Curriculum

Ph.D.

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Indian Institute of Technology Jodhpur

Ph.D. (Electrical Engineering)

Cat.	Course Number: Course Title	L-T-P	Credits		Cat.	Course Number: Course Title	L-T-P	Credits
I Semester					**II Semester**			
E	*Electives*				E	*Electives*		
	Total					*Total*		
III Semester					**IV Semester**			
H	**EE799 Ph.D. Thesis**				H	**EE799 Ph.D. Thesis**		
	Total					*Total*		
V Semester					**VI Semester**			
H	**EE799 Ph.D. Thesis**				H	**EE799 Ph.D. Thesis**		
	Total					*Total*		
VII Semester					**VIII Semester**			
H	**EE799 Ph.D. Thesis**				H	**EE799 Ph.D. Thesis**		
	Total					*Total*		

Electives			
EE751	Bandgap Engineering	3-0-0	3
EE752	Multiuser MIMO Communications	3-0-0	3
EE753	Robust Control	3-0-0	3

S.No.	*Category*	*Category Title*	Students with	*Total Courses*	*Total Credits*
1	E	*ELECTIVES*	Master’s Degree	4	12
			M. Sc. Degree	10	30
			Bachelor’s Degree	10	30
2	H	Thesis	-	-	-

Course Title	***Bandgap Engineering***	Course No.	**EE751**
Department	Electrical Engineering	Structure	3 0 0 3
Offered for	PhD	Status	*Elective*
Pre-requisite	*Basic Semiconductor physics, Electromagnetic theory*	To take effect from	running

Objectives

1. To teach fundamental physical models of energy band theory and photonic band theories

Learning Outcomes

1. Ability to understand and predict, electrical and optical properties of real world devices

Course Content

1. Energy Band Structures: Free-Electron Model, Bloch Theorem, Kronig-Penney Model, Reduced Zone Scheme, pseudopotential Method, Tight-Binding (LCAO) Approximation, k . p Perturbation, Effective Mass Concept, band-offset and band bending, effect of doping and bias on band diagram.
2. Photonic band structures: Maxwell equations, refractive indices, photonics bands and bandgaps,
3. Example of devices: HEMT, Super lattices, MIS structures.

Reference Books

1. Pierret, Robert F, *Semiconductor Fundamentals: Volume I*. 2^{nd} edition, Prentice Hall, 1988.
2. John D Joanopoulos, Steven G Johnson, Joshua N Winn and Robert D Meade, *Photonic crystals: Molding the flow of light*, 2^{nd} edition, Princeton University Press, 2008
3. Kittel, Charles., *Introduction to Solid State Physics*. 8^{th} edition, Wiley, 2004.
4. Saleh, Bahaa E. A., and Malvin Carl Teich., *Fundamentals of Photonics*. 2^{nd} edition, Wiley-Interscience, 2007.
5. Rolf E. Hummel, *Electronic Properties of Materials: An Introduction for Engineers*, Springer Verlag, 1985
6. Relevant Research Publications

Course Title	***Multiuser MIMO Communications***	Course No.	**EE752**			
Department	Electrical Engineering	Structure (LTPC)	3	0	0	3
Offered for	PhD	Status			*Elective*	
Pre-requisite	*Consent of Teacher*	To take effect from				

Objectives

1. To provide students the fundamentals of MIMO communication from the perspective of signal processing and communication theory
2. To cover the issues most pertinent to the design and analysis of multiuser MIMO communication systems

Learning Outcomes

1. Analyse and design MIMO communications systems
2. Apply interference management concepts and techniques to multiuser MIMO communication systems
3. Develop the ability to compare and contrast the strengths and weaknesses of various multiuser MIMO communication systems

Course Content

Introduction to space-time communication

MIMO Channel Models: Review of channel modelling principles, Classification of models including Rayleigh, Rician, correlated, and models from different standards.

MIMO Information Theory: Capacity with channel state information at the transmitter and receiver, Spatial Multiplexing, Ergodic capacity, Summary of recent capacity results.

MIMO Communication Theory: Maximum likelihood detection and probability of error, Diversity analysis using the pairwise error probability, Spatial multiplexing with linear receivers and nonlinear receivers, Linear precoding.

Space-Time Block Coding: The Alamouti code and orthogonal designs, Quasi-orthogonal space-time block codes and full-rate space-time codes, H-ARQ space-time block codes.

Multiuser MIMO Information Theory: Multiuser MIMO algorithms - multiuser diversity, Linear and non-linear precoding, Scheduling, Delayed and limited feedback.

Reference Books

1. Tse, D. and Viswanath, P., *Fundamentals of wireless communication*, Cambridge University Press, 2005
2. Goldsmith, A., *Wireless Communications*, Cambridge University Press, 2005
3. Paulraj, A., Nabar, R. and Gore, D., *Introduction to Space-Time Wireless Communication*, Cambridge University Press, 2003
4. Simon, M. K. and Alouini, M. S., *Digital communication over fading channels*, John Wiley and Sons, 2005
5. Relevant Research Publications

Course Title	***Robust Control***	Course No.	**EE753**			
Department	Electrical Engineering	Structure	3	0	0	3
Offered for	PhD	Status			*Elective*	
Pre-requisite		To take effect from				

Objectives

1.To learn modeling and control of uncertain systems

2. To learn estimation of states of uncertain systems

Learning Outcomes

1. Tools like LMI, SMC and Optimal Control to handle uncertainty

2. Ability to incorporate observers for uncertain systems

Course Content

Review of state-space modeling and system uncertainties: Review of state space modeling. Different types of uncertainties-- parametric, matched, unmatched and external disturbances. Introduction to Linear Matrix Inequalities (LMIs)

Robust pole placement and eigen-structure assignment: Eigen structure assignment for MIMO systems, LMI based algorithms for robust pole placement for system with parametric uncertainties

Optimal control approach to control linear uncertain systems: LQR approach to control matched and unmatched uncertainties. Optimal control of plant with uncertainty in input matrix

Sliding mode control of uncertain systems: Different methods to design switching hyperplane which include pole placement, LQR based, robust eigen-structure based and nonlinear approaches. Control law to ensure finite time reaching and reachability condition. Chattering effect and its mitigation techniques. Integral sliding mode and its applications. Discrete-time sliding mode. Techniques to estimate disturbances in discrete-time system. Output feedback based sliding mode control algorithms. Introduction to higher order sliding mode control design principles

Robust estimation: Problem of state estimation with system uncertainties. Sliding mode based observers. Robust functional observers. Higher order sliding mode observers

Applications of robust control and estimation: Sliding mode control of Induction motor, robust control of power converters, servo systems. State estimation of drives using robust observers

Reference Books

1. Feng Lin, *Robust Control Design, John Wiley and Sons, 2007*
2. Edawards and Spurgeon, *Sliding mode control: theory and applications*, Taylor & Francis, 1998
3. V. Utkin, J. Guldner and J. Shi, *Sliding mode control in electromechanical systems*, aylor & Francis, 2e 1999
4. A. Sabanovic, L. Fridman and S. Spurgeon, *Variable structure systems: from principles to implementation* IET, 2004
5. Relevant Research Publications