



# Fundamentals of Wireless Systems and Networks

603A

5 day

## Overview :

This unique, fast-track course has been designed to meet the needs of staff wanting a broad understanding of a range of modern wireless communications systems and networks. The course provides a solid understanding of wireless networks, technologies, protocols, and a comprehensive, vendor-neutral coverage of wireless solutions and supporting technologies, including RF, microwave, HF/UHF, GSM, GPRS, EDGE, UMTS (3G), CDMA, W-CDMA, TETRA trunk mobile networks, 802.11 Wi-Fi Wireless LANs, Wireless WANs, WiMAX networks, 4G and 5G networks, Bluetooth and ZigBEE.

The course begins with an overview of the motivations for wireless communications, and a review of the technical constraints of wireless communications. Delegates learn how radio communications works, and examine the challenges and new developments in fundamental wireless technologies.

The course then examines the leading technologies and protocols used in modern radio systems and wireless networks.

## Target Audience :

## Objectives:

- Understand and explain the fundamental principles of a range of wireless communications systems.
  - Understand and apply the essential concepts of Radio Frequency (RF) technology, including RF planning, RF-related calculations and spread spectrum technologies.
  - Understand some of the fundamental problems and constraints of wireless systems, and apply these to problem analysis and troubleshooting of wireless networks.
  - Understand the essentials of radio frequency (RF) propagation, Fresnel Zone, and more.
  - Understand the design and operation of wireless radio hardware and antenna.
  - Understand the sources, causes and effects of RF interference, and techniques for mitigating against interference.
  - Describe the rules governing wireless operation in the licensed and license-exempt bands, to comply with local radio regulations.
  - Understand and explain the roles of modulation, multiplexing, coding (including Block, RS, Viterbi decoding), puncturing, and more.
  - Describe the mainstream media and multiple access schemes used in modern wireless networks, including FDMA, TDMA and CDMA
  - Describe spread spectrum technologies, multiplexing and modulation technologies, including FHSS, DSSS, PBCC and OFDM
  - Understand and explain the concepts behind 1G, 2G, 2.5G, 3G, 4G and 5G networks.
  - Understand and explain the modern wireless network architectures, including Cellular Mobile Communications, Wireless LAN, Wireless PAN, Hot Spots, Mesh, Wireless WAN, Roaming, Voice and Multi-Media over Wireless
- Describe the architecture and operation of the following wireless networks at a technical level:
- Global System for Mobile communications - GSM
  - General Packet Radio Service - GPRS
  - Universal Mobile Telecommunications System - UMTS
  - Terrestrial Trunked Radio - TETRA
  - IEEE 802.11 Wireless LANs - Wi-Fi
  - IEEE 802.16 - WiMAX
  - IEEE 802.15.1 - Bluetooth
  - IEEE 802.15.4 - ZigBee
  - Understand the security issues with 802.11 WLANs, and the security countermeasures that are available.
  - Describe the security mechanisms used in GSM, GPRS, UMTS, TETRA, Wi-Fi, WiMAX, Bluetooth and ZigBee wireless networks.

## Course Content :

Essential principles of radio communications  
Electromagnetic radiation  
Review of RF bands  
Radio propagation principles  
Super heterodyne receiver  
RF propagation  
Free Space Path Loss (FSPL)  
Reflection, Refraction, Diffraction, Absorption  
Multipath effects  
Multipath Rayleigh fading  
Delay spread  
Frequency-selective fading  
Fresnel Zones

Radio Frequency Equipment and Transmissions  
The basics of radio  
Radio antennas  
- Omni-directional  
- Semi-directional  
- Highly-directional  
Dipole, patch, yagi, grid, parabolic  
Cables and connector usage requirements  
Amplifiers, attenuators, lightning arrestors, splitters  
Spread Spectrum technologies: FHSS, DSSS, PBCC, OFDM  
WLAN data rates and ranges

Fundamentals of 3G and UMTS  
What defines 3G networks?  
What is iMode?  
What is UMTS?  
The role of UMTS as a 3G System  
Services offered by UMTS Systems  
Evolving services from GSM and GPRS to UMTS  
The Virtual Home Environment (VHE)  
Wideband CDMA (W-CDMA)  
UMTS Radio Access Network (UTRAN)  
Latest developments with UMTS  
IMT-2007  
HSDPA Fundamentals (UMTS Rel 5)  
HSUPA Fundamentals (UMTS Rel 6)

Fundamentals of TETRA  
Overview of Trunk Mobile Communications  
Trunking concepts  
Overview of iDEN  
Overview of Tetrapol  
Introduction to TETRA technology  
Operational TETRA systems and equipment  
TETRA Features and Services  
Voice and Data services  
Circuit-switched data  
IP packet data

Fundamentals of WiMAX  
WiMAX applications  
WiMAX implementation scenarios  
WiMAX in LOS and NLOS environments  
WiMAX market opportunities  
WiMAX vendor and market review  
Market size, rate of growth  
Review of leading WiMAX equipment vendors  
Current WiMAX deployments  
The role of IEEE 802.16  
WiMAX versus IEEE 802.20 (MBWA)  
802.16 Connections and Layers  
The Standards organisations:  
- IEEE  
- ETSI  
- WiMAX Forum  
Current 802.16 standards  
- 802.16  
- 802.16a  
- 802.16-2007 (802.16)  
- 802.16c  
- 802.16e  
- 802.16f  
- 802.16i  
Overview of IEEE 802.16

RF channels Channel reuse Interference Common Causes of RF Interference Signal Range System Operating Margin (SOM) What are Hidden Nodes? What is the Near/Far issue?	Short Data Service, SDS Voice coding Direct Mode Operation (DMO) Spectral efficiency TETRA Architecture BS, LSC, MSC, LS, MT, TE TM Air Interfaces Direct Mode Air Interface Gateway and Repeater stations Spectrum allocations and channel assignments Physical and Logical channels TDMA structure Medium Access Control sublayers Logical Link Control layer Frame, slot and burst structures TETRA voice coding TETRA and Data Networks TETRA IP TETRA over IP (ToIP) solutions TETRA authentication, encryption and End-to-End encryption	Physical network architecture Protocol architecture PHY layer PMD layers MAC layer Higher protocol layers 10-66GHz bands 802.16a extension for 2-11GHz bands Orthogonal Frequency Division Multiplexing (OFDM) Orthogonal Frequency Division Multiple Access (OFDMA) Adaptive modulation Physical Layer for 10-66GHz Physical Layer for 2-11GHz Time Division Duplexing (TDD) Frequency Division Duplexing (FDD) WiMAX Mobility - 802.16e
Modulation and Performance Comparison of modulation techniques Types of modulators and demodulators BPSK, QPSK, MPSK, pi/4-QPSK QAM BFSK, MFSK Performance of modulations over fading channels Antenna and space diversity Multi-antenna array to improve bandwidth efficiency BLAST MSK-type signals: SQPSK, MSK, GMSK Adjacent channel interference	Introduction to Wireless LANs The Wireless LAN industry Wireless LAN applications Organisations and Vendors FCC and ETSI rules for RF Worldwide frequency ranges and channels IEEE 802.11 family of standards IEEE 802.11a, b, g, Pre-n Wi-Fi Alliance standardisation Access Points, Service Sets SSID, BSSID The Distribution System (DS) Wireless stations (STA) Client devices and accessories SOHO WiFi networks Wireless Residential gateways Wireless Repeaters Wireless LAN switches Wireless Routers Enterprise Wireless Gateways Enterprise Encryption Gateways Voice over Wi-Fi (VoWiFi) systems Wireless Bridges Wireless workgroup bridges	802.16 Physical and MAC Layers Downlink Data Path Uplink Data Path Radio Aspects Space Time Coding (STC) Adaptive Antenna Systems (AAS) Multiple Inputs, Multiple Outputs (MIMO) Spatial Division Multiple Access (SDMA) The WiMAX MAC Layer Convergence Layers Roles of ATM and IP WiMAX frame formats Starting up a Subscriber Station WiMAX Quality of Service (QoS) Current WiMAX VoIP solutions The WiMAX security architecture
Information Theory Shannon's equation Why code? Orthogonal Frequency Division Multiplexing (OFDM) Coding Techniques Block and Reed-Solomon coding Interleaving Viterbi algorithm Trellis coding Convolutional coding Turbo coding Continuous Phase Modulation, CPM	Wireless Ad Hoc Networks Ad Hoc WLAN concepts IBSS processes Creating and using an Ad Hoc network	Fundamentals of Bluetooth The role of Bluetooth Bluetooth standards Applications for Bluetooth, Bluetooth usage models The Bluetooth protocol architecture Frequency band and RF channels Bluetooth frequency hopping The Packet format SCO links and ACL links, data rates Device addressing Controller states, Access procedures Piconets, Scatternets Bluetooth Security: - Authentication, Encryption Example Bluetooth hardware Bluetooth antenna designs Size constraints Interference and Co-existence with other ISM band users
Fundamental Multiple Access Schemes FDMA TDMA CDMA CSMA PRMA	802.11 MAC Layer Joining a wireless LAN Beacons, Passive Scanning, Active Scanning (Probing) Authentication Association Dynamic Rate Selection (DRS / ARS) Roaming in a wireless network IEEE 802.11f Inter-Access Point Protocol (IAPP) 802.11 Power management RTS/CTS Packet fragmentation	Fundamentals of ZigBee What is ZigBee? Networking capabilities Data rates, ranges Target markets and applications ZigBee Standards and technology IEEE WPAN standards overview ZigBee Frequencies and channels Power levels Antenna 802.15.4 PHY 802.15.4 MAC layer Addresses CSMA/CA MAC scheme Beacons Scanning Association Data transfer ZigBee topologies and applications Point-to-point topology: Star topology: Cluster tree Wired integration: Roaming and bridging to other networks
Wireless Network Architectures Defining 1G, 2G, 2.5G, 3G, 4G and 5G networks Wireless LAN Wireless PAN Hot Spots Mesh networking Wireless WAN Roaming between wireless networks Voice and Multi-Media over Wireless		
Mobile Radio System Fundamentals Cellular radio systems Frequency reuse Handoff Near-far problem Coverage evaluation Capacity and quality of service		
Overview of Current Cellular Standards NMTS AMPS, TACS, D-AMPS GSM TDMA, IS-136 CDMA, IS-95 WCDMA	Wireless LAN Security Types of wireless network attacks War Driving - how easy is it? Netstumbler, Kismet, Aircnort Wireless packet sniffers and analysers Wired Equivalence Privacy (WEP) Configuring WEP The problems with WEP Effective wireless security solutions What is IEEE 802.1x? What is EAP? RADIUS / AAA authentication What is TKIP? Cisco LEAP EAP-TLS, EAP-TTLS and PEAP Wi-Fi Protected Access (WPA) v1	
Fundamentals of GSM GSM features and services The GSM Architecture GSM in operation Attaching to the network GSM MO and MT calls Overview of the GSM Air Interface Circuit-Switched Data (CSD)		

## Course Outline

High-Speed Circuit-Switched Data (HSCSD) Short Message Service (SMS) Unstructured Supplementary Services Data (USSD)	WPA v2 / IEEE 802.11i Advanced Encryption Standard (AES) VPN-based security solutions Issues with VPNs and wireless LANs	ZigBee Upper layer protocols ZigBee Security ZigBee security modes ACL Data encryption
Fundamentals of GPRS Drivers for mobile data Features and applications of GPRS GPRS architecture and operation GPRS and the Internet GPRS protocol architecture EDGE and E-GPRS GPRS in 3G networks Current GPRS services GPRS products and applications Blackberry		Review of Wireless Systems Security Security measures built into: - GSM - GPRS - UMTS - 802.11 Wi-Fi networks - Wi-Fi war driving - ASLEAP - Bluetooth - Bluetooth exploits, Bluesnarfing, etc

**Course Prerequisites :****Testing and Certification :****Follow on Courses :****Further Information :**

Hands-on practical exercises

The course incorporates a range of hands-on practical exercises, including the following:

- Scanning radio frequencies and identifying radio network transmissions.
- Building IEEE 802.11 Wi-Fi Networks.
- Configuring and working with 802.11 Wi-Fi wireless clients.
- Securing 802.11 Wi-Fi networks with WEP, WPA personal, and WPA enterprise.
- Working with Bluetooth equipment and Piconets
- Working with GPRS and UMTS equipment for mobile data network access.

603A/	For More information, or to book your course, please call us on 0118 977 7766 email <a href="mailto:info@globalknowledge.co.uk">info@globalknowledge.co.uk</a> Global Knowledge, Mulberry Business Park, Fishponds Road, Wokingham Berkshire RG41 2GY UK  <a href="http://www.globalknowledge.co.uk/">http://www.globalknowledge.co.uk/</a>
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