International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-10, Issue-3, June 2023
https://doi.org/10.55524/ijirem.2023.10.3.26
Article ID IJIRP2413, Pages 182-185
www.ijirem.org

A ThingSpeak IOT on Real-Time Ionospheric Monitoring System

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ABSTRACT-The primary factor for the ionospheric monitoring system that we take into consideration in this paper is the Total electron content (TEC). This TEC value varies over time, space, and as the ionospheric area absorbs solar heat. The ThingSpeak ionospheric monitoring system can be put into practice by taking into saved at several TEC receiver locations, such as Port Blair and Bengaluru. Along with the information on solar index values, these stations also have data on geometric index values. Additionally, all of the TEC values are taken into account and examined to develop the necessary monitoring system for the ionospheric region. By doing this, we will be able to check the report by using IOT to connect it to ThingSpeak, which can then be utilized or checked from anywhere using the API key.

I. INTRODUCTION

Given the widespread availability of radio navigation signals and its exceptional performance, the worldwide Positioning System (GPS) is the most currently one of used worldwide navigation positioning satellite systems. It offers location, timing, and navigation (PTN) services everywhere in the world and in every kind of weather [1]. There are different navigation systems like Global Positioning System (GPS) maintained by the USA, NAVIC/IRNSS developed by India, Galileo developed by Europe, Glonass developed and operated by Russia, and Bei Dou developed by China [2]. These are the most known navigation systems that are developed by are being used by the countries. Among all these navigation systems, GPS is being considered by almost all countries. So, here we are going to consider the data that is being stored and recorded in GPS for PNT, which is developed by the US [3].

Global, regional, and augmentation systems have been built over the past three decades as a result of advancements in technology in the fields of satellite radio wave propagation, space-based navigation, and communication requirements [4]. In terms of GNSS, there are four of them: the Global Positioning System of the United States of America, the GLONASS satellite constellation of Russia, the Galileo satellite constellation of Europe, and the Compass/BeiDou satellite constellation of China. The Japanese Multi-functional Satellite-Based Augmented Systems (MSAS), the European Geostationary Navigation Overlay System (EGNOS) in Europe, the US Wide Area Augmentation System, and India's GPS Aided GAGAN are all examples of SBAS. The SBAS - System for Differential Correction in Russia is currently being developed. The initial purpose of satellite navigation systems was to give users accurate location, navigation, and time transfer data. The dynamic nature of the ionosphere, however, prevents the time delays in their signals, which gradually reduces the navigation system's performance. While the ionosphere in between must be crossed, as it gradually impairs the guidance system's performance [5]. Total electron content measured as the number of electrons in a vertical column with a cross-sectional area of 1 m2 along the signal path, is the characteristic indicator of ionospheric electron density that accounts. The ionospheric delay is inversely proportional to the square of the signal frequency and directly related to TEC along the ray path of the GPS received signal. Due to the ionosphere's dispersive characteristics. As a result, numerous ionosphere models have been created at both the global and regional levels.

II. LITERATURE SURVEY

Positioning, timing, and navigation (PTN) services are offered all over the world using the GPS. In the earth's orbit, there are 24 GPS satellites that rotate around the planet [6]. These 24 satellites are separated into 6 longitudes, with 4 satellites in each. These 4 satellites are necessary in order to pinpoint the precise location of any object on Earth.

The rapid development of GNSS to deliver 4services for positioning precise applications has caused significant improvements in satellite navigation technology. The estimation of TEC variations using GNSS satellites uses a variety of methodologies. Even though we use these 4 satellites to locate ourselves, navigation faults occasionally make it challenging to pinpoint our exact location. To describe the ionospheric morphology over many regions, including Japan , and Southern Africa , several scholars proposed the regional TEC. Numerous studies have been conducted to examine the ionospheric TEC changes with reference to the EIA phenomena and the solar-terrestrial as well as geomagnetic impacts across the equatorial and low latitude region over the Indian subcontinent [7]. The tremendous complexity of the ionospheric structure and some small-scale abnormalities that are frequently present at low latitudes, however, compromise the accuracy of enhanced systems space-based based on the single approach.

Darshini Rajasekar et al.[10] proposed the system, an IoT prototype of a large-scale system which uses high-end and expensive sensors that measures the various air pollutants in the atmosphere is designed.

III. OBJECTIVE

The primary objectives of this project are as follows:

- Design and develop a compact, low-cost ionospheric monitoring device.
- Interface the monitoring device with ThingSpeak IoT platform for data collection and visualization.
- Create a user-friendly web interface for accessing real-time ionospheric data.
- Implement data analytics and visualization tools for researchers and users.
- Provide open access to the collected data for scientific research and educational purposes.

IV. PROPOSED WORK

This proposed work outlines the development of a real-time Ionospheric Monitoring System using ThingSpeak IoT (Internet of Things) technology. The system aims to provide continuous, remote monitoring of ionospheric conditions, enabling researchers, scientists, and enthusiasts to access valuable data for a variety of applications, including radio communications and space weather forecasting.

Due to their impact on the radio wave propagation, charged particles have the potential to create inaccuracies in Global Navigation Satellite Systems, such as GPS. The ionosphere is responsible for the GPS signal delay, which may be observed using the TEC measurements that need to be processed as shown in Figure 1 and 2.

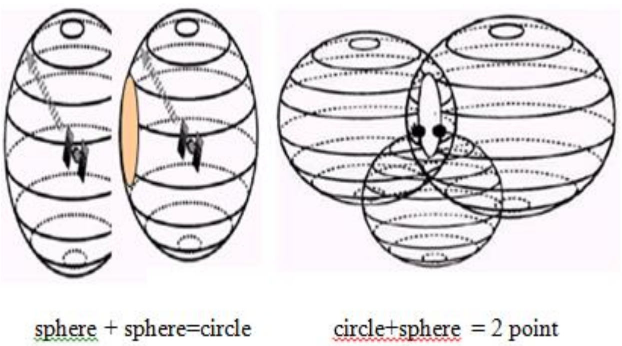

Figure 1: Concepts in GPS

The three obvious elements that make up the GPS system are the Space Control, and User (many antennas and receivers) segments.

The various error factors that reduce GPS accuracy can be divided into three categories: Ephemeris, satellite clock biases, receiver-based errors (receiver clock errors, and receiver noise), and propagation errors are examples of faults that can occur.

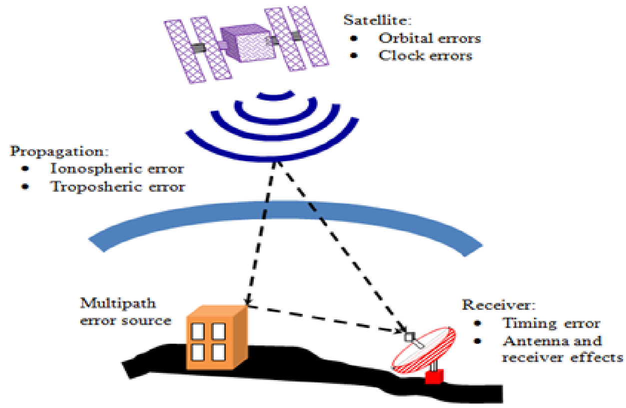

Figure 2: Sources of Error in GPS Signal

This proposed work aims to contribute to the field of ionospheric monitoring by creating a user-friendly, cost-effective, and accessible solution. Real-time data from the Ionospheric Monitoring System will support various applications, including radio communication optimization, space weather forecasting, and scientific research. By leveraging ThingSpeak IoT technology, this project seeks to bridge the gap between researchers and valuable ionospheric data.

V. RESULTS

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 [8].

If we look at the data, we can see that the geomagnetic and solar indices are at their highest in July 2015. This indicates that the GPS signal's transmission error is at its greatest level [9]. We can infer from the statistics that the geomagnetic index is higher in the months of April and July. Additionally, the solar index is higher in the month of July, indicating that the TEC values are higher as well. From this, we can infer that the month of July may see greater variations in the precise GPS positional data [11].

Figure 3 :Ionospheric Monitoring Using ThingSpeak

We considered the geomagnetic and solar index of the year 2015, then the TEC values are computed to get theday-of-the-year graph as shown in Figure 3 and 4.

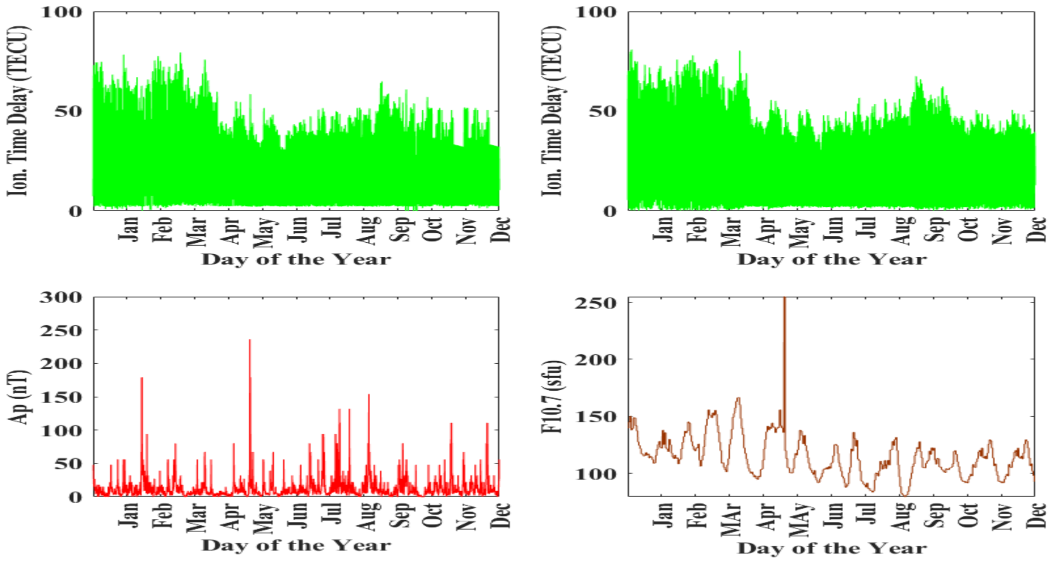

Figure 4: Computed TEC, Solar, and Geomagnetic time series for the year 2015

VI. CONCLUSION

Ionospheric conditions can be tracked and analyzed in real time with the help of the Things Speak IoT real-time ionospheric monitoring system. To deliver precise and current information regarding ionospheric conditions, the system combines sensors, microcontrollers, and cloud-based data analysis.

All things considered, the Things Speak IoT real-time ionospheric monitoring system is a promising technology for enhancing ionospheric monitoring and comprehension, and it has the to aid potential in the development of more efficient communication and navigational systems.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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