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Multi-frequency GLONASS signal outages observed from the anomaly crest location

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Modern society with extensive use of applications, based on satellite communication and navigation, calls for higher robustness of satellite signals. Ionosphere being a dispersive medium, diffraction and scattering of signals caused by irregularities embedded in the medium, may often lead to complete outage of the signal. Plasma density depleted regions in the ionosphere, often referred to as 'bubbles', can affect the transionospheric signal properties, giving rise to intense, fast and random fluctuations of amplitude and phase of the signal commonly referred to as scintillations [1].The effects are observed to be most severe and dramatic near the equatorial and polar region of the Earth's ionosphere [2]. Effects of intense scintillations on the signal traversing the ionosphere, especially during high solar activity period may result in degradation of the receiver's tracking loop performance, which in turn gives rise to cycle slip and loss of lock [3]. Such cases of signal outages, caused by adversity of the medium, can have critical life threatening implications in the domain of aviation.

Global Navigation Satellite System (GNSS) signals can be a useful tool to study the adversities of the ionosphere in order to improve the performance of the same. Monitoring the Phase Lock Loop (PLL) of commercial GNSS receivers can provide information about fading of a signal due to ionosphere-induced effects. While a lot of emphasis has been put on studying GPS signal performance under signal fading conditions, ionospheric effects on GLONASS signals have not been extensively reported from the Indian low latitude sector [4][5]. The present paper reports cases of cycle slip and loss of lock encountered on GLONASS L1 and L2 signals observed from Calcutta (22.58°N, 88.38°E geographic; magnetic dip 32°N) during March 2014. The station being located near the northern crest of Equatorial Ionization Anomaly (EIA), such cases of signal outages from this location sets a benchmark for the scientific community in terms of severity of system degradation due to such effects. Assuming that a satellite signal is affected by the same irregularity at different frequencies, understanding inter-frequency performance of a constellation helps to study the robustness of the signal, which is a function of the different scattering mechanism for each signal intersecting the ionospheric irregularity and signal structure. A representative case of loss of lock detected in GLONASS L1 and L2 occurred on March 12 2014 in SV55 of 6.22 s in L1 and 15.78 s in L2 around mention time interval. It is important to mention that both of these values are in excess of the safety limit specified by International Civil Aviation Organization (ICAO) for aviation operations, which is 6 sec for APV-I (Aeronautical Approach with Vertical Guidance) and 10 sec for APV-II [6]. Such analyses have been extended for all cases of GLONASS loss-of-lock as observed from Calcutta.

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