Co-ordinate Transformation of Satellite Orbits for Ionospheric and Tropospheric Pierce Points: Visualization and Computation

Pooja S.K[1], Pooja Arekal K[2], T Hithaishi Mohan[3], Yashodha A B[4], Prof. Santhosh S[5], Junior Scientist. Himanshu Sethi[6]

[1, 2, 3, 4, 5, 6]*Dept. of Electronics and Communication*

Alva's Institute of Engineering and Technology, Moodbidri, Mangaluru, Karnataka, India

Abstract: **Ionosphere, as one of the Earth's air layers, evolving condition, both spatially and transiently. It reaches out to a tallness of around 50 to 1000 km and is the fundamental assurance of the Earth and life on Earth from the risky impact of the Sun and the universe itself. One of real restrictions to accomplish precision when utilizing single recurrence GPS (Global position framework) recipients is the issue of postponements in flag proliferation through the ionosphere. Troposphere is the most minimal locale of the earth air and it stretches out from 6-10kms from the earth surface. Troposphere contains water atoms this prompts a tropospheric delay. These deferrals can be estimated by ascertaining ionospheric and tropospheric penetrate focuses.**

Keywords: **Ionospheric and tropospheric delay, Ionospheric Pierce Points (IPP), GPS. Total Electron Content(TEC)**

I. INTRODUCTION

A disentangled model of ionosphere is anticipated as it is hard to figure the Total Electron Content(TEC) along the observable pathway. The anticipated disentangled model is expected that the ionosphere is the thin, uniform thickness shell about the ionosphere which is situated close to the mean elevation H of most extreme TEC which is roughly 350km about the earth as appeared in the Fig.1. The flag which is transmitted from the satellite to the collector will cross the ionospheric shell, in this manner the convergence between the viewable pathway and this shell is known as Ionospheric Pierce Points (IPP).

The electron thickness in the ionosphere causes to the refraction of GPS signals. Nonetheless, this structure of ionosphere varies every day, regularly, opportune and it likewise fluctuates in like manner to geographic area. Because of that, the IPP or the elevation in the ionosphere where the structure of electron thickness is most prominent does changes contingent upon those criteria expressed before. Thusly, when the altitudes or IPP of those carrier frequencies GPS carrier frequencies, L1 and L2, propaga contingent upon those criteria expressed before. Thusly, when the elevations or IPP of those transporter frequencies are different. Regularly, the refraction of L2 is constantly more prominent than L1. This is additionally because of the nearness of ionospheric even inclination. The more noteworthy the slope, the more prominent the separation amongst L1 and L2 at one specific elevation or IPP.

Ionospheric Pierce Point

Ionosphere is one of the motivation to actuate blunders to a large portion of the Global Navigation Satellite System (GNSS). Since the speed of the microwave flag is influenced by ionospheric delay contingent upon their recurrence, this is known as scattering. By at least two recurrence groups postponements can be estimated which is utilized to quantify scattering, and this estimation can be utilized to compute delay at every recurrence. The Total Electron Content (TEC) in the ionosphere along the observable pathway from the satellite to the recipient is the primary wellspring of the scattering and ionospheric shell is given as IPP.

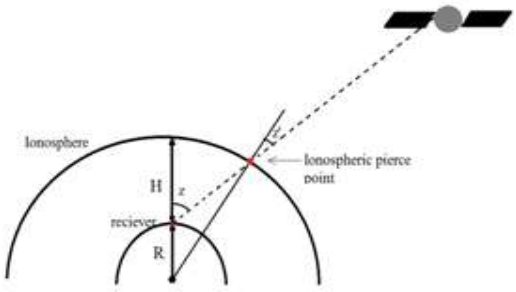

Fig 1: model of Ionospheric Pierce Point

Earth Centred and Earth Fixed (ECEF):

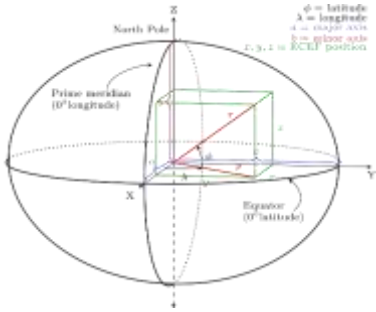

Fig 2: Model of ECEF

Cartesian co-ordinate framework and geographic co-ordinate framework. It speaks to positions as X, Y, and Z co-ordinates. Point (0, 0, 0) is the focal point of the mass of the earth. So it is called "Earth fixed". Its axis are lined up with the International Reference Pole (IRP) and International Reference Meridian (IRM) that are settled as for the surface of the earth. Subsequently it is called "Earth centred".

The z-pivot reaches out through True north, which does not harmonize with the momentary earth rotational axis.[3] The slight "wobbling" of the rotational hub is known as polar motion.[5] The x-hub crosses the circle of the earth at 0° scope (the equator) and 0° longitude (prime meridian in Greenwich). This implies ECEF pivots with the earth, and along these lines directions of a point settled on the surface of the earth don't change. Transformation from a WGS84 datum to ECEF can be utilized as a halfway advance in changing over speeds toward the north east down arrange framework.

North East Down (NED):

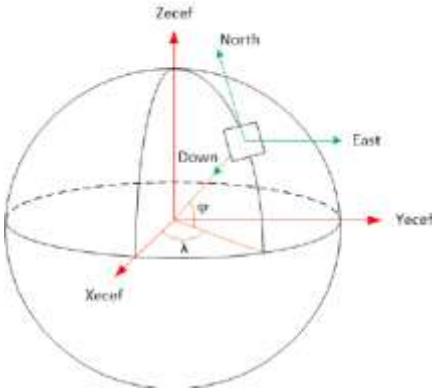

Fig 3: Model of NED

It speaks to state vectors that are regularly utilized as a part of enactment. It comprises of three numbers one speaks to the situation along the northern pivot, on along the eastern hub, and one speaks to vertical position down is picked rather than up keeping in mind the end goal to consent to one side – hand run the show. The birthplace of this co-ordinate framework is generally been the flying machines focal point of gravity.

East North Up (ENU):

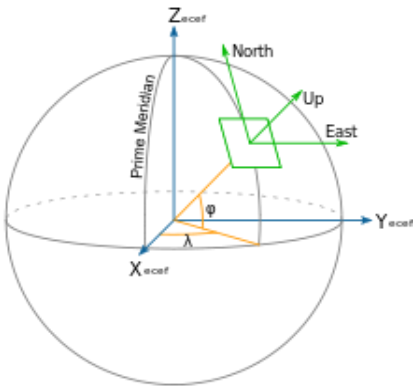

Fig 5: Modelof ENU

In numerous focusing on and following applications the nearby ENU Cartesian organize framework is much more instinctive and functional than ECEF or Geodetic directions. The local ENU arranges are shaped from a plane digression to the Earth's surface settled to a particular area and subsequently it is once in a while known as a "Nearby Tangent" or "local geodetic" plane. By tradition the east pivot is marked, the north and the up.

II. METHODOLOGY

Read sp3 file:- In this archive the NGS orbital arrangement SP3 (Standard Product # 3) for Global Positioning System (GPS) satellites is talked about. The real expansion to prior configurations is the satellite clock adjustment data which is figured at the same time with the circles. The fundamental arrangement is a position and clock record; a moment, discretionary, record contains, speeds and clock rates-of-progress. The position record signal, P, in line one demonstrates that no speeds are incorporated. The speed record hail, V, in line one shows that at every age and for each satellite, a satellite speed and clock rate of progress has been processed. The SP3 arrange has been composed with the end goal that satellites other than GPS could be depicted too. All circumstances alluded to in this archive are GPS times, notwithstanding when they are spoken to as Gregorian or Modified Julian Dates. Along these lines, data for change of GPS time to Universal TimeCoordinated (UTC) isn't given as a component of the SP3 organize.

Concentrate the x, y, z estimations of each of the 32 satellites from sp3 record. Utilizing Lagrange interjection introduce the x, y, z estimation of the considerable number of satellites for one day term and check the chart of unique x, y, z and the inserted esteems. In numerical investigation, Lagrange polynomials are utilized for polynomial addition. For a given arrangement of focuses with no two esteems level with, the Lagrange polynomial is the polynomial of most reduced degree that accept at each esteem the relating esteem (i.e. the capacities concur at each point). The introducing polynomial of the minimum degree is one of a kind, in any case, and since it can be landed at through different techniques, alluding to "the Lagrange polynomial" is maybe not as right as alluding to "the Lagrange shape" of that special polynomial.

Get the beneficiary position from the Receiver Independent Exchange Format (RINEX) record. In the field of geodesy, RINEX is an information trade design for crude satellite route framework information. This enables the client to post-process the got information to deliver a more exact outcome — more often than not with other information obscure to the first beneficiary, for example, better models of the barometrical conditions at time of estimation. The last yield of a route recipient is typically its position, speed or other related physical amounts. In any case, the figuring of these amounts depend on a progression of estimations from at least one satellite heavenly bodies. Despite the fact that collectors figure positions continuously, as a rule it is intriguing to store

middle measures for later utilize. RINEX is the standard arrangement that permits the administration and transfer of the measures created by a collector, and additionally their disconnected handling by a large number of utilizations, whatever the maker of both the beneficiary and the PC application.

Subtract every individual interjected satellite position with the collector position taken from RINEX document.

Discover the scope and longitude esteems utilizing the recipient position. Longitude is a geographic arrange that determines the east-west position of a point on the Earth's surface. It is a precise estimation, generally communicated in degrees and signified by the Greek letter lambda (λ). Meridians (lines running from the North Pole toward the South Pole) interface focuses with a similar longitude. In geology, scope is a geographic organize that determines the north– south position of a point on the Earth's surface and signified by phi (φ). Scope is a point which ranges from 0° at the Equator to 90° (North or South) at the shafts. Lines of steady scope, or parallels, run east– west as circles parallel to the equator. Scope is utilized together with longitude to indicate the exact area of highlights on the surface of the Earth.

Convert from ECEF co-ordinate systemto ENU.

$$ENU = \begin{bmatrix} -\sin(\lambda) & \cos(\lambda) & 0 \\ -\sin(\Phi)\cos(\lambda) & -\sin(\Phi)\sin(\lambda) & \cos(\Phi) \\ \cos(\Phi)\cos(\lambda) & \cos(\Phi)\sin(\lambda) & \sin(\Phi) \end{bmatrix}$$

Where λ = longitude

Φ = latitude

ENU= ENU*R

Where R = satellite position – receiver position

Find azimuth and elevation angle for all 32 satellites per one day. The azimuth and elevation angle is calculated by using below formula,

$$A = 180 + arctan\left(\frac{\tan G}{\sin L}\right)$$

Where A is the azimuth angle

$$E = arctan\left(\frac{\cos(G)\cos(L) - 0.1512}{\sqrt{1 - cos^2(G)cos^2(L)}}\right)$$

Where G = S-N

E - Elevation angle

S - Satellite longitude in degrees

N - Site longitude in degrees

Find longitude IPP and latitude IPP for all the 32 satellites.

The calculation of latitude IPP and longitude IPP is given below

re = 6378137.0;

h = 350;

$$Lat\_IPP = \Phi + \cos(A)$$

$$lon\_IPP = \lambda + z\left(\frac{\sin A}{\cos(Lat\_IPP)}\right)$$

Where $z = \cos^{-1}\left[\frac{re}{re+h}\right] cosE - E$

Where, re = radius of the earth

h = height

Φ = latitude

λ = longitude

E = Elevation Angle

A = Azimuth Angle

Re = Radius of Earth

Lat_IPP = Latitude of IPP

Lon_IPP = Longitude of IPP

IPP plot is obtained by plotting longitude IPP versus latitude IPP.

III. CONCLUSION

With addition to geodesy or geophysics, GPS has an awesome hugeness in logical research. Satellites circling the Earth at an elevation of 20,200 km, send signals that, on their way to the recipient, go through the ionosphere which stretches out from 50 - 1000 km over the Earth's surface. The free electrons that are found in this locale of the environment, influence the spread of the flag, altering the speed and course of engendering of the flag. Due to the in homogeneity of the ionosphere, the course of engendering of the GPS flag is bended. The impact of the ionosphere can cause situating blunders for clients who require profoundly exact estimations.

The ionospheric parameter that has the best effect on radio signs channeled from satellites is the TEC. With the demonstrating of TEC, blunders caused by ionospheric refraction can be distinguished and rectified. To figure TEC first we have to plot IPP. Utilizing IPP TEC can be estimated.

In this paper, by estimating the elevation angle and azimuth angle of satellites regardingGPS receiver antenna located at Mangalore. By using azimuth and elevation of satellites estimate Latitude of IPP and Longitude of IPP. By plotting longitude of IPP versus Latitudeof IPP. The IPP model can be obtained by plotting latitude of IPP and Longitude of IPP. By using these IPP data TEC and ionospheric delay can be measured.

REFERENCES

[1]. Milos MARKOVIC,"Determination of Total Electron Content in the Ionosphere Using GPS Technology" Vol. 2, No. 2 (2014).

[2]. Webster, I. R. "A Regional Model for the Prediction of Ionospheric Delay for Single Frequency Users of the Global Positioning System". M.Sc.E thesis, Department of Surveying Engineering Technical Report No. 166, 1993.

[3]. K Nagarajoo, "GPS Ray Tracing to Show the Effect of Ionospheric Horizontal Gradient to L1 and L2 at Ionospheric Pierce Point" Proceeding of the 2009 International Conference on Space Science and Communication 26-27 October 2009, Port Dickson, Negeri Sembilan, Malaysia.

[4]. P. V. S. Rama Rao, K. Niranjan, D. S. V. V. D. Prasad, S. Gopi Krishna, and G.Uma, "On the validity of the ionospheric pierce point (IPP) altitude of 350km in the Indian equatorial and low-latitude sector" ,Space Physics Laboratory, Departmentof Physics, Andhra University, Visakhapatnam – 530003, India, 13 September 2006.

[5]. F.Gafoori and S. Skone,"Impact of Equatorial ionospheric irregularities on GNSS receivers using real and synthetic scintillation signals",Radio Science,Volume:50 Issue: 4,April 2015.