Training Course on 5G/6G Wireless Communication System Design

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 foundational and cutting-edge aspects of 5G and 6G Wireless Communication System Design. Participants will gain a comprehensive understanding of the architectural principles, key enabling technologies, and performance metrics that define these revolutionary generations of wireless connectivity. Training Course on 5G/6G Wireless Communication System Design emphasizes the intricate interplay of Massive MIMO, millimeter-wave (mmWave) and Terahertz (THz) communications, Software-Defined Networking (SDN), and Network Function Virtualization (NFV), equipping engineers and researchers with the skills to design, analyze, and optimize next-generation wireless networks that are pivotal for ubiquitous connectivity and the Internet of Everything (IoE).

As the world rapidly approaches the era of 6G, this course goes beyond the current capabilities of 5G to explore emerging concepts such as Integrated Sensing and Communication (ISAC), Reconfigurable Intelligent Surfaces (RIS), AI/ML Native Networks, and holographic communications. Attendees will develop a forward-looking perspective on the future of wireless, addressing challenges in ultra-low latency, high reliability, and massive connectivity for applications like Extended Reality (XR), autonomous systems, and the metaverse. Through practical design exercises, simulations, and case studies, this program prepares professionals to innovate and lead in the development of the intelligent, hyper-connected digital future.

Programme Curriculum

Training Course on 5G/6G Wireless Communication System Design

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Course Objectives

1. Understand the core principles and evolution from 5G to 6G wireless communication.
2. Analyze and design components of 5G New Radio (NR) physical layer and network architecture.
3. Master Massive MIMO and beamforming techniques for enhanced spectral efficiency.
4. Comprehend millimeter-wave (mmWave) and Terahertz (THz) communication challenges and solutions.
5. Design and optimize ultra-reliable low-latency communication (URLLC) scenarios.
6. Implement network slicing and Software-Defined Networking (SDN) for flexible network management.
7. Explore Network Function Virtualization (NFV) and cloud-native network deployment.
8. Understand the role of AI/ML in 5G/6G network optimization and resource allocation.
9. Investigate Integrated Sensing and Communication (ISAC) for converged functionalities.
10. Analyze the potential of Reconfigurable Intelligent Surfaces (RIS) for smart radio environments.
11. Evaluate security and privacy concerns in 5G/6G networks and design mitigation strategies.
12. Discuss emerging 6G technologies like holographic communications and quantum networking.
13. Contribute to the design and deployment of future-proof hyper-connected ecosystems for Industry 4.0 and beyond.

Organizational Benefits

1. Accelerated 5G Deployment and Optimization: Efficient rollout and management of current networks.
2. Strategic Positioning for 6G: Early understanding and adaptation to future standards.

3. Enhanced Network Performance: Higher speeds, lower latency, and greater capacity.
4. Reduced Operational Costs: Optimized resource allocation and automated network management.
5. Development of New Services: Enabling applications like AR/VR, autonomous vehicles, and smart cities.
6. Improved Network Security and Reliability: Designing robust and resilient communication systems.
7. Competitive Advantage: Leading innovation in wireless technology and service delivery.
8. Skilled Workforce: Empowered employees with expertise in cutting-edge wireless design.
9. Efficient Resource Utilization: Maximizing spectral and energy efficiency.
10. Cross-Domain Innovation: Fostering interdisciplinary approaches with AI, IoT, and sensing.

Target Participants

- Wireless Communication Engineers
- Telecom Network Architects
- R&D Engineers in Telecommunications
- PhD Students and Researchers in Wireless Communications
- Network Planners and Optimizers
- Software-Defined Networking (SDN) and NFV Engineers
- IoT Solution Architects
- AI/ML Engineers specializing in Network Optimization

Course Outline

Module 1: Evolution of Wireless Communication & 5G Fundamentals

- **From 1G to 5G:** Key milestones, drivers, and capabilities of each generation.
- **5G Use Cases and Requirements:** eMBB, mMTC, URLLC, and their KPIs.
- **5G NR Air Interface:** Frame structure, numerology, and channel types.
- **5G Architecture Overview:** Core Network (5GC), RAN, and transport network.
- **Case Study:** Analyzing the network architecture for a 5G smart factory deployment.

Module 2: Massive MIMO and Beamforming

- **Massive MIMO Principles:** Large antenna arrays, channel hardening, and spatial multiplexing.
- **Beamforming Techniques:** Digital, analog, and hybrid beamforming for mmWave.
- **Channel Estimation and Reciprocity:** Acquiring Channel State Information (CSI).
- **MIMO in 5G NR:** Multi-user MIMO (MU-MIMO) and its performance gains.
- **Case Study:** Optimizing beamforming strategies for enhanced coverage in an urban 5G network.

Module 3: Millimeter-Wave (mmWave) Communications

- **mmWave Propagation Characteristics:** High path loss, atmospheric absorption, blockage.
- **Antenna Design for mmWave:** Phased arrays, steerable antennas.
- **Link Budget Analysis for mmWave:** Calculating coverage and capacity.

- **Hybrid Beamforming Architectures:** Combining digital and analog processing.
- **Case Study:** Designing a mmWave link for a high-speed fixed wireless access application.

Module 4: Ultra-Reliable Low-Latency Communication (URLLC)

- **URLLC Requirements and Use Cases:** Industrial IoT, autonomous vehicles, tactile internet.
- **Enabling Technologies for URLLC:** Short Transmission Time Intervals (TTI), mini-slots, redundant transmissions.
- **Resource Allocation for URLLC:** Prioritization and scheduling mechanisms.
- **Reliability Metrics and Analysis:** Probability of error, availability.
- **Case Study:** Designing a URLLC solution for real-time control in a robotic manufacturing plant.

Module 5: Network Slicing and Virtualization

- **Concept of Network Slicing:** Customizing virtual networks for diverse services.
- **Software-Defined Networking (SDN):** Decoupling control and data planes in 5G.
- **Network Function Virtualization (NFV):** Deploying network functions as software on commodity hardware.
- **Orchestration and Management of Slices:** Automation and lifecycle management.
- **Case Study:** Designing a network slice for an autonomous vehicle fleet with specific QoS requirements.

Module 6: 5G Core Network (5GC) Design

- **Service-Based Architecture (SBA):** Modular and flexible core network design.
- **Key Network Functions:** AMF, SMF, UPF, UDM, AUSF, NEF.
- **Session Management and Mobility Management:** Handling user sessions and handovers.
- **Edge Computing Integration:** Deploying computing resources closer to the user.
- **Case Study:** Analyzing the flow of a PDU session establishment in a 5G core network.

Module 7: AI/Machine Learning for 5G/6G Networks

- **AI/ML in RAN Optimization:** Intelligent resource allocation, interference management, beamforming.
- **AI/ML for Network Automation:** Self-organizing networks (SON), predictive maintenance.
- **AI/ML for Security and Anomaly Detection:** Identifying network threats.
- **Data Collection and Model Training for Wireless Systems:** Best practices and challenges.
- **Case Study:** Implementing an AI-driven resource allocation algorithm for a congested 5G cell.

Module 8: Integrated Sensing and Communication (ISAC)

- **ISAC Concept and Motivations:** Unifying communication and sensing functionalities.
- **Key ISAC Technologies:** Joint waveform design, interference management between sensing and communication.
- **Use Cases for ISAC:** Autonomous driving, smart cities, human-robot interaction.
- **Performance Metrics for ISAC:** Communication throughput vs. sensing accuracy.
- **Case Study:** Designing an ISAC system for concurrent vehicle-to-everything (V2X) communication and radar sensing.

Module 9: Reconfigurable Intelligent Surfaces (RIS)

- **RIS Principles:** Passive and active RIS, metasurfaces, signal reflection/refraction.

- **RIS Channel Modeling:** Near-field and far-field considerations.
- **RIS for Coverage Extension and Interference Mitigation:** Enhancing signal quality.
- **Joint Optimization of RIS and Transceiver:** Beamforming with RIS.
- **Case Study:** Deploying RIS to extend 5G coverage into a challenging indoor environment.

Module 10: Terahertz (THz) Communication for 6G

- **THz Spectrum and Characteristics:** Ultra-high bandwidth, short range, molecular absorption.
- **THz Transceiver Design:** Novel hardware, plasmonic antennas.
- **Channel Modeling for THz:** Propagation models, atmospheric effects.
- **Applications of THz Communication:** Holographic communication, high-speed data centers.
- **Case Study:** Designing a THz communication link for ultra-fast data transfer within a data center.

Module 11: Non-Terrestrial Networks (NTN) and Global Coverage

- **Integration of Satellites, Drones, and HAPS:** Extending network coverage.
- **Low Earth Orbit (LEO) Satellite Constellations:** Starlink, OneWeb, Project Kuiper.
- **Challenges of NTN Integration:** Handover, latency, resource management.
- **NTN for Underserved Areas and Disaster Relief:** Providing ubiquitous connectivity.
- **Case Study:** Designing a hybrid terrestrial-satellite network for remote area connectivity.

Module 12: Security and Privacy in 5G/6G

- **5G Security Architecture:** Authentication, key management, network slicing security.
- **Threat Vectors in 5G/6G:** Supply chain attacks, IoT vulnerabilities, AI/ML security risks.
- **Privacy Enhancing Technologies:** Federated learning, differential privacy.
- **Quantum Cryptography and Post-Quantum Security:** Future-proofing communication.
- **Case Study:** Analyzing a cyber-attack scenario on a 5G private network and proposing mitigation.

Module 13: Edge Computing and Distributed AI in 6G

- **Mobile Edge Computing (MEC) / Multi-access Edge Computing:** Processing data at the network edge.
- **Distributed AI Architectures:** Collaborative intelligence across devices and networks.
- **Edge AI for Real-time Applications:** AR/VR, autonomous systems, industrial automation.
- **Orchestration and Management of Edge Resources:** Load balancing, task offloading.
- **Case Study:** Implementing an edge computing solution for real-time video analytics for smart city traffic management.

Module 14: Emerging Technologies for 6G Vision

- **Holographic Communications:** Enabling truly immersive experiences.
- **Tactile Internet and Haptic Communications:** Real-time physical interaction over networks.
- **Blockchain for Decentralized Network Management:** Security and transparency.
- **Digital Twins for Network Modeling and Optimization:** Virtual r

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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