

Table of Contents

1	Digital Television – a First Summary (REIMERS)	1
1.1	Definitions and Range of Application.	1
1.2	The Genesis of Recommendations for Digital Television . . .	4
1.2.1	Work in the United States of America.	5
1.2.2	Work in Europe.	6
1.2.3	Work in Japan, Canada and Korea	9
1.3	Objectives in the Development of Digital Television	9
1.4	Data Reduction as the Key to Success.	11
1.5	Possible Means of Transmission for Digital Television	13
1.6	Standards and Norms in the World of Digital Television . . .	16
2	Digitisation and Representation of Audio and Video Signals (JOHANSEN)	19
2.1	Sampling and Quantising.	19
2.2	Digitising Video Signals	20
2.2.1	ADCs and DACs for Video Signals	22
2.2.2	Representation of Video Signals	24
2.3	Digitising Audio Signals	27
2.3.1	Representation of Audio Signals	28
2.3.2	ADCs and DACs for Audio Signals	28
3	MPEG Source Coding of Audio Signals (FECHTER)	35
3.1	Basics of Bit-rate Reduction	35
3.2	Psychoacoustic Basics	37
3.2.1	Threshold of Audibility and Auditory Sensation Area.	37
3.2.2	Masking	38
3.3	Source Coding of Audio Signals Utilising the Masking Qualities of the Human Ear.	42
3.3.1	Basic Structure of the MPEG Coding Technique	43
3.3.2	Coding in Accordance with Layer 1	47
3.3.3	Coding in Accordance with Layer 2	49
3.3.4	Coding in Accordance with Layer 3	50
3.3.5	Decoding.	52

3.3.6	The Parameters of MPEG Audio	52
3.3.7	MPEG-2 Audio Coding	53
3.4	Summary	54
4	JPEG and MPEG Source Coding of Video Signals (RICKEN)	57
4.1	Coding in Accordance with JPEG	58
4.1.1	Block Diagram of Encoder and Decoder	58
4.1.2	Discrete Cosine Transform	59
4.1.3	Quantisation	61
4.1.4	Redundancy Reduction	63
4.1.5	Specific Modes	65
4.1.6	Interchange Format	68
4.2	Coding in Accordance with the MPEG Standards	69
4.2.1	Block Diagrams of Encoder and Decoder	71
4.2.2	Motion Estimation	73
4.2.3	Reordering of Pictures	76
4.2.4	Data-rate Control	77
4.2.5	Special Features of MPEG-1	78
4.2.6	Special Features of MPEG-2	81
4.3	Summary	87
5	MPEG-2 Systems and Multiplexing (RICKEN)	89
5.1	Differences between Programme Multiplex and Transport Multiplex	89
5.2	Positioning of Systems in the ISO/OSI Layer Model	90
5.3	End-to-end Synchronisation	92
5.4	Service Information	97
6	Forward Error Correction (FEC) in Digital Television Transmission (Roy)	99
6.1	Basic Observations	99
6.2	Reed-Solomon Codes	102
6.2.1	Introduction to the Arithmetic of the Galois Field	103
6.2.2	Definition of the RS Code and the Encoding/Decoding in the Frequency Domain	109
6.2.3	Error Correction Using the RS Code	110
6.2.4	Examples of Encoding/Decoding in the Frequency Domain	113
6.2.5	Encoding and Decoding in the Time Domain	115
6.2.6	Efficiency of the RS Code	116
6.3	Convolutional Codes	117
6.3.1	Basics of the Convolutional Codes	117
6.3.2	Examples of Convolutional Encoding and Decoding	119

6.3.3	Hard Decision and Soft Decision	124
6.3.4	Puncturing of Convolutional Codes	126
6.3.5	Performance of Convolutional Codes	126
6.4	Code Concatenation	128
6.4.1	Block-Code Concatenation	128
6.4.2	Interleaving	129
6.4.3	Error Correction in DVB	131
6.5	Further Reading	133
7	Digital Modulation Techniques (JAEGER)	135
7.1	NRZ Baseband Signal	135
7.2	Principles of the Digital Modulation of a Sinusoidal Carrier Signal	141
7.2.1	Amplitude Shift Keying (2-ASK)	143
7.2.2	Frequency Shift Keying (2-FSK)	145
7.2.3	Phase Shift Keying (2-PSK)	146
7.3	Quadrature Phase Shift Keying (QPSK)	148
7.4	Higher-level Amplitude Shift Keying (ASK) and Vestigial- Sideband Modulation (VSB)	151
7.5	Digital Quadrature Amplitude Modulation (QAM)	155
7.6	Orthogonal Frequency Division Multiplex (OFDM)	161
8	Conditional Access for Digital Television (VERSE)	169
9	The Satellite Standard and Its Decoding Technique (VERSE)	175
9.1	The Basics of Satellite Transmission	175
9.1.1	Transmission Distance	175
9.1.2	Processing on Board a Satellite	176
9.1.3	Polarisation Decoupling	178
9.1.4	Energy Dispersal	179
9.1.5	Signal Reception	179
9.1.6	Reference Data of a Television Satellite with Astra 1D as an Example	180
9.2	Requirements of the Satellite Standard	180
9.3	Signal Processing at the Encoder	182
9.3.1	System Overview	182
9.3.2	Energy Dispersal	183
9.3.3	Error-protection Coding	183
9.3.4	Filtering	185
9.3.5	Modulation	185
9.4	Decoding Technique	186

9.4.1	Demodulator	187
9.4.2	Filtering and Clock Recovery	187
9.4.3	Viterbi Decoder	188
9.4.4	Sync-byte Detector	189
9.4.5	De-interleaver and RS Decoder	190
9.4.6	Energy-dispersal Remover	190
9.4.7	Baseband Interface	191
9.5	Performance Characteristics of the Standard	191
9.5.1	Useful Bit Rates.	191
9.5.2	Required Carrier-to-noise Ratio in the Transmission Channel	192
9.5.3	Antenna Diameter	193
9.6	Local Terrestrial Transmission	193
10	The Cable Standard and Its Decoding Technique (JAEGER) . .	195
10.1	Cable Transmission Based on the Example of the German Telecom CATV Network	195
10.1.1	Intermodulation	197
10.1.2	Thermal Noise	198
10.1.3	Reflections	200
10.2	User Requirements of the Cable Standard.	200
10.3	Signal Processing at the Encoder	202
10.3.1	Conversion of Bytes to Symbol Words	203
10.3.2	Differential Coding of MSBs	203
10.3.3	Modulation.	205
10.4	Decoding Technique	208
10.4.1	Cable Tuner	208
10.4.2	IF Interface.	209
10.4.3	Recovery of the Carrier Signal	210
10.4.4	Generating the Clock Signal	212
10.4.5	Demodulation of the QAM Signal.	213
10.4.6	Differential Decoding of MSBs	216
10.4.7	Conversion of Symbol Words to Bytes	216
10.4.8	Detection of MPEG Sync Bytes	217
10.5	Performance Details of the Standard	218
10.5.1	Determination of Useful Data Rates	218
10.5.2	Carrier-to-noise Ratio Required in the Transmission Channel	220
10.6	DVB Utilisation in Master Antenna Television Networks.	221
10.7	Local Terrestrial Transmission (MMDS)	223

11	The Standard for Terrestrial Transmission and Its Decoding Technique (REIMERS)	225
11.1	Basics of Terrestrial Television Transmission	226
11.2	User Requirements for a System for Terrestrial Transmission of DVB Signals	231
11.3	Encoder Signal Processing	233
11.3.1	Inner Interleaver and Symbol Mapping	234
11.3.2	Choosing the OFDM Parameters	235
11.3.3	Arrangement of the Transmission Frame	239
11.4	Decoding Technique	243
11.5	Hierarchical Modulation	244
11.6	Features of the Standard	249
11.6.1	Determination of Useful Data Rates	249
11.6.2	Required Carrier-to-noise Ratio in the Transmission Channel	252
12	Measurement Techniques for Digital Television (JOHANSEN, LADEBUSCH, TRAUBERG)	257
12.1	Measurement Techniques for Source-Signal Processing in the Baseband	258
12.1.1	Quality Evaluation of Video Source Coding	258
12.1.2	Checking Compressed Audio and Video Signals	260
12.1.3	Checking the MPEG-2 Transport Stream	260
12.1.4	Checking the Functionality of the Decoder	266
12.2	Measurements for Digital Transmission Technology	267
12.2.1	Representation of the Eye Diagram	268
12.2.2	Measurements Carried out at Modulators and Demodulators	269
12.2.3	Measurement of Error Rate	273
13	Bibliography	277
14	Acronyms and Abbreviations	285
15	Index	291