectral analysis.				
POs	1. Students can perform rudimentary statistical analysis of univariate and bivariate signals. 2. Students can estimate and filter signals in different communication scenarios. 3. Student utilizes estimation and filter theory to other engineering problems.				
Semester	**Autumn: Yes**		**Spring: No**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	
Contact Hours	3	0	0	3	
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Text Books:					
1.	Author	Charles W. Therrien			
	Publisher	Prentice Hall Signal Processing Series			
	Edition	2004			
2.	Title	Statistical Digital Signal Processing and Modeling			
	Author	M. H. Hayes			
	Publisher	John Wiley & Sons, Inc			
	Edition	2004			
3.	Title	Statistical and Adaptive Signal Processing			
	Author	D.G. Manolakis, V.K. Ingle and S.M. Kogon			
	Publisher	McGraw Hill,			
Reference Books:	Edition	2000			
1.	Title	Adaptive Filter Theory			
	Author	Simon Haykin			
	Publisher	Prentice Hall			
	Edition	1996			
Contents	**UNIT I: Introduction to the stochastic phenomenon:** Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random				

	variables, Schwarz Inequality Orthogonality principle in estimation, Central Limit theorem, Random processes, wide-sense stationary processes, autocorrelation and auto-covariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, innovation process and whitening filter, .Random signal modelling: MA(q), AR(p) , ARMA(p,q) models.
	UNIT II: Parameter Estimation Theory: Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer Rao bound, Efficient estimators;Criteria of estimation:the methods ofmaximum likelihood and its properties; Bayseanestimation: Mean squareerror and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation.
	UNIT III: Estimation of signal in presence of white Gaussian Noise: Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Non-causal IIR Wiener filter, Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters.
	UNIT IV: Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm; Application of Adaptive filters; RLS algorithm, derivation, Matrix inversion Lemma, Initialization, tracking of non-stationarity.
	UNIT V: Kalman filtering: State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter. filter. motion base segmentation; Texture Analysis: Co-occurrence matrix, Gabor filter.motion base segmentation; Texture Analysis: Co-occurrence matrix, Gabor filter.
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course no:	Open course (YES/NO)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)

ECB 609	No	**Yes**	**No**	**No**
Type of Course				
Course Title	**Applied Game Theory**			
Course Coordinator				
Course objectives:	1. Understand the different types of games and their use in strategic thinking. 2. Identify strategic situations and represent them as games. 3. Solve simple games using game-theoretic techniques. 4. Employ game theory to model real-world scenarios in engineering and other areas. 5. Design correct and robust solutions (mechanisms, algorithms, protocols) for real-life problems			
POs				

Semester	**Autumn: Yes**		**Spring: No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

Text Books:

1.	Title	An Introduction to Game Theory
	Author	Martin J. Osborne
	Publisher	Oxford University Press
	Edition	2003
2.	Title	Game Theory And Mechanism Design
	Author	Y. Narahari
	Publisher	World Scientific Publishing Co Pt Ltd

	Edition	2020	
Reference Books:			
	Title	Essentials of Game Theory	
	Author	Kevin Leyton-Brown and Yoav Shoham	
	Publisher	Morgan & Claypool Publishers	
	Edition	2008	
			Number of Hours
Content	**UNIT I: Introduction** Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy and mixed strategy Nash equilibrium, dominant strategies.		**08**
	UNIT II: Alternate Solution Concepts for Games Iterative removal of strictly dominated strategies, minimax strategies and the minimax theorem for zero-sum game, correlated equilibria.		**08**
	UNIT III: Extensive-Form Games Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium, introduction to imperfect-information games, mixed versus behavioral strategies.		**08**
	UNIT IV: Repeated Games Repeated prisoners dilemma, finite and infinite repeated games, limited-average versus future-discounted reward, folk theorems, stochastic games and learning.		**06**
	UNIT V: Bayesian Games General definitions, ex ante/interim Bayesian Nash equilibrium.		**04**
	UNIT VI: Coalitional Games Transferable utility cooperative games, Shapley value, Core, applications.		**04**
Course Assessment	**Theory**: Continuous Evaluation 25% Mid Semester 25% End Semester 50%.		

Course no:	**Open course (YES/NO)**	**HM Course (Y/N)**	**DC (Y/N)**	**DE (Y/N)**
ECB 610	No	**Yes**	**No**	**No**
Type of Course				

Course Title	**Block chain and its application**				
Course Coordinator					
Course objectives:	1. Understand the working of current financial system work? 2. Understand the structure of a Blockchain, and identify its advantages 3. Categorization of the most prominent Blockchain service providers and networks on the basis of their structure 4. Apply Blockchain in domains other than cryptocurrency. 5. Assess the new challenges that arise in monetizing businesses around Blockchain				
POs					
Semester	**Autumn: Yes**		**Spring: No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Prerequisite Credits					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Text Books:					
1.	Title		Mastering Bitcoin: Unlocking Digital Cryptocurrencies		
	Author		Andreas M. Antonopoulos		
	Publisher		O'Reilly		
	Edition		1st		
2.	Title		Blockchain		
	Author		Melanie Swan		
	Publisher		O'Reilly		
	Edition		January 2015		

		Number of Hours
Content	**UNIT I: Introduction** Blockchain Components and Concepts, Smart Contracts. Overview of the current financial system and its drawbacks. Advantages of Blockchain as an alternate financial system.	**08**
	UNIT II: Basics of cryptocurrencies Cryptography, Hash Functions, Public Key Cryptography and Digital Signature.	**06**
	UNIT III: Bitcoin Fundamentals Bitcoin's block structure, Consensus and mining processes in Bitcoin Bitcoin Trading, Scripting language in Bitcoin.	**08**
	UNIT IV: Permissioned Blockchain Permissioned Blockchain Architecture, RAFT Consensus, Byzantine General Problem, Practical Byzantine Fault Tolerance.	**08**
	UNIT V: Overview of Hyperledger Fabric Key Frameworks and Tools, Membership and Identity Management, Hyper ledger composer.	**04**
	UNIT VI: Application of Blockchain Blockchain's implications on Traditional Business,Practical use-cases of Blockchain in Finance, Industry and Governance.	**08**
Course Assessment	**Theory**: Continuous Evaluation 25% Mid Semester 25% End Semester 50%.	

Course no:	**Open course (YES/NO)**	**HM Course(Y/N)**	**DC(Y/N)**	**DE(Y/N)**
ECB 611	No	**Yes**	**No**	**No**
Type of Course	Theory			
Course Title	**Real Time Embedded Systems**			
Course Coordinator				

Course objectives:	• To expose the students to the fundamentals of embedded system design. • To enable the students to understand and use embedded computing platform. • To introduce networking principles in embedded devices. • To learn real time characteristics in embedded system design. • To explore system design techniques.				
POs					
Semester	**Autumn:Yes**		**Spring:No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total TeachingHours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

Text Books:		
1.	Title	Computers as Components: Principles of Embedded Computing System Design
	Author	Wayne Wolf
	Publisher	Morgan Kaufman Publishers 2012
	Edition	3rd Edition
2.	Title	Real-Time systems
	Author	Jane.W.S. Liu
	Publisher	Pearson Education Asia, 2001
	Edition	1st Edition
Refrence Books:		
1.	Title	Real-Time Systems
	Author	C. M. Krishna and K. G. Shin
	Publisher	McGraw-Hill, 1997
	Edition	1st Edition
2.	Title	Embedded System Design: A Unified Hardware/Software Introduction
	Author	Frank Vahid and Tony Givargis
	Publisher	John Wiley & Sons, 2002

	Edition	1st Edition
Content		**Number of Hours**
	UNIT I: Embedded Processors Embedded Computers, Characteristics of Embedded Computing Applications, Challenges in Embedded Computing system design, Embedded system design process- Requirements, Specification, Architectural Design, Designing Hardware and Software Components, System Integration, Formalism for System Design- Structural Description, Behavioral Description, and Design Example: Model Train Controller, ARM processor- processor and memory organization.	**08**
	UNIT II: Embedded Computing Platform Data operations, Flow of Control, SHARC processor- Memory organization, Data operations, Flow of Control, parallelism with instructions, CPU Bus configuration, ARM Bus, SHARC Bus, Memory devices, Input/output devices, Component interfacing, designing with microprocessor development and debugging, Design Example : Alarm Clock.	**08**
	UNIT III: Networks Distributed Embedded Architecture- Hardware and Software Architectures, Networks for embedded systems- I2C, CAN Bus, SHARC link supports, Ethernet, Myrinet, Internet, Network-Based design- Communication Analysis, system performance Analysis, Hardware platform design, Allocation and scheduling, Design Example: Elevator Controller..	**10**
	UNIT IV: Real-Time Characteristics Clock driven Approach, weighted round robin Approach, Priority driven Approach, Dynamic Versus Static systems, effective release times and deadlines, Optimality of the Earliest deadline first (EDF) algorithm, challenges in validating timing constraints in priority driven systems, Off-line Versus On-line scheduling.	**08**
	UNIT V: System Design Techniques Design Methodologies, Requirement Analysis, Specification, System Analysis and Architecture Design, Quality Assurance, Design Example: Telephone PBX- System Architecture, Ink jet printer- Hardware Design and Software Design, Personal Digital Assistants, Set-top Boxes.	**08**
Course Assessment	**Theory**: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%.	

Course no:	**Open course (YES/NO)**	**HM Course(Y/N)**	**DC(Y/N)**	**DE(Y/N)**
ECB 612	No	**Yes**	**No**	**No**
Type of Course	Theory			
Course Title	**Digital IC Design**			

Course Coordinator					
Course objectives:	• To introduce the transistor level design of all digital building blocks common to all CMOS microprocessors, network processors, digital backend of all wireless systems etc., • To introduce the principles and design methodology in terms of the dominant circuit choices, constraints and performance measures. • To learn all important issues related to size, speed and power consumption.				
POs					
Semester	**Autumn:Yes**		**Spring:No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total TeachingHours**
ContactHours	3	0	0	3	**45**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

Text Books:		
1.	Title	Digital Integrated Circuit: A design perspective
	Author	J. M. Rabaey, A. Chandrakasan, B. Nikolic
	Publisher	Pearson Education, Delhi-2005
	Edition	2nd Edition
2.	Title	CMOS VLSI Design
	Author	Weste, Neil HE, and David Money Harris
	Publisher	Pearson/Addison Wesley, 2010. Geiger
	Edition	1st Edition
Refrence Books:		
1.	Title	Low power design methodologies
	Author	J. M. Rabaey., and MassoudPedram, eds
	Publisher	Springer Science & Business Media, 2012
	Edition	1st Edition
2.	Title	CMOS Digital Integrated Circuits Analysis and Design
	Author	Sung-Mo Kang & Yusuf Leblebici
	Publisher	McGraw-Hill, 1998.

	Edition	1st Edition	
Content			**Number of Hours**
	UNIT I: MOS Transistor Principles and CMOS Inverter MOS (FET) Transistor Characteristic under Static and Dynamic Conditions, MOS Transistor Secondary Effects, CMOS Inverter-Static Characteristic, Dynamic Characteristic, Power, Energy, and Energy Delay parameters, Stick diagram and Layout diagrams.		**10**
	UNIT II: Combinational Logic Circuits Static CMOS design, Different styles of logic circuits, Logical effort of complex gates, Static and Dynamic properties of complex gates, Interconnect Delay, Dynamic Logic Gates.		**08**
	UNIT III: Sequential Logic Circuits Static Latches and Registers, Dynamic Latches and Registers, Timing Issues, Pipelines, Nonbistable Sequential Circuits.		**10**
	UNIT IV: Arithmetic Building Blocks Data path circuits, Architectures for Adders, Accumulators, Multipliers, Barrel Shifters, Speed and Area Tradeoffs. Pass Transistor, charge sharing, sources of charge loss, TG logic, Dynamic D-Latch		**08**
	UNIT V: Memory Architectures Memory Architectures and Memory control circuits: Read-Only Memories, ROM cells, Read-write memories (RAM), dynamic memory design, 6 transistor SRAM cell, and Sense amplifiers.		**09**
Course Assessment	**Theory**: Continuous Evaluation 25% Mid Semester 25% End Semester 50%.		

Course no:	**Open course (YES/NO)**	**HM Course(Y/N)**	**DC(Y/N)**	**DE(Y/N)**
ECB 613	No	**Yes**	**No**	**No**
Type of Course	Theory			
Course Title	**System-on-Programmable Chip Design**			

Course Coordinator					
Course objectives:	• To introduce the overall System on Chip (SoC) Design flow. • To introduce the System-level Design from processor selection to interconnection of all the modules. • To introduce the on-chip various bus architectures. • To introduce the IP based system design inorder to reduce the design cost and time. • To introduce the SoC implementation and Tesiting methods.				
POs					
Semester	**Autumn: Yes**		**Spring: No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	**45**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

Text Books:		
1.	Title	Computer system Design: Systemon-Chip
	Author	Michael J.Flynn, Wayne Luk
	Publisher	Wiley-India, 2012
	Edition	16/e
2.	Title	On Chip Communication Architectures: System on Chip Interconnect
	Author	Sudeep Pasricha, NikilDutt
	Publisher	Morgan Kaufmann Publishers, 2008.
	Edition	1st Edition
Refrence Books:		
1.	Title	Computers as Components: Principles of Embedded Computing System Design
	Author	W.H.Wolf
	Publisher	Elsevier, 2008.
	Edition	1st Edition
2.	Title	A Practical Introduction to Hardware/Software Co-design
	Author	Patrick Schaumont

	Publisher	Springer, 2012	
	Edition	2nd Edition	
3.	Title	Modern VLSI Design: IP Based Design	
	Author	Wayne Wolf	
	Publisher	Prentice-Hall India, Fourth edition, 2009	
	Edition	1st Edition	
Content			**Number of Hours**
	UNIT I: System-level Design Driving Forces for SoC - Components of SoC - Design flow of SoC- Hardware/Software nature of SoC - Design Trade-offs - SoC Applications, Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), Elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory.		**10**
	UNIT II: Interconnection On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, CoreConnect, Wishbone, Avalon - Network-onchip: Architecture-topologies-switching strategies- routing algorithms-flow control, Quality-of-Service- Reconfigurability in communication architectures.		**08**
	UNIT III: IP based system design Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration – IP evaluation on FPGA prototypes.		**10**
	UNIT IV: SoC Implementation Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.		**08**
	UNIT V: SoC Testing Manufacturing test of SoC: Core layer, system layer, application layer- P1500 Wrapper Standardization-SoC Test Automation (STAT).		**09**
Course Assessment	**Theory**: Continuous Evaluation 25% Mid Semester 25% End Semester 50%.		

Course no:	**Open course (YES/NO)**	**HM Course (Y/N)**	**DC (Y/N)**	**DE (Y/N)**
ECB 614	No	**Yes**	**No**	**No**
Type of Course	Theory			

Course Title	**Cloud Computing and Machine Learning**				
Course Coordinator					
Course objectives:	**1.** The fundamental ideas behind Cloud Computing,, its applicability; in IOT systems, as well as current and future challenges; **2.** Identify various IOT hardware platforms and their utilization with various sensors and actuators. **3.** Examine various cloud platforms & Apps for monitoring, control and analysis using web development and IOT boards. **4.** Experiment with the basic concepts of python programming and make use of them in cloud computing for developing IOT applications.				
POs					
Semester	**Autumn: Yes**		**Spring: No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Prerequisite Credits					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					

Text Books:		
1.	Title	Internet of Things: A Hands-on Approach
	Author	Arshdeep Bahga and Vijay Madisetti
	Publisher	Universities Press
	Edition	2014
2.	Title	Mastering in Cloud Computing
	Author	Rajkumar Buyya, Christian Vecchiola and ThamariSelvi S
	Publisher	McGraw Hill Education (India) Private Limited,

	Edition	2013	
Refrence Books:			
1.	Title	The Internet of Things: Enabling Technologies, Platforms, and Use Cases	
	Author	Pethuru Raj and Anupama C. Raman	
	Publisher	Taylor and Francis (CRC Press)	
	Edition	2017	
			Number of Hours
Content	**UNIT I: Introduction to cloud computing** Cloud computing at a Glance – Historical Development – Building Cloud Computing Environments – Computing Platform and Technologies – Principles of Parallel and Distributed Computing – Elements of parallel and Distributed Computing.		**06**
	UNIT II: IoT Architecture & Technologies The second module "IoT Architecture & Technologies" focuses on the functionality and characteristics of the IoT architecture layers as well as the characteristics of IoT technologies, which include WSN (Wireless Sensor Networks), IoT cloud computing, IoT R&D (Research & Development), and IoT hardware technologies. Further details are provided in the descriptions of the characteristics of IoT sensors types, actuator types, and RFID types as well as the functionality and characteristics of IoT device platforms, which include the Arduino, Raspberry Pi, and BeagleBoard products. Next, a comparison of the representative IoT developer platform products is presented, which include the Raspberry Pi, Raspberry Pi 3 Model B, BeagleBoard, Beaglebone Black, and the Arduino systems Uno R3 (for entry and general purpose), Yun (for IoT), and Lilypad (for wearable).		**18**
	UNIT III: Introduction to Machine Learning (ML) and its application with IOT and cloud computing Introduction to Supervised ML and Unsupervised ML, Mathematical Background for ML-Matrix ops Probability Theory(Bayes' Theorem), Statistical knowledge for ML- Mean, Median, Mode, Tools required for development -Anaconda, Jupyter NB, ML libraries Explained: Scipy, Numpy, Matplotlib, ML Glossary- Variable types, k-fold, CV, AUC, F1 score, Overfitting/Underfitting, Generalization, Data split & hyper parameter training, Data wrangling using Pandas, Preprocessing data and feature engineering, Exploratory Data analysis using Visualisation, Scikit-learn Library for ML, Classification-Regression, Different types of Regression-Linearand Logistic, Decision tree Algorithms, Naive Bayes' Classification, KNN Classification,		**08**
	UNIT IV: Application of Machine Learning (ML) with IOT and cloud computing Revisiting Python, Real-world code exercises Clustering Introduction, k-means clustering, SVM and Artificial Neural Networks.		**10**
Course Assessment	**Theory**: Continuous Evaluation 25%, Mid Semester 25% End Semester 50%.		

Course no:	Open course (YES/NO)	HM Course(Y/N)	DC(Y/N)	DE(Y/N)
ECB 615	No	**Yes**	**No**	**No**
TypeofCourse				
CourseTitle	**Introduction to IOT System Design**			
Course Coordinator				

Course objectives:	**1.** Outline the various IOT communication models & terminologies with networking and protocol considerations. **2.** Identify various IOT hardware platforms and their utilization with various sensors and actuators. **3.** Examine various cloud platforms & Apps for monitoring, control and analysis using web development and IOT boards. **4.** Experiment the basic concepts of python programming and make use of them in image processing, data analytics and Raspberry Pi for developing IOT applications.				
POs					
Semester	**Autumn:Yes**		**Spring:No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

TextBooks:		
1.	Title	Internet of Things: A Hands-on Approach
	Author	ArshdeepBahga and Vijay Madisetti
	Publisher	Universities Press
	Edition	2014
Refrence Books:		
1.	Title	The Internet of Things: Enabling Technologies, Platforms, and Use Cases
	Author	Pethuru Raj and Anupama C. Raman
	Publisher	Taylor and Francis (CRC Press)
	Edition	2017

		Number of Hours

Content	**UNIT I: IOT Comm. Models and Terminologies** Introduction to IOT (People Connecting to Things, Things Connecting to Things, Definition of IOT, History of IOT), IOT Components (Sensors & Actuators, Things, Communications,Networks, The Internet, Protocol Stack), IOT Communication Models, IOT Applications, IOT Companies, Baseline Technologies (Machine to Machine(M2M)Communication, Web of Things (WOT)), Address Crunch in IOT, IOT Terminologies (IOT Node, LAN, MAN & WAN, IOT Gateway & Proxy), IOT Network Configuration (Gateway Prefix Allotment, Impact of Mobility on Addressing, Concept of Tunneling, Multi-homing), IPv4 Versus IPv6.	**06**
	UNIT II: IOT Networking Protocols Introduction to IOT Networking, Networking Standards and Technologies (Network Access & Physical Layer, Internet Layer, Transport Layer, The application layer), IOT Networking Protocols, Network Access and Physical layer IoT Network Technologies ((LPWAN (Low Power Wide Area Network), Cellular, Bluetooth Low Energy (BLE), RFID, NFC, Zigbee, Wifi, Ethernet), Internet layer IoT network technologies (IPv6, 6LoWPAN, and RPL), Application layer IoT network technologies (HTTP, HTTPS, MQTT, AMQP, and XMPP), IoT networking considerations and challenges, IoT Platforms Capabilities.	**08**
	UNIT III: IoT supported Hardware platforms(Arduino&NodeMcu) Introduction to Arduino (Different Arduino boards, Arduino Uno board description and its pin configuration, Arduino IDE and program uploading, different functions related to GPIOs and special functions (PWM and Serial communication), Interrupts, Introduction to NodeMcu (board description & pin configuration), Integration of NodeMcu in Arduino IDE,Interfacing with Arduino/NodeMcu using processing language (LED, Switch, Seven Segment, LCD, DC Motor, Relay, IR, LDR and DHT11 sensor), use of simulator and compiler, Configuring NodeMcu as Wifi Module (ESP8266).	**08**
	UNIT IV: Web Development and Interaction with Apps &Cloud Platform Basics of HTML programming (elements, attributes, paragraph, image etc), CSS, Tables and Forms, Creating local server and webserver using NodeMcu, Creating a Web page tocontrolactuatorWifi, Introduction to Thingspeak Cloud Platform (creating account and configure channel for live data feed, Concept of Write and Read APIs), Case Studies: Controlling an actuator connected to NodeMcu using remote web interface via cloud, Visualization of sensor data on the cloud and integrate them onto thewebpage, Introduction to IFTTT & Adafruit IO (creatingaccount and configuration), Controlling home appliances using Google Assistant AI application via IFTTT and Adafruit I/O (MQTT protocol).	**10**
	UNIT V: Introduction to Python , Raspberry pi & their Applications Introduction to python, python IDE, Data types, various programming constructs (loops, if, else etc.), operators, functions,	**10**

	modules, data handling (pandas), file operations, Image operations (PIL-pillow), data plotting in python (Matplotlib), Introduction to Raspberry pi (Raspberry pi different model comparison, Pin Configuration, Set up your Raspberry pi, Raspbian OS, Remote Access using SSH, Interfacing with Raspberry pi using python and use of open source libraries (LED, Switch, LCD, DC Motor, Relay, IR, LDR and DHT11 sensor), IOT based Case Studies.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%.	

Course no:	**Open course (YES/NO)**	**HM Course(Y/N)**	**DC(Y/N)**	**DE(Y/N)**
ECB 616	No	**Yes**	**No**	**No**
Type of Course				
Course Title	**DIGITAL SIGNAL & IMAGE PROCESSING**			
Course Coordinator				

Course objectives:	**1.** Recall the principles of various transform techniques like Z, Chirp Z, Hilbert, and Discrete Fourier transform and Fast Fourier Transform. **2.** Demonstrate the ability to apply different methods to design and analyze digital FIR (Finite Impulse Response) and IIR (Infinite Impulse Response) filters with its structural realization. **3.**AnalyzeMultirate signal processing and examine its application. **4**. Comprehend different methods for designing adaptive filters and examine its application.				
POs					
Semester	**Autumn:Yes**		**Spring:No**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total TeachingHours**
Contact Hours	3	0	0	3	**42**
Prerequisite course code as per proposed course numbers					
Equivalent course codes as per proposed course and old course					
Overlap course codes as per proposed course numbers					
Prerequisite course code as per proposed course numbers					

Text Books:

1.	Title	Digital Signal Processing, Principles, Algorithms and Applications
	Author	J.G. Proakis& D.G. Manolakis
	Publisher	PHI
	Edition	2012

Refrence Books:

1.	Title	Adaptive Signal Processing: Next Generation Solutions
	Author	Tulay Adah and Simon Haykins
	Publisher	Wiley India
	Edition	2012

		Number of Hours

Content	**UNIT I: Review of Digital Signal Processing:** Review of discrete-time sequences and systems, Linear Shift Invariant (LSI) systems. Causality and stability Criterion, FIR & IIR represenetations, Z-Transform,Discrete Fourier Transform (DFT), Fast Fourier Transform(FFT) algorithms using decimation in time and decimation in frequency techniques, Chirp Z-Transform, Hilbert Transform and applications.	**06**
	UNIT II: Design of IIR and FIR Filters: Digital filter specifications, selection of filter type, and filter order, FIR filter design; using windowing Techniques, Fourier Series and frequency sampling method, Design of IIR Filters Using Butterworth, Chebyshev and Elliptic Approximations, Frequency Transformation Techniques; approximation of derivatives, Impulse invariant method, Bilinear transformation, Structures for IIR Systems – Direct Form I & II, Cascade, Parallel, Lattice & Lattice-Ladder Structures, Structures For FIR Systems – Direct , Cascade, Parallel, Lattice & Lattice ladder Structures.	**12**
	UNIT III: Multirate Digital Signal Processing: Decimation & Interpolation, Sampling rate conversion, Identities, polyphase decomposition, General polyphase framework for Decimator and Interpolator, Multistage decimator and Interpolator, Efficient transversal structure for Decimator and Interpolator, FIR and IIR structure for Decimator, Filter design for FIR decimator and Interpolator, Application of Multirate Signal processing.	**14**
	UNIT IV: Adaptive Filters: Introduction, Application of adaptive filters, correlation structure, FIR Weiner Filter, Adaptive Direct-form FIR filters Adaptive Lattice-Ladder filters, Introduction to linear prediction, linear prediction and autoregressive modeling.	**10**
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%.	

Course No.:	**Open Course (Yes/No)**	**HM Course (Yes/No)**	**DC (Y/N)**	**DE (Y/N)**	
ECB 617	**No**	**No**	**Yes**	**No**	
Type of Course	Theory				
Course Title	**Real-time Signal Processing**				

Course Coordinator					
Course Objectives:	To provide the overview of signal processing techniques. To apply and implement various transforms in real-time applications. To introduce efficient computation method of discrete Fourier transform for the real-time applications. Apply the signal processing algorithms for a wide range of real-time applications.				
POs	Understand basic concepts of digital signal processing, its practical applications. Ability to develop systems for various applications of digital signal processing				
Semester	**Autumn:**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
Contact Hours	3	0	0	3	36
Prerequisite course code as per proposed course numbers	NIL				
Equivalent course codes as per proposed course and old course	NIL				
Overlap course codes as per proposed course numbers	NIL				
Text Books:					
1.	Title	Digital Signal Processing: A Computer-Based Approach			
	Author	S. K. Mitra			
	Publisher	McGraw-Hill			
	Edition	Third edition, 2006			
2.	Title	Discrete-Time Signal Processing			
	Author	A.Oppenheim and R. Schafer			
	Publisher	Prentice Hall			
	Edition	Second edition, 1999			
3.	Title	Digital Signal Processing: Principles, Algorithms and Applications			
	Author	J. Proakis, D. Manolakis			
	Publisher	Prentice-Hall			
	Edition	Fourth edition, 2006			
Reference Book					

1.	Title	Theory and Application of Digital Signal Processing
	Author	L.R. Rabiner and B. Gold
	Publisher	Phi Learning
	Edition	First edition, 2008
Contents	**Unit 1: The Discrete Fourier Transforms** Discrete Fourier transform, properties of DFT. Frequency domain sampling, Frequency analysis of signals using the DFT. DFT of discrete time signals, Relation between DFT and Z-transform. IDFT.	
	Unit 2: Fast Fourier Transforms Direct computation of DFT, Need of efficient computation of DFT, Radix-2 Decimation in time domain and decimation in frequency domain algorithms (DIT-FFT and DIF-FFT), Linear filtering methods based on DFT Goertzel Algorithms	
	Unit 3 : Implementation of Discrete time systems FIR Systems- Direct Form-I, Direct Form-II, Cascade, Parallel structure IIR Systems- Direct Form, Cascade, Linear phase structure, Frequency sampling structure	
	Unit 4: Design of IIR and FIR filters Design of digital IIR digital filters from analog filters, Impulse invariance method and bilinear transformation method. frequency transformations. Design of digital FIR filters using window method	
	Unit 5 : Multirate DSP and Applications Decimation and Interpolation, Multistage design of interpolators and decimators; Poly-phase decomposition and FIR structures, DSP device architecture and programming (TMS320C6x), Real-time system development, Code Composer Studio and DSP BIOS, Mini project (real-time application of DSP)	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	