ABSTRACT

Navigation is the process of identifying, directing and controlling the movement of an object/person from one place to another. Satellite based navigation systems such as the Global Positioning System (GPS) are being implemented nowadays all over the world due to their global coverage and operational ease. At present GPS is the only available fully operational Global navigation satellite system (GNSS). However the required accuracy, availability and integrity cannot be obtained with stand-alone GPS, which are very important for precision approach applications in both civilian and defence sectors.

The desired positional accuracy over a pre-defined area can be obtained by augmenting the GPS. In recent times, several countries are developing their own Satellite Based Augmentation Systems (SBAS), for their increased safety and security. In India also, Indian Space Research Organization (ISRO) and Airport authority of India (AAI) are jointly developing “GAGAN” (GPS Aided GEO Augmented Navigation) system over the Indian Air Space and is expected to become operational by 2013.

The positional accuracy of GPS is predominantly affected by the ionospheric time delay, which is a function of Total Electron content (TEC). The variations in TEC are subjected to geographical, seasonal, diurnal and solar activity variations. Further as the Indian subcontinent is spread over equatorial and low latitude regions where the ionospheric behavior is highly volatile with large horizontal gradients and day-to-day variability, the accuracy of GPS signals will
get affected. Precise ionospheric time delay estimation can be obtained by employing the dual frequency GPS receivers. However, single frequency GPS users rely on ionospheric TEC models for computing the required corrections for positioning and navigation.

Global ionospheric TEC models such as the International Reference Ionosphere (IRI) could not predict the delay variations accurately with respect to the Indian conditions. Further, as there is no suitable regional ionospheric TEC model available for the Indian conditions, efforts are made to develop a new region specific ionospheric TEC model for the low latitude region. The data used for analysis is from the SOPAC data archive of the International GNSS Service (IGS).

The quality of local TEC information is very much essential in developing a region specific empirical prediction model. Hence, the various ionospheric effects on SBAS are studied. The current state of the ionosphere can be estimated by obtaining the Ionospheric time delay statistics. Analysis of TEC variations over some of the low latitude stations around the globe is helpful to develop a region specific TEC model. Correspondingly, ten low latitude stations around the globe were considered for the analysis of TEC variations. They are Singapore (1.35°N, 103.68°E), Medan (3.62°N, 98.71°E), Managua (12.15°N, 86.25°W), Bangalore (13.03°N, 77.51°E), Guatemala (14.59°N, 90.53°W), Quezon (14.64°N, 121.08°E), Dakar (14.68°N, 17.47°W), Hyderabad (17.42°N, 78.55°E), Christiansted (17.76°N, 64.58°W), Kunming (25.03°N, 102.80°E). All the ten stations were considered from the northern hemisphere of the globe. Out of
which, six stations are from the eastern side and the remaining four stations are from western side of the globe with reference to Greenwich line.

The diurnal, monthly and seasonal variations of $TEC$ and the Cumulative Probability of Range Delays with respect to all the seasons during the year 2003 for ten low latitude stations around the globe are analyzed. It is evident from the results, that the $TEC$ exhibits an appreciable day to day variability. The monthly mean maximum $TEC$ values are small in the months of summer season and large in Vernal Equinox period for most of the stations.

Further, major magnetic storms originated from solar bursts will cause strong disturbances in the geo space environment which ultimately affect the performance of GNSS. The $TEC$ values ten low latitude stations around the globe during the major geomagnetic storm events that occurred from January 2003 to July 2012 are presented. Strong $TEC$ enhancements were observed during the storm days. Moreover as a major geomagnetic storm occurred during October 2003, the $TEC$ values for ten low latitude stations around the globe are estimated and compared with different prediction models. It is observed that the models are not able to accurately predict the $TEC$ variations for the low latitude conditions.

Hence, a neural network based $TEC$ model has been developed using GPS data for ten low latitude stations around the globe for both quiet and storm days using the back propagation algorithm. The $TEC$ values thus obtained are then compared with original GPS $TEC$
values and with IRI-07 model predicted $TEC$ values. It is evident from the results that the proposed neural network model is predicting the $TEC$ values more efficiently than the existing IRI model.

The methodology used to obtain the neural network based $TEC$ model for a low latitude station can be extended to develop a more complete model for the Indian subcontinent with data from other stations. The neural network model, once developed, can be used as an input to the GAGAN system for accurate predictions.