Quadrature Amplitude Modulation:
From Basics to Adaptive Trellis-Coded,
Turbo-Equalised and Space-Time Coded OFDM,
CDMA and MC-CDMA Systems

by

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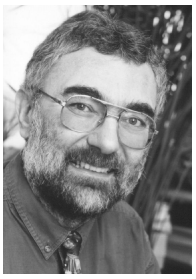

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Related Wiley and IEEE Press Books [1]

- R. Steele, L. Hanzo (Ed): *Mobile Radio Communications: Second and Third Generation Cellular and WATM Systems*, John Wiley and IEEE Press, 2nd edition, 1999, ISBN 07 273-1406-8, 1064 pages
- L. Hanzo, W. Webb, and T. Keller, *Single- and Multi-Carrier Quadrature Amplitude Modulation: Principles and Applications for Personal Communications, WLANs and Broadcasting*, John Wiley and IEEE Press, 2000, 739 pages
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[1] For detailed contents and sample chapters please refer to http://www-mobile.ecs.soton.ac.uk

Preface

Since its discovery in the early 1960s, quadrature amplitude modulation (QAM) has continued to gain interest and practical application. Particularly in recent years many new ideas and techniques have been proposed, allowing its employment over fading mobile channels. This book attempts to provide an overview of most major QAM techniques, commencing with simple QAM schemes for the uninitiated, while endeavouring to pave the way towards complex, rapidly evolving areas, such as trellis-coded pilot-symbol and transparent-tone-in-band assisted schemes, or arrangements for wide-band mobile channels. The second half of the book is targetted at the more advanced reader, providing a research-oriented outlook using a variety of novel QAM-based single- and multi-carrier arrangements.

The book is structured in five parts. Part I - constituted by Chapters 1-4 - is a rudimentary introduction for those requiring a background in the field of modulation and radio wave propagation. Part II is comprised of Chapters 5-9 and concentrates mainly on classic QAM transmission issues relevant to Gaussian channels. Readers familiar with the fundamentals of QAM and the characteristics of propagation channels, as well as with basic pulse shaping techniques may decide to skip Chapters 1-5. Commencing with Chapter 6, each chapter describes individual aspects of QAM. Readers wishing to familiarize themselves with a particular subsystem, including clock and carrier recovery, equalisation, trellis coded modulation, standardised telephone-line modem features, etc. can turn directly to the relevant chapters, whereas those who desire a more complete treatment might like to read all the remaining chapters.

Parts III-V, including Chapters 10-24, are concerned with QAM-based transmissions over mobile radio channels. These chapters provide a research-based perspective and are dedicated to the more advanced reader. Specifically, Chapter 10 concentrates mainly on coherent QAM schemes, including reference-aided transparent-tone-in-band and pilot-symbol assisted modulation arrangements. In contrast, Chapter 11 focuses on low-complexity differentially encoded QAM schemes and on their performance with and without forward error correction coding and trellis coded modulation. Chapter 12 details various timing recovery schemes.

Part IV of the book commences with Chapter 13, which is concerned with variable rate QAM using one- to six-bits per symbol signal constellations. Chapter 14 is dedicated to high-rate wide-band transmissions and proposes a novel equaliser arrangement. Various QAM-related orthogonal signaling techniques are proposed in Chapter 15, while the spectral efficiency of QAM in cellular frequency re-use structures is detailed in Chapter 16. This is followed by Chapter 17, which concentrates on the employment of QAM in a source-matched speech communications system, including various speech codecs, error correction codecs, a voice activity detector and packet reservation multiple access, providing performance figures in contrast to one and two bits per symbol bench-mark schemes.

Part V first appeared in this new edition of the book, concentrating on multi-carrier modulation. Specifically, following a rudimentary introduction to Orthogonal Frequency Division Multiplexing (OFDM) in Chapter 18, Chapters 19-23 detail a range of implementational and performance aspects of OFDM over both Gaussion and wideband fading channels. Lastly, Chapter 24 concentrates on the performance aspects of various standard-compliant and enhanced OFDM-based Digital Video Broadcasting (DVB) systems designed for transmission to mobile receivers.

To the original text of the first edition dealing with many of the fundamentals of single-carrier QAM and QAM-based systems we have added six new chapters dealing with the complexities of the exciting subject of multi-carrier modulation, which has found wide-ranging applications in a past decade, ranging from Wireless Local Area Network (WLAN) to broadcast systems. Whilst the book aims to portray a rapidly evolving area, where research results are promptly translated into products, it is our hope that you will find this second edition comprehensive, technically challenging and above all, enjoyable.

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Acknowledgements

The authors would like to express their warmest thanks to Prof. Raymond Steele. Without his shrewd long-term vision the research on single-carrier QAM would not have been performed, and without his earnest exhortations a book on the subject would not have been written. Furthermore, Professor Steele has edited some of the chapters and given advice on the contents and style of this book.

Contributions by Dr. P.M. Fortune, Dr. K.H.H. Wong, Dr. R.A. Salami, D. Greenwood, R. Stedman, R Lucas and Dr. J.C.S. Cheung who were formerly with Southampton University are thankfully acknowledged. We thank Multiple Access Communications Ltd. for supporting the work on QAM, particularly in the framework of the DTI LINK Personal Communications Programme, dealing with high data rate QAM transmission over microcellular mobile channels. Special thanks goes to Peter Gould and Philip Evans for the major part they played in the construction of the star QAM test-bed. We are grateful to John Williams of Multiple Access Communications Ltd. for the many simulation results he provided for Chapter 17, the production of many of the figures involving simulated waveforms. Much of the QAM work at Multiple Access Communications Ltd. derives from the support of BT Labs. Martlesham Heath, the DTI and the Radio Communications Agency. Specifically, we thank the latter for the support of the research on spectral efficiency which facilitated Chapter 16.

Much of the results in Chapters 19-22 are based on our work conducted as a subcontractor of Motorola ECID, Swindon, UK; as part of our involvement in a collaborative Pan-European Wireless Asyncrhonous Transfer Mode (WATM) project known as Median, which was genereously supported by the European Commission (EC), Brussels, Belgium. We would like to acknowledge all our valued friends and colleagues - too numerous to mention individually - who at some stage were associated with the Median consortium and with whom we have enjoyed a stimulating collaboration under the stirling management of IMST, Germany. Our gratitude is due to Andy Wilton and to Paul Crichton of Motorola, who have whole-heartedly sponsored our research. Further thanks are also due to Dr. Joao Da Silva, Bartolome Aroyo, Bernard Barani, Dr. Jorge Pereira, Demosthenes Ikonomou and to the other equally supportive members of the EC's programme management team in Brussels for their enthusiastic support. Furthermore, we enjoyed the valuable support of EPSRC, Swindon UK, and the Mobile VCE, for which we are equally grateful.

Lastly, we express our gratitude for the creative atmosphere to our colleagues Derek Appleby, Steve Braithwaite, Sheng Chen, David Stewart, Jeff Reeve as well as Stephan Weiss at Southampton University, UK and gratefully acknowledge the stimulating embryonic discussions with Prof. G. Gordos (Technical University of Budapest, Hungary), Prof. H.W. Schüssler (University of Erlangen-Nürnberg, Germany) and Dr.Ing. H.J. Kolb as well as the numerous thought-provoking contributions by many established authorities in the field, who

appear also in the Author Index Section of the book.

A number of colleagues have influenced our views concerning various aspects of wireless communications and we thank them for the enlightment gained from our collaborations on various projects, papers and books. We are grateful to J. Brecht, Jon Blogh, Marco Breiling, M. del Buono, Clare Brooks, Peter Cherriman, Stanley Chia, Byoung Jo Choi, Joseph Cheung, Peter Fortune, Lim Dongmin, D. Didascalou, S. Ernst, Eddie Green, David Greenwood, Hee Thong How, Thomas Keller, W.H. Lam, C.C. Lee, M.A. Nofal, Xiao Lin, Chee Siong Lee, Tong-Hooi Liew, Matthias Muenster, V. Roger-Marchart, Redwan Salami, David Stewart, Juergen Streit, Jeff Torrance, Spyros Vlahoyiannatos, William Webb, John Williams, Jason Woodard, Choong Hin Wong, Henry Wong, James Wong, Lie-Liang Yang, Bee-Leong Yeap, Mong-Suan Yee, Kai Yen, Andy Yuen and many others with whom we enjoyed an association. Special thanks are due to Dr. Lie-Liang Yang for his insightful contributions on the theory of the coding schemes used in Chapter 23, to Tong-Hooi Liew for his kind assistance in the preparation of a co-authored paper, which was the basis of Chapter 23, which resulted in a joint journal submission. Similarly, the contributions of Matthias Muenster in Sections 22.3 and 22.7 are thankfully acknowledged along with those of Chee-Siong Lee and Spyros Vlahoyiannatos to the papers, which consituted the basis of Chapter 24. Lorenzo Piazzo's permission to expand the material of his Electronics Letter on optimum power- and bit-allocation of OFDM is thankfully acknowledged. We are also grateful to our editors, Mark Hammond and Sarah Hinton and Sarah Lock at Wiley. Finally, the authors warmly thank Rita Hanzo, Denise Harvey and Dr. Peter Cherriman for their dedicated and skilful assistance in typesetting the manuscript in Latex as well as in amalgamating the new material of the second edition with the first edition.

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Glossary

16QAM	16-level Quadrature Amplitude Modulation
3G	Third generation
4PSK	4-level Phase Shift Keying
4QAM	4-level Quadrature Amplitude Modulation
64QAM	64-level Quadrature Amplitude Modulation
8-DPSK	8-Phase Differential Phase Shift Keying
8PSK	8-level Phase Shift Keying
ACF	autocorrelation function
ADC	Analog–to–Digital Converter
ADM	adaptive delta modulation
ADPCM	Adaptive Differential Pulse Coded Modulation.
AGC	Automatic Gain Control
AM-PM	amplitude modulation and phase modulation
AOFDM	Adaptive Orthogonal Frequency Division Multiplexing
APP	A Posteriori Probability
ARQ	Automatic Repeat Request, Automatic request for retransmission of corrupted data
ATM	Asynchronous Transfer Mode
AWGN	Additive White Gaussian Noise

BbB	Burst-by-Burst
BCH	Bose-Chaudhuri-Hocquenghem, A class of forward error correcting codes (FEC)
BCM	block code modulation
BER	Bit error rate, the fraction of the bits received incorrectly
BICM	Bit Interleaved Coded Modulation
BICM-ID	Bit-Interleaved Coded Modulation with Iterative decoding
BPF	Bandpass Filter
BPS	Bits Per Symbol
BPSK	Binary Phase Shift Keying
BS	A common abbreviation for Base Station
CCI	Co-Channel Interference
CCITT	Now ITU, standardisation group
CD	Code Division, a multiplexing technique where signals are coded and then combined, in such a way that they can be separated using the assigned user signature codes at a later stage.
CDMA	Code Division Multiple Access
CIR	Carrier to Interference Ratio, same as SIR.
CISI	controlled inter-symbol interference
CM	Coded Modulation
CM-GA-MUD	Coded Modulation assisted Genetic Algorithm based Multiuser Detection
CM-JD-CDMA	Coded Modulation-assisted Joint Detection-based CDMA
CRC	Cyclic Redundancy Checksum
CT-TEQ	Conventional Trellis-based Turbo Equalisation
D/A	Digital to Analogue
DAB	Digital Audio Broadcasting

DC	Direct Current, normally used in electronic circuits to describe a power source that has a constant voltage, as opposed to AC power in which the voltage is a sine-wave. It is also used to describe things which are constant, and hence have no frequency component.
DECT	A Pan-European digital cordless telephone standard.
DFE	Decision Feedback Equalizer
DFT	Discrete Fourier Transform
DoS-RR	Double-Spreading aided Rake Receiver
DS	Direct Sequence
DTTB	Digital Terrestrial Television Broadcast
DTX	discontinuous transmission
DVB	Digital Video Broadcasting
ECL	The Effective Code Length or the "length" of the shortest error event path.
EFF	Error Free Feedback
EQ	Equaliser
E_b/N_0	Ratio of bit energy to noise power spectral density.
FD	Frequency Division, a multiplexing technique, where different frequencies are used for each communications link.
FDM	Frequency Division Multiplexing
FEC	Forward Error Correction
FED	Free Euclidean distance
FER	Frame error rate
FFT	Fast Fourier Transform
FSK	Frequency Shift Keying
G	Coding Gain
GA	Genetic Algorithm
GF	Galois field

GMSK	Gaussian Mean Shift Keying, a modulation scheme used by the Pan-European GSM standard by virtue of its spectral compactness.
GSM	A Pan-European digital mobile radio standard, operating at 900MHz.
HT	Hilly Terrain, channel impulse response of a hilly terrain environment.
I	The In-phase component of a complex quantity.
I/Q-TEQ	In-phase/Quadrature-phase Turbo Equalisation
IC	Interference Cancellation
ICI	Inter–Channel Interference
IF	Intermediate Frequency
IFFT	Inverse Fast Fourier Transform
IL	interleaver block length
IMD	Intermodulation Distortion
IQ-CM	IQ-interleaved Coded Modulation
ISI	Inter Symbol Interference, Inter Subcarrier Interference
JD	Joint Detection
JD-MMSE-DFE	Joint Detection scheme employing MMSE-DFE
LAR	Logarithmic area ratio
LMS	Least Mean Square, a stochastic gradient algorithm used in adapting the equalizer's coefficients in a non-stationary environment
log-domain	logarithmic-domain
LOS	Line–Of–Sight
LP	Logarithmic-domain Probability
LPF	low pass filter
LS	Least Square, a category of adaptive algorithms which uses recursive least squres methods in adapting the equalizer or channel estimators in a non-stationary environment
LSB	least significant bit

LSF	Least Squares Fitting
LTP	long term predictor
MAI	Multiple Access Interference
MAP	Maximum–A–Posteriori
MC-CDMA	Multi-Carrier Code Division Multiple Access
MDI	multi-dimensional interference
MIMO	Multi-Input Multi-Output
ML	Maximum Likelihood
MMSE	Minimum Mean Square Error
MMSE-BLE	Minimum Mean Square Error based Block Linear Equaliser
MMSE-DFE	Minimum Mean Square Error based Decision Feedback Equaliser
MPSK	M-ary Phase Shift Keying
MRC	Mixed Radix Conversion
MS	A common abbreviation for Mobile Station
MSE	Mean Square Error, a criterion used to optimised the coefficients of the equalizer such that the ISI and the noise contained in the received signal is jointly minimised.
MUD	Multi-User Detection
NLA	non-linear amplification
NLF	non-linear filtering
OFDM	Orthogonal Frequency Division Multiplexing
OMPX	Orthogonal Multiplexing
OOB	out of band
OQAM	offset quadrature amplitude modulation
OQPSK	offset quadrature phase shift keying
OSWE	one-symbol window equaliser
PAM	pulse amplitude modulation
PCM	pulse code modulation

PCN	Personal Communications Network
PD	phase detector
PDF	Probability Density Function
PLL	phase locked loop
PLMR	Public Land Mobile Radio
PN	Pseudo-Noise
PR	PseudoRandom
PSAM	Pilot symbol assisted modulation, a technique where known symbols (pilots) are transmitted regularly. The effect of channel fading on all symbols can then be estimated by interpolating between the pilots
PSD	Power Spectral Density
PSK	Phase Shift Keying
PSTN	Public switched telephone network
Q	The Quadrature-phase component of a complex quantity.
QAM	Quadrature Amplitude Modulation
QMF	Quadrature Mirror Filtering
QOS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RBF	Radial Basis Function
RBF-DFE	RBF assisted Decision Feedback Equaliser
RBF-TEQ	Radial Basis Function based Turbo Equalisation
RCPC	Rate-Compatible Puncture Convolutional
RF	radio frequency
RLS	Recursive Least Squares, an adaptive filtering technique where a recursive method is used to adapt the filter tap weights such that the square of the error between the filter output and the desired response is minimized
RPE	regular pulse excited

RPE-LTP	Regular pulse excited codec with long term predictor
RRNS	Redundant Residual Number System
RS	Reed Solomon Codes
RSC	Recursive Systematic Convolutional
RSSI	Received Signal Strength Indicator, commonly used as an indicator of channel quality in a mobile radio network.
SbS	Symbol-by-Symbol
SER	Symbol Error Ratio
SINR	Signal to Interference plus Noise ratio, same as signal to noise ratio (SNR), when there is no interference.
SIR	Signal to Interference ratio
SISO	Soft-Input-Soft-Output
SNR	Signal to Noise Ratio, noise energy compared to the signal energy
SOVA	Soft-Output Viterbi Algorithm
SP	Set Partitioning
STB	Space-Time Block
STBC	Space-Time Block Coding
STBC-DoS-RR	Space-Time Block Coding-assisted Double-Spread Rake Receiver
STBC-IQ	Space-Time Block Coding based IQ-interleaved
STC	Space-Time Coding
STP	Short term predictor
STS	Space-Time Spreading
STT	Space-Time Trellis
STTC	Space-Time Trellis Coding
TC	Trellis Coded
TCM	trellis code modulation

TDD	Time-Division Duplex, a technique where the forward and reverse links are multiplexed in time.
TDMA	Time Division Multiple Access
TEQ	Turbo Equalisation
TTCM	Turbo Trellis Coded Modulation
TTIB	transparent tone in band
TU	Typical Urban, channel impulse response of an urban environment.
TuCM	Turbo Coded Modulation
TWT	travelling wave tube
UHF	ultra high frequency
UMTS	Universal Mobile Telecommunications System, a future Pan-European third generation mobile radio standard.
UTRA	UMTS Terrestrial Radio Access
VA	Viterbi Algorithm
VCO	voltage controlled oscillator
VE	Viterbi equalizer
WATM	Wireless Asynchronous Transfer Mode (ATM)
WMF	Whitening Matched Filter
WN	white noise
ZF	Zero Forcing, a criterion used to optimised the coefficients of the equalizer such that the ISI contained in the received signal is totally eliminated.
ZFE	Zero Forcing Equalizer.

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