Ionospheric Scintillation Effects on Global Positioning System Receivers

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Abstract

The Global Positioning System (GPS) is used extensively in both the military and civilian communities for such diverse activities as navigation, surveying, remote sensing, asset management and precise timing. The tremendous popularity of GPS has stemmed from the low cost and small size of modern GPS receivers, and from the high accuracy and reliability of the system. This second factor has also resulted in GPS being considered as a sole means of navigation for critical safety of life applications such as precision approach and landing for aircraft and narrow channel navigation for ships.

A number of environmental factors are known to affect the performance of GPS, including electromagnetic interference, multipath, foliage attenuation, atmospheric delays and ionospheric scintillations. In this thesis, the effects of ionospheric scintillations on GPS will be examined.

Ionospheric scintillations are rapid variations in the amplitude and phase of transionospheric radio signal resulting from density irregularities in the ionosphere. Scintillations have the capacity to affect both the accuracy and reliability of GPS systems by compromising the performance of the code and carrier tracking loops of a receiver. In order to quantify this effect, a widely used stochastic model of scintillation activity is combined with various tracking and acquisition models to produce a collection of receiver performance measures. These include the magnitude of the code and carrier range measurement errors, a measure of the tracking state of the carrier loop, the mean time to acquire, and the bit error probability for the navigation data. An advantage of the stochastic model chosen in this study is that it is linked to an existing predictive scintillation model which is based on large amounts of scintillation data collected over the previous 20 years or so. Consequently, by combining these models it is possible to predict the performance of a given receiver type at any future time and location.