# The LNMIIT, Jaipur
# Electronics and Communication Department
# Antenna for Biomedical Applications
# (ECE-5021)-RFE-ABA)

| Subject Code: **ECE-5021** | Course Title: **Antenna For Biomedical Applications (ABA)** | Total Contact Hours: **40** | **L: 3** | **T: 0** | **P: 0** | **C: 3** |
|---|---|---|---|---|---|---|
| Pre-requisite: **Engineering Electromagnetics, RF and Microwave Engineering, Antenna Engineering** | | Year: 4th and DD (5th) | Semester: 7th and 9th | | | |
| Type of Course: **PE/RFE** | | | | | | |

***** L → Lectures, T → Tutorials, P → Practical C → Credit***

**Learning Objective:**

Body implantable and wearable antenna becomes the central topic in the development of healthcare and biomedical technologies. Increasing healthcare quality, in addition to the continuous miniaturization of sensors and the advancement in wearable electronics, embedded software, digital signal processing and biomedical technologies, has led to a new era of biomedical devices and increases possibility of continuous monitoring, diagnostic and/or treatment of many diseases. The human body is a hostile environment from a radio propagation perspective. This environment is a highly lossy and has a high effect on the antenna elements, channel parameters and, hence a dramatic drop in the implanted and wearable antenna performance. Antenna is the integral part of any biomedical devices. Therefore, this course focuses on design, simulation and testing of biomedical antenna for human health monitoring application.

**Course Outcomes (COs):**

| **On completion of this course, the students will have the ability to:** | | **Bloom's Level** |
|---|---|---|
| **CO-1** | Design, analyze and test the performance of various planar antenna. | **5** |
| **CO-2** | Design, analyze the response of different periodic structure for various applications. | **5** |
| **CO-3** | Design and analyze the performance of wearable and body-implantable antenna using phantom models for health monitoring. | **5** |
| **CO-4** | Design wireless power transfer system for the implantable medical devices (IMDs). | **4** |

| **Course Topics** | **Lecture Hours** | | **COs** |
|---|---|---|---|
| **1. UNIT – I: BASICS OF PATCH ANTENNA AND ITS SIMULATION** | | **10** | **CO1** |
| 1.1 Antenna basics and performance parameters, Patch and slot antenna, Linear and circular polarized patch antenna, Broadband Antenna, Fractal Antenna. | **5** | | |

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|---|---|---|---|
| 1.2 Introduction to Antenna Simulation Tool (HFSS, CST MWS, ADS). Design and Simulation of some basic antenna (RMPA, CMPA, SMPA), Visualize the effect of physical parameters on Antenna performance using Simulator. | **5** | | |
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| **2. UNIT-II: IMPROVEMENT OFANTENNA PERFORMANCE USING ARTIFICIAL SURFACE** | | | |
| **2.1** Antenna miniaturization using conventional approaches. | **1** | **10** | **CO2** |
| **2.2** Performance improvement of Antenna using Periodic Surface: Active and Passive Array, Dipole versus Slot array, Complementary array, Design and simulation of periodic structure like AMC, RIS, FSS, etc. | **4** | | |
| **2.3** Definition of Metamaterial and Left-Handed Metamaterial. Maxwell Equation of Left-Handed Metamaterial, Single Negative, Double Negative, Negative Refractive Index Metamaterial. Application of metamaterial in Antenna (such as, miniaturization and gain enhancement). | **3** | | |
| **2.4** Application of periodic surface in biomedical antenna. | **2** | | |
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| **3. UNIT – III: WEARABLE, IMPLANTABLE AND INGESTIBLE ANTENNA** | | **14** | **CO3** |
| **3.1** Introduction to wearable antenna and its application, wideband wearable antenna for 5G communication system, IOT and Medical systems, wearable textile antenna. reconfigurable wearable antenna, wearable antenna in vicinity of human body, Design, simulation and performance study of wearable antenna. | **4** | | |
| **3.2** Introduction to body implantable and ingestible antenna, Phantom Models: skin, muscle, fat, Impact of body tissues over the antenna performances, impact of antenna orientation inside the human body, Consideration of SAR, Link budget calculation, impact of Microelectronics circuits towards the design of a practical implantable antenna. | **7** | | |
| **3.3** Implantable health care system, Ingestible health care system, Performance study of implantable antenna with the help of Simulation. Familiarization with some biomedical measuring environment: Skin gel preparation (Vivo-testing), real tissue environment (vitro measurement). | **3** | | |
| | | | |
| **4. UNIT-IV: WIRELESS POWER TRANSFER TO THE IMDs** | | **6** | **CO4** |
| **4.1** Basics of WPT, Various power transfer mechanism in Near and Far field, Wireless charging of the battery for the implantable devices, Various approaches to improve power transfer efficiencies in implantable environment. Rectenna, Design of rectenna in ADS. | **6** | | |
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**Textbook References:**

**Text Books:**

1. *Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Edition, Wiley, 2016.*
2. *Caloz, Christophe, and Tatsuo Itoh. Electromagnetic metamaterials: transmission line theory and microwave applications. John Wiley & Sons, 2005.*
3. *Munk, Ben A. Frequency selective surfaces: theory and design. John Wiley & Sons, 2005.*
4. *Wireless Power Transfer for Medical Microsystems, T Sun et.al., Springer, 2013.*
5. *Wearable system and antenna technologies for 5G, IOT and medical systems, Albert Sabban, CRC Press, 2020.*

**Reference Book:**

1. *The handbook of Antenna Design, A W Rudge, IEE Electromagnetic Wave Series, 1982*
2. *Handbook of Biomedical Telemetry, First Edition, Konstantina S. Nikita, John Wiley & Sons, 2014.*
3. *Modern Antenna Hand book, Constantine A. Balanis et. al., John Wiley & Sons, 2008.*

**Additional Resources:**

1. *https://www.digimat.in/nptel/courses/video/108101092/L01.html*
2. *https://nptel.ac.in/courses/117/105/117105139/*
3. *Implantable Antenna for Biomedical Application, Thesis Paper by Francesco Merli, Ecole Polytechnique Federal the Lausanne, 2011.*
4. *K N Paracha, "Wearable Antennas: A Review of Materials, Structures, and Innovative Features for Autonomous Communication and Sensing", IEEE Access, Vol. 7, 2019*

| Evaluation Method | | |
|---|---|---|
| **Item** | **Weightage (%)** | **COs** |
| Quiz | **10** | **CO1-CO3** |
| Assignment-1 (simulation) | **10** | **CO1-CO2** |
| Assignment-2 (simulation) | **10** | **CO3** |
| Project | **20** | **CO1-CO4** |
| Midterm | **20** | **CO1-CO2** |
| Final Examination | **30** | **CO1-CO4** |

**CO and PO Correlation Matrix for B. Tech ECE and B. Tech ECE Dual Degree**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 2 | 0 |
| CO2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 0 |
| CO3 | 3 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 2 | 2 | 0 |

**Proposed By: Dr. Gopinath Samanta and Dr. Jeet Ghosh**