A Model for Detection of Error Factors in GPS Signals

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Abstract

The earth's ionosphere acts as a perturbing medium on satellite-based navigational systems like GPS. Variations in the ionosphere due to weather conditions caused by solar flares and coronal mass ejection can scatter Trans - Ionosphere radio signals producing fluctuations in both amplitude and phase and GPS cycle slips disrupting satellite communications and navigation. The ionosphere delay is one of the fundamental reasons for inaccuracy in GPS positioning and routing. The Total Electron Content (TEC) along the radio wave path from a GPS satellite to the ground receiver is directly proportional to the ionosphere delay. This paper proposes a method allowing to calculate the TEC with a correctness of about 2–3 TECU and to sense Travelling Ionosphere Disturbances using GPS measurements.

Keywords - *Epoch, GPS, Ionosphere, Satellite, TEC.*

I. INTRODUCTION

Under the name of GPS, the compact radio navigation receivers have proliferated in the civilian market place from past several years. The position calculated by a GPS receiver requires the current time, the position of the satellite and the measured delay of the received signal and then by using the triangulation rule the position of the receiver is determined.

The large sources of error in GPS are produced by the atmospheric effect (ionospheric, tropospheric), clock errors of the satellite, multipath effect, satellite orbits errors and calculation-rounding errors. The satellite signal slows as it passes through the atmosphere. The GPS framework utilizes an inherent model that computes a normal measure of delay to in part right for this sort of mistake. Receiver's inherent timekeepers are not exact as the atomic clocks installed the GPS satellite. Along these lines, it may have extremely slight timing errors. GPS error is a combo of clamor, inclination, and botches. Clamor mistakes are the consolidated impact of PRN code disorder (around 1 meter) and clamor inside the receiver disorder (around 1 meter). Inclination mistakes are the deliberate corruption of the SPS motions by a period shifting inclination [1]. The primary goal of this work is to process the error correction factors in the GPS signals and to create the information handling programming module to satisfy necessities.

In this paper GPS information is prepared and diagram is computed utilizing MATLAB tool. For this GPS equipmental setup is carried out. A dual frequency GPS receiver can wipe out (to the first order) the ionospheric delay through a direct mix of L1 and L2 observables [2]. The vast majority of the civilians utilizes low-cost single frequency GPS receivers that can't utilize this alternative. Henceforth for precise navigation differential GPS is chosen. Investigation of GPS position error and correcting method is done.

II. THE EFFECT OF SPHERES ON GPS SIGNAL

As radio signal pass through ionosphere and troposphere, they slow down based on the density of atmosphere and they can be modeled as a bent path as in Fig. 1.

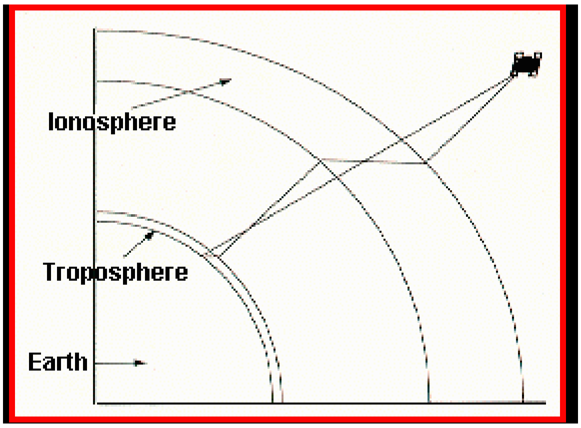

Figure 1 GPS Signal Distorted by Spheres.

The Charged particles in the Ionosphere expel vitality from radio waves. Non – Uniform Electron thickness alters course of propagation. The bearer stage is progressed and balance stage is impeded. The polarization is rotated because of Faradays rotation. Ionosphere and Ionosphere Delays – The satellite Signal passes through the atmosphere because of ionosphere changes generates delay [3]. Receiver Clock Errors – Receiver Build in Clock is not exact as that of atomic clock. Orbital Error - Inaccuracy of the satellites reported Locations. Geographic latitude, longitude, local time, season, geomagnetic activity and viewing direction are the factors which decide the TEC [4] and it can be estimated by forming the linear combination of the GPS measurement on L1 and L2 frequencies, either by using GPS carrier phase or pseudo-ranges observables. The ionosphere compels the most unfavorable results for the radio wave passing through it. Dispersive nature of the ionosphere and usage of two frequencies in GPS facilitate estimation of ionospheric TEC which is a basic parameter in the examination of L-Band correspondence. Rate of TEC (ROT) from GPS can illustrate the features of the ionospheric glimmers. Very irritated ionosphere can result in cycle slips in GPS information. Very good correlation is found between the ionospheric scintillations and the number of cycle slips in GPS data.

GPS receivers can either track only C/A codes or both C/A and P(Y) codes. Most receivers have multiple channels, where each channel tracks transmission from a single satellite. There can be a most extreme of 12 such channels. The receiving unit forwards the signals to the processor. The processor performs position, velocity, and time estimation from the signals received from the receiving unit. The processor is responsible for issuing commands to the receiving and input/output units.

The I/O device acts as an interface between the receiver equipment and other user equipment. By and large the I/O devices is a basic showcase unit that shows the immediate position while in configurations where the GPS is used along with other sensors, the interface could be a RS- 232, RS-422 or ARINC 429.

The power supply could be either external or integrated into the receiver. It may even be a combination of both. Typically, alkaline or lithium batteries are used for integrated power supplies while external supplies are generally AC adapters.

III. GPS EQUIPMENTAL SET-UP

The collector gear comprises of a receiving antenna, an accepting unit, a processor, a data/ yield gadget and a force supply indicated in Fig.3.1. GPS receiving antenna can be single frequency or double frequency receiving antenna. The physical configuration of the radio antenna can vary from helical to micro strip. There are number of variables that need to be considered for receiving antenna choice, for example, radio gain, mounting area, multipath execution, and stability of the electrical stage censer of the radio wire [5].

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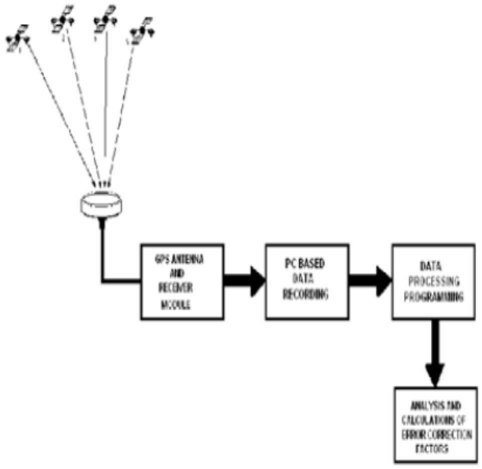

Fig. 2 Overview of Research Work

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IV. GRAPHICAL REPRESENTATION OF ERROR PROCESSED IN IONOSPHERE

All the data interpreted is taken from Indian Institute of Geomagnetism, Shivaji University, Kolhapur from LICA Receiver.

The system designed has following objectives:

- Extraction of alpha, beta, GPS coordinates and GPS time for a epoch
- Evaluation of errors contributed by Ionosphere, Troposphere and satellite clock error is to be done.

To understand the system working, it needs to follow the steps mentioned in block diagram Fig. 3 Keeping the alpha, beta, GPS coordinates and GPS time available from ephemeris table as a reference, the drifts in the values for known epochs has to be calculated. The meaning of drifts in the value is the delays introduced by Ionosphere, troposphere and also the offset error in satellite clock values. As per the diagram Ionosphere error model consists of evaluation of Slant delay using vertical delay at the Ionosphere Pierce Point (IPP) [6]. Knowing the value of α_n the Earth centered angle φ and hence ϕ the geomagnetic latitude of the IPP can be calculated using Klobuchar algorithm.

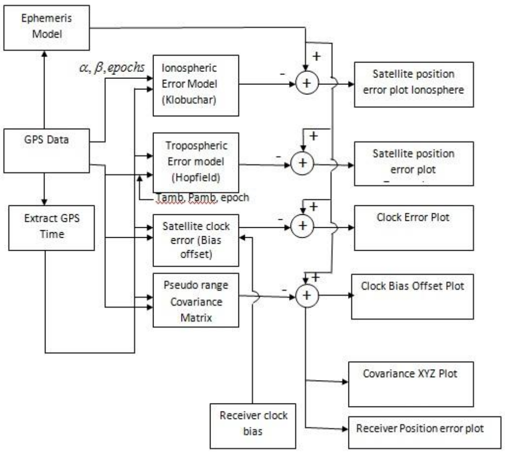

Fig. 3 Overview of Research Work

A. *Calculation of Ionosphere Error for Normal Day*

X-Co-ordinate ionosphere error initially starts to increase from a negative value and crosses zero level. It then increases in more fraction amount. At an instant it gradually reduces to an intermediate fraction value. Further it approaches approximately 0.5 values very slowly. Now it suddenly falls to -1 and after -1 it tries approaching zero level and further some positive value Y & Z co-ordinates show similar fluctuations at different interval which is calculated by

$$T_{iono} = F \times \left[5 \times 10^{-9} + \sum_{n=0}^{3} \alpha_n \phi_m^n \times \left(1 - \frac{x^2}{2} + \frac{x^4}{24} \right) \right]$$

Where F = Slant Factor

ϕ_m = Geometric Latitude

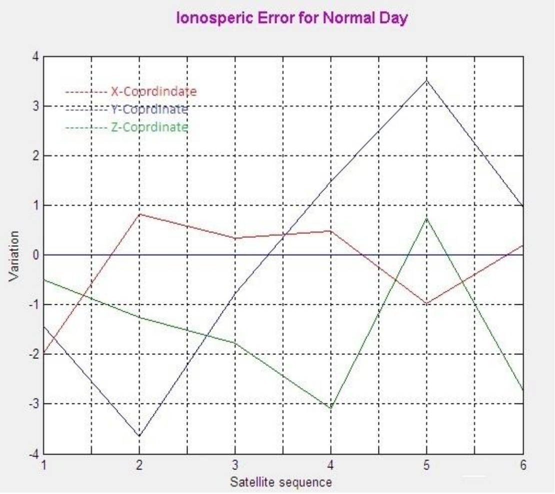

Fig. 4 Ionosphere Error for Normal Day

B. *Calculation of Ionosphere Error for Abnormal Day*

The graph is quite self explanatory. It shows many irregularities around zero level. X-co-ordinate is initially at zero level, but it suddenly falls sharply at -2.5. From there it rises suddenly, approaches zero and gradually falls again at nearly -0.2.

It continues to fall gradually and finally reaches -3. Similarly Y co-ordinates, Z co-ordinates show complex fluctuations Y-co-ordinate gradually moves from -1.5 and ascends to 2.5. It then falls linearly to -3.2 and again increases to 0.4. Z co-ordinate declines down continuously from 2.2 to -0.9 and finally step by step approaches -1.2 values.

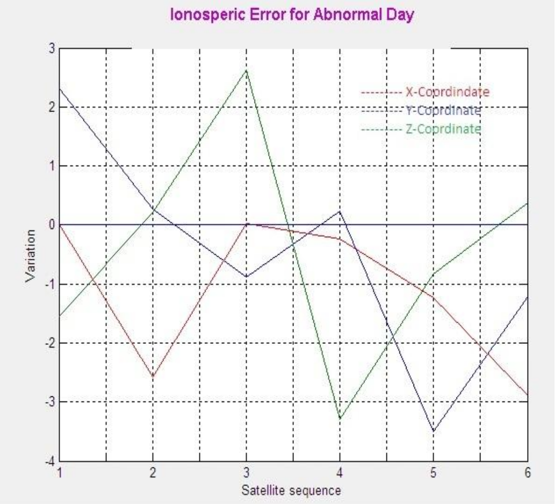

Fig. 5 Ionosphere Error for Abnormal Day

V. GRAPHICAL REPRESENTATION OF ERROR PROCESSED IN TROPOSPHERE

A. Calculation of Troposphere Error for Normal Day

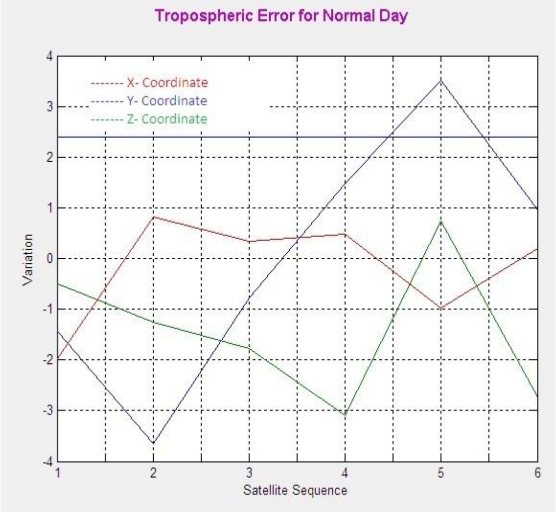

Fig. 6 Ionosphere Error for Abnormal Day

The Troposphere error in case of X co-ordinates increases from -2 to 0.9 on some further fluctuation it reach 0.1 for Y co-ordinate error linearly decreases in negative region from -1.4 to -3.5.It further increases to 3.5 and again decreases at 1. The error in Z co-ordinate decreases gradually & increases sharply but linearly in negative region. It is the only of all co-ordinates to cross zero level, increase in a fraction amount & decrease linearly.

The tropospheric delay is calculated by

$$\Delta T = \frac{K_d}{\sin\left(\sqrt{El^2 + 1.904E-3}\right)} + \frac{K_w}{\sin\left(\sqrt{El^2 + 0.6854E-3}\right)}$$

Where k_d & k_w are zenith delay of dry and wet component respectively.

B. Calculation of Troposphere Error for Abnormal Day

The graph shows many peaks and valleys for all co-ordinates. X co-ordinates has initial decrease in error value, but further linear increase. After this, there is a gradual decrease. Z co-ordinate displays continuous linear decrease in negative valued region. Y co-ordinate error rises from negative valued region & crosses zero level attains a fraction value in positive region & then continuous to decline & gradually improve in negative region.

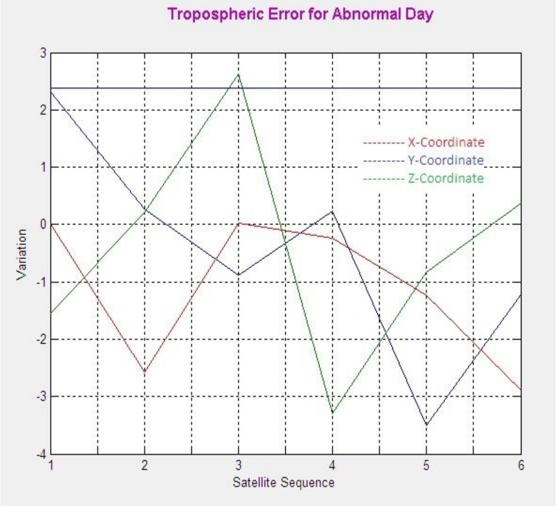

Fig. 7 Ionosphere Error for Abnormal Day

VI. GRAPHICAL REPRESENTATION OF CLOCK ERROR

A. Calculation of Clock Error for Normal Day

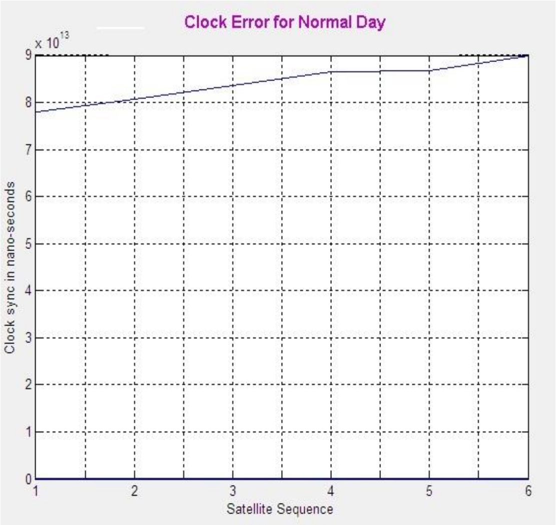

Fig. 8 Ionosphere Error for Abnormal Day

The graph shows that clock error is initially 7.8*10. It then increase gradually & linearly and approaches approx 8.8*10.

B. Calculation of Clock Error for Abnormal Day

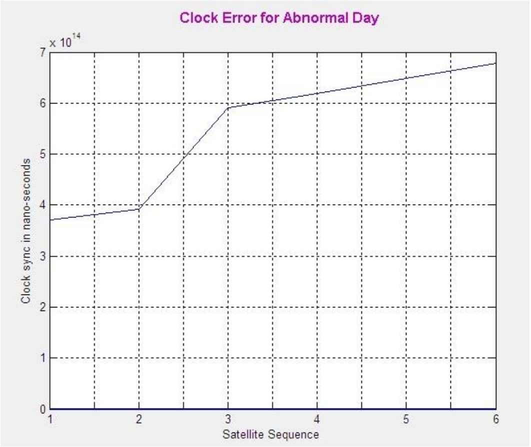

Fig. 9 Ionosphere Error for Abnormal Day

After this it attains stability for some time & then linearly increases finally to 9*10 sec which is calculated by

$$\Delta t_{sv} = af_0 + af_1\left(t - t_{oc}\right) + af_2\left(t - t_{oc}\right)^2 + \Delta t_R - T_{gd}$$

Where SV is pseudorandom noise.

T_{gd} is a group delay

Δt_R is a reference time for cock correction.

Clock bias error for normal day is initially at zero and increases gradually to 0.2*10. After this point it decreases sharply to -3*10.The upper end of graph explains decrease in clock error in case of abnormal day. At very initial stage clock error is approx 3.7*10 and then gradually rises to around 3.9*10. Now it rises linearly & approaches 5.9*10.There upon it moves slowly towards 7*10.

VII. GRAPHICAL REPRESENTATION OF BIAS ERROR

A. Calculation Bias Error for Normal Day

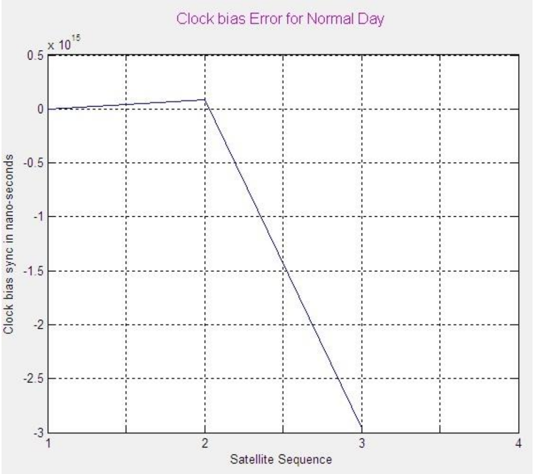

Fig. 10 Ionosphere Error for Abnormal Day

B. Clock Bias Error for Abnormal Day

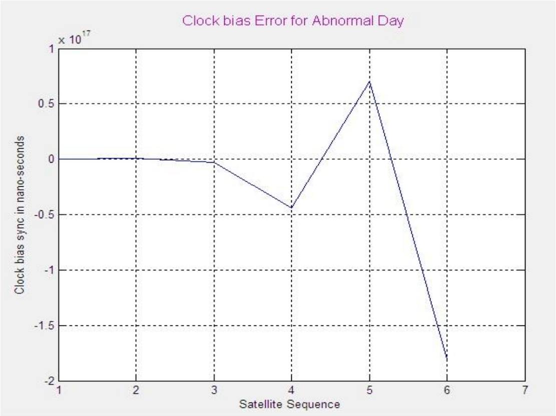

Fig. 11 Ionosphere Error for Abnormal Day

For abnormal day clock bias error is initially zero and tries to be same for some amount. But later it decrease gradually to -0.4*10 and then increases sharply to 0.7*10 sec. Finally it goes on decreasing sharply to -2*10.

VIII. SIGNIFICANCE OF RESEARCH WORK

There are numerous purposes behind error correction factors considered in GPS signal however some major point that influence the GPS signal altogether are clarified as follows (1) GPS errors are combination of noise, bias and blunders. (2) Noise errors are the consolidated impact of PRN code noise (around 1 meter) and noise inside the receiver noise (around 1 meter). (3) Selective Ability (SA) is the intentional degradation of the SPS signals by a time varying bias. SA is controlled by the DOD to farthest point precision for non- U. S. military and government clients. The potential exactness of the C/A code of around 30 meters is reduced to 100 meters (two standard deviations). The SA bias on each one satellite signal is diffrent, along these lines the ensuing position arrangement is a capacity of the consolidated SA inclination from every SV utilized as a part of the route arrangement [7]. Since SA is a changing predisposition with low recurrence terms in overabundance of a couple of hours, position arrangements alternately individual SV pseudo-ranges can't be viably found the middle value of over periods shorter than a couple of hours. Differential revisions must be redesigned at a rate short of what the relationship time of SA (and different inclination blunders). (4) Troposphere defers: 1 meter. The troposphere is the lower part (ground level to from 8 to 13 km) of the environment that encounters the changes in temperature, weight, and moistness connected with climate changes [8]. Complex models of Troposphere deferral oblige evaluations or estimations of these parameters. (5) Ionospheres defers: 10 meters. The ionosphere is the layer of the environment from 50 to 500 km that comprises of ionized air. The transmitted model can just evacuate about a large portion of the conceivable 70 ns of deferral leaving a ten meter unmodelled lingering.

IX. CONCLUSION

The signals from the GPS Satellites will be picked up by receiving antenna. The GPS receiver might contain the inbuilt information recording and storage facility however this recorded information again reformatted and transferred in the PC (for case Navigation and Observation Data). This information contains all the terms of the navigational and observational structures of the guidelines utilized as a part of the GPS framework. The computational assignment for the algorithm and software for information handling will be executed. At long last the obtained results will be investigated and the execution of the framework will be observed. The computed error correction factors may be used to rectify different GPS parameters which will be useful to acquire the error free corrected GPS information.

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