Training Course on Advanced Radar Systems and Signal Processing

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This intensive training course provides a deep dive into the theoretical underpinnings and practical applications of Advanced Radar Systems and Signal Processing. Participants will gain a comprehensive understanding of how cutting-edge DSP techniques are leveraged to enhance radar performance, including target detection, tracking, imaging, and classification in complex and challenging environments. Training Course on Advanced Radar Systems and Signal Processing covers essential concepts such as waveform design, pulse compression, Doppler processing, adaptive beamforming, and Space-Time Adaptive Processing (STAP), equipping engineers and researchers with the specialized skills to design, analyze, and optimize state-of-the-art radar systems for diverse applications, from defense and aerospace to autonomous vehicles and weather monitoring.

In today's rapidly evolving technological landscape, the demand for intelligent and robust radar capabilities is at an all-time high, driven by the proliferation of autonomous systems, the need for enhanced situational awareness, and the challenges posed by electronic warfare. This course explores trending topics such as MIMO radar, cognitive radar, Synthetic Aperture Radar (SAR), Inverse SAR (ISAR), millimeter-wave (mmWave) radar, and the transformative role of AI/Machine Learning (ML) in radar signal processing. Through rigorous theoretical analysis, practical simulations using industry-standard tools, and real-world case studies, attendees will develop the advanced expertise necessary to innovate and lead in the development of next-generation radar technologies.

Programme Curriculum

Training Course on Advanced Radar Systems and Signal Processing

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Course Objectives

1. Understand the fundamental principles and architectural components of advanced radar systems.
2. Design and analyze various radar waveforms for optimal detection and resolution.
3. Apply advanced signal processing techniques including pulse compression and Doppler processing.
4. Implement Constant False Alarm Rate (CFAR) detection algorithms for robust target detection.
5. Master adaptive filtering and beamforming for interference and clutter suppression.
6. Comprehend the principles and applications of Synthetic Aperture Radar (SAR) and Inverse SAR (ISAR).
7. Analyze and design MIMO radar systems for enhanced performance and angular resolution.
8. Understand the concepts of cognitive radar and its adaptive capabilities.
9. Apply AI/Machine Learning algorithms for target recognition, classification, and tracking.
10. Analyze and mitigate the effects of electronic warfare (EW) on radar systems.
11. Design and implement radar tracking algorithms including Kalman filtering and multi-target tracking.
12. Utilize computational tools for radar system modeling, simulation, and performance evaluation.
13. Contribute to the development of next-generation intelligent radar systems for diverse applications.

Organizational Benefits

1. Enhanced Radar Performance: Improved target detection, tracking, and imaging capabilities.

2. Increased System Robustness: Better resilience against noise, clutter, and jamming.
3. Optimized Resource Utilization: Efficient use of transmit power and bandwidth.
4. Faster Development Cycles: Streamlined design and testing of radar algorithms.
5. Innovation in Product Development: Enabling new features and capabilities in radar products.
6. Competitive Advantage: Leading-edge expertise in advanced radar technology.
7. Reduced Operational Costs: Proactive maintenance and optimized system performance.
8. Improved Situational Awareness: More accurate and reliable environmental sensing.
9. Skilled Workforce: Empowered employees proficient in advanced radar design and analysis.
10. Strategic Capabilities: Development of advanced defense, surveillance, and autonomous systems.

Target Participants

- Radar Engineers and Designers
- Signal Processing Engineers
- Aerospace and Defense Engineers
- Electronic Warfare (EW) Specialists
- Researchers in Radar and Remote Sensing
- Robotics and Autonomous Systems Engineers
- Telecommunications Engineers (with interest in radar principles)
- PhD Students in Electrical Engineering and related fields

Course Outline

Module 1: Radar Fundamentals and the Radar Equation

- **Basic Radar Principles:** Range, velocity, angle measurements.
- **Radar Equation Derivations:** Monostatic and bistatic radar equations.
- **Target Characteristics:** Radar Cross Section (RCS) and its statistical models.
- **Clutter and Noise Models:** Understanding environmental interference.
- **Case Study:** Calculating the maximum detection range of an air surveillance radar for a fighter jet target.

Module 2: Radar Waveform Design

- **Pulse Radar Basics:** Simple pulse, pulse repetition interval (PRI), duty cycle.
- **Pulse Compression Techniques:** Linear Frequency Modulation (LFM), Phase Coded Pulses (Barker, Complementary).
- **Ambiguity Function:** Understanding range and Doppler resolution trade-offs.
- **Waveform Diversity and Design for Specific Applications:** Optimizing for target type, environment.
- **Case Study:** Designing an LFM waveform for a high-resolution automotive radar.

Module 3: Matched Filtering and Detection Theory

- **Matched Filter Principles:** Maximizing SNR for known signals in noise.
- **Receiver Architecture:** RF front-end, IF processing, baseband processing.
- **Statistical Detection Theory:** Neyman-Pearson criterion, Probability of Detection (Pd?), Probability of False Alarm (Pfa?).

- **Detection in Noise:** Single pulse and coherent/non-coherent integration.
- **Case Study:** Analyzing the Pd? vs. SNR curve for a radar system with a given Pfa? requirement.

Module 4: Constant False Alarm Rate (CFAR) Detection

- **Motivation for CFAR:** Maintaining constant Pfa? in varying clutter/noise environments.
- **Cell Averaging CFAR (CA-CFAR):** Principles and limitations.
- **Order-Statistic CFAR (OS-CFAR):** Robustness to multiple targets and non-homogeneous clutter.
- **Adaptive CFAR Techniques:** GO-CFAR, SO-CFAR, and their variants.
- **Case Study:** Implementing and comparing the performance of CA-CFAR and OS-CFAR in a simulated cluttered environment.

Module 5: Doppler Processing and Moving Target Indication (MTI)

- **Doppler Effect in Radar:** Measuring target velocity.
- **Moving Target Indication (MTI):** Filtering out stationary clutter.
- **Pulse Doppler Radar:** Resolving range and Doppler ambiguities.
- **Clutter Rejection Techniques:** Delay-line cancellers, FIR filters.
- **Case Study:** Designing an MTI filter to suppress ground clutter for an airborne radar.

Module 6: Synthetic Aperture Radar (SAR)

- **SAR Principles:** Achieving high azimuth resolution using platform motion.
- **SAR Modes:** Stripmap, Spotlight, ScanSAR.
- **SAR Imaging Algorithms:** Range-Doppler algorithm, Backprojection algorithm.
- **Applications of SAR:** Remote sensing, surveillance, mapping.
- **Case Study:** Processing simulated raw SAR data to generate a high-resolution image of a ground scene.

Module 7: Inverse Synthetic Aperture Radar (ISAR)

- **ISAR Principles:** High-resolution imaging of rotating targets.
- **Motion Compensation in ISAR:** Correcting for translational and rotational motion.
- **ISAR Image Formation:** Range-Doppler method for ISAR.
- **Applications of ISAR:** Target identification and classification.
- **Case Study:** Generating an ISAR image of a simulated aircraft target based on its rotation.

Module 8: Adaptive Beamforming

- **Phased Array Antennas:** Principles, beam steering, and null steering.
- **Adaptive Beamforming Algorithms:** Sample Matrix Inversion (SMI), Least Mean Squares (LMS).
- **Minimum Variance Distortionless Response (MVDR) Beamforming:** Optimal interference rejection.
- **Digital Beamforming (DBF):** Flexibility and performance advantages.
- **Case Study:** Designing an adaptive beamformer to suppress a strong jamming signal from a specific direction.

Module 9: Space-Time Adaptive Processing (STAP)

- **STAP Principles:** Jointly processing spatial and temporal data for clutter and jammer suppression.
- **STAP Architectures:** Fully adaptive STAP, reduced-dimension STAP (JDL, Factored).

- **STAP Algorithm Design:** Optimal STAP filter, adaptive STAP.
- **Applications of STAP:** Airborne radar, ground moving target indication (GMTI).
- **Case Study:** Simulating STAP performance for detecting a slow-moving target in strong airborne clutter.

Module 10: MIMO Radar

- **MIMO Radar Architectures:** Colocated MIMO vs. Distributed MIMO.
- **Advantages of MIMO Radar:** Enhanced spatial resolution, diversity gain, virtual apertures.
- **MIMO Radar Signal Processing:** Transmit beamforming, receive processing, parameter estimation.
- **Applications of MIMO Radar:** Automotive radar, target classification.
- **Case Study:** Designing a basic MIMO radar system for improved angular resolution in a multi-target scenario.

Module 11: Radar Tracking and Data Association

- **Target Tracking Fundamentals:** State estimation, prediction.
- **Kalman Filter:** Optimal linear filter for linear Gaussian systems.
- **Extended Kalman Filter (EKF) and Unscented Kalman Filter (UKF):** For nonlinear systems.
- **Data Association:** Nearest Neighbor, Probabilistic Data Association (PDA), Multiple Hypothesis Tracking (MHT).
- **Case Study:** Implementing a Kalman filter to track a target's position and velocity from noisy radar measurements.

Module 12: Cognitive Radar

- **Introduction to Cognitive Radar:** Learning and adaptation in radar systems.
- **Cognitive Loop Elements:** Sensing, learning, decision-making, adaptation.
- **Adaptive Waveform Design:** Dynamic adjustment of transmit signals.
- **AI/ML for Cognitive Radar:** Reinforcement learning for resource management, deep learning for environment awareness.
- **Case Study:** Exploring how a cognitive radar system can adapt its waveform to optimize detection in a changing interference environment.

Module 13: AI/Machine Learning in Radar Signal Processing

- **Deep Learning for Target Classification:** CNNs for radar imagery.
- **AI for Automatic Target Recognition (ATR):** Identifying targets from radar signatures.
- **Machine Learning for Anomaly Detection:** Identifying unusual radar returns.
- **Reinforcement Learning for Radar Resource Management:** Optimizing transmit power, scanning patterns.
- **Case Study:** Training a deep learning model to classify different types of vehicles from micro-Doppler radar signatures.

Module 14: Electronic Warfare (EW) and Radar Countermeasures

- **Radar Jamming Techniques:** Noise jamming, deception jamming.
- **Radar Electronic Protection (EP):** Anti-jamming strategies, LPI/LPD (Low Probability of Intercept/Detection).
- **Digital Radio Frequency Memory (DRFM):** Generating sophisticated deceptive jammers.
- **Cognitive EW:**Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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