

Contents

About the Series Editors	xiii
Preface	xv
Acknowledgements	xvii
1 Introduction	1
1.1 Scope	1
1.2 Perspective	2
1.3 Background and Applications	3
1.3.1 <i>Background</i>	3
1.3.2 <i>Applications</i>	5
1.4 Trends	14
1.5 Overview of this Book	17
References	18
Part I BASIC CONCEPTS	19
2 Satellites and High-Altitude Platforms	21
2.1 Introduction	21
2.2 Satellites	22
2.2.1 <i>Orbital Motion</i>	22
2.2.2 <i>Principal Types of Orbit</i>	26
2.2.3 <i>Position in Different Reference Frames</i>	35
2.2.4 <i>Satellite Bus</i>	39
2.3 High-Altitude Platforms	41
2.3.1 <i>Overview</i>	41
2.3.2 <i>Heavier-than-Air Platforms</i>	43
2.3.3 <i>Lighter-than-Air Platforms</i>	44
2.3.4 <i>Viability and Trade-offs</i>	47
Revision Questions	48
References	48
3 Spectrum and Propagation	51
3.1 Introduction	51
3.2 Spectrum	52
3.2.1 <i>Atmospheric Windows</i>	52
3.2.2 <i>Regulation and the ITU-R</i>	54

3.3	Propagation	57
3.3.1	<i>Impact of Propagation on Service Availability</i>	58
3.3.2	<i>Wave Propagation Fundamentals</i>	59
3.3.3	<i>Tropospheric Effects</i>	64
3.3.4	<i>Ionospheric Effects</i>	77
3.3.5	<i>Multipath</i>	80
	Revision Questions	85
	References	85
4	Antennas and Noise	89
4.1	Introduction	89
4.2	Antennas	90
4.2.1	<i>General Concepts</i>	90
4.2.2	<i>Antenna Properties</i>	90
4.2.3	<i>Transmission Between Two Antennas</i>	99
4.2.4	<i>Antennas for Personal Satellite Applications</i>	100
4.2.5	<i>Optical Antennas</i>	111
4.3	Noise	113
4.3.1	<i>Overview</i>	113
4.3.2	<i>Antenna Noise</i>	114
4.3.3	<i>Electronic Noise</i>	117
4.3.4	<i>System Noise</i>	118
4.3.5	<i>Signal-to-Noise Density and Receiver Figure of Merit</i>	119
	Revision Questions	121
	References	121
5	Modulation and Coding	123
5.1	Introduction	123
5.2	Modulation	124
5.2.1	<i>Modulation/Demodulation</i>	124
5.2.2	<i>Baseband Digital Signals</i>	125
5.2.3	<i>Binary Digital Modulation Schemes</i>	134
5.2.4	<i>Modulation Schemes for High Spectral Efficiency</i>	138
5.2.5	<i>Modulation Schemes for High Spectral Purity</i>	142
5.2.6	<i>Modulation Techniques for Frequency-Selective Channels</i>	143
5.3	Error Control Coding	144
5.3.1	<i>Overview</i>	144
5.3.2	<i>Linear Block Codes</i>	146
5.3.3	<i>Convolutional Codes</i>	150
5.3.4	<i>Interleaving and Code Concatenation</i>	152
5.3.5	<i>Turbo and LDPC Codes</i>	153
5.3.6	<i>Lower Bound on Code Performance</i>	157
	Revision Questions	158
	References	158
6	Satellite Access and Networking	161
6.1	Introduction	161
6.2	Satellite Access	161
6.2.1	<i>Single Access</i>	161
6.2.2	<i>Multiple-Access Methods</i>	165

6.2.3	<i>Random Access</i>	166
6.2.4	<i>FDM and FDMA</i>	167
6.2.5	<i>SDMA (Frequency Reuse)</i>	172
6.2.6	<i>TDM and TDMA</i>	173
6.2.7	<i>CDM and CDMA</i>	176
6.3	Payloads	181
6.3.1	<i>Unprocessed Payloads</i>	181
6.3.2	<i>Processed Payloads</i>	182
6.4	Networks	184
6.4.1	<i>Network Architectures</i>	184
6.4.2	<i>Network Models</i>	185
	Revision Questions	191
	References	191
7	Doppler and Pseudorange (Navigation)	193
7.1	Introduction	193
7.2	Doppler	194
7.2.1	<i>Doppler Shift</i>	194
7.2.2	<i>Position Location Using the Doppler Shift</i>	194
7.3	Pseudorangeing	198
7.3.1	<i>Pseudorange</i>	198
7.3.2	<i>Position Determination Using Ranging</i>	199
7.3.3	<i>Accuracy and Dilution of Precision</i>	205
7.3.4	<i>Differential Positioning</i>	207
	Revision Questions	208
	References	209
8	Compression, Speech, Audio and Video Encoding	211
8.1	Introduction	211
8.1.1	<i>Why Digital?</i>	212
8.2	Lossless Data Compression	212
8.2.1	<i>Lossless versus Lossy Compression</i>	213
8.2.2	<i>Entropy Encoding</i>	213
8.2.3	<i>Dictionary Encoding</i>	216
8.3	Digitizing Analogue Signals	217
8.3.1	<i>Sampling</i>	217
8.4	Speech Encoding	220
8.4.1	<i>Waveform Encoding</i>	220
8.4.2	<i>Vocoders</i>	220
8.5	Audio Encoding	224
8.5.1	<i>Audio Source Encoding</i>	224
8.5.2	<i>Psychoacoustic Encoding</i>	224
8.6	Video Encoding	226
8.6.1	<i>Image Encoding</i>	226
8.6.2	<i>Lossy DCT Image Encoding</i>	227
8.6.3	<i>Encoding Video Signals</i>	228
8.6.4	<i>Motion Estimation</i>	230
	Revision Questions	232
	References	232

Part II	TECHNIQUES AND SYSTEMS	235
9	Digital Broadcasting Techniques and Architectures	237
9.1	Introduction	237
9.2	MPEG Multimedia Standards	238
9.2.1	<i>Audio Broadcasting</i>	238
9.2.2	<i>Video Broadcasting</i>	239
9.2.3	<i>Multiplexing and Transporting</i>	239
9.3	Direct-to-Home Broadcast System	240
9.3.1	<i>Architecture</i>	241
9.3.2	<i>Transmission Standards</i>	246
9.4	Direct Broadcasts to Individuals and Mobile Users	251
9.4.1	<i>Architecture and Standards</i>	256
9.5	Military	259
	Revision Questions	260
	References	261
10	Broadcast Systems	263
10.1	Introduction	263
10.2	Satellite Radio Systems	263
10.2.1	<i>XM Satellite Radio Inc.</i>	264
10.2.2	<i>Sirius Satellite Radio</i>	266
10.2.3	<i>Iworldspace</i>	267
10.3	Direct Multimedia Broadcast	270
10.3.1	<i>MBCO and TU Multimedia</i>	271
10.3.2	<i>European Initiatives</i>	272
10.4	Direct-to-Home Television	273
10.4.1	<i>Implementation Issues</i>	273
10.4.2	<i>DTH Services</i>	276
10.4.3	<i>Representative DTH Systems</i>	276
10.4.4	<i>European Region</i>	277
10.4.5	<i>United States</i>	280
10.5	Military Multimedia Broadcasts	281
10.5.1	<i>US Global Broadcast Service (GBS)</i>	281
	Revision Questions	284
	References	284
11	Communications Architectures	287
11.1	Introduction	287
11.2	Role	287
11.2.1	<i>Service Definition</i>	288
11.3	Circuit-Switched Services	288
11.3.1	<i>Quality of Service</i>	288
11.4	Packet-Switched and Converged Services	290
11.4.1	<i>Internet Protocol Suite</i>	290
11.4.2	<i>IP Over Satellite</i>	292
11.4.3	<i>ATM</i>	294
11.4.4	<i>DVB-RCS</i>	295
11.5	Satellite Communications Networks	296
11.5.1	<i>Topology</i>	296

11.5.2	<i>Network Connectivity, Functions and Interfaces</i>	297
11.6	High-Altitude Platform Systems	301
11.6.1	<i>Overview</i>	301
11.6.2	<i>HAP Applications</i>	302
11.6.3	<i>HAP Network Topology</i>	303
11.6.4	<i>Challenges</i>	303
11.6.5	<i>Technology Status</i>	304
	Revision Questions	305
	References	305
12	Satellite Communications Systems	307
12.1	Introduction	307
12.2	Mobile Communications	308
12.2.1	<i>GEO Broadband Systems</i>	308
12.2.2	<i>GEO Narrowband System</i>	314
12.2.3	<i>LEO Systems</i>	318
12.3	Fixed Communications	325
12.3.1	<i>GEO Broadband Systems</i>	325
12.4	Military Communications	329
12.4.1	<i>Military Portable Satellite Communications Systems</i>	329
12.5	Amateur Communications	339
12.5.1	<i>Overview</i>	339
12.5.2	<i>OSCAR Satellites</i>	339
12.6	HAP Communications	343
12.6.1	<i>EU Research Programmes</i>	343
12.6.2	<i>Commercial Initiatives</i>	347
	Revision Questions	348
	References	349
13	Satellite Navigation Techniques	351
13.1	Introduction	351
13.2	Categorization	352
13.3	Doppler-Assisted Navigation	354
13.3.1	<i>Errors and Countermeasures</i>	356
13.4	Range-Assisted Navigation	357
13.4.1	<i>Reference Frames</i>	357
13.4.2	<i>Error and Countermeasures</i>	358
13.5	Satellite Augmentation System	362
13.6	Navigation–Communication Hybrid Architecture	364
13.7	Receiver Architecture	365
13.8	Distress, Safety and Location-Based Services	371
13.8.1	<i>Distress and Safety Service</i>	372
13.8.2	<i>Location Based Service</i>	374
	Revision Questions	375
	References	376
14	Navigation, Tracking and Safety Systems	379
14.1	Introduction	379
14.2	Global Navigation Satellite Systems	380
14.2.1	<i>Global Positioning System (GPS)</i>	380

14.2.2	<i>GLONASS</i>	389
14.2.3	<i>Galileo</i>	390
14.2.4	<i>Argos</i>	396
14.3	Regional Navigation Systems	398
14.3.1	<i>Beidou and Compass</i>	398
14.3.2	<i>Indian Regional Satellite System</i>	398
14.4	Satellite-Based Augmentation Systems	399
14.4.1	<i>Wide-Area Augmentation System</i>	399
14.4.2	<i>European Geostationary Navigation Overlay Service</i>	400
14.4.3	<i>GAGAN</i>	401
14.5	Distress and Safety	401
14.5.1	<i>Cospas-Sarsat</i>	402
14.5.2	<i>Inmarsat Distress System</i>	404
14.6	Location-Based service	405
	Revision Questions	407
	References	407
15	Remote Sensing Techniques	409
15.1	Introduction	409
15.2	Remote Sensing Data	411
15.3	Sensors	412
15.3.1	<i>Overview</i>	412
15.3.2	<i>Optical Sensors: Cameras</i>	414
15.3.3	<i>Non-Optical Sensors</i>	414
15.4	Image Processing	416
15.5	Image Interpretation	418
15.6	System Characteristics	418
	Revision Questions	420
	References	420
16	Remote Sensing Systems	421
16.1	Introduction	421
16.2	Commercial Imaging	424
16.2.1	<i>DigitalGlobe</i>	424
16.2.2	<i>GeoEye</i>	426
16.3	Meteorology	426
16.3.1	<i>Meteosat</i>	429
16.4	Land Observation	432
16.4.1	<i>Landsat</i>	433
	Revision Questions	436
	References	436
17	The Future	437
17.1	Introduction	437
17.2	Influences	438
17.3	Trend	440
17.4	The Long Term	446

17.5	Satellites and the Environment	447
17.6	Conclusion	448
	Revision Questions	449
	References	449
Appendix	A List of Personal Applications	451
Index		453

