EENINDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code**: EEN-611** Course Title**: FPGA Implementation of Signal Processing Systems**

2. Contact Hours: **L: 3 or 2** **T: 1 or 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 20-35 PRS:0 MTE: 20-30 ETE: 40-50 PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: PEC**

8. Pre-requisite**: Basic courses on Digital Circuits and Signal Processing**

9. Objective:

Introduce the Verilog hardware description language and implementation of signal processing systems with FPGA.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to FPGA: programmability, challenges, technology review. DSP fundamentals: DSP system, transforms, filter structures, basics of adaptive filtering.	**4**
2.	Verilog: Introduction, use in synthesis, modelling combinational and sequential logic, writing test benches. Logic synthesis: two level and multi gate-level optimization tools, state assignment of finite state machines. Physical design automation: floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing.	**8**
3.	Arithmetic Basics: Number representations, fixed-point vs floating-point, arithmetic operations, MAC, CORDIC, Computation of special functions, and Architectures.	**6**
4.	Design methodology requirements for FPGA, Digital filter with FPGA, FIR and IIR filters.	**6**

S. No.	Contents	Contact Hours
5.	Multi-rate Signal Processing with FPGA: decimation and interpolation, multi-stage decimator, frequency sampling filters, filter banks.	**6**
6.	Fourier Transform Implementation: DFT, FFT, Goertzel Algorithm, and DCT.	**6**
7.	Adaptive filter Implementation: Application of adaptive filter, Optimum estimation technique, FPGA design of LMS and RLS.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Zvi Kohavi and Niraj K. Jha, "Switching and Finite Automata Theory", third edition, Cambridge University Press.	**2010**
2.	Stephen Brown, Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design", second edition, Tata Mcgraw-Hill.	**2007**
3.	Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", second edition, Prentice Hall.	**2003**
4.	Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", second edition, Pearson.	**2011**
5.	Roger Woods, John Mcallister, Gaye Lightbody, Ying Yi, "FPGA-based Implementation of Signal Processing Systems", second edition, John Wiley & Sons, Ltd.	**2017**
6.	Uwe Meyer-Baese, "Digital Signal Processing with Field Programmable Gate Arrays", third edition, Springer.	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code**:** **EEN-612** Course Title**:** **Electrical Transients in Power Systems**

2. Contact Hours: **L: 3 or 2** **T: 1 or 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits**:** **4** 6. Semester**:** **Spring** 7. Subject Area**:** **Departmental Elective**

8. Pre-requisite**:** **Power Transmission and Distribution**

9. Objective:

To develop a physical understanding of electromagnetic transients, and study how to model and analyze electromagnetic transients with computer simulation tools.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Fundamentals of Transients**: Simple switching transients in RL, RC and RLC circuits, Damping, Transients in 3-phase circuits, load Switching.	**4**
2.	**Traveling Waves:** Computation of transients with distributed lines parameters; Traveling wave concept, standing waves and natural frequencies, reflection and refraction of travelling waves, Bewely's lattice diagram.	**5**
3.	**Modeling of Power Apparatus for Transient Analysis:** Constant parameter transmission line and cable models, Frequency dependent line and cable models, Transformer models, Electric machines, Surge arresters, Network Equivalents.	**8**
4.	**Switching Transients:** Over voltages due to switching transients, resistance switching, current suppression, current chopping, effective equivalent circuit, Capacitance switching, capacitance switching with a restrike, with multiple restrikes; ferro-resonance.	**6**
5.	**Lightning Transients:** Review of the theories in the formation of charge in clouds, mechanism of lightning discharges and characteristics of lightning strokes, model for lightning stroke, factors contributing to good line design, protection using ground wires, Interaction between lightning and power system.	**5**

6.	**Protection of Power Apparaturs From Overvoltages:** Lightning Shielding of Substation, Surges Suppressors and Lightning arresters, Application of Surge Arresters, Surge Protection of Rotating Machines, Transient Voltages and Grounding Practices, Protection of Control Circuits, Surge Protection Scheme for industrial Drive System.	**5**
7.	**Insulation Coordination:** Basics of insulation coordination, The Strength of Insulation, Classification of overvoltages, Insulation design for switching, Lightning and temporary overvoltages, Statistical methods of insulation coordination, Risk of failure, Test prescriptions. Insulation coordination procedures (IEC) for low voltage systems.	**5**
8.	**Computation of Power System Transients:** The Electromagnetic Transients Program (EMTP), The Hybrid Program.	**4**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	J.C. Das, *Transients in Electrical Systems*. McGraw-Hill, 2010.	**2010**
2.	A. Greenwood, *Electrical Transients in Power Systems, second edition*, Wiley-Interscience,	**1991**
3.	L. van der Sluis, *Transients in Power Systems*, Wiley.	**2001**
4.	Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, and Teruo Ohno, *Power System Transients: Theory and Applications*, CRC Press, Taylors and Francis group, Boca Raton.	**2013**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EEN-613** Course Title: **Sliding Mode Control and Observation**

2. Contact Hours: **L: 3 or 2** **T: 1 or 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 20-35** **PRS: 0** **MTE: 20-30** **ETE: 40-50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring/Autumn** 7. Subject Area**: PEC**

8. Pre-requisite**: Control System Basics**

9. Objective:

The course aims at familiarizing students with the concepts of variable structure control and sliding modes, with their theoretical explorations in various directions, both in continuous time and discrete time domains. The students would get an understanding of this highly useful robust methodology and be able to use it in their control and estimation tasks in real practical systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Classical Sliding Modes:** Sliding modes in nature, Variable Structure Systems, Development of Sliding Mode Control (SMC), Concept of Sliding Surface, Reachability Conditions, Switching Control Action, Fillipov Trajectories.	**6**
2.	**Estimation using Sliding Modes:** Luenberger Observers, Sliding Mode Observers – Utkin, Walcott and Zak, Canonical Structures, Fault Detection.	**10**
3.	**Special Sliding Mode Controllers:** Integral SMC, Terminal SMC.	**4**
4.	**Discrete Time SMC**: Chattering in Continuous Time, Discrete time development, quasi-sliding mode, discrete reaching laws and sliding surface design, multirate output feedback, discrete time integral and terminal sliding modes.	**10**

S. No.	Contents	Contact Hours
5.	**Higher Order Sliding Modes:** Concept of relative degree, Order of sliding mode, New features in HOSM, Twisting and Super-twisting algorithms, Majorant curve and Lyapunov proofs.	**8**
6.	**Higher Order SM in Discrete Time**: Concept of relative degree in discrete time, New properties with higher relative degree output, Reaching laws for higher relative degree outputs.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books / Publishers	Year of Publication/ Reprint
1.	Utkin V., Guldner J. and Shi J., "Sliding Mode Control in Electromechanical Systems", 2nd Ed., Taylor and Francis.	**2009**
2.	Edwards C. and Spurgeon S. K., "Sliding Mode Control: Theory and Applications", 1st Ed., Taylor and Francis.	**1998**
3.	Shtessel Y., Edwards C., Fridman L. and Levant A., "Sliding Mode Control and Observation", 1st Ed., Springer, Birkhauser.	**2014**
4.	Bandyopadhyay B. and Janardhanan S., "Discrete-time Sliding Mode Control: A Multirate Output Feedback Approach", 1st Ed., Springer.	**2006**

Institute Elective
PG/UG

INDIAN INSTITUTE OF TEHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EEN-614** Course Title: **Bio-Medical Robotics**

2. Contact Hours: **L: 3** **T: 1** **P: 2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 1**

4. Relative Weight: **CWS: 10-25** **PRS: 25** **MTE: 15-25** **ETE: 30-40** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring/Autumn** 7. Subject Area: **PEC**

8. Pre-requisite: **Bio-Medical Instrumentation, Introduction to Robotics, Control Systems Basics**

9. Objective:

To develop competence in designing, developing and controlling bio-medical robots and image guided techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Bio-Medical Robotics** Introduction to application and paradigms of Bio-Medical Robots. Basic kinematics concepts – forward, inverse, spatial transformations, joints, degrees of freedom of biological systems. Tendon driven systems.	8
2.	**Minimally Invasive Surgery** Video images in MIS. Teleoperation. Augmented and Virtual Reality.	8
3.	**Image-Guided Interventions** Medical Imaging Modalities – CT, US, MRI. Needling System – Passive and Active Needles – Unicycle, Bicycle Modeling, Design concepts, Actuation involving smart actuator such as Shape Memory Alloy actuators, Image-Guided Feedback Control.	10
4.	**Rehabilitation Robotics** Exoskeletons-Design, Development and Control.	8

	Human Hand Biomechanics – Manipulability analysis, Redundancy resolution. EMG, EEG signal recording and processing using LabView.	
5.	**Current Topics in Bio-Medical Robotics** Haptic Augmentation in Exoskeletons. Robotic Catheters for percutaneous interventions. Unsupervised learning for mapping in Bio-Robots.	**8**
	Total	**42**

11. Laboratory Components:

S. No.	**Experiments**	**Contact Hours**
1.	Introduction to Laboratory Equipments – Exoskeletons, Ultrasound Imaging Modality and Electromagnetic Tracking System	**2**
2.	Simulation Study on Robot Dynamics	**2**
3.	Simulation Study on Robot Kinematics and Control	**2**
4.	Position Control of a Hand Exoskeleton using Subject's Intention.	**2**
5.	Force Control of a Hand Exoskeleton in Real-Time LabView Platform.	**2**
6.	Needle Maneuverability in Tissue Phantom through Image Guidance.	**2**
7.	Human Hand Biomechanics Study.	**2**
	Total	**14**

12. Suggested Books:

S. No.	**Name of Authors/Books/Publishers**	**Year of Publication/Reprint**
1.	Paula Gomes, "Medical robotics: minimally invasive surgery", Woodhead Publishing.	2012
2.	Shane Xie, "Advanced Robotics for Medical Rehabilitation: Current state of the art and recent advances", Springer.	2016
3.	John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd Ed., Pearson Prentice Education.	2005
4.	Mark W. Spong and M. Vidya Sagar, "Robotics Dynamics and Control", 2nd Ed., Wiley Education.	1989
5.	William R. Sherman and Alan B. Craig, "Understanding Virtual Reality, 1st Ed., Interface, Application and Design", Morgan Kaufmann Publication.	2003
6.	Eugene N. Bruce, "Biomedical Signal Processing and Signal Modeling", John Wiley and Sons Publication.	2000