GPS Signal Fading due to Scintillation & Multipath and its Impact on Satellite Geometry and Positioning over the Appleton Anomaly Region

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ABSTRACT

Ionospheric scintillation poses a great challenge to navigation and communication facilities all over the world. Its impact is even worse in equatorial ionization anomaly (Appleton anomaly) region. Airports Authority of India is planning to demonstrate Satellite Based Augmentation System (SBAS) named GAGAN (GPS Aided Geo Augmented Navigation) in collaboration with Indian Space Research Organization (ISRO). The aim of GAGAN is to demonstrate Accuracy, Integrity, Availability and Continuity of SBAS signal over Indian airspace. As ionosphere is biggest hurdle in implementing the SBAS over Indian region, which lies in equatorial anomaly region, wide network of GPS receivers was set up in year 2004 all over India to study the ionospheric effects on GPS signal. The GPS receivers installed are dual frequency GPS Silicon Valley Ionospheric Scintillation Monitors (GISM) which provide total electron content (TEC), scintillation parameters- S4 index and $\sigma_{\Delta\phi}$, code-carrier divergence and its variance ($\sigma_{ccd}$), C/N0, etc as the output values.

The GPS signal experiences fading due to small-scale irregularities in the electron density known as scintillation. It has already been established that scintillation occurs after sunset till midnight and causes loss of lock during strong scintillation activity (high S4 value). But very high S4 values have been observed during day time which needs to be investigated thoroughly as it is not considered a normal phenomenon. Strong scintillation and Multipath can cause a serious challenge to accuracy, availability and continuity of SBAS/GPS signal.

As severely affected satellite due to scintillation or multipath causes loss of lock, it affects the geometry of visible satellites, which in turn reduces the accuracy. We have analyzed the effects of deep signal fading on satellite visibility and geometry which can be expressed in terms of Geometrical Dilution of Precision (GDOP). Higher the GDOP, poorer is the positioning accuracy. GDOP was computed and analysed with respect to scintillation and Multipath activity mainly on stations lying in equatorial ionization anomaly (EIA or Appleton anomaly) region of India using the data of low solar activity period 2006. It has been observed that at some stations during high scintillation coupled with poor geometry of GPS satellites, GDOP value goes beyond 10 which severely affect the accuracy in positioning.

In this paper we have investigated the factors responsible for GPS signal fading i.e. scintillation and Multipath or receiver malfunction and their characteristics. We present the observation of scintillation/Multipath at number of stations and their impact on Satellite Geometry and Positioning. We have tried to investigate how the number of visible satellites reduces due to severe scintillation/Multipath and affects the GDOP.

REFERENCES