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

Performance of small form GNSS module vis-à-vis standard precision GNSS receiver under adverse ionospheric condition

T. Biswas *(1), P. Chakraborty(1), P. Banerjee (2)and A. Paul (1)
(1) Institute of Radio Physics and Electronics, University of Calcutta, India
(2) Ex-National Physical Laboratory, New Delhi, India

Abstract

This study aims to compare the performance of a high-end GNSS receiver with an economical GNSS module under similar ionospheric adverse conditions. The analysis is primarily conducted from a low-latitude station, in terms of signal strength, availability and position accuracy, when ionospheric perturbations are present during post-sunset hours.

1. Introduction

Precise and accurate positioning of a static or kinematic receiver has become a pressing priority in modern days, with growing use of applications based on satellite navigation and communication by civilian users. Therefore, availability of various geodetic receivers has led to a scope of research in terms of quality and precision of recorded data.

This study aims to compare the performance of a high-end multifrequency GNSS Rx (SeptentrioPolaRx) and an economical GNSS module (Ublox NEO-M8T) [1], under similar ionospheric conditions.

2. Data

Both of the receivers are simultaneously operated at IRPE, University of Calcutta, under a single high-precision geodetic choke ring antenna (PolaNt), using an RF splitter. The Septentrio PolaRx is capable of recording data (amplitude, phase) at a sampling interval of 50 Hz, 1Hz (C/N_O) and 1 min (Total Electron Content) at L1 frequency, while the NEO-M8T has an altogether sampling rate of 1 Hz for SNR, position, PDOP, VDOP, HDOP recorded at L1 band. Being operated at single frequency, NEO-M8T is not equipped to provide TEC. The file format of data obtained from high-end receiver is binary, while that for the NEO-M8T is NMEA (National Marine Electronics Association) and raw (.ubx). These raw data (.ubx) can be converted to comma-separated value format by u-center_v21.09 software. Previously, some exemplary studies on performance of low-cost GNSS module have been reported in literature [2][3]. The present analyses is targeted towards understanding the diverse effects of ionospheric conditions, if any, on the two types of receivers.

3. Result and Discussion

Calcutta (22.58°N, 88.38°E geographic; magnetic dip 34.54°) being located near the northern crest of EIA, some of the major events of signal perturbation, caused by adversity of the ionosphere, can be witnessed from this station. During March 2022 (monthly smoothed SSN:78.6; F10.7: 104.95 SFU), intense scintillation at L band has been observed on multiple days from Calcutta. Comparative analyses of Septentrio PolaRx and NEO-M8T receivers have been performed during this period.

On a particular day (March 03 2022), total 26 GNSS (GPS, GLONASS, Galileo and BeiDou) satellites were tracked on NEO-M8T [Figure 1] while that for Septentrio PolaRx was 137 (GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS) from station Calcutta. As can be observed from the Figure 1, number of GPS satellites tracked is higher than other GNSS satellites, over the entire day. However, it should be noted that the configuration of NEO-M8T allows 3 concurrent GNSS data recording on a total of 72 channels [1].

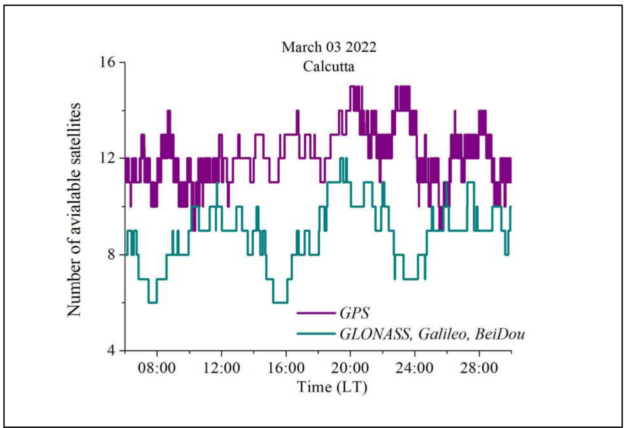

Figure 1. Satellite availability at NEO-M8T on March 03 2022 as a function of Local Time (LT).

On March 03 2022, intense scintillation (amplitude scintillation index S_4> 0.6) was observed at L1 band on 12 GNSS satellites from Septentrio PolaRx, during 20:00 - 23:30 LT. During this time, GPS SV12, as observed from Septentrio PolaRx, is encountered with a peak-to-peak C/N_O fading depth of 25 dB at an elevation>15° [Figure 2]. However, from NEO-M8T the peak-to-peak signal fading depth was around 30dB during 21:52 – 22:45 LT [Figure 3].

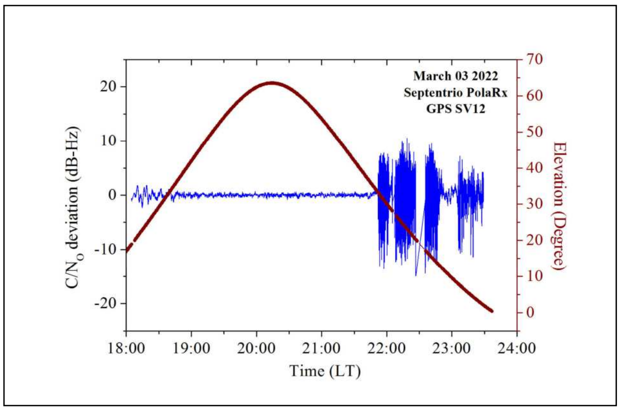

Figure 2. C/N_O deviation with respect to Local Time and Elevation, as observed at GPS SV12 from Septentrio PolaRx, on March 03 2022 .

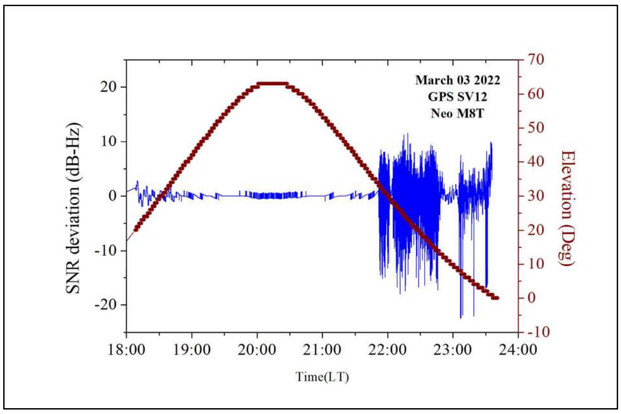

Figure 3. SNR deviation with respect to Local Time and Elevation, as observed at GPS SV12 from NEO-M8T, on March 03 2022 .

Position deviation was observed from NEO-M8T over the entire day of March 03 2022 [Figure 4]. As can be observed from the figure, maximum deviation in latitude is found between 09 – 14 LT, when it reached approximately 7.5 m. This can be explained in terms of local TEC maxima occurring at noon. However, during post-sunset period, maximum value of 5.78 m in latitude deviation and 2.02 m in longitude deviation can be observed at around 20:15LT which indicates possible perturbation of signal due to ionospheric plasma irregularity.

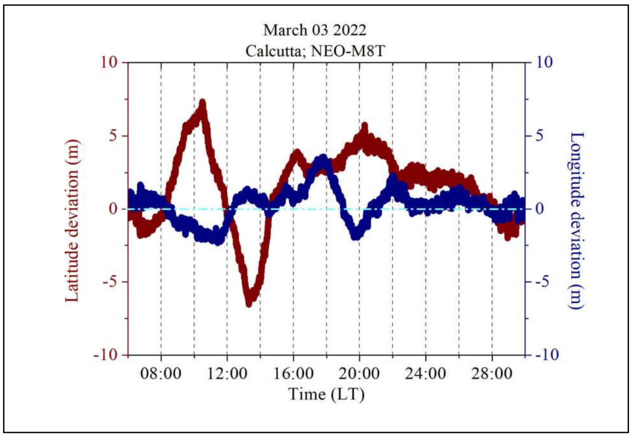

Figure 4. Diurnal latitude and longitude deviation (in meter) as observed from NEO-M8T on March 03 2022 .

Further analysis on the comparative study of the two receivers will be processed for cases of March 2022 and September 2022. Observations of receiver performance from an ionospheric perspective have not been extensively reported previously. Therefore, this study will be beneficial for utility evaluation of economical GNSS modules, especially from a low-latitude station.

6. Acknowledgements

This research has been sponsored in part by the Centre of Advanced Studies in Radio Physics and Electronics at University of Calcutta. One of the authors (T. Biswas) acknowledges the support provided by Council of Scientific and Industrial Research (CSIR), Govt. of India, at Institute of Radio Physics and Electronics (IRPE), University of Calcutta, in the form of a fellowship. Authors are thankful to Kyoto University for providing geomagnetic data on the website http://wdc.kugi.kyoto-u.ac.jp/dstdir/.

7. References

1.NEO-M8Tmodule.https://content.u-blox.com/sites/default/files/products/documents/NEO-LEA-M8T_ProductSummary_%28UBX-16000801%29.pdf

2. Mahato, S., Santra, A., Dan, S., Banerjee, P., Kundu, S., & Bose, A. (2021). Point Positioning Capability of Compact, Low-Cost GNSS Modules: A Case Study. *IETE Journal of Research*, 1-14.

3. Stempfhuber, W., & Buchholz, M. (2011). A precise, low-cost RTK GNSS system for UAV applications. *Proc. of Unmanned Aerial Vehicle in Geomatics, ISPRS.*