

Table of contents

Abstract	i
Acknowledgement	iii
List of Tables	vii
List of Figures	viii
1 Introduction	1
1.1 Statement of the problem	4
1.2 The thesis objectives	6
1.3 The thesis structure	7
2 GPS Basics and Definitions	8
2.1 History of NAVSTAR GPS	8
2.2 GPS Segments and system overview	11
2.2.1 Space Segment.....	11
2.2.1.1 Satellites Orbits	16
2.2.2 Control Segment	19
2.2.3 User Segment	22
2.3 GPS Navigation Signal and Signal Structure.....	24
2.3.1 Satellite Frequencies	26
2.4 Basic Concept of GPS Positioning	27
2.5 Correcting a GPS receiver's clock	28
2.6 C/A Code.....	30
2.6.1 Demodulation and decoding	30
2.6.2 GPS Position Calculation	34
2.7 P(Y) Code.....	39
2.8 Carrier phase tracking	40
2.9 GPS Error Sources	44
2.9.1 System Errors	44
2.9.2 Receiver Dependent Errors	47
2.9.3 Point Selection Errors	49

2.9.4 Operation Errors	51
2.9.5 Data Processing Errors	54
3 GPS Observations Techniques.....	56
3.1 Absolute and Relative Positioning	56
3.2 Differential Solutions	58
3.2.1 Code Differential.....	58
3.2.2 Carrier Phase Differential	58
3.3 Relative Observation Techniques.....	60
3.3.1 Static observation technique.....	61
3.3.2 Fast-Static observation technique.....	63
3.3.3 Kinematics observation technique.....	64
3.3.3.1 Stop and Go observation technique.....	64
3.3.3.2 Kinematics on the fly observation technique.....	66
3.3.4 Real Time Kinematics observation technique	67
3.4 Real time kinematics basics	71
3.4.1 Principal of data correction basic idea	71
3.4.2 Real Time – DGPS Data correction transmission.....	76
3.4.3 The range and accuracy of RTK	77
3.4.4 Real Time DGPS Communication link consideration.....	79
3.5 Real time kinematics and GNSS improvements	82
3.5.1 Global Navigation Satellite System GNSS improvement	82
3.5.1.1 Modernization of GPS	84
3.5.1.2 Galileo Funding and Signal Structure	85
3.5.1.3 Compass development	86
3.5.2 GNSS improvement RTK user benefits	86
3.5.3 Modern RTK receivers improvement	89
3.5.3.1 Signal tracking improvement	89
3.5.3.2 Number of channels improvement	89

3.5.3.3	The position update rate improvement.....	90
3.5.3.4	The ambiguity checks improvement.....	91
3.5.3.5	The online map view improvement.....	92
3.5.3.6	The data storage improvement.....	92
3.5.3.7	The Communications improvement	93
3.5.4	The Real Time Network (RTN) RTK Surveys.....	94
4	Testing of the Main Factors Affecting on RTK Accuracy	95
	(Numerical experiments and results)	
4.1	Introduction	95
4.1.1	Preparation of sample area (1)	96
4.1.2	Static Observations and Data Processing.....	99
4.2	The influence of the cut off angle.....	101
4.3	The influence of the number of base stations.....	117
4.4	The influence of the inter visibility between the base and the rover.....	122
4.5	The influence of the data transmission frequency.....	129
4.6	The influence of the number of observations.....	134
4.7	The influence of the number of satellites.....	138
4.8	Preparation of Sample Area (2).....	143
4.9	The influence of the distance between the Base and the Rover.....	148
4.10	The influence of the Base line Azimuth.....	153
5	Summary , Conclusions and Recommendations	157
5.1	Summary	157
5.2	Conclusions	160
5.3	Recommendations	163
Appendix A		165
A-1 Terminology		165
References		182

List of tables

4-1	Distribution and specifications of the sample points.....	96
4-2	The Geodetic coordinates of the 14 sample points.....	100
4-3	The UTM coordinates of the 14 sample points.....	100
4-4	Differences with cut off angle changing for point no. 2.....	102
4-5	Differences with cut off angle changing for point no. 8.....	103
4-6	Differences with cut off angle changing for point no. 11.....	104
4-7	Differences with cut off angle changing for point no. (8)-case2.....	112
4-8	Differences with cut off angle changing for point no. (2)-case2.....	113
4-9	The inter visibility and distances between the point and base stations.....	117
4-10	Differences with different numbers of base stations (case1).....	118
4-11	Differences with different numbers of base stations (case2).....	118
4-12	The case of inter visibility between BS and the 14 sample points.....	122
4-13	Differences with different inter visibility degrees(session1).....	123
4-14	Differences with different inter visibility degrees(session2).....	123
4-15	Differences with different inter visibility degrees (session3).....	124
4-16	Differences with different data transmission frequencies (case1).....	130
4-17	Differences with different data transmission frequencies (case2).....	130
4-18	Differences with different numbers of epochs.....	135
4-19	Differences with number of satellites for point no. (2).....	139
4-20	Differences with number of satellites for point no. (8).....	139
4-21	The geodetic coordinates of the 13 sampler points.....	147
4-22	The UTM coordinates of the 13 sample points.....	147
4-23	Differences with different base line lengths for group A.....	149
4-24	Differences with different base line lengths for group B.....	149
4-25	Differences with different base line azimuths for groups A and B.....	154

List of figures

2-1	GPS-Block I Satellite.....	11
2-2	GPS-Block IIA Satellite	12
2-3	Small atomic clock.....	13
2-4	GPS-Block IIR and IIR-M Satellite	14
2-5	GPS-Block IIF Satellite	15
2-6	Orbits of the GPS-Satellites.....	17
2-7	Inclination of the orbital planes.....	17
2-8	Position of the monitor stations and the master control stations.....	20
2-9	Satellite tracking station on Hawaii.....	20
2-10	The “master control station” Schriever AFB , Colorado	21
2-11	Diagram depicting satellite 4 , sphere , p4,r4 and da.....	29
2-12	Demodulating and Decoding GPS satellite signals	30
2-13	Two spheres intersecting in a circle.....	35
2-14	Surface of a sphere intersecting a circle at two points.....	36
2-15	Sunspot predictions.....	46
2-16	Multipath example.....	50
3-1	Simple diagram for the ambiguity resolution.....	59
3-2	The static observation technique procedure.....	63
3-3	The kinematic observation technique procedure.....	66
3-4	The RTK observation technique procedure	68
3-5	Principal of DGPS Using the Block Shift Method.....	73
3-6	Principal of DGPS Using the Range Correction Method.....	73
3-7	Centre frequencies of currently transmitted and future satellite signals.....	83
3-8	GPS Manufacturers Market Introduction.....	84
3-9	Sunspot numbers of solar cycles 23 and 24.....	88
4-1	Distribution of points in sample area (1).....	97
4-2	Difference in position with cut off angle variation for point no.(2).....	105
4-3	Difference in position with cut off angle variation for point no.(8).....	106
4-4	Difference in position with cut off angle variation for point no.(11).....	107
4-5	Sky plot using 30 degrees cut off angle.....	110
4-6	Satellite availability using 30 degrees cut off angle	111
4-7	Difference in position with cut off angle variation for point no.(8)-Case2.....	114

4-8	Difference in position with cut off angle variation for point no.(2)-Case2.....	115
4-9	Differences with different numbers of base stations for point no.14(case1).....	119
4-10	Differences with different numbers of base stations for point no.14(case12).....	120
4-11	Simple sketch for using one RTK base station or more than one base station.....	121
4-12	Differences with different inter visibility degrees (session1).....	125
4-13	Differences with different inter visibility degrees (session2).....	126
4-14	Differences with different inter visibility degrees (session3).....	127
4-15	Differences with different data transmission frequencies (case1).....	131
4-16	Differences with different data transmission frequencies (case2).....	132
4-17	Differences with different numbers of observations for point no.13.....	136
4-18	Differences with number of satellites for point no.(2)-Case1.....	140
4-19	Differences with number of satellites for point no.(2)-Case2.....	141
4-20	Sample area 2	144
4-21	The relation between points in sample area 2	145
4-22	Differences with base line length for group A.....	150
4-23	Differences with base line length for group B	151
4-24	Differences with the base line azimuth for the two groups A and B.....	155
4-25	Sky Plot for GPS Satellites Paths Over Egypt	156