

# Conclusion

The first book introduces the reader to the existing systems of fixed and mobile communications. Particular attention is paid to changes in the structure of wireless multi-station radio access networks and how it affected the architecture of radio receivers. The introduction of digital modulation techniques and optimal signal processing techniques on the receiving side has led to changes in the traditional receiver structures of analog modulation modes and the emergence of new ones based on the advantages of digital signal processing methods.

The classical structure of radio engineering systems has radically changed with the organization of communication between mobile users and the division of the service area into cells included in the terrestrial radio access network. This led to an increase in the role of the physical channel between the subscriber and the BS, which determines the performance indicators of the system, and the organization of packet data transmission over cable (copper and optical) and radio lines. Such a complex configuration of networks and their interaction made it possible to organize handover of subscribers within their own network and in the networks of other operators due to the use of compatible interfaces at various levels of interaction of open OSI systems.

All processes at the physical layer are controlled from the upper OSI layers, forming at the output of the BS transmitter of each cell a set of commands to MS characterizing the data transmission rate, modulation type, frequency band, clock signals, MS transmitter power control, etc. All this indicates the complexity signal processing algorithms in the receivers of each BS and MS, not taking into account the algorithms introduced in the system to increase the noise immunity of signals, antenna control, methods of coding, and signal detection. All this indicates a close relationship between the structure of radio access networks and the architecture of the receiver.

Open space, as a signal transmission guiding system, is affected by the external environment and highly dependent on the occupied bandwidth allocated to system, operating frequency, and signal propagation features. To reduce the influence of the external environment, the transmission of information about the state of the channel in the “up” direction is organized, which are included in the instructions for the MS, which determine the type of modulation and the data transmission rate for the transmitter.

A separate problem solved in the receiver is to build a non-tunable RF front-end when operating in the frequency ranges of systems of different standards and the occupied bandwidth of operating frequencies. This becomes especially relevant when mastering the frequency band allocated to the 5G standard. The RF front-end and its components must be designed to meet the stringent standards of each interoperating wireless communication system.

It is proposed to assess the properties of individual stages of the receiver and the RF front-end as a whole, with the possibility of analysis in the frequency domain and in the time interval in the MicroCap environment, which has a friendly interface and allows the use of conventional graphic designations adopted for the circuit diagrams of radio engineering devices.

The book describes the interconnection of systems, networks, and radio receivers as an integral part of such architectures. Possible ways of constructing receivers at the level of structural diagrams are shown, and influencing effects are described, starting with the properties of the radio channel and ending with the components used, as well as ways to assess their properties using circuit simulation.

The designs of the individual stages and possible ways of their implementation will be described in the second book “Elements of radio receivers of digital radio electronic systems” (in press).

# Abbreviations

|          |  |
|----------|--|
| AAA      | Authentication, authorization, accounting                            |
| AAC      | Advanced audio coding  |
| AAS      | Adaptive antenna system  |
| AC       | Adjacent channel   |
| ACF      | Auto-correlation function  |
| ACI      | Adjacent channel interference, adaptive compensator of interferences |
| ACK/NACK | Acknowledge/not acknowledge  |
| ADC      | Analog to digital conversion   |
| ADSL     | Integrated digital subscriber line                                   |
| AE       | Active element   |
| AES      | Automatic error correction   |
| AFC      | Amplitude-frequency characteristic, automatic frequency control      |
| AFR      | Amplitude-frequency response   |
| AGC      | Automatic gain control   |
| AGCN     | Access grant channel   |
| AIS      | Analyzer of interference situation                                   |
| AM       | Amplitude modulation   |
| AMPS     | Advanced mobile personal system                                      |
| AMR      | Adaptive multi-rate  |
| AMS      | Adaptive MIMO switching  |
| AP       | Access point   |
| APC      | Automatic power control  |
| ARN      | Active remote node   |
| ASK      | Amplitude shift keying   |
| ASM      | Antenna switch module, analog signal multiplier                      |
| ASN      | Access service network   |
| ATM      | Asynchronous transfer mode   |
| ATS      | Automatic telephone station  |
| ATSC     | Advanced television systems committee                                |
| AUC      | Authentication center  |
| AWGN     | Additive white Gaussian noise  |
| AWPM     | Amplitude-width pulse modulation                                     |
| BB       | Base band  |
| BBU      | Base band unit   |
| BCCH     | Broadcast control channel  |
| BER      | Bit error rate   |
| BLAST    | Bell laboratories layered space-time                                 |
| BM       | Base model   |
| BPF      | Band pass filter   |
| BPSK     | Binary phase shift keying  |
| BS       | Base station   |
| BSC      | Base station controller  |
| BSIC     | Base station identity code   |

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|         |   |
|---------|---|
| BSS     | Basic service set, base station subsystem                           |
| BT      | Bipolar transistor  |
| BTS     | Base transceiver station  |
| BOC     | Binary offset code  |
| BQM     | Balanced quadrature mixers  |
| CA      | Collision avoidance, carrier aggregation                            |
| CAT     | Cable television  |
| CC      | Component carrier   |
| CCCH    | Common control channel  |
| CCI     | Co-channel interference   |
| CCK     | Complementary code keying   |
| CCN     | Cognitive control network   |
| CCS     | Control-correcting station  |
| CD      | Compact disk  |
| CDMA    | Code division multiple access                                       |
| CDMA-DS | Code division multiple access direct spread                         |
| CDMA-FH | Code division multiple access frequency hopping                     |
| CDMA-TH | Code division multiple access time hopping                          |
| CEPT    | European Conference of Postal and Telecommunication Administrations |
| CMN     | Cognitive mesh network  |
| CMOS    | Complementary metal-oxide semiconductor                             |
| C-NMS   | Cognitive network management system                                 |
| CO      | Central office  |
| C-OFDM  | Code OFDM   |
| CoMP    | Coordinated multi-point   |
| CP      | Central port  |
| CPE     | Customer premises equipment   |
| CPC     | Cognitive pilot channel   |
| CR      | Cognitive radio   |
| C-RAN   | Cloud radio access network  |
| CRC     | Cycling redundancy check, cyclic redundancy code                    |
| CSMA    | Carrier-sense multiple access                                       |
| CSN     | Circuit switched network  |
| CSP     | Central system processor  |
| CSPDN   | Circuit-switched public data network                                |
| CSS     | Customer switching system   |
| CT      | Cordless telephony  |
| CTA     | Cordless terminal adapter   |
| CTM     | Cordless terminal mobility  |
| CTV     | Color TV  |
| CWN     | Cognitive wireless network, composite wireless network              |
| DAA     | Data access arrangement   |
| DAB     | Digital audio broadcasting  |
| DAMA    | Demand assigned multiply access                                     |
| DAMPS   | Digital advanced mobile phone system                                |
| DBPSK   | Differential double-position phase shift keying                     |
| DC      | Directional coupler, direct current, data center                    |
| DCI     | Downlink control information  |
| DCMS    | Differential correction and monitoring system                       |
| DCS     | Digital cellular system   |
| DDS     | Direct digital frequency synthesizer                                |
| Det     | Detector  |
| DECT    | Digital enhanced cordless telecommunication                         |
| DFS     | Dynamic frequency selection   |
| DRiVE   | Dynamic radio for IP services in vehicular environments             |

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|          |  |
|----------|--|
| DRM      | Digital radio mondiale                             |
| D-RAN    | Distributed RAN                                    |
| DRSF     | Double-circuit pass-band filter                    |
| DQPSK    | Differential quadrature phase shift keying         |
| DSP      | Dynamic spectrum allocation                        |
| DSMA     | Digital sense multiple access                      |
| DS-CDMA  | Direct spectrum CDMA                               |
| DSP      | Digital signal processor                           |
| DSSS     | Direct sequent spread spectrum                     |
| DSL      | Digital subscriber line                            |
| DSS-UWB  | Direct spread spectrum UWB                         |
| DTV      | Digital television                                 |
| DVB      | Digital video broadcasting                         |
| DVB-T    | Digital video broadcasting terrestrial             |
| DWDM     | Dense wavelength-division multiplexing             |
| E-UTRAN  | Enhanced UMTS terrestrial radio access network     |
| ECC      | Electronic communications committee (of Europe)    |
| RMF      | Electromotive force                                |
| EDACS    | Enhanced digital access system                     |
| EDGE     | Enhanced data rate for global evolution            |
| EGSM     | Extended Global System for Mobile Communications), |
| EIR      | Equipment identification register                  |
| eMBB     | Enhanced Mobile Broadband                          |
| EMC      | Electromagnetic compatibility                      |
| EMF      | Electromotive force                                |
| EMI      | Electromagnetic interference                       |
| EPC      | Electronic product code                            |
| eNB      | Evolution node B, base station                     |
| EPIC     | Electrical-physical information converter          |
| ET       | Ephemerid time                                     |
| ETSI     | European Telecommunications Standards Institute    |
| FBC      | Feedback circuit                                   |
| FBMC     | Filter bank multi carrier                          |
| FC       | Frequency converter                                |
| FCC      | Federal Commission of Communication                |
| FCCH     | Frequency correction channel                       |
| FCD      | Frequency channel division                         |
| FDD      | Frequency division duplex, full function device    |
| FDM      | Frequency division multiple                        |
| FDMA     | Frequency division multiple access                 |
| FEC      | Forward error correction                           |
| FEM      | Front-end module                                   |
| FET      | Field-effect transistor                            |
| FFD      | Full function device                               |
| FFT      | Fast Fourier transform                             |
| FIC      | Fast information channel                           |
| FH       | Frequency hopping                                  |
| FHDC     | Frequency hopping diversity coding                 |
| FHSS     | Frequency hopping spread spectrum                  |
| FHSS-UWB | Frequency hopping spread spectrum UWB              |
| FI       | Fluctuation interference                           |
| FIC      | Fast information channel                           |
| FIFO     | First in, first out                                |
| FLS      | Filter of lumped selectivity                       |
| FM       | Frequency modulation                               |

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|          |   |
|----------|---|
| F-OFDM   | Filtered orthogonal division multiplexing                           |
| FS       | Frequency synthesizer   |
| FSA      | Field spectrum allocation   |
| FSK      | Frequency shift keying  |
| FSS      | Federal communication commission (of USA)                           |
| FUSC     | Fully used sub-carrier  |
| GBCMC    | Ground-based complex for monitoring and control                     |
| GBS      | Ground-based station  |
| GERAN    | GSM EDGE radio access network                                       |
| GFDM     | Generalized frequency division multiplexing                         |
| GMSC     | Gateway mobile switching center                                     |
| GMSK     | Gaussian minimum shift keying                                       |
| GNSS     | Global navigational satellite system                                |
| GoS      | Grade of service  |
| GPIO     | General purpose input/output  |
| GPRS     | General packet radio service  |
| GPON     | Gigabit passive optical network                                     |
| CP       | Compression point, cyclic prefix                                    |
| CR       | Cognitive radio   |
| GSO      | Geostationary orbit   |
| GTP      | GPRS tunneling protocol   |
| HARQ     | Hybrid automatic repeat request                                     |
| HBT      | Heterojunction bipolar transistor                                   |
| HD       | High definition   |
| HDTV     | High-definition television  |
| HDR      | High data rate  |
| HEMT     | High emitted mobility transit                                       |
| HF       | High frequency  |
| HI       | HARQ indicator  |
| HIPERLAN | High performance local area network                                 |
| HIPERMAN | High performance metropolitan area network                          |
| HLR      | Home location register  |
| HoA      | Home address  |
| HSAGC    | High-speed AGC  |
| HSCSD    | High-speed circuit switched data                                    |
| HSDPA    | High-speed downlink packet access                                   |
| HSPA     | High-speed packet access  |
| HSUPA    | High-speed uplink packet access                                     |
| I        | Inphase   |
| IASA     | Inter access spectrum anchor  |
| IBOC     | In band on channel  |
| IC       | Integrated circuit, input circuit                                   |
| ICI      | Inter-channel interferences   |
| iDEN     | Interactive data entry network, integrated digital enhanced network |
| IGSL     | Integrated digital subscriber line                                  |
| IEEE     | Institute of Electrical and Electronics Engineers                   |
| IEC      | International Electrotechnical Commission                           |
| IF       | Intermediate frequency  |
| IFA      | Intermediate frequency amplifier                                    |
| IMA2     | Intermodulations-apart-product 2                                    |
| IMD      | Intermodulation distortion  |
| IMP2     | Intermodulations-product 2  |
| IMP3     | Intermodulations-product 3  |
| IMS      | IP multimedia subsystem   |
| IMSI     | International mobile subscriber identity                            |

|                               |   |
|-------------------------------|---|
| IMT/UMTS                      | International mobile telecommunication/universal mobile telecommunications system     |
| IN                            | Input circuit   |
| IOS                           | International organization on standardization   |
| IP                            | Internet protocol   |
| IP2                           | Intercept point on 2 harmonic   |
| IP3                           | Intercept point on 3 harmonic   |
| IPD                           | Incumbent profile detection   |
| IPv4                          | Internet protocol version 4   |
| iPSDN                         | Integrated packet switched digital network  |
| IRI                           | Industrial radio interference   |
| IRFM                          | Input RF module   |
| ISDN                          | Integrated switched digital network   |
| ISM                           | Industry science medicine (range)   |
| ISO                           | Open system interconnection   |
| ITU                           | International Telecommunications Union  |
| JRRM                          | Joint radio resource management   |
| LAI                           | Location area identity  |
| LAN                           | Local area network  |
| LDSS                          | Local differential sub-system   |
| LFM                           | Linear frequency modulation   |
| LNA                           | Low-noise amplifier   |
| LO                            | Local oscillator, low-orbit   |
| LSI                           | Large-scale IC  |
| LTE                           | Long-term evolution   |
| LTE/E-UTRAN                   | Long-term evolution/evolved-UMTS-terrestrial radio access network                     |
| MAC                           | Media access control  |
| MAHO                          | Mobile-assisted handover  |
| MAI                           | Multi-access interference   |
| MAN                           | Metropolitan area network   |
| MB-OFDM                       | Multiband OFDM  |
| MBS                           | Multicast and broadcast service   |
| MBWA                          | Mobile broadband wireless access  |
| MC                            | Multicarrier  |
| MCS                           | Mobile communication system   |
| MDHO                          | Macro diversity handover  |
| MESFET                        | Metalized semiconductor field-effect transistor)                                      |
| METIS                         | Mobile and wireless communications enablers for the twenty-twenty information society |
| MF                            | Matched filter  |
| MFA                           | Amplifier of the modulation frequency   |
| MI                            | Multiplicative interference   |
| MIMO-OFDM multi-channel input | multi-channel output  |
| MISO                          | Multiple input single output  |
| MLH                           | Maximal load hour   |
| MME                           | Mobility management entity  |
| MMSE                          | Minimum mean squared error  |
| mMTC                          | Massive machine type communications   |
| MO                            | Middle orbit  |
| MPEG                          | Motion pictures experts group   |
| M-PSK                         | Multi-phase shift keying  |
| MP2MP                         | Multipoint-to-multipoint  |
| MS                            | Mobile station  |
| MSC                           | Main service channel, mobile switching center   |
| M2M                           | Machine to machine  |

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|         |  |
|---------|--|
| MTC     | Machine type communications                                    |
| MUE     | Multiuser equipment  |
| MU MIMO | Multiuser MIMO   |
| N       | Noise factor   |
| NAP     | Network access provider  |
| NCO     | Numerically controlled oscillator                              |
| NE      | Nonlinear element  |
| NF      | Noise factor, dB   |
| NGN     | Next-generation network  |
| NG-PON2 | New generation of passive optical network                      |
| NLS     | Noise-like signal  |
| NMS     | Network management system                                      |
| NMT     | Nordic mobile telecommunication                                |
| NRZ     | Not return to zero   |
| NSA     | Navigational space apparatus                                   |
| NSP     | Network service provider                                       |
| NSS     | Noise shape signal   |
| NVF     | Network function virtualization                                |
| OATS    | Office automatic telephone station                             |
| OFDM    | Orthogonal frequency division multiplexing                     |
| OFDMA   | Orthogonal frequency division multiple access                  |
| OLT     | Optical line terminal  |
| OMC     | Operating and maintenance center                               |
| ONU     | Optical network units  |
| OOB     | Of-of-band   |
| OOK     | On-off keying  |
| OS      | Open service   |
| OSI     | Open system interconnection                                    |
| OSM     | Operator spectrum management                                   |
| PaLFI   | Passive low-frequency interface                                |
| PAA     | Phased antenna array   |
| PAC     | Perceptual audio coding  |
| PAN     | Personal area network  |
| PBCC    | Packet binary convolution coding                               |
| PCH     | Paging channel   |
| PCM     | Pulse-code modulation  |
| PCS     | Personal communication system, personal communication services |
| PDC     | Personal digital cellular                                      |
| PDN     | Public data network  |
| PDP     | Packet data protocol   |
| RFA     | Radio-frequency amplifier                                      |
| PFC     | Phase-frequency characteristic                                 |
| PG      | Processing gain  |
| PHS     | Personal handyphone system                                     |
| PHY     | Physical layer protocol  |
| PI      | Pulse interference   |
| PLL     | Phase locked loop  |
| PMP     | Point-to-multipoint  |
| PNF     | Physical network function                                      |
| PNI     | Pseudo-noise in-phase  |
| PON     | Passive optical network  |
| PPM     | Pulse position modulation                                      |
| PNQ     | Pseudo-noise quadrature  |
| PRS     | Pseudo-random sequence, public regulated service               |
| PRCS    | Personal radio call systems                                    |

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|              |   |
|--------------|---|
| RPE-LTP      | Regular pulse excitation long-term prediction                       |
| PRMA         | Packet reservation multiply access                                  |
| PRP          | Pseudo-random process   |
| PRS          | Pseudo-random sequence, public regulated service                    |
| PRS          | Public regulated service  |
| PSTN         | Public switched telephone network                                   |
| PT           | Potable termination   |
| PTN          | Public telephone network  |
| PUSC         | Partially used sub-carrier,   |
| Q            | Quadrature  |
| QC           | Quadratic couplers  |
| QPSK         | Quadrature phase shift keying                                       |
| QoS          | Quality of service  |
| RACE         | Research in advanced communications equipment                       |
| RACH         | Random access channel   |
| RAM          | Radio access method, random access memory                           |
| RAN          | Radio access network  |
| RBER         | Residual bit error ratio  |
| RDSS         | Regional differential sub-system                                    |
| RFA          | Radio-frequency amplifier   |
| RF front-end | Radio-frequency front-end   |
| RFID         | Radio-frequency identification                                      |
| RFN          | Reduced frame number  |
| RLL          | Radio local loop  |
| RNS          | Radio navigation system   |
| RM           | Reversible modulator  |
| RO           | Reference oscillator  |
| ROADM        | Reconfigurable optical add/drop multiplexer                         |
| ROG          | Reference oscillation generator                                     |
| RR           | Radio receiver  |
| RRL          | Radio relay line  |
| RRNP         | Reference radio navigation point                                    |
| RRS          | Radio relay system, reconfigurable radio system, remote radio heads |
| RS           | Relay station   |
| RSSI         | Receive signal strength indicator                                   |
| SAE          | System architecture evolution                                       |
| SB           | Single band   |
| SBR          | Spectral band replication   |
| SC           | Single carrier  |
| SC-FDMA      | Single carrier frequency division multiple access                   |
| SCH          | Synchronization channel   |
| SD           | Subtraction device  |
| SDM          | Space division multiplexing   |
| SDMA         | Space division multiplex access                                     |
| SDN          | Software defined networking   |
| SDR          | Soft defined radio  |
| SE           | Subscriber equipment  |
| SF           | Spreading factor  |
| SIM          | Subscriber identity module  |
| SISO         | Single input single output  |
| SMS          | Short message service   |
| SMR          | Specialized mobile radio (system)                                   |
| SNR          | Signal noise ratio  |
| SoC          | System-on-chip  |
| SOC          | Single oscillating circuit  |



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|            |  |
|------------|--|
| S-OFDMA    | Scaling-OFDMA  |
| SPDT       | Single pole double throw   |
| SPI        | System programming interface   |
| SPRC       | System of the personal radio call                                    |
| SR         | Soft radio   |
| ST         | Subscriber terminal  |
| STBC       | Space timing block code  |
| STC        | Space-time coding  |
| SU MIMO    | Single user MIMO   |
| SV         | State vector   |
| TCP        | Transmission control protocol  |
| TDD        | Time division duplex   |
| TDMA       | Time division multiple access  |
| TD-SCDMA   | Time division-synchronous CDMA                                       |
| TH-UWB     | Time hoping UWB  |
| 3G1X EV-DO | Enhanced version data only   |
| TLL        | Time of the largest load   |
| TETRA      | Terrestrial trunked radio  |
| TH-SS      | Time hoping spread spectrum  |
| TMSI       | Temporal identifier of the mobile station                            |
| TPC        | Transmit power control   |
| UCN        | Unified communication network  |
| UE         | User equipment   |
| UFMC       | Universal filtered multicarrier                                      |
| UHD        | Ultra-high definition  |
| ULP        | Ultra-low power  |
| UMB        | Ultra-mobile broadband   |
| UMTS       | Universal mobile telecommunications system                           |
| UPE        | User plane entity  |
| URLLC      | Ultra-reliable and low latency communications                        |
| UTRA       | UMTS terrestrial radio access  |
| UTRA-FDD   | UMTS terrestrial radio access, frequency division duplex             |
| UTRA-TDD   | UMTS terrestrial radio access, time division duplex                  |
| UTRAN      | UMTS terrestrial radio access network                                |
| UWB        | Ultra-wideband   |
| VAC        | Volt-ampere characteristic   |
| VC         | Virtual cell   |
| VCN        | Virtual cellular network   |
| VCCO       | Voltage controlled crystal oscillator                                |
| VCO        | Voltage controlled oscillator  |
| VHE        | Virtual home environment   |
| VHF        | Very high frequency  |
| VLR        | Visitor location register  |
| VOFDM      | Vector OFDM  |
| VoIP       | Voice over IP  |
| VoLTE      | Voice over LTE   |
| VPN        | Virtual private network  |
| VSAT       | Very small aperture terminal   |
| WBS        | Wideband signals   |
| WCDMA      | Wideband CDMA  |
| WCDMA/UMTS | Universal mobile telecommunication services in WCDMA                 |
| WDM        | Wavelength-division multiplexing                                     |
| WDSS       | Wide-zone differential sub-system wide-zone differential sub-systems |
| WiFi       | Wireless fidelity  |
| WiFiG      | Wireless fidelity gigabit  |

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|--------|---|
| WiMAX  | Worldwide interoperability for microwave access |
| WLAN   | Wideband local-area network                     |
| WLD    | Wideband-limiter-decision                       |
| WLL    | Wireless local loop                             |
| WLN    | Wideband-limiter-narrowband                     |
| WMAN   | Wireless local area network                     |
| WP     | Wireless port                                   |
| WPAN   | Wireless personal area network                  |
| WRS    | Wireless relay station                          |
| WRZ    | Without the return to zero                      |
| WSD    | White space devices                             |
| WSN    | Wireless sensor network                         |
| WWAN   | Wireless world area network                     |
| ZigBee | Zigzag bee                                      |
| ZIF    | Zero intermediate frequency                     |

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