ACADEMIC AFFAIRS OFFICE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No. Acd./ 192 /IAPC-95 Dated: December 21, 2020

<u>Head, Department of Electronics & Communication Engg.</u>

The IAPC in its 95th meeting held on 09.12.2020 and 11.12.2020 vide Item No. 95.2.7 considered and approved the following PECs of Department of Electronics & Communication Engg. with minor modifications:

1. ECN-524: Power Electronic Devices, Circuits and systems
2. ECN-525: Hardware architecture for deep-learning
3. ECN-526: Statistical Machine Learning

The modified syllabi are attached as **Appendix-A**.

Reeti

Assistant Registrar (Curriculum)

<u>Encl:</u> as above

<u>Copy to</u> <u>(through e mail)</u>:-

1. All faculty
2. All Heads of Departments/ Centres
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Channel I/ Academic webpage of iitr.ac.in

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Electronics and Communication Engineering

1. **Subject Code:** ECN-524 **Course Title:** Power Electronic Devices, Circuits and systems
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** PEC
8. **Pre-requisite:** A knowledge of fundamentals of semiconductor device physics
9. **Objective:** To introduce concepts of power electronic semiconductor devices, power conversion circuits and systems.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Introduction**: Evolution of Power Semiconductor Devices; Continuous and Switch Mode Operations; Control Switches; Power Losses; Resistive Inductive and Capacitive Load.	3
2.	**Carrier Transport and Breakdown:** Review of Semiconductor Transport Mechanisms: Drift, Diffusion and Recombination Mechanisms in Power Electronics; Avalanche Breakdown: Impact Ionization Integral and Multiplication Coefficients; Edge-Termination Techniques.	7
3.	**Power Semiconductor Devices**: P-N Junction Diode; Fast Recovery Diode; Schottky Diodes; Silicon Controlled Rectifier (SCR); Triode; Bipolar Junction Transistors (BJTs); MOSFETs; Insulated Gate Bipolar Transistors (IGBTs); Baliga Figure of Merit (BFOM); Freewheeling and Flyback Diodes.	10
4.	**Passive Components**: Theory of Inductors and Capacitors, Active and Passive Filters, Design of Inductors in Power Electronics.	4
5.	**Power circuits:** Single-phase and Three-phase Rectifiers, AC-AC Converters, Isolated and Non-isolated DC-DC converters, Inverters, Half-Bridge Converter, Other Power Circuits From Recent Literature, Simulation of Selected Circuits in MATLAB or SPICE.	10
6.	**Control Circuitry for Power Electronics:** Gate Drive Circuits, Snubber Circuit, Pulse-Width Modulation, Basics of PID Controller, Sensing Circuitry, Integrated Power Electronic Systems, Hybrid Integration.	8
	Total	**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	B. Jayant Baliga, "Fundamentals of Power Semiconductor Devices (second edition)," Springer.	2019
2.	J. Lutz, H. Schlangenotto, U. Scheuermann and R. D. Doncker "Semiconductor Power Devices Physics, Characteristics, Reliability (second edition)," Springer.	2018

3.	Daniel W. Hart, “Power Electronics,” McGraw Hill Companies Inc.	2011
4.	Issa Batarseh and Ahmad Harb, “Power Electronics Circuit Analysis and Design,” Springer	2018
5.	Frede Blaabjerg, “Control of Power Electronic Converters and Systems,” Academic Press, Elsevier Inc.	2018
6.	Stefanos Manias, “Power Electronics and Motor Drive Systems,” Academic Press, Elsevier Inc.	2016
7.	Liuping Wang, Shan Chai, Dae Yoo, Lu Gan and Ki Ng, “PID and Predictive Control of Electrical Drives and Power Converters using Matlab/Simulink,” John Wiley & Sons Singapore Pte. Ltd	2014
8.	Hebertt Sira-Ramirez and Ramón Silva-Ortigoza, “Control Design Techniques in Power Electronics Devices,” Springer	2006

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NAME OF DEPARTMENT/CENTRE: Department of Electronics and Communication Engineering

1. **Subject Code:** ECN-525 **Course Title:** Hardware Architecture for Deep-Learning
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** PEC
8. **Pre-requisite:** None
9. **Objective:** To learn the design of hardware architectures and accelerators for deep-learning/artificial-intelligence. This course is at the intersection of deep-learning and computer-architecture/embedded-system/VLSI.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Background topics:** Approximate computing and storage, Roofline Model, Cache tiling (blocking), GPU architecture, CUDA programming, understanding GPU memory hierarchy, FPGA architecture, Matrix multiplication using systolic array	8
2.	**Convolutional strategies:** Direct, FFT-based, Winograd-based and Matrix-multiplication based.	3
3.	**Deep Learning on various hardware platforms:** Deep learning on FPGAs and case study of Microsoft's Brainwave, Deep learning on Embedded System (especially NVIDIA's Jetson Platform), Deep learning on Edge Devices (smartphones), Deep learning on an ASIC (especially Google's Tensor Processing Unit.), Deep-learning on CPUs and manycore processor (e.g., Xeon Phi), Memristor-based processing-in-memory accelerators for deep-learning.	15
4.	Model-size aware Pruning of DNNs, Hardware architecture-aware pruning of DNNs, Understanding soft-errors. Understanding reliability of deep learning algorithms and accelerators	6
5.	Comparison of memory technologies (SRAM, DRAM, eDRAM, STT-RAM, PCM, Flash) and their suitability for designing memory-elements in DNN accelerator, Neural branch predictors and their applications	4
6.	Hardware/system-challenges in autonomous driving, Distributed training of DNNs and addressing memory challenges in DNN training	6
	Total	**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	**Computer Architecture: A quantitative approach** (Sixth Edition), Hennessy, J. L., & Patterson, D. A., Elsevier https://www.google.co.in/books/edition/Computer_Architecture/cM8mDwAAQBAJ	2017

2.	**Deep Learning for Computer Architects** Brandon Reagen, Robert Adolf, Paul Whatmough, Gu-Yeon Wei, and David Brooks Synthesis Lectures on Computer Architecture, August 2017, Vol. 12, No. 4, Pages 1-123 (https://doi.org/10.2200/S00783ED1V01Y201706CAC041)	2017
3.	**General-Purpose Graphics Processor Architectures** Tor M. Aamodt, Wilson Wai Lun Fung, and Timothy G. Rogers, Synthesis Lectures on Computer Architecture, May 2018, Vol. 13, No. 2, Pages 1-140 (https://doi.org/10.2200/S00848ED1V01Y201804CAC044)	2018
4.	Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). **Deep learning (Vol. 1, No. 2)**. Cambridge: MIT press.	2016
5.	Selected research papers	

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NAME OF DEPARTMENT/CENTRE: Department of Electronics and Communication Engineering

1. **Subject Code:** ECN-526 **Course Title:** Statistical Machine Learning for Variation-Aware Electronic Device and Circuit Simulation
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** PEC
8. **Pre-requisite:** Knowledge of basic concepts in probability and statistics
9. **Objective:** To familiarize students with the fundamental concepts, techniques and algorithms needed to perform stochastic simulation and uncertainty quantification of electronic devices, circuits and systems.

10. **Details of the Course**

S.No.	Contents	Contact hours
1.	**Introduction**: Introduction to stochastic modeling of general systems, key differences between stochastic simulation and classical deterministic simulation. The need for uncertainty quantification in general device, circuit, and system simulation.	**2**
2.	**Introduction to Random Variables:** Discrete and continuous random variables: distribution and density functions, conditional distributions and expectations, functions of random variables, statistical moments, sequence of random variables, central limit theorem, Gaussian and non-Gaussian correlation among random variables	**3**
3.	**Random Sampling Techniques**: Utilization of random sampling techniques for statistical analysis such as Monte Carlo, quasi-Monte Carlo, Latin hypercube sampling, analysis of computational complexity and convergence rate of different random sampling techniques	**5**
4.	**Statistical Machine Learning - Generalized Polynomial Chaos (PC) Theory**: Basic foundation of polynomial chaos, generalization of polynomial chaos for different known distributions, Wiener-Askey scheme of polynomials, generation of orthonormal basis functions using three-term recurrence series and Gram-Schmidt algorithm, training of polynomial chaos metamodels using quadrature techniques and least-squares linear regression. Deployment of PC theory for calculating statistical moments and density functions in linear and nonlinear VLSI as well as RF/microwave devices, circuits, and systems via test cases and illustrative examples.	**6**
5.	**Correlations in PC Theory:** Considering uncorrelated, Gaussian correlated, and non-Gaussian (mixed Gaussian model) correlated parametric variations.	**5**
6.	**Advanced PC theory:** Complexity analysis of PC theory and techniques: limitations of curse of dimensionality in PC theory, emphasis on sensitivity analysis-based dimension reduction, active subspaces, sliced inverse	**13**

	regression, compressed sensing, partial least-squares algorithm, and multi-fidelity methods.	
7.	**Inverse Problems:** Bayes rule, Bayesian formulation of inverse problems, prior and posterior distributions, calculation of maximum likelihood function using PC theory. Applications into inverse uncertainty quantification in linear/nonlinear devices, circuits and systems	**8**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	D. Xiu, "Numerical Methods for Stochastic Computations: A Spectral Method Approach," New Jersey: Princeton University Press	2010
2.	D. Dubois and H. Prade, "Possibility Theory: An Approach to Computerized Processing of Uncertainty," vol. 2, New York, NY: Plenum Press	1988
3.	K. C. Gupta and Q. J. Zhang, "Neural Networks for RF and Microwave Design," Arctech House	2000
4.	A. Papoulis and S. Pillai, "Probability, Random Variables and Stochastic 2017 Processes", 4th Edn., Mc Graw Hill.	2017
5.	R. Shen, S. X.-D. Tan, and H. Yu, Statistical Performance Analysis and Modeling of Nanometer VLSI. New York, NY: Springer	2012