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Comparison of TEC Estimation Techniques using S1 and L5 Signals of IRNSS[1]

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Abstract—Indian Regional Navigation Satellite System (IRNSS) is a satellite based navigation system developed by Indian Space Research Organization (ISRO). The positional accuracy of IRNSS is limited by several errors including ionospheric delay. Ionospheric delay can be estimated with precise calculation of total electron content (TEC). However, TEC is biased by multipath and thermal noise. Therefore, multipath and thermal noise free relative TEC measurements are made and compared with two other methods, namely, code TEC and IRNSS Receiver Software (IRS) techniques. In this investigation L5 (1176.45 MHz) and S1 (2492.028 MHz) signals from IRNSS 1A to 1G satellites are considered. The results indicate that relative TEC estimation technique removes the multipath and thermal noise from the TEC measurements. Further, the TEC for signals coming from various IRNSS satellites are evaluated by calculating the standard deviation (SD). In the analysis the data is divided into segments with duration of 1 h each. The results indicate that SDs for the relative TEC estimation (2.5 TECU in case of IRNSS 1B) are lesser than the other two techniques indicating the relative TEC can be used in the receiver for the estimation of ionospheric delay. Further, the high ratio of the operating frequencies indicates a better TEC estimation.

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1. INTRODUCTION

Global Navigation Satellite Systems (GNSS) signals are delayed when propagating through space to Earth. Various error sources affect these signals through the propagation path. Ionospheric time delay is one of the prominent errors that affect the accuracy of the user. When two signals from the same satellite propagate through dispersive ionosphere, the ionospheric delay can be estimated using the dual frequency signals.

Several ionospheric time delay models, such as Anisotropic IDW with Jackknife and relative TEC (total electron content) are available for navigation signals [1, 2]. In these models, the precise estimation of TEC plays a major role as the ionospheric time delay is directly proportional to TEC. Further, for GPS, the ratio of frequencies of L1, L2 and L5 signals (L1/L2 = 1.28; L1/L5 = 1.34) is much less than the ratio of IRNSS S1 and L5 signals (S1/L5 = 2.19). A high ratio is expected to facilitate a better estimation of TEC. Hence, it is likely that TEC can be better estimated if S1 and L5 signals are used.

The TEC estimation is biased by the multipath and thermal noise. A signal arriving at an antenna through different paths due to reflection/diffraction represents multipath phenomenon [3]. Thermal noise is a basic electric noise produced by random movement of electrons in any conductor (including components in IRNSS/GPS receiver) [4]. These error sources need to be removed from the TEC estimation.

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