

**DETERMINATION OF IONOSPHERIC TOTAL ELECTRON
CONTENT (TEC): PHASE MEASUREMENT BASED ON
LEVELLING TECHNIQUE**

**This thesis is presented in partial fulfillment for the award of the
Bachelor of Electrical Engineering (Honors)
Universiti Teknologi MARA**



**MOHD AMIRSHAIFULRAZAIN ABU ZAINI
FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM,
SELANGOR, MALAYSIA
MAY 2009**

ACKNOWLEDGEMENT

In the Name of Allah, the Most Beneficent, the Most Merciful.

I would like to acknowledge the people who made this project possible: my supervisors, Mr. Mohamad Huzaimy Jusoh for their valuable ideas, patient guidance and encouragement throughout this project. Their input has afforded immeasurable help during my study in Universiti Teknologi MARA.

Thousand thanks to JUPEM (Department of Survey and Mapping Malaysia) located in Kuala Lumpur for giving the co-operation and permission to get the data.

Furthermore, thanks to Research assistant, Miss Faizatul Noor Abu Bakar for giving guidance, helps and information to complete this project.

Thanks to Mr. Muhd Farid Abd Khalid and Mrs. Ros Norhayati Hamzah for their willingness to evaluate my project presentation and technical paper.

Last but not least, thanks to my project group partner, Mr Mohd Zaffan Mohd Zaini and Mr. Mohd Naqiuddin Mohammed. My family, friends and anybody who involved directly or indirectly for their support, understanding, help and advice.

My sincere thanks to all of you.

ABSTRACT

GPS has become a great tool for ionospheric studies and research. The accuracy or quality of coordination data of GPS receiver can be increased by determining the source and factor of the disturbances that produce at ionosphere layer. Basically, dual frequency carrier-phase and code-delay Global Positioning System (GPS) observations are combined to obtain ionospheric observables related to the slant TEC (TECs) along the satellite-Receiver line of sight (LoS). The Total Electron Content (TEC) data was taken from receiver station located at Universiti Teknologi Malaysia, Johor, UTMJ station and Wisma Tanah, Kuala Lumpur, KTPK station. A code-delay data produce high noise level compared to carrier-phase data. This research assessing the conversion of code-delay to carrier-phase data ionospheric observable and so-called "Levelling process" which applied to reduce code-delay ambiguities. It was found that the levelled carrier-phase has a low noise level and the remaining noise was discarded.

TABLE OF CONTENTS

| | |
|---|------|
| ACKNOWLEDGEMENT | i |
| ABSTRACT | ii |
| TABLE OF CONTENTS | iii |
| LIST OF FIGURES | v |
| LIST OF TABLES | vii |
| ABBREVIATIONS | viii |
| 1.0 INTRODUCTION | 1 |
| 1.1 PROJECT OVERVIEW | 1 |
| 1.2 OBJECTIVES | 2 |
| 1.3 SCOPE OF THE PROJECT | 2 |
| 1.4 THESIS LAYOUT | 3 |
| 2.0 LITERATURE REVIEW IONOSPHERE..... | 4 |
| 2.1 INTRODUCTION..... | 4 |
| 2.2 THE IONOSPHERIC LAYER | 5 |
| 2.3 IONOSPHERIC VARIABILITY | 9 |
| 2.4 IONOSPHERIC SCINTILLATION | 11 |
| 2.5 PRODUCTION AND LOSS OF ELECTRONS..... | 12 |
| 3.0 GLOBAL POSITIONING SYSTEM (GPS) | 13 |
| 3.1 INTRODUCTION..... | 13 |
| 3.2 OVERVIEW OFGPS | 13 |
| 3.3 GPS SEGMENTS..... | 14 |
| 3.3.1 SPACE SEGMENT | 15 |
| 3.3.2 CONTROL SEGMENT | 16 |
| 3.3.3 USER SEGMENT..... | 17 |
| 3.4 GPS SATELLITE GENERATIONS..... | 17 |
| 3.5 BASIC GPS SIGNAL STRUCTURE..... | 20 |
| 3.6 GPS: THE BASIC IDEA | 22 |
| 3.7 NAVIGATION SATELLITE SYSTEM..... | 24 |
| 3.8 DUAL FREQUENCY GPS SYSTEM..... | 25 |

| | | |
|-------|--|----|
| 3.9 | SOURCES OF GPS SIGNAL ERRORS | 26 |
| 3.9.1 | SATELLITE GEOMETRY | 26 |
| 3.9.2 | MULTIPATH EFFECT | 28 |
| 3.9.3 | ATMOSPHERIC EFFECTS..... | 28 |
| 3.9.4 | OTHER EFFECTS..... | 29 |
| 3.10 | GPS RECEIVER STATION IN MALAYSIA..... | 30 |
| 3.11 | RECEIVER INDEPENDENT EXCHANGE FORMAT (RINEX) | 31 |
| 4.0 | TOTAL ELECTRON CONTENT (TEC)..... | 35 |
| 4.1 | INTRODUCTION..... | 35 |
| 4.2 | IONOSPHERIC DELAY AND TEC..... | 36 |
| 4.3 | CALCULATION OF SLANT AND VERTICAL TEC..... | 37 |
| 4.4 | TEC MAPPING FUNCTION | 39 |
| 4.5 | PHASE LEVELLING MEASUREMENT..... | 42 |
| 4.5.1 | SHIFTED PHASE LEVELLING (SLEV) & TECS..... | 42 |
| 5.0 | METHODOLOGY..... | 43 |
| 5.1 | LOAD GPS DATA FROM RINEX FILE | 44 |
| 5.2 | DEFINE CONSTANT | 47 |
| 5.2.1 | RINEX Parameters..... | 47 |
| 5.2.2 | Dual Frequency GPS satellites..... | 47 |
| 5.3 | CHECK EXISTING OF P ₁ OR C ₁ | 47 |
| 5.3.1 | If P ₁ is exist..... | 47 |
| 5.3.2 | If C ₁ is exist | 48 |
| 5.4 | SHIFTED VALUE FOR LEVELLED CARRIER-PHASE DIFFERENT | 48 |
| 5.5 | TECs FROM THE PHASE | 50 |
| 6.0 | RESULTS & DISCUSSIONS | 52 |
| 7.0 | CONCLUSION AND FUTURE RECOMENDATIONS..... | 65 |
| 7.1 | CONCLUSION | 65 |
| 7.2 | FUTURE RECOMENDATIONS | 66 |
| | REFERENCES..... | 67 |
| | APPENDIX..... | 71 |