Course number: EE 540
Course Name: Wide Band Gap Devices in Power Electronics Applications
Credit: L-T-P-C: 3-0-0-3
Prerequisite: Power Electronics (EE 309/EE527/ EE504) or Power Semiconductor Devices (EE526) or equivalent
Intended for: UG/MS/MTech/PhD
Distribution: Elective: B. Tech III and IV year /M.S./ M.Tech / PhD

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1. Preamble:

This course is designed to build up an in-depth understanding among the UG/PG students about the wide bandgap devices for power electronics applications. The major goal of this course is to familiarize the students with the properties of the wide bandgap devices and designing driver board to demonstrate the basic operating principles and their designing in PCB and thermal distribution for real world applications. Moreover, the modern designing challenges associated for high frequency power converter design by considering parasitic elements will also be presented, such as parasitic inductance and parasitic capacitance of the PCB. Power density advantages by using these devices for high power applications while operating at high operating frequency for emerging power applications are integral part of the course. Additionally, it will introduce methods of designing high frequency magnetics for high frequency operation of the power converters. Finally, the benefits of using the device in real life application will be discussed. In brief, the objective of this course is to provide a detailed understanding of wide bandgap devices and the state-of-the-art of design of power converters for real life application using these devices.

2. Course Modules with quantitative lecture hours:

Module 1: Wide band gap devices **[4 hours]**

- Introduction of wide band-gap
- Vertical and lateral structures of wide band-gap devices
- Different types of the wide band gap devices
- Advantages of wide band-gap semiconductors
- Challenges in designing converters with wide band-gap devices

Module 2: Switching characteristics **[4 hours]**

- Turn-on and Turn-off characteristics of the device
- Hard switching loss analysis
- Double pulse test set-up

Module 3: Drivers for wide band-gap devices **[8 hours]**

- Gate driver
- Impact of gate resistance
- Gate drivers for wide bandgap power devices
- Transient immunity integrated gate drivers

- Overcurrent protection, UVLO protection

Module 4: Thermal management of power converters **[6 hours]**

- Thermal modelling
- Thermal management and reliability
- Improving the performance with heatsink

Module 5: High frequency design complexity **[4 hours]**

- Effects of parasitic inductance
- Effects of parasitic capacitance
- EMI filter design for high frequency power converters

Module 6: PCB designing **[4 hours]**

- High frequency PCB design
- Conventional power loop design
- High frequency power loop optimization
- Single and multi-layer PCBs
- Separation of power from signal PCB

Module 7: Power density advantages **[4 hours]**

- Power density of wide bandgap devices
- High power density power electronics converters

Module 8: Applications of wide bandgap devices **[8 hours]**

- Consumer electronics applications
- Wireless power transfer applications
- Electric vehicle applications
- Renewable energy sources applications
- Students will carry out one project based on modeling, simulation of any of the wide bandgap device in power electronics applications. This work can be extended with the practical work.

3. Text books:

1. A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, GaN Transistors for Efficient Power Convertion, Wiley, 2014, ISBN-13: 978-1118844762.
2. G. Meneghesso, M. Meneghini, E. Zanoni, "Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion," Springer International Publishing, 2018, ISBN: 978-3-319-77993-5.

4. References:

A. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics," John Wiley & Sons, 2003.

B. F. Wang, Z. Zhang and E. A. Jones, Characterization of Wide Bandgap Power Semiconductor Devices, IET, ISBN-13: 978-1785614910 (2018).

C. L. Umanand and S. R. Bhat, "Design of Magnetic Components for Switched Mode Power Converters," John Wiley & Sons Australia, Limited, 1992.

D. B.J.Baliga, "Gallium Nitride and Silicon Carbide Power Devices," World Scientific Publishing Company (3 Feb. 2017).

E. L. Corradini, D. Maksimovic, P. Mattavelli, R. Zane, "Digital Control of High-Frequency Switched-Mode Power Converters", Wiley, ISBN-13: 978-1118935101 (9th June, 2015).