Training Course on Software-Defined Radio (SDR) and Cognitive Radio

Professional Development Training Course Outline

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

Course Introduction

This intensive training course provides a comprehensive exploration of Software-Defined Radio (SDR) and Cognitive Radio (CR), equipping participants with the foundational knowledge and practical skills to design, implement, and analyze flexible and intelligent wireless communication systems. Training Course on Software-Defined Radio (SDR) and Cognitive Radio delves into the architectural principles of SDR, emphasizing the migration of traditional hardware functions to reconfigurable software, and then extends into the realm of CR, where radios can intelligently sense, learn, and adapt to their environment. Attendees will gain hands-on experience with popular SDR platforms and programming tools, preparing them to innovate in areas such as 5G/6G communication, dynamic spectrum access, electronic warfare, and the Internet of Things (IoT).

In an increasingly complex and crowded electromagnetic spectrum, the demand for adaptable and efficient wireless solutions is paramount. This course covers trending topics including spectrum sensing algorithms, dynamic spectrum sharing, reinforcement learning for cognitive control, AI/ML in SDR architectures, and the role of SDR/CR in Non-Terrestrial Networks (NTN) and Integrated Sensing and Communication (ISAC). Through a blend of theoretical derivations, practical programming exercises, and real-world case studies, participants will develop invaluable expertise in building advanced, intelligent radio systems that can optimize performance, mitigate interference, and ensure robust connectivity in challenging and unpredictable environments.

Programme Curriculum

Training Course on Software-Defined Radio (SDR) and Cognitive Radio

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10 Days

Course Objectives

1. Understand the core concepts and architectural components of Software-Defined Radio (SDR).
2. Grasp the fundamental principles and benefits of Cognitive Radio (CR).
3. Design and implement digital front-end processing for SDR receivers and transmitters.
4. Utilize popular SDR platforms (e.g., USRP, RTL-SDR) for practical experimentation.
5. Develop and apply spectrum sensing algorithms for environmental awareness.
6. Implement dynamic spectrum access and spectrum sharing techniques.
7. Understand and apply machine learning algorithms for cognitive decision-making in radios.
8. Design adaptive modulation and coding schemes based on channel conditions.
9. Explore the role of SDR/CR in electronic warfare (EW) and counter-EW.
10. Analyze performance metrics and challenges in cognitive radio networks.
11. Understand the integration of SDR/CR with 5G/6G communication systems.
12. Discuss emerging trends such as AI-native radios and integrated sensing and communication (ISAC).
13. Contribute to the development of intelligent and flexible wireless communication systems.

Organizational Benefits

1. Increased Flexibility and Adaptability: Rapid deployment and modification of wireless systems.
2. Optimized Spectrum Utilization: Efficient use of scarce and valuable radio spectrum.
3. Enhanced System Performance: Intelligent adaptation to improve reliability and data rates.
4. Reduced Hardware Costs: Leveraging generic hardware and software reconfigurability.
5. Faster Innovation Cycles: Rapid prototyping and testing of new wireless concepts.
6. Improved Interference Mitigation: Intelligent techniques to counter jamming and interference.
7. Competitive Advantage: Leading-edge expertise in advanced wireless technologies.
8. Cost-Effective Research & Development: Simulating and experimenting with complex radio scenarios.
9. Skilled Workforce: Empowered employees proficient in SDR/CR design and implementation.
10. Strategic Positioning: Preparedness for future wireless standards and applications.

Target Participants

- Wireless Communication Engineers
- RF Engineers
- DSP Engineers
- Network Architects and Planners
- R&D Engineers in Telecommunications
- Electronic Warfare (EW) Specialists
- Researchers and PhD Students in Wireless Communications
- Professionals involved in 5G/6G, IoT, and Next-Gen Wireless Systems
- Software Engineers with an interest in wireless technology

Course Outline

Module 1: Introduction to Software-Defined Radio (SDR)

- **What is SDR?** Definition, evolution from traditional radio, key advantages.
- **SDR Architecture:** RF Front-End, Analog-to-Digital Converter (ADC), Digital-to-Analog Converter (DAC), Digital Signal Processor (DSP), General Purpose Processor (GPP).
- **Benefits of SDR:** Flexibility, reconfigurability, rapid prototyping, cost-effectiveness.
- **Hardware Platforms for SDR:** USRP, RTL-SDR, LimeSDR, BladeRF.
- **Case Study:** Overview of a typical SDR setup for basic signal reception and transmission.

Module 2: Digital Signal Processing (DSP) for SDR

- **Review of Digital Filtering:** FIR, IIR filters for baseband processing.
- **Sampling Rate Conversion:** Decimation, Interpolation, Polyphase filters.
- **Digital Up/Down Conversion:** Converting between RF and baseband frequencies.
- **FFT and Spectral Analysis:** Real-time spectrum monitoring.
- **Case Study:** Implementing a digital down-converter in software to process an RF signal.

Module 3: SDR Programming Environments and Tools

- **Introduction to GNU Radio:** Flowgraph design, blocks, and signal processing.
- **Python for SDR:** Integrating SDR hardware with Python libraries.
- **C++/Python Development for SDR:** Custom block creation and performance optimization.
- **API and Driver Interfaces for SDR Hardware:** Interacting with USRP/RTL-SDR.
- **Case Study:** Building a simple FM radio receiver using GNU Radio Companion.

Module 4: Modulation and Demodulation in SDR

- **Digital Modulation Schemes:** ASK, FSK, PSK, QAM implementation.
- **Demodulation Algorithms:** Coherent vs. non-coherent detection.
- **Synchronization Techniques:** Carrier synchronization, symbol timing recovery.
- **Adaptive Modulation:** Adjusting modulation order based on channel conditions.
- **Case Study:** Implementing and testing a QPSK modulator and demodulator in an SDR environment.

Module 5: Introduction to Cognitive Radio (CR)

- **Definition of Cognitive Radio:** Intelligence, learning, and adaptation.
- **CR Capabilities:** Sensing, learning, decision-making, reconfigurability.
- **Cognitive Cycle:** Observe, Orient, Decide, Act (OODA loop) for radio.
- **Enabling Technologies for CR:** SDR, AI/ML, dynamic spectrum access.

- **Case Study:** Discussing the potential benefits of CR for public safety communication.

Module 6: Spectrum Sensing Techniques

- **Energy Detection:** Simplicity and limitations.
- **Matched Filter Detection:** Requires knowledge of primary user signal.
- **Cyclostationary Feature Detection:** Exploiting cyclic statistics.
- **Waveform-Based Sensing:** Using known patterns for detection.
- **Case Study:** Implementing an energy detection-based spectrum sensor using an SDR platform.

Module 7: Dynamic Spectrum Access (DSA) and Sharing

- **DSA Paradigms:** Spectrum overlay (interweave), spectrum underlay, spectrum incumbent access.
- **Spectrum Sharing Models:** Licensed shared access (LSA), Citizens Broadband Radio Service (CBRS).
- **Challenges in DSA:** Interference management, regulatory compliance.
- **Resource Allocation for DSA:** Optimizing power, bandwidth, and time.
- **Case Study:** Designing a dynamic spectrum access strategy for secondary users in a TV white space scenario.

Module 8: Machine Learning for Cognitive Radio

- **Supervised Learning:** Classification for modulation identification, spectrum occupancy.
- **Unsupervised Learning:** Clustering for unknown signal classification.
- **Reinforcement Learning (RL):** Optimal policy learning for dynamic resource allocation.
- **Deep Learning for Spectrum Sensing and Optimization:** CNNs, LSTMs for complex environments.
- **Case Study:** Training an RL agent to select optimal transmit power in a dynamic interference environment.

Module 9: Cognitive Radio Network Architectures

- **Centralized vs. Distributed CR Networks:** Control plane options.
- **Cooperative Spectrum Sensing:** Combining sensing results from multiple radios.
- **Routing in Cognitive Networks:** Adapting routes based on spectrum availability.
- **Cross-Layer Design for CR:** Optimizing across physical, MAC, and network layers.
- **Case Study:** Designing a cooperative spectrum sensing system for a sensor network.

Module 10: SDR/CR for Electronic Warfare (EW)

- **Electronic Support (ES):** Signal intelligence, reconnaissance using SDR.
- **Electronic Attack (EA):** Jamming and deception using SDR.
- **Electronic Protection (EP):** Anti-jamming and LPI/LPD techniques.
- **Cognitive EW:** Adaptive jamming and counter-jamming strategies.
- **Case Study:** Simulating a simple jamming scenario and designing an anti-jamming technique using SDR.

Module 11: SDR/CR in 5G/6G and Beyond

- **SDR for 5G New Radio (NR):** Flexible base station and user equipment.
- **Cognitive Radio for 6G Vision:** AI-native air interface, self-organizing networks.
- **Dynamic Spectrum Management in 5G/6G:** Enhancing spectral efficiency.
- **AI/ML for Network Automation:** Self-healing, self-optimizing networks.
- **Case Study:** Discussing how SDR principles enable flexible deployment of different 5G numerologies.

Module 12: Advanced SDR Applications

- **Cognitive IoT and LPWAN:** Adaptive connectivity for resource-constrained devices.
- **Non-Terrestrial Networks (NTN):** SDR-enabled satellite and drone communications.
- **Integrated Sensing and Communication (ISAC):** Dual-use radios for communication and sensing.
- **SDR for Amateur Radio and Scientific Research:** Flexible experimentation platforms.
- **Case Study:** Developing an SDR-based platform for monitoring and communicating with IoT devices.

Module 13: SDR Hardware and Software Integration

- **Digital Hardware Acceleration:** FPGAs for high-speed DSP in SDR.
- **Software-Hardware Co-design:** Optimizing performance between software and hardware.
- **Real-time Operating Systems (RTOS) for SDR:** Ensuring deterministic behavior.
- **Interfacing with External Systems:** Ethernet, USB, PCIe for data transfer.
- **Case Study:** Integrating an FPGA-based accelerator with a GPP-based SDR system for high-throughput processing.

Module 14: Practical SDR Projects and Experimentation

- **Building a Custom Transceiver:** From basic components to a functional system.
- **Spectrum Monitoring and Analysis:** Real-time spectrum visualization and analysis.
- **Implementing a Simple Cognitive Loop:** Sensing, decision, and reconfigurability.
- **Troubleshooting SDR Setups:** Common issues and solutions.

Training Methodology

- Interactive instructor-led sessions
- Hands-on practical exercises and labs
- Real-world case study simulations
- Group activities and peer learning
- Quizzes and post-module assessments

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

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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