GPS Signal Strength Due to Ionospheric Scintillation: Preliminary Models Over Sarawak

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Abstract— **The renowned effect of space weather is fluctuation in the amplitude of the radio signal that propagates in the ionosphere especially in the equatorial region. This fluctuation is also referred to as scintillation that will intense, degrades the signal quality, reduce the information content, or cause failure of the signal reception. Space-based radio navigation systems such as the Global Positioning System (GPS) will provide us with a unique opportunity to characterize the ionospheric scintillation effect as the signals propagate from the satellites to the GPS receiver. Sarawak, which is located near to the equatorial region, has been selected for the aim of this research. By using amplitude scintillation data recorded by the GPS Ionospheric Scintillation & TEC Monitor (GISTM), ionospheric irregularities along the path was examined and related to the signal strength performance. Methods and procedures to study and analyze the amplitude scintillation data are presented. Furthermore, the amplitude scintillation parameter is related to signal-to-noise ratio (SNR) in order to model the GPS satellite signal strength in this region. The preliminary developed SNR empirical models are a function of amplitude scintillation from the reference station path to the satellites. These contribute to the knowledge of received satellite signals strength performance in terms of ionospheric amplitude scintillation.**

Keywords- Ionosphere; GPS; amplitude scintillation; GISTM; SNR

I. INTRODUCTION

Modeling and understanding the behavior of the satellite signal performance is required by the scientific community which is of great interest. Global Positioning System (GPS) is a globally available space-based radio navigation system. It has become increasingly sophisticated and famous in the space weather research. With the advent of GPS, ionospheric studies got an additional boost given the coverage of L-band communication links on satellites, including those used by GPS satellites.

The GPS signal performance is studied based on the parameter of signal-to-noise ratio (SNR) in a 1 Hz-bandwidth [1]. The larger the SNR ratio is, the stronger the signal is. It is a function of transmitted signal, distance and receiver hardware with value that is typically 30 to 55 dBHz at outdoors [2]. Many factors affect the signal quality with the signal strength decreases as the distance between the satellites and GPS receiver increases. These are essentially due to attenuation caused by geometric spreading and the attenuation in the troposphere and ionosphere layers. Ionosphere is a region of ionized gas or plasma which is about 60 km to 1500 km above the Earth's surface [3]. One of the main characteristics of the ionosphere contributes to the degradation of GPS signals is irregularities along the path that is mainly attributed by scintillation. Ionospheric scintillation is caused by irregularities in the electron density of the ionosphere [4, 5]. That causes rapid changes in the phase and amplitude of the transmitted signals. Amplitude scintillation in GPS degrades positioning accuracy, cycle slips and may cause data loss in GPS receiver, while phase scintillation can affect the phase lock loops in GPS receivers which results in losing the phase lock [6, 7]. Therefore, studies are necessary to characterize ionospheric scintillation impact on GPS signal.

Ionospheric scintillation influences all space-based communication, surveillance, broadcasting, and navigation systems. It has important impact on Global Navigation Satellite System (GNSS) as the effect range from degradation of positioning, velocity, and timing accuracy to receiver loss-of-lock. Due to the increasing demand on GNSS applications, understanding of characteristics and effect of ionospheric scintillation on GNSS signals and receivers has gained world-wide attention from both scientific research and engineering application fields especially space science and radio telecommunication communities.

Furthermore, ionospheric scintillation is particularly significant at L-band frequencies and is dependent on geomagnetic location, season, solar activity (sunspots) and local time as shown in Fig. 1. There are two intense zones of scintillation, one at high latitudes and the other at equator. Besides, there is a pronounced night-time maximum of scintillation activity in the equatorial sector. In addition, ionospheric scintillation occurs more frequent in years of solar