Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:** EE6xxx

2. **Course Title:** EMI/EMC in Power Electronics

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:** Power electronics is an integral part of cutting-edge technologies like electric vehicles, renewable energy harvesting systems, data centers, consumer electronics, and high-end medical equipment, etc. In most of these systems, a power electronic converter is physically placed close to communication networks, analog/digital electronic circuits, and other power converters. This makes electromagnetic interference (EMI) and compatibility (EMC) aspects of power converter design critical for the seamless operation of such systems. This course aims to introduce the students to standard practices followed during the hardware implementation of power electronic converters to address EMI/EMC issues.

   This course is divided into ten modules and begins with an introduction to different noise-coupling mechanisms and related terminologies. This is followed by two fundamental modules focusing on parasitic circuit element calculation and Fourier analysis of typical waveforms observed in power converters. The subsequent three modules cover conducted, inductive, capacitive, and electromagnetic noise coupling phenomena, highlighting different shielding techniques to reduce these effects. The seventh module demonstrates a few practical noise coupling scenarios. The eighth module identifies various noise sources in some widely used power converter topologies and analyzes the impact of different operating modes on noise emission. Finally, the key aspects of printed circuit board (PCB) design like grounding, signal routing, component selection, and placement are covered in the last two modules of this course.

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

- Appreciate the need for EMI/EMC studies in power electronic systems
- Understand the differences among various noise coupling mechanisms
- Quantify EMI emissions caused by commonly used power converters
- Learn EMI/EMC-compliant hardware design guidelines followed in the 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	Different components in a power electronic system, general terminologies related to EMI/EMC, and an overview of noise coupling mechanisms.	2
2.	Parasitic circuit elements	Inductance and capacitance of different wire loops, identification of the least impedance path, and printed circuit board (PCB) layout examples.	2
3.	Fourier analysis	Typical waveforms in power electronic circuits, and approximate envelope of their Fourier spectrums.	2
4.	Conducted noise	Common and differential modes, measurement techniques, filtering techniques, and line impedance stabilization network (LISN).	2
5.	Inductive and capacitive coupling	Self and mutual inductance, capacitive coupling, measurement techniques, noise reduction, and shielding techniques.	2

6.	Electromagnetic (EM) noise coupling	Basics of antenna, condition for EM emission, measurement, and shielding techniques.	2
7.	Noise coupling case studies	Practical examples of conducted, inductive, and capacitive noise coupling mechanisms.	2
8.	Noise sources in power electronic converters	Buck, flyback, CCM and DCM operation, modulation techniques, soft-switched converters, and power factor correction rectifiers.	6
9.	Grounding techniques	Difference between ground and signal return, ground loop, ground bounce, and Kelvin connection.	3
10.	Component placement and PCB layout	Signal routing, return plane, placement of vias, decoupling capacitor, DC bus bar, gate loop, and power loop in a half-bridge leg.	3
		Total Lectures (1.5 hours each)	26

C) **Pre-requisites:** EE360 (Power electronics) or EE660 (Basics of power electronic converters)

D) **Short summary for including in the Courses of Study Booklet:** Noise coupling mechanisms: conductive, inductive, capacitive, and electromagnetic; Parasitic circuit element calculations; Fourier analysis of commonly observed waveforms in power electronics; Noise coupling case studies, measurement, and shielding techniques; Analysis of noise sources in widely used power electronic converters: Buck, flyback, and resonant topologies, power factor correction rectifiers; Standard practices for EMI/EMC-compliant hardware design.

7. Recommended books:

[1] Erickson & Maksimovic, Fundamentals of Power Electronics, 3rd Ed., Springer, 2020.
[2] Clayton R. Paul, Introduction to Electromagnetic Compatibility, 2nd Ed., Willey, 2017.
[3] 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
Preferred lecture timing: Any slot between 10 am to 1:30 pm
Preferred days of the week: Tuesdays and Thursdays

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 (39L)	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:___18/09/2024___Proposer:___Utsab Kundu___

Dated:________________DUGC/DPGC Convener:____________________

The course is approved / not approved

Chairman, SUGC/SPGC

Dated:________________________________