URSI - RCRS 2022, IIT (Indore), India, 1 - 4 December, 2022

Studies on NavIC Timing Capabilities using Geodetic and Compact GNSS receivers

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Global Navigation Satellite System (GNSS) is now very popular for providing precise Position, Navigation and Timing (PNT) solutions. Together with the global systems, Indian Regional Navigation Satellite System (IRNSS or NavIC) is designed, developed, deployed, and maintained by the Indian Space Research Organization (ISRO) to provide PNT solutions in and around the Indian region. NavIC broadcasts system time using a 7-satellite constellation where the satellites are placed in geostationary (GEO) or inclined geosynchronous (IGSO) orbits. The NavIC system time is steered to UTC (NPLI) and thus, NavIC satellite signal may be used as a reliable means for the dissemination of UTC (NPLI). Though there are many reported works on the application of NavIC for positioning and atmospheric studies, not many reports are available on the study of its timing capability.

This work firstly reports the results of an experimental study to explore the performance of a geodetic grade NavIC dual-frequency receiver for time transfer. An IRSO-Accord IRNSS-GPS-SBAS geodetic NavIC receiver (known as IGS receiver) with a L5+S band enabled Antenna is operated in L5+S band NavIC pure dual operation. Hardware 1 pulse per second (1PPS) from the IGS receiver is compared with UTC(NPLI) through a time interval counter (TIC) of high resolution. The average fluctuations in NavIC-NPLI are found to lie around 110 ns with standard deviation (1σ) of around 10 ps with a reasonably good stability. The modified Allan deviation analysis shows the frequency stability improves from the order of 10^{-11} to 10^{-12} for τ >10s.

The next effort is made using a compact, low-cost NavIC module. To facilitate the GNSS applications, the compact, low-cost single (CLS) and dual (CLD) frequency modules became commercially available those have attracted the attention of the GNSS user and researcher community for their advantages of cost, size, low power requirements and easy integration. Compact, low-cost receivers have been studied and used extensively for various positioning applications. Although many of this low-cost module has the provision of 1 pulse per second (1PPS) output, not much work has been reported to demonstrate their utility for timing applications. An experiment is carried out to investigate the performance of such a low-cost NavIC-enabled GNSS module timing utility. A TELIT SL869-T3I single frequency GNSS (L1), NavIC (L5) Evaluation Kit (EVK) is used for the study that provides 1PPS output together with position solution; the TELIT CLS GNSS-NavIC module is operated once in NavIC-only mode and then in GPS-only mode and the respective 1PPS out is compared with NPLI using a TIC. The average (NPLI-GPS) values lie around 40 ns with a standard deviation of 5.43 ns, while in (NPLI-NavIC) operation the average fluctuations lie around 130 ns with a standard deviation of 5.58 ns. The frequency stability in the GPS mode is marginally better than the NavIC-only operation for higher τ values.

A comparative analysis of the timing performance of the NavIC geodetic receiver and the compact, low-cost CLD NavIC module shows that, the low-cost CLD module is an order less stable compared to the geodetic one. But nevertheless, the compact module has the potential to cater the needs of medium accuracy timing users. The results obtained from the geodetic receiver would help in enhancing the confidence level for the NavIC timing users and the novel results using the low-cost NavIC single frequency module would help in understanding the applicability of such compact modules for the Indian timing community.

During the time of the experiment, the equinox period of March 2022, severe amplitude scintillation has been observed on the NavIC signals, however, the timing performance of the geodetic NavIC receiver remained undisturbed by the effect.

The presentation would consist of detailed discussion on the experimental setup and results.