ADAPTIVE AND SMART ANTENNAS (3-0-0)

Course Objectives

- Understand the fundamentals of adaptive antenna arrays and smart antenna systems.
- Analyse optimum array processing techniques for interference suppression.
- Study adaptive algorithms used in beam forming applications.
- Learn recursive estimation methods for adaptive signal processing.
- Investigate mutual coupling effects and compensation techniques in adaptive arrays.

Module I (6 Hours)

Fundamentals of Adaptive Array Systems:

Introduction to Adaptive Arrays: Motivation and applications of adaptive arrays, adaptive array problem statement, signal environment and interference scenarios, array geometry and element spacing considerations, performance measures of adaptive arrays, beam steering and null formation, limitations due to practical array effects.

Module II (6 Hours)

Optimum Array Processing:

Mathematical preliminaries for adaptive array processing signal models for conventional and signal-aligned arrays, Wiener solution and MMSE criterion, steady-state performance limits, optimum processing for narrowband arrays, broadband adaptive processing, adaptive processing under perturbed propagation conditions.

Module III (6 Hours)

Adaptive Beam forming Algorithms:

Principles of adaptive algorithms, steepest descent method, Least Mean Square (LMS) algorithm, Normalized LMS concept, differential steepest descent algorithm, accelerated gradient methods, constrained gradient algorithms, convergence and stability analysis.

Module IV (6 Hours)

Recursive Adaptive Processing Techniques:

Weighted Least Squares Error (WLSE) processor, Recursive Least Squares (RLS) concept, covariance matrix inversion techniques, matrix update methods, Kalman filter approach for adaptive arrays, minimum variance distortion less response (MVDR) processor.

Module V (6 Hours)

Mutual Coupling Effects and Advanced Applications:

Mutual coupling in antenna arrays, modelling of mutual coupling effects, compensation using open-circuit voltage methods, minimum norm compensation techniques, effect of mutual coupling on desired signals and jammers, adaptive compensation methods, impact of elevation angle variation, applications in smart antennas.

Course Outcomes:

After successful completion of the course, students will be able to:

CO1: Explain the principles and performance characteristics of adaptive antenna arrays.
CO2: Apply optimum array processing techniques for interference suppression and beam forming.
CO3: Analyze and implement adaptive algorithms such as LMS and gradient-based methods.
CO4: Evaluate recursive adaptive processing methods including RLS and Kalman filtering.
CO5: Assess mutual coupling effects and design compensation techniques for smart antenna applications in modern wireless communication systems.

Text Books:

1. C. A. Balanis & P. I. Ioannides, Introduction to Smart Antennas, Morgan & Claypool Publication , 2014
2. Frank Gross, Smart Antennas with MATLAB, McGraw-Hill Professional, 2015

Supplementary Reading:

1. Lal Chand Godara, Smart Antennas, CRC Press
2. T.S. Rappaport, Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location, IEEE Press, PTR – PH publishers