Contents

Preface			xiii
1	Intr	1	
	1.1	Overview of wireless communications	1
	1.2	Spectrum access	3
		1.2.1 Multiple access	4
		1.2.2 Random access	5
	1.3	Duplexing	6
	1.4	Digital wireless transmissions	9
	1.5	Further readings	11
	Prob	blems	11
	Bibl	iography	11
2	Lar	13	
		Wireless communication channels	13
	2.2	Path loss models	15
	2.3	Interference analysis for cellular systems	19
		2.3.1 Cellular concept	20
		2.3.2 Cochannel interference analysis	21
	2.4	Shadowing model	26
	2.5	Outage and coverage analysis	27
	2.6	Further readings	30
	Prob	blems	30
	Bibl	iography	31
3	Mul	tipath fading	33
	3.1	General fading channel model	33
	3.2	Time-domain variation	36
		3.2.1 Doppler effect	36
		3.2.2 Slow vs fast fading	38
	3.3	Multipath delay spread	40
		3.3.1 Power delay profile	41
		3.3.2 Frequency-flat vs frequency-selective fading	43
	3.4	Simplified models for fading channels	44
		3.4.1 Frequency-flat fading	45

			Autocorrelation of complex channel gain Frequency-selective fading	48 51	
	3.5	Furthe	er readings	53	
	Prob	olems		53	
	Bibl	iograph	Ŋ	54	
4	Digi		nsmission over flat fading	55	
	4.1		s of digital bandpass transmission	55	
			bandpass modulation	57 61	
		Optimal detection in presence of AWGN			
	4.4	1			
	4.5		of flat fading channel phase	67	
			Channel estimation	69	
			Differential modulation	70	
			$\pi/4$ Differential QPSK	72	
	4.6		of flat fading channel magnitude	75	
			Performance measures	76	
			Statistical models for flat fading channel gain	78	
	4.7		mance analysis over fading channels	81	
			Outage analysis	82	
			PDF-based average error rate analysis	83	
			MGF-based average error rate analysis	84 87	
	4.8 Further readings				
		Problems			
	Bibl	iograph	Ŋ	90	
5	Fading mitigation through diversity combining 91				
			s of diversity combining	91	
		5.1.1	Implementation strategies	91	
		5.1.2	Antenna reception diversity	92	
		5.1.3	Framework for performance analysis	93	
	5.2	Select	ion combining	94	
	5.3	Maxir	num ratio combining	98	
		5.3.1	Optimal linear combining	98	
		5.3.2	Performance analysis	100	
		5.3.3	Equal gain combining	103	
	5.4	Thresh	nold combining and its variants	104	
		5.4.1	Dual-branch switch and stay combining	105	
		5.4.2	Multibranch switch and examine combining	107	
		5.4.3	Threshold combining with post-examining selection	108	
	5.5	Transr	nit diversity	110	
		5.5.1	Channel knowledge available at transmitter	110	
		5.5.2	Channel knowledge unavailable at transmitter	112	

	5.6	Further readings	116	
	Prol	blems	116	
	Bibl	liography	117	
6	Transmission over frequency-selective fading			
	6.1	Effect of frequency-selective fading	119	
	6.2	Equalization	123	
		6.2.1 Equalizing receiver	123	
		6.2.2 Digital implementation	125	
		6.2.3 Adaptive implementation	129	
	6.3	Multicarrier transmission	130	
	6.4	Discrete implementation/OFDM	135	
	6.5	5 Challenges of OFDM transmission		
	6.6	6.6 Further readings		
	Prol	Problems		
	Bibl	Bibliography		
7	Spr	ead-spectrum transmission	147	
	7.1	Direct-sequence spread spectrum	147	
		7.1.1 Spreading code design	151	
		7.1.2 Effect of DSSS receiver on interference and noise	153	
		7.1.3 RAKE receivers	155	
	7.2	Multiple access with CDMA	157	
		7.2.1 Spreading codes for multiple access	159	
		7.2.2 Performance analysis	160	
	7.3	.3 Frequency-hopping spread spectrum		
	7.4 Further readings			
	Problems			
	Bibliography			
8	Cha	nnel capacity and coding	167	
	8.1	Capacity of AWGN channels	167	
	8.2	Channel coding for AWGN channels	170	
		8.2.1 Block codes	170	
		8.2.2 Performance benefit with coding	173	
		8.2.3 Convolutional codes and turbo codes	175	
	8.3	Capacity of flat fading channels	177	
		8.3.1 Ergodic capacity	177	
		8.3.2 Capacity with outage	179	
		8.3.3 Optimal power and rate adaptation	181 183	
	8.4			
	8.5	6 6		
	8.6	6		
	Problems			
	Bibliography			

9	Cha	nnel adaptive transmission	191	
	9.1	Adaptive transmission	191	
	9.2	Rate adaptation	192	
		9.2.1 Adaptive modulation	196	
		9.2.2 Performance analysis over fading channels	197	
	9.3	Power adaptation	199	
		9.3.1 Full channel inversion	199	
		9.3.2 Truncated channel inversion	201	
	9.4	Joint power and rate adaptation	203	
	9.5	Implementation issues	205	
	9.6	Further readings	206	
	Prob	Problems		
	Bibl	iography	207	
10	MIN	IO transmission	209	
	10.1	MIMO channel model	209	
	10.2	Diversity over MIMO channels	211	
		10.2.1 Channel knowledge available at transmitter	211	
		10.2.2 Channel knowledge unavailable at transmitter	214	
	10.3	Multiplexing over MIMO channels	216	
		10.3.1 Parallel decomposition	216	
		10.3.2 Spatial multiplexing	220	
		10.3.2.1 Uncoded transmission	220	
		10.3.2.2 Coded transmission	222	
	10.4	10.4 Diversity-multiplexing trade-off		
	10.5	225		
	Prob	Problems		
	Bibl	iography	226	
11	Adv	anced wireless transmission	229	
	11.1	Multiuser diversity transmission	229	
		11.1.1 Scheduling strategies	230	
		11.1.2 Implementation issues	232	
	11.2	Cooperative relay transmission	233	
		11.2.1 Amplify-and-forward relaying	234	
		11.2.2 Decode-and-forward relaying	235	
		11.2.3 Cooperative diversity	236	
	11.3	Multiuser MIMO transmission	237	
		11.3.1 Linear zero forcing beamforming	238	
		11.3.2 Spatial multiplexing with random beamforming	241	
	11.4	Further readings	242	
	Prob	blems	243	
	Bibliography			

Appendices			245
A.1	Fourier transform		245
	A.1.1	Fourier transforms for continuous-time signals	245
	A.1.2	Fourier transform for discrete-time signal	247
A.2	Probab	pility and random variables	249
	A.2.1	Probabilistic modeling with random variables	250
	A.2.2	Properties of random variables	251
	A.2.3	Sample random variables	253
	A.2.4	Multiple random variables	254
	A.2.5	Random processes	256
A.3	Vectors and matrices		258
	A.3.1	Definition	258
	A.3.2	Operations	260
	A.3.3	Matrix decomposition	262
A.4	Lagra	nge multipliers	263
Bibl	iograph	У	264

Index

265