
Contents

Acknowledgements	ix
Preface	xi
Introduction	xiii
History Pages	xxxv
List of Acronyms	xxxix
Chapter 1. Modulation	1
1.1. Modulation?	1
1.1.1. Main reasons for modulation	1
1.1.2. Main modulation schemas	1
1.1.3. Criteria for modulation via electronics	2
1.1.4. Digital modulation: why do it?	2
1.2. Main technical constraints	2
1.3. Transmission of information (analog or digital)	6
1.3.1. Characteristics of the signal that can be modified	7
1.3.2. Amplitude and phase representation in the complex plane	7
1.4. Probabilities of error	10
1.4.1. Bit error ratio versus signal to noise ratio	11
1.4.2. Demodulator: intended recipient decoder	12
1.5. Vocabulary of digital modulation	14
1.6. Principles of digital modulations	17
1.6.1. Polar display	19
1.6.2. Variations of parameters: amplitude, phase, frequency	19
1.6.3. Representation in a complex plane	20
1.6.4. Eye diagram	21

1.7. Multiplexing	23
1.7.1. Frequency multiplexing	24
1.7.2. Multiplexing – time	25
1.7.3. Multiplexing – code	26
1.7.4. Geographical (spatial) multiplexing	26
1.8. Main formats for digital modulations	26
1.8.1. Phase-shift keying	28
1.8.2. BPSK	31
1.8.3. The QPSK	37
1.9. Error vector module and phase noise.	63
1.9.1. Plot QPSK reference constellation	69
1.9.2. Effects of phase noise on 16-QAM	75
1.9.3. Phase noise: effects of the signal spectrum.	76
1.9.4. Algorithms	78
1.9.5. Spectrum analyzer	79
1.9.6. Measures of the error vector module of a signal modulated by a noisy 16-QAM.	81
1.10. Gaussian noise (AWGN)	81
1.10.1. AWGN channel	83
1.10.2. Ratio between EsNo and SNR	84
1.10.3. Behavior for real and complex input signals	85
1.11. QAM modulation in an AWGN channel	85
1.11.1. QAM demodulation.	89
1.11.2. Detecting phase error	90
1.12. Frequency-shift keying	93
1.12.1. Binary FSK.	94
1.13. Minimum-shift keying	95
1.13.1. Bit error ratio (BER)/Gaussian channel	97
1.13.2. Typical analytical expressions used in “berawgn”	98
1.14. Amplitude-shift keying	99
1.14.1. On–off keying	99
1.14.2. Modulation at “M states”	101
1.15. Quadrature amplitude modulation.	104
1.15.1. Limits on theoretical spectral efficiency.	105
1.15.2. I/Q imbalance	106
1.15.3. QAM-M constellations	109
1.16. Digital communications transmitters	117
1.16.1. A digital communications receiver.	118
1.16.2. Measures of power	120
1.16.3. Power of the adjacent channel.	121
1.16.4. Frequency measures	121
1.16.5. Synchronization measures	123
1.17. Applications.	129

1.17.1. Domains	129
1.17.2. Digressions or precisions, around modulations.	131
Chapter 2. Some Developments in Modulation Techniques	137
2.1. Orthogonal frequency division multiplexing	137
2.1.1. Introduction	137
2.1.2. Multicarrier modulations	138
2.1.3. General principles	143
2.1.4. How to choose N?	145
2.1.5. Practical aspects.	145
2.1.6. COFDM	147
2.1.7. Equalization and decoding	149
2.1.8. The multiuser context	150
2.1.9. Code division multiple access	150
2.1.10. Schematic ordinogram	152
2.1.11. Data in OFDM.	155
2.1.12. OFDM: advantages and disadvantages	156
2.1.13. Intermediate conclusion	157
2.1.14. QPSK and OFDM with MATLAB system objects	159
2.1.15. FDM versus OFDM: difference between FDM and OFDM	162
2.2. A note on orthogonality	170
2.3. Global System for Mobile Communications	174
2.3.1. Introduction	174
2.3.2. Forming a GSM.	175
2.4. MIMO	178
2.4.1. Introduction	178
2.4.2. Principles.	178
2.4.3. Uses	182
Chapter 3. Signal Processing: Sampling	183
3.1. Z-transforms	183
3.1.1. Transforms.	183
3.1.2. Inverse z-transform.	184
3.2. Basics of signal processing.	187
3.3. Real discretization processing.	190
3.3.1. Real discretization comb.	190
3.3.2. Real sampled signal	191
3.3.3. Blocked, sampled signal.	191
3.3.4. Model of real sampled signals	192
3.3.5. Uniform quantifying	192
3.3.6. Signal quantification step: rounding.	192
3.3.7. Signal quantification step: troncature	193

3.3.8. Quantification solution.	193
3.3.9. Additive white Gaussian noise (AWGN): a simple but effective model	193
3.3.10. Quantification error and quantification noise.	193
3.3.11. In practice, sample and hold and CAN	194
3.3.12. Spectra of periodic signals.	195
3.3.13. Non-periodic signal spectrums	195
3.3.14. PSD versus delay	197
3.3.15. FT of a product: the Plancherel theorem	197
3.3.16. Periodic signal before sampling.	198
3.3.17. Spectrum of sampled signals	198
3.3.18. Conditions for sampling frequency.	199
3.4. Coding techniques (summary).	200
Chapter 4. A Little on Associated Hardware	203
4.1. Voltage-controlled oscillator.	203
4.2. Impulse sensitivity function	209
4.3. Phase noise	210
4.3.1. At passage to zero	212
4.3.2. At the peaks	212
4.4. Phase-locked loop	219
4.4.1. Study of a fundamental tool: the PLL	219
4.4.2. Schematic structure of the PLL	220
4.4.3. Operation of the loop: acquisition and locking.	222
4.4.4. Charge pump	229
Conclusion	231
Appendices	233
Appendix 1	235
Appendix 2	243
Appendix 3	263
References	291
Index	293