

Contents

1	Introduction	1
1.1	General	1
1.2	TT&C and Information Transmission	2
1.3	Tasks, Functions, and Classification of TT&C and Information Transmission	3
1.4	Engineering Applications of TT&C and Information Transmission Technologies	9
1.4.1	Unified Carrier C&T System	9
1.4.2	Space-Based C&T System	10
1.4.3	Deep-Space C&T System	11
1.4.4	Phased Array C&T System	12
1.4.5	High-Accuracy Missile Range-Measuring System	13
1.4.6	Near-Space Vehicle TT&C and Information Transmission System	13
	References	14
2	Theories and Technologies of Tracking and Orbit-Measuring	15
2.1	General	15
2.2	Localization and Orbit-Measuring	16
2.2.1	Localization	16
2.2.2	Station Distribution Geometry and Localization Accuracy	21
2.2.3	Trajectory Measurement System	30
2.3	Velocity-Measuring Theory and Technology: Two-Way, Three-Way, and Single-Way Velocity-Measuring Technologies	33
2.3.1	CW Velocity-Measuring	33
2.3.2	Doppler Frequency Measurement Method	36
2.3.3	Theoretical Analysis of Two-Way Coherent Doppler Velocity-Measuring Error	39
2.3.4	Three-Way Noncoherent Doppler Velocity Measuring and $\dot{S}$ Measuring	69

2.3.5	Two-Way Noncoherent Doppler Velocity Measuring	72
2.3.6	One-Way Noncoherent Doppler Velocity Measuring	79
2.3.7	Theoretical Calculation of Velocity-Measuring Accuracy	81
2.4	Ranging Techniques Theory and Technology: Two-Way, Three-Way, and Single-Way Ranging Technologies	86
2.4.1	Continuous Wave Two-Way Ranging Methods	86
2.4.2	Vector Analysis Method of Ranging Error	104
2.4.3	Group Delay Characteristics Analysis Method of Ranging Error	113
2.4.4	Random Ranging Error	124
2.4.5	Theoretical Calculation of Ranging Accuracy	131
2.4.6	One-Way Ranging Technique	135
2.4.7	Three-Way Ranging Technique	139
2.4.8	Deep-Space Ranging System	140
2.5	Angle Measurement Theory and Technology	143
2.5.1	Angle Measurement Using Antenna Tracking – Three-Channel, Dual-Channel, and Single-Channel Monopulse Technologies	143
2.5.2	Angle Measurement with Interferometer	155
2.5.3	Theoretical Calculation of Angle Tracking Accuracy	163
2.5.4	Theoretical Analysis of Angle Tracking of Wideband Signal – Cross-Correlation Function Method	167
2.5.5	Angle Measurement by Phased Array Tracking and Angle Measurement Accuracy – Space Window Sliding and Projective Plane Methods	178
2.5.6	Independent Guidance, Self-Guidance, and Multi-beam Guidance	199
2.5.7	Polarization Diversity-Synthesized Technology of Angle Tracking	217
	References	225
3	Information Transmission Technologies	227
3.1	Analog Transmission Technology in C&T	228
3.1.1	Analog Signal Modulation	228
3.1.2	Demodulation of Analog Signal	236
3.1.3	Two-Way Carrier Acquisition in C&T – “Frequency Sweep to Acquisition” and “Following Sweep Slope Determination”	242
3.1.4	Combined Interference in the Unified Carrier C&T System – “Modulation/Demodulation Integration Characteristic Analysis Method”	250

3.2	Digital Signal Transmission Technology in C&T	259
3.2.1	Overview	259
3.2.2	Optimum Transmission Response of Digital Signal Transmission	261
3.2.3	Digital Modulation/Demodulation Technology	267
3.2.4	Channel Coding/Decoding Technology	277
3.2.5	Impacts of Noise on Data Transmission BER – Amplitude Noise Equivalent Method	291
3.2.6	Impacts of Linear Distortion on Data Transmission BER	297
3.2.7	Impacts of Non-linear Distortion on Data Transmission BER	308
3.3	Information Transmission Techniques for Telemetry, Command and Remote Sensing	322
3.3.1	Information Transmission Techniques for Telemetry	322
3.3.2	Command Information Transmission Technology	334
3.3.3	Remote Sensing Information Transmission Technique	347
	References	359
4	Spread Spectrum TT&C	361
4.1	General	361
4.2	Features of Spread Spectrum TT&C	362
4.3	Basic Methods for Spread Spectrum TT&C	365
4.3.1	Direct Sequence Spread Spectrum (DSSS)	366
4.3.2	Frequency Hopping Spread Spectrum (FHSS)	372
4.3.3	Hybrid Spread Spectrum of DSSS and FHSS	375
4.3.4	Time Hopping Spread Spectrum	375
4.3.5	Code Hopping	376
4.4	Acquiring and Tracking of Spread Spectrum TT&C Signals	380
4.4.1	Acquiring and Tracking of DSSS Signals	380
4.4.2	Acquiring and Tracking of Frequency Hopping Spread Spectrum Signals	386
4.4.3	Velocity Measuring of Frequency Hopping Spread Spectrum—“Two-Step Method” Frequency Hopping Velocity Measuring	388
4.5	Measuring Accuracy and Tracking Threshold for Direct Spread Spectrum TT&C	391
4.5.1	Phase Error in Carrier Loop of Spread Spectrum Receiver	392
4.5.2	Range Measurement Error in Spread Spectrum TT&C	393
4.5.3	Rate Measurement Error in Spread Spectrum TT&C	395

4.6	“Double Spread Spectrum” and Its Application in TDRSS	395
4.6.1	Problems Raised	395
4.6.2	“Code Division Multiplexing” and “Double Spread Spectrum”	396
4.6.3	Main Technical Problems of “Double Spread Spectrum”.	398
4.7	Chaotic Sequence and Chaotic Spread Spectrum TT&C	401
4.7.1	Characteristics of Chaotic Sequence	401
4.7.2	Type, Selection, and Generation of Chaotic Sequence	405
4.7.3	Synchronization and Ranging of Chaotic Spread Spectrum Signals	414
	References	424
5	Special Issues on Radio Transmission Channel in C&T	425
5.1	C&T Frequency Band Developing to Ka-Band and Optical Bands	425
5.1.1	Principle for Selecting C&T Frequency Band	425
5.1.2	Development Trend	428
5.1.3	Background of Developing Ka-Band C&T System	430
5.1.4	Characteristics of Ka-Band C&T System	432
5.1.5	Main Technical Issues of Ka-Band C&T System	436
5.2	Rain Attenuation and Atmospheric Attenuation in Signal Transmission Channel	438
5.2.1	Significance of Rain Attenuation Study	438
5.2.2	Characteristics of Rain Attenuation	439
5.2.3	Calculation of Rain Attenuation	439
5.2.4	Increment in System Noise Temperature Caused by Rainfall	446
5.2.5	Rain Attenuation Countermeasure Technology	446
5.2.6	Atmospheric Attenuation in Signal Transmission Channel	450
5.3	Influence of Multipath Transmission	453
5.3.1	Three Types of Fast Fading Caused by Multipath Effect	455
5.3.2	Nature of Reflection Coefficient	458
5.3.3	Path Loss and Scintillation Fading in Case of Multipath Propagation	463
5.3.4	Orbit Determination Error Caused by Multipath Propagation	468
5.3.5	Effect of Multipath Interference on Data Transmission Bit Error Rate	472
5.3.6	Anti-multipath Interference Measures	475
5.4	New Methods for Simulation and Calibration	498
5.4.1	Dynamic Simulation Method Based on Motion Equation	498
5.4.2	Phase Calibration Using Radio Star Noise	503

5.4.3	On-Orbit Phase Calibration by Measuring “Cross-Coupling” Value	508
5.4.4	Geometric Optics Application for Range Calibration	511
5.4.5	Effect of Radio Wave Propagation Characteristic on Orbit Determination Accuracy	516
5.4.6	Tropospheric Radio Wave Refraction Error Correction . . .	522
5.4.7	Ionospheric Refraction Correction Methods	525
5.4.8	Factors Affecting Correction Accuracy	530
	References	531

Spacecraft TT&C and Information Transmission Theory
and Technologies

Liu, J.

2015, XI, 531 p. 265 illus., 53 illus. in color., Hardcover

ISBN: 978-3-662-43864-0