Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:** EE678A (Old Course No)

2. **Course Title:** Power Management Systems (Old Course Title: Power Management Circuits)

3. **Per Week Lectures:** 3_(L), Tutorial:____(T), Laboratory: ____(P), Additional Hours[0-2]:____(A), Credits (3*L+2*T+P+A):_9 **Duration of Course:** Full Semester

4. **Proposing Department/IDP:** EE

   Other Departments/IDPs which may be interested in the proposed course: SEE

   Other faculty members interested in teaching the proposed course:

5. **Proposing Instructor(s):** Dr. Utsab Kundu

6. **Course Description:** Low-voltage, high-current power converter topologies are adopted in smartphones, laptops, servers, network switches, etc. These power management systems include power circuits, gate drivers, control circuits, and communication protocols. Therefore, a systems engineer in the power semiconductor industry must develop a block-level understanding of complete power management integrated circuits (PMICs). This course will introduce the students to the system specifications and how power electronic circuits and peripherals are designed to meet those requirements.

   This course is divided into ten modules and begins with an introduction to different power management system requirements. This is followed by two fundamental modules focusing on synchronous buck and other basic PWM converters. The subsequent two modules cover dynamic modeling and voltage-mode control of PWM converters. The sixth module deals with block-level understanding of PMICs. The seventh module discusses the PMBUS communication protocol. The last three course modules deal with advanced control techniques and converter topologies, including multi-phase synchronous buck.

A) Objectives: By the end of this course, the students will be able to

- Understand the specifications and requirements of different power management systems
- Develop a block-level understanding of power management integrated circuits (PMICs)
- Design closed-loop controlled power management circuits
- Develop required skill sets for a systems engineer in the power semiconductor industry

B) Contents (*preferably in the form of 5 to 10 broad titles)*:

S. No.	Broad Title	Topics	No. of Lectures (1.5 hours each)
1.	Introduction	Power delivery network for wearable electronics, smartphones, laptops, servers, and network switches. Requirements: allowable voltage variation, dynamic voltage scaling, load slew rate, and concept of load line.	3
2.	Synchronous Buck Converter	Recap of CCM and DCM. FCCM operation. Selection of commercial inductors, input, and output capacitors. Boot-strap gate driver. Power loss analysis. ZVS characteristics.	3
3.	Basic PWM Converters	Synchronous boost, buck-boost, and non-inverting buck-boost converters. Design considerations for common PMIC solutions for buck, boost, and buck-boost operations.	2
4.	Dynamic Modeling	Circuit averaging technique. Large-signal and small-signal models. Converter dynamics under CCM and DCM.	3
5.	Analog Voltage Mode Control	Type-I, II, and III compensator implementation using analog electronics. Design considerations for finite bandwidth amplifiers.	2
6.	Internal architecture of PMICs	LDO, POR, Bandgap reference, DAC, ADC, MUX, PLL, and Non-volatile memory. Soft-start and shut-down sequences. Importance of Enable and Power Good signals	5

		in system design. Fault detection and responses. Typical trimming requirements and procedures for different blocks.	
7.	PMBUS Communication	Clock, data, alert. Commands - read/write byte, word. Number formats - Linear11, Ulinear16. PMBUS registers - Voltage commands, Telemetry, Fault/warning Status. SMBAlert signal and Alert response address (ARA).	2
8.	Advanced Control Techniques	Recap of current program mode control and analog implementation considerations. Hysteresis and Constant on/off time (COT) control architectures. Current sensing techniques.	3
9.	Multi-phase Synchronous Buck	Power circuit component selection. Design considerations for closed-loop control.	2
10.	Advanced Converter Topologies	48V Point-of-Load Converters: Two-stage and single-stage configurations, Resonant DCX operation, Switched-capacitor, and switched-tank converters.	2
		Total Lectures (1.5 hours each)	26

C) **Pre-requisites:** None

D) **Short summary for including in the Courses of Study Booklet:** Power delivery network: wearable electronics, smartphones, laptops, servers; Synchronous buck and basic PWM converters; Dynamic modeling and voltage mode control; Internal architecture of power management ICs; PMBUS communication protocol; Advanced control techniques and converter topologies for next-generation power management systems.

7. Recommended books:

[1] Erickson & Maksimovic, Fundamentals of Power Electronics, 3rd Ed., Springer, 2020.
[2] A. S. Sedra and K. C. Smith, Microelectronic circuits, 5th Ed., Oxford University Press, 2004.
[3] R. Mancini, "Op Amps for Everyone: Design Reference", Texas Instruments.
[4] V. Ramanarayanan, Switched Mode Power Conversion, 2007.
Link: https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC_VRamnarayanan.pdf

8. Any other remarks: Preferred lecture schedule: Two slots per week, 1.5 hours each

Evaluation Policy: Relative grading will be done after aggregating all course components

Sr. No.	Component (Counts)	Weightage	Comments
1	Home Assignments (5)	20%	Analysis and simulation
2	Attendance (26L)	5%	Signatures will be collected
3	Quiz (3)	10%	Open book (Best of 2)
4	Midterm Exam (1)	25%	Open book
5	Final Exam (1)	40%	Open book

Dated: 03/09/2025 Proposer: Utsab Kundu

Dated: _____ DUGC/DPGC Convener: _____

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: _____