# HIGH FREQUENCY MAGNETIC COMPONENTS

**PE-IV:EPS**

| Course Code | Category | Hours / Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| BPSC22 | Elective | 3 | 0 | 0 | 3 | 30 | 70 | 100 |
| Contact Classes: 45 | Total Tutorials: Nil | Total Practical Classes: Nil | | | | Total Classes: 45 | | |

## I. COURSE OVERVIEW:

This course will cover topics in the area of high-frequency power magnetic components, such as inductors and transformers. Concepts that will be studied: such as complex permeability, eddy currents, skin effect, proximity effect, winding losses, Dowell's equation, core losses, self-capacitance, area-product method, core-geometry method, integrated inductors. Optimization of conductor dimensions will be performed. Design procedures of high-frequency inductors and transformers will be presented.

## II. COURSE OBJECTIVES:

**The students will try to learn:**

I. The fundamentals of magnetic devices and the different materials used for magnetic cores.
II. The causes of skin and proximity effects in windings.
III. The Nature of Winding Resistance at High Frequencies.
IV. The computation of inductance for different types of integrated inductors.
V. Calculation of self-capacitance for different kinds of conductors.

## III. COURSE OUTCOMES:

| After successful completion of the course, students will be able to: | | |
|---|---|---|
| CO 1 | **Demonstrate** the different materials and their properties used for magnetic cores. | Apply |
| CO2 | **Explain** the concept of skin effect and proximity effect for different types of conductors. | Analyze |
| CO 3 | **Calculate** the winding resistance for different types of conductors. | Apply |
| CO 4 | **Estimate** the winding power loss for current with harmonics. | Evaluate |
| CO 5 | **Analyze** the self capacitance components of different conductors. | Analyze |
| CO 6 | **Estimate** the self capacitance ofParallel-Plate Capacitor, Two Parallel Round Conductors etc. | Evaluate |

## IV. SYLLABUS

### MODULE –I: FUNDAMENTALS OF MAGNETIC DEVICES AND MAGNETIC CORE(09)

Introduction, Magnetic Relationships, Magnetic Circuits, Magnetic Laws, Eddy Currents, Core Saturation, Volt-Second Balance, Inductance, Inductance Factor, Magnetic Energy, Self-Resonant Frequency, Classification of Power Losses in Magnetic Components, Non-inductive Coils. Magnetic Cores: Introduction, Properties of Core Materials, Magnetic Dipoles, Magnetic Domains, Curie Temperature, Magnetization, Magnetic Materials, Hysteresis, Core Permeability, Core Geometries, Iron Alloy Cores, Amorphous Alloy Cores, Nickel–Iron and Cobalt–Iron Cores, Ferrite Cores, Powder Cores, Nano-crystalline Cores, Superconductors, Hysteresis Core Loss, Eddy-Current Core Loss, Total Core Loss, Complex Permeability.

### MODULE –II: SKIN EFFECT & PROXIMITY EFFECT (10)

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, Other Methods of

Determining the Round Wire Inductance, 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, Appendix: Derivation of Proximity Power Loss.

**MODULE –III: WINDING RESISTANCE AT HIGH FREQUENCIES (09)**

Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Solution for Round Conductor Winding in Cylindrical Coordinates, Litz Wire,

Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current, Thermal Model of Inductors.

**MODULE –IV: INTEGRATED INDUCTORS (08)**

Introduction, Resistance of Rectangular Trace, Inductance of Straight Rectangular Trace, Construction of Integrated Inductors, Meander Inductors, Inductance of Straight Round Conductor, Inductance of Circular Round Wire Loop, Inductance of Two-Parallel Wire Loop, Inductance of Rectangle of Round Wire, Inductance of Polygon Round Wire Loop, Bond-wire Inductors, Single-Turn Planar Inductor, Inductance of Planar Square Loop, Planar Spiral Inductors.

**MODULE –V: SELF-CAPACITANCE (09)**

Introduction, High-Frequency Inductor Model, Self-Capacitance Components, Capacitance of Parallel-Plate Capacitor, Self-Capacitance of Foil Winding Inductors, Capacitance of Two Parallel Round Conductors, Capacitance of Round Conductor and Conducting Plane, Self-Capacitance of Single-Layer Inductors, Self-Capacitance of Multi-layer Inductors, Capacitance of Coaxial Cable.

**V. Text Books:**


1. "Design of Magnetic Components for Switched Mode Power Converters, Umanand L., Bhat, S.R., ISBN: 978-81-224-0339-8, Wiley Eastern Publication, 1992.


**VI. Reference Books:**


1. Marian K. Kazimierczuk, "High-Frequency Magnetic Components", ISBN: 978-0-470-71453-9 John Wiley & Sons, Inc.
2. G. C. Chryssis, "High Frequency Switching Power Supplies, McGraw Hill, 2nd Edition, 1989
3. Eric Lowdon, Practical Transformer Design Handbook, Howard W. Sams& Co., Inc., 1980


**VII. Web References:**

1. https://www.researchgate.net
2. https://www.aar.faculty.asu.edu/classes
3. https://www.facstaff.bucknell.edu/
4. https://www.electrical4u.com

**VIII. E-Text Books:**

1. https://www.jntubook.com/
2. https://www.freeengineeringbooks.com