DIGITAL CONTROL IN SWITCHED MODE POWER CONVERTERS AND FPGA-BASED PROTOTYPING

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PRE-REQUISITES : Qualification (i) BE/B.Tech in Electrical/Electronics Engg. (degree completed or final year UG students) or (ii) PG M.Tech in Power Electronics or Power Systems (degree enrolled or completed) or (iii) one year or more experience in power electronics or power management converters

INTENDED AUDIENCE : M.Tech, Ph.D. as well as final year B.Tech students from AICTE approved institutes, design engineers from power management and power electronics industries, such as STMicroelectron ics, Qualcomm, TI, NXP, GE, HCL Technology, Mahindra, etc.

INDUSTRY SUPPORT : STMicroeletronics, Qualcomm , Texas Instruments , NXP, Mahindra Electric, GE, HCL Technology, Microchip Technology

COURSE OUTLINE :

Leading power electronics and power management industries are aggressively exploring digital control solutions for their mainstream product lines in the near future to meet ever increasing demands of performance, efficiency, safety, EMI, hot swapping , scalability, modularity, adaptability, compatibility with smart digital communication . This course will be the first one in NPTEL to cover Digital Control and FPGA-based Implementation for Switched Mode Power Converters, which is aimed to develop skilled manpower and to facilitate academic as well as corporate research and development. This course will benefit industry practitioners, students and teachers from AICTE approved colleges to know about latest digital control trends in power electronics industries. , particularly to understand (i) benefits of digital control, (ii) modulation and digital control architectures, (iii) MATLAB and SIMPLIS simulation, (iv) modelling and analysis techniques, (v) design and tuning methods, (vi) embedded control implementation platforms, (vii) Verilog HDL and fixed point implementation, (viii) hardware development and FPGA-based prototyping, (ix) reference design with case studies and practical demonstration.

ABOUT INSTRUCTOR :

Prof. Santanu Kapat received the M.Tech. and Ph.D. degrees in Electrical Engineering (EE) from IIT Kharagpur, India, in 2006 and 2010, respectively. He was a Visiting Scholar with the ECE Department, University of Illinois at Urbana-Champaign, USA during 2009 to 2010, and a Research Engineer with GE Global Research, Bengaluru from 2010 to 2011. Since August 2011, he has been with the EE Department (EEO), IIT Kharagpur, where he is presently an Associate Professor. From July to November 2019, he was with the EEO, IIT Delhi (on LIEN from IIT Kharagpur) . His research interests include power management converters and high-performance digital control, applications to 48V-to Direct converters, data center, LED drivers, DC micro-grid, fast chargers and BMS. Dr. Kapat was the recipient of the INSA Young Scientist and INAE Young Engineering Award in 2016, and DAE Young Scientist Research Award in 2014. He has been serving as the Associate Editor, IEEE Trans. Power Electronics, IEEE Trans. Circuits and Systems-II, and IEEE Journal of Emerging and Selected Topics in Power Electronics.

COURSE PLAN :

Week 1: Introduct ion to digital control in switched mode power converters, industry trends, simulation/hardware platforms
Week 2: Fixed and variable frequency digital control architectures
Week 3: Model development for digitally controlled switched mode power converters using MATLAB custom coding and/or SIMULINK
Week 4: Modeling techniques in digitally controlled switched mode power converters and model validation using MATLAB
Week 5: Time and frequency domain digital control design methods and MATLAB validation of closed-loop performance
Week 6: Digital control implementation - power stage design and BOM, selection of ADC, DAC, signal conditioning, digital controller platforms (system level and IC implementation perspectives)
Week 7: Demonstration of reference design, component selection, schematic design and layout, PCB development, steps for FPGA based hardware prototyping, testing and measurement
Week 8: Introduction to Verilog HDL and simulation using Xilinx Webpack
Week 9: Fixed point implementation using Verilog HDL (P, PI, PIO, etc.)
Week 10: Step-by-step implementation of digital voltage mode control using Verilog HDL and prototyping using FPGA
Week 11: Step-by-step implementation of digital current mode control using Verilog HDL and prototyping using FPGA
Week 12: Demonstration of hardware case studies of multimode digital control, course summary and key takeaways