PRINCIPLES AND TECHNIQUES OF MODERN RADAR SYSTEMS

PROF. AMITABHA BHATTACHARYA

Department of Electrical Engineering
IIT Kharagpur

PRE-REQUISITES : Basic Knowledge of Electromagnetic Theory and Microwave Engineering is required. Following NPTEL courses are suggested: (a) Electromagnetic Theory (b) Basic Tools in Microwave Engineering (c) Basic Building Blocks of Microwave Engineering (d) Analysis and Design Principles of Microwave Antennas

INTENDED AUDIENCE : BE/B.Tech Electronics Engineering/Electronics and Communication Engineering/ ME/M.Tech/MS students belonging to RF and Microwave Engineering, PhD fellows having research area of Radar system design

INDUSTRIES SUPPORT : Radar Industry, Space Industry, Avionics industry, Defense Industry,Internal Security Industry, Mining industry, Geo-exploration Industry.

COURSE OUTLINE :

The course “Principles and Techniques of Modern Radar Systems” covers a broad spectrum of the radar system design and analysis, starting with the basic concepts of microwave radar principles. It first develops a simplified model called “radar range equation” to introduce the basic concepts of the Radar. Then it introduces the simple CW Radar and shows it limitations and how that can be overcome with the help of frequency modulation. Then it introduces the concept of pulsed radar to increase the range of the radar detection, Thereafter the concept of MTI filtering to discriminate clutter in the Doppler domain is introduced and performance metric of MTI filtering is introduced. The drawback of MTI filtering in airborne radar is introduced next to highlight the concept of pulsed Doppler radar. Thereafter tracking radar is introduced alongwith monopulse concept to measure angular position of a target with very high accuracy. Then the detection theory is introduced by elaborate description of match filtering, ambiguity function, range resolution and Doppler resolution concepts. Thereafter pulse compression is introduced to increase the downrange resolution and synthetic aperture processing to increase cross range resolution. Thus the concept of the imaging radar is introduced. The statistical nature of target and environment parameter fluctuations is introduced next by introducing the concept of probability of false alarm and probability of detection. Swerling models are introduced and with their help the radar equation model is modified to make it more realistic. The modern trend of close sensing of targets with ground penetrating radar is next introduced and also the topic of radar tomography is introduced to give the course students a thrill of various modern civil, industrial and mining applications of radar technology. This trend of radar technology evolution from defence applications to civilian applications is emphasized at the end of the course.

ABOUT INSTRUCTOR :

Prof. Amitabha Bhattacharya was born in Kolkata, West Bengal in the year 1964. He received his B.Tech. (E&ECE) Degree from IIT Kharagpur in 1986, M.E. (E&TCE) from Jadavpur University in 1994 and Ph.D. (E. & ECE) from IIT Kharagpur in 1998.

He started his professional career in 1986 by joining as Junior Research Engineer in an ISRO- sponsored research project at IIT Kharagpur and continued thereafter as a Senior Research Assistant in a DRDO sponsored Research Project till 1991. In 1997, he joined SAMEER, Mumbai and then Defence Lab, Jodhpur as a Research Scientist. From 2000 onwards he joined teaching profession, first as an Assistant Professor in the Electronics and Instrument Department of Indian School of Mines, Dhanbad and then in 2007, in the faculty of Electronics and Electrical Communication Engineering Department of IIT Kharagpur in 2007. Presently he is working as a Professor in the same Department and is involved in the teaching and research activities of the RF and Microwave Group of the E&ECE Department.

Prof. Bhattacharya's research interest is in the areas of Microwave Imaging, Microwave Propagation, High Power Microwaves and Microwave Stealth Technology. He has published 127 research publications, two technical reports for Indian Defense, written a Tata McGraw Hill published text book on "Digital Communication" and co-authored a book chapter on "Modal Analysis of Reflector backed Hybrid Printed dipole antenna". He has also developed 6 NPTEL online courses on microwave Technology. He has been principal Investigator / consultant of 20 completed research projects and consultancies sponsored by agencies like DRDO, ISRO, Indian Army, BARC, MHRD, Wipro etc., has conducted 19 short term courses specially training scientists from HAL, ISRO, DRDO, Indian tri-services etc. in the areas of Electromagnetic Environments and Microwave Technologies. Dr. Bhattacharya has supervised ten Ph.D. thesis and forty-two postgraduate theses. Presently he is supervising five research students.

Prof. Bhattacharya is a fellow of Summa Foundation, USA and a senior member of IEEE, USA.

COURSE PLAN :

Week 1: Basic Principles: Radar Equation, Radar Cross section
Week 2: CW Radar, FMCW Radar
Week 3: Pulsed Radar Principles
Week 4: Clutter Analysis, MTI Improvement Factor, Pulsed Doppler Radar,
Week 5: Tracking Radar, Angular resolution, Monopulse Technique
Week 6: Detection Theory: Match Filtering, Radar Ambiguity Function
Week 7: Imaging Radar: Resolution Concept, Pulse Compression
Week 8: Synthetic Aperture Processing, ISAR Imaging
Week 9: Probability of False Alarm and Detection, Modified Radar Range Equation with Swerling Models
Week 10: Ground Penetrating Radar for close sensing
Week 11: Radar Tomography and Radar based Microwave Imaging
Week 12: Emerging and Modern Applications of Radar Principles