23EE802 DESIGN OF INDUCTORS AND HIGH FREQUENCY TRANSFORMERS 2-0-0-2

Course Description:

Magnetic components such as inductors and transformers have been key components in electrical systems. The increased demand of high power density and high efficiency transformers directed to the consumer market, solar converters, electric and hybrid vehicles have put higher requirements on the inductor and transformer and consequentially the design procedure.

Learning Objectves:

- To understand the fundamentals of magnetic devices.
- To design high frequency transformers and inductors.
- To know the skin and proximity effects in windings

Pedagogy: Normal Mode

Syllabus:

Module I
Introduction – Magnetic circuits - Self and Mutual Inductance -Energy Stored in the Magnetic Field of an Inductor – Need of Core - Distributed Gap - Self and Mutual Inductance of Circular Coils - Circular Filaments - Circular Coils - Fringing Effects around the Air Gap

Design of Inductors: The Design Equations - Inductance - Maximum Flux Density - Winding Loss - Optimum Effective Permeability - Core Loss - The Thermal Equation - Current Density in the Windings - Dimensional Analysis - The Design Methodology - Window Utilization Factor- Temperature Rise of Inductors - Mean Turn Length of Inductors - Area Product Method - AC Inductor Design -Inductor Design for power converters.

Design of transformers - single phase and three phase transformers - distribution and power transformers - output equation - core design - window area - window space factor - overall dimensions of core. Windings – no. of turns - current density - conductor section - Cooling of transformers.

Module II: Winding at High Frequencies:

Skin Effect & Proximity Effect:
Introduction - Magnet Wire - Wire Insulation - Skin Depth - Ratio of AC-to-DC Winding Resistance - Skin Effect in Long Single Round Conductor - Current Density in Single Round Conductor - Impedance of Round Conductor - Magnetic Field Intensity for Round Wire - Power Density in Round Conductor - Skin Effect on Single Rectangular Plate - Proximity and Skin Effects in Two Parallel Plates - Anti-proximity and Skin Effects in Two Parallel Plates - Proximity Effect in Multiple-Layer Inductor

Winding Resistance at High Frequencies:
Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Litz Wire, Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current.

High frequency transformer and inductor design and modelling using Finite element analysis

References:

1. Design of Magnetic Components for Switched Mode Power Converters, Umanand L., Bhat,
2. S.R., ISBN: 978-81-224-0339-8, Wiley Eastern Publication, 1992.
3. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics: Converters, Applications and Design", Third Edition, John Wiley & Sons, 2007
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
5. Transformers and Inductors for Power Electronics Theory Design and Applications By W G Hurley and W H Wolfle.

Course Outcome:-

CO1: To design inductors and transformers of High frequency used in converters

CO2: To appreciate the skin and proximity effects in various windings

Evaluation Pattern:

Midterm Exam
Assignments
Design Exercise
End Exam

Employability:
Analytical research