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ThingSpeak an IOT Application and Analytics System for GNSS with MATLAB Analysis

N.D. Parameswara Rao[1], E. Sneha Priya[2], Sk.Haneef[3], K.Sowmya[4], U. Abhishek Chowdary[5], and U. Sushmita[6]

[1]Assistant Professor, Department of Electronics and Communication Engineering, PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India
[2,3,4,5,6] UG Students, Department of Electronics and Communication Engineering, PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India

Correspondence should be addressed to N.D. Parameswara Rao: parameswara_nd@pace.ac.in

ABSTRACT- The ionosphere is an essential component of the Global Navigation Satellite System (GNSS) that can affect the accuracy and dependability of GNSS location. MATLAB provides comprehensive tools for the analysis of ionospheric data and its impact on GNSS positioning. To examine the ionospheric data utilized in GNSS positioning, we advise utilizing MATLAB in this application. The analysis is based on a determination of the Total Electron Content (TEC) of the ionosphere in order to account for the ionospheric delay in the GNSS signals.

The system consists of a GNSS receiver module connected to a microcontroller with Wi-Fi capabilities, which transmits data to Matlab. The data is processed in Matlab before being used there. Then, in order to account for the ionospheric delay in the GNSS signals, the TEC of the ionosphere is calculated using Matlab. The recommended system provides a scalable and flexible environment for GNSS-based ionospheric data analysis.

The system is practical for a range of applications, including surveying, geodesy, and navigation, and it may be readily adapted to fulfill specific customer requirements.For Matlab analysis, the approach has a number of advantages. In order to measure the TEC of the ionosphere precisely, it first provides cutting-edge signal processing technologies. Additionally, it makes it possible to display ionospheric data in a number of different ways, such as maps, graphs, and time-series plots. This can be applied to the data to identify patterns and trends. The proposed MATLAB-based system offers a scalable, flexible, and cutting-edge platform for the estimation of the ionosphere's TEC and the correction of the ionospheric delay in the GNSS signals.

KEYWORDS- THINGSPEAK, IOT, GNSS, MATLAB Analysis

I. INTRODUCTION

Due to recent technological developments in satellite radio wave propagation, space-based navigation, and communication requirements, global and regional satellite systems as well as augmentation systems have been established over the past three decades. Satellite-based global positioning systems (GNSS) include four satellite navigation systems, including the Global Positioning System (GPS) of the United States of America, GLONASS of Russia, Galileo of Europe, and Compass/Bei Dou of China, while regional navigation satellite systems (RNSS) include the Quasi-Zenith Satellite System (QZSS) for Japan and Navigation with Indian Constellation (NAVIC) for India of a similar vein, SBAS includes the European Geostationary Navigation Overlay System (EGNOS) of Europe, the Japanese Multi-functional Satellite-Based Augmented Systems (MSAS), and the GPS Aided GEO Augmented Navigation (GAGAN) of India[1]. The SBAS - System for Differential Correction (SDCM) in Russia is currently being developed. Initially, the main purpose of satellite navigation systems was to give users accurate information about positioning, navigation, and time transmission. The dynamic nature of the ionosphere, however, prevents the time delays in their signals, which gradually reduces the navigation system's performance. While navigating through the intervening ionosphere is a serious worry since it gradually reduces the navigation system's performance. Total electron content (TEC), measured as the number of electrons in a vertical column with a cross-sectional area of 1 m2 along the signal path, is a characteristic measure of ionospheric electron density that accounts for the first-order delays (more than 90% of total delays) in the GNSS signal[2].

The ionospheric delay is inversely proportional to the square of the signal frequency and directly related to the TEC along the ray path of the GPS received signal. Due to the ionosphere's dispersive characteristics, GNSS dual-frequency receivers can adjust by calculating the ionospheric time delay error and TEC[3]. As a result, numerous ionosphere models have been created at both the global and regional levels as shown in Fig 1 & 2. By reducing ionospheric delay errors in the signals, a precise estimation of the ionospheric configuration always increases navigational accuracy. However, there are occasional variations in the ionosphere that influence diverse regions of the world due to numerous internal and external contributing factors. ThinkSpeak is an IOT Application and Analytics System for GNSS with Matlab Analysis. Therefore, a thorough investigation of variability ionospheric and its modeling is crucial as shown in Fig 3 & 4. The current study examines ionosphere properties and keeps track of it using information gathered from various sites[4].

II. LITERATURE SURVEY

All across the world, location, timing, and navigation (PTN) services are offered using the GPS. In the earth's orbit, there are 24 GPS satellites orbiting the planet; these 24 satellites are divided into 6 longitudes, with 4 satellites in each.

The causes of the navigational errors include:

• Satellite-based errors.

• Errors based on propagation.

• Errors caused by receivers.

To define the ionospheric morphology over many regions, including China, Denmark, Japan, and Southern Africa, several studies proposed the regional TEC. Numerous studies have been conducted to analyze the ionospheric TEC changes with reference to the EIA phenomena, the solar-terrestrial as well as the geomagnetic influences across the equatorial and low latitude region over the Indian subcontinent.

Due to anomalies and Equatorial Ionization Anomaly (EIA) circumstances, characterizing the ionosphere in India, a low-latitude region, requires additional consideration. The magnetic equator and the 30° geomagnetic latitudes in each hemisphere are within the range of the Equatorial anomaly phenomena. Large temporal and geographical gradients in the ionospheric delays are a characteristic of the equatorial and low-latitude areas. Using GNSS satellites, a variety of approaches are employed to estimate TEC fluctuations [5].

Numerous empirical models have been developed to specify the needs of scientific applications based on the enormous volume of TEC data[6]. Empirical and semi-empirical ionospheric models like the International Reference Ionosphere (IRI), Bent, and Ne quick model are well-known prediction models that aid in understanding ionospheric morphology . Right now, ionosphere variability research is more important than ever for determining future time epochs and their time-varying `characteristics [7].

The development of the global and regional ionospheric TEC models has been extensively studied by many authors using a variety of techniques, including statistical eigen mode (EM), involving Taylor series as well as principal component analysis (PCA), SCHA, SVD, and EOF Fourier series expansion techniques.

III. PROPOSED WORK

To improve the accuracy and dependability of GNSS-based navigation and positioning, MATLAB analysis of GNSS [8] signals in the ionosphere aims to create models and techniques for reducing ionospheric impacts on GNSS signals.

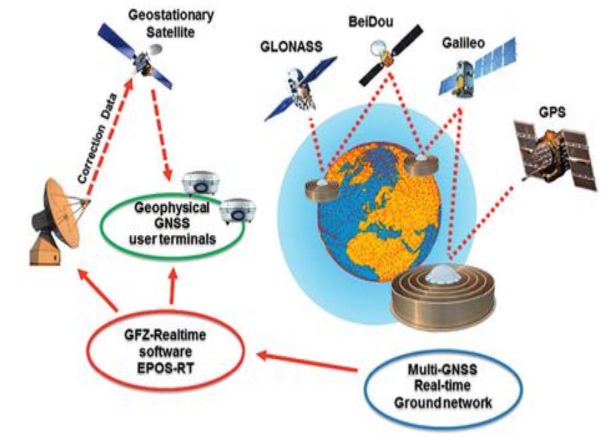

Figure 1: Types of GNSS Systems

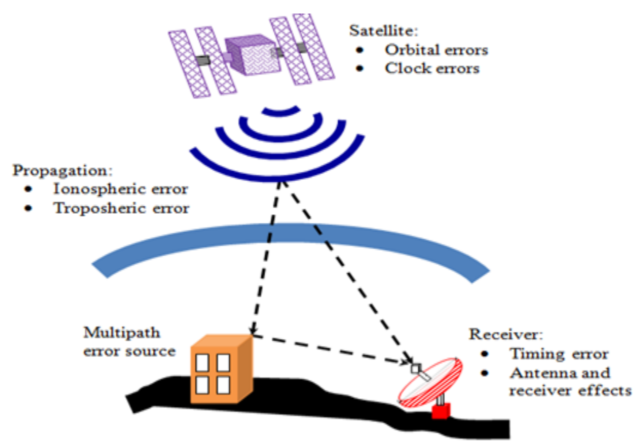

Figure 2: Sources of Error in GPS Signal

- Ionospheric error is discovered to be the most predominate of all mistakes.

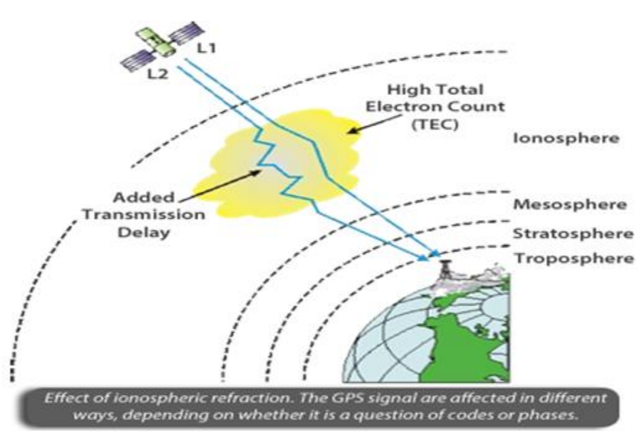

Figure 3: Varying conditions in the ionosphere

Figure 3 shows how satellite transmissions can be delayed by varying conditions in the ionosphere

- The layer of the Earth's atmosphere known as the ionosphere. Its height varies between 50 km and 1000 km above the surface of the Earth [9].
- The most significant factor determining the refractive index for radio waves is the electron density in the ionosphere. varying ionospheric delays on GPS observations result from the varying refractive indices that describe the ionospheric situation as the Global Positioning System (GPS) signals are sent on radio waves.

IV. RESULT

The project demonstrated the effectiveness of using ThingSpeak as an IoT platform and MATLAB for in-depth GNSS data analysis. The combination of real-time data acquisition, advanced analytics, and visualization tools provides a valuable resource for researchers, scientists, and engineers working with GNSS technology. The system offers improved data accuracy, reliability, and accessibility for various applications, including navigation, geospatial analysis, and environmental monitoring.

Once the data has been processed, it is uploaded into the IoT software program ThingSpeak. A little piece of Matlab code is used to automatically submit this data(see figure 4,5 and 6).

Figure 4: Ionospheric Monitoring Using THINGSPEAK

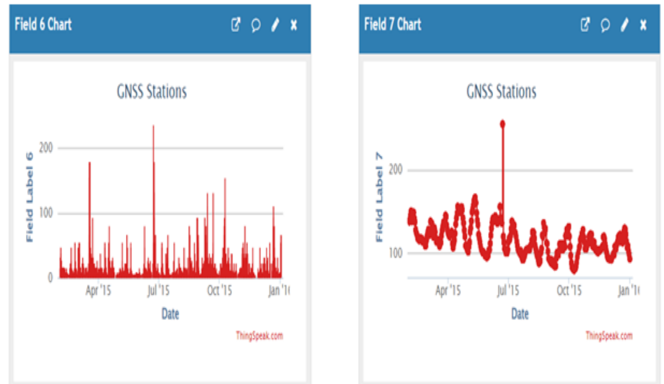

Figure 5: Ionospheric GNSS Influence Parameters Monitoring Using THINGSPEAK

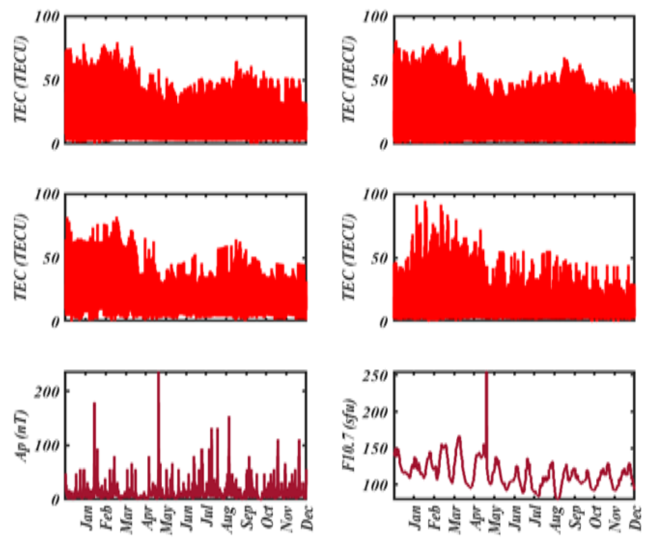

Figure 6: Computed Tec, Solar, And Geomagnetic Time Series for the Year of 2015 Based on Thingspeak and MATLAB

V. CONCLUSION

The linear time series model TEC has been used to extract the influences of various causes on ionospheric TEC climatological changes and its properties at various latitudes as shown in Fig 5.

Solar activity was the primary factor that affected the ionospheric daily averaged TEC, according to analysis of the various components. At low latitudes, geomagnetic activity component values have a favorable affect; however, this influence varies depending on the latitude.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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