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Challenges in Acquiring and Tracking NavIC S-Band Signals Due to Wi-Fi Interference

Sudhanshu Kumar Pandey*(1), Rajesh Kumar(1), D Suresh(1), M V Roopa(1) and T Subramanya Ganesh(1)
(1) ISTRAC, ISRO, Peenya Industrial Area, Bangalore-560058

Abstract

Navigation with Indian Constellation (NavIC), is a regional satellite navigation system developed and controlled by the Indian Space Research Organization (ISRO). The constellation consists of 7 Inclined Geosynchronous Orbit (IGSO) satellites. The Ground segment of NavIC consists of multiple One way ranging stations called IRIMS having NavIC receiver and antenna. The NavIC signals have very low received power levels and hence their vulnerability to RF interference is a concern. The NavIC Antenna needs to operate in interference benign zone. The interference can result in degraded navigation accuracy or complete loss of receiver's signal acquisition and tracking. This paper provides the details of experiment simulated to study the effect of S band interference on NavIC receivers. Wi-Fi signals were generated to simulate the S band interference signals.

1. Wi-Fi Interference Phenomenon

The 2.4GHz ISM band is an unlicensed band and becoming populated day by day with the manmade signals. It brings many terrestrial users a great utility but does render the S-band ineffective for NavIC based applications. The received power level of NavIC signal-in-space is very low (-160dBW) in comparison to the terrestrial interfering signals and hence their susceptibility to RF interference such as Wi-Fi signals is a serious concern. In order to find out the effect of interfering Wi-Fi signals on NavIC receivers specifically in S Band frequencies, an experiment is conducted by generating Wi-Fi signals in the intended NavIC S-band (2492.028 ± 8.25 MHz) through a Wi-Fi modem.

RF Noise with power level ≥-130dBm at NavIC Antenna is considered as threat to NavIC Receiver's signal acquisition and tracking. In order to achieve the receiver's measurement accuracy of 10cm RMS, a minimum Power spectral density (C/N_0) of 44 dB-Hz is required. The signal degradation intensity directly depends on Transmit power of Wi-Fi device which is directly proportional to the distance between NavIC antenna and Wi-Fi device. The in-band RF interference due to Wi-Fi affects the NavIC receiver S-band acquisition and tracking performance leading to:

(a) C/N_0 degradation resulting in delayed signal acquisition and cross correlation
(b) Complete loss of receiver tracking and
(c) Increase in Measurement noise.

2. Experimental setup to observe the impact of S band interference

The prime objective of this experimental setup is to find the degradation in C/No of NavIC receiver in presence of interference in the intended NavIC S frequency band, 2492.028 MHz ± 8.25 MHz. The experimental setup consists of following:

- A Wi-Fi router
- RF interference detection setup
- NavIC receiver setup

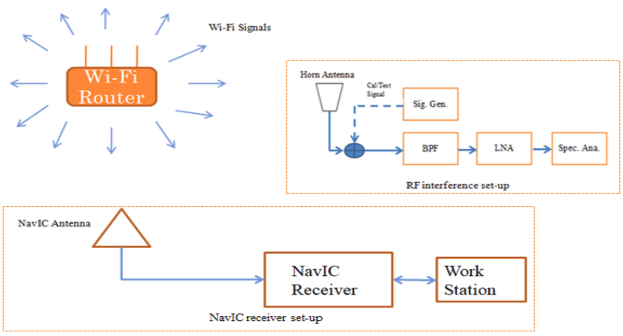

Figure-1: Setup for S-band interference simulation, detection and its impact on NavIC signal

A Wi-Fi modem was installed in the vicinity of NavIC receiver setup and RF interference detection setup. The Wi-Fi channel-13 signals were generated using the Wi-Fi modem. The frequency band of Wi-Fi Channel-13 Signal is 2461-2483 MHz, which is near to NavIC S band.

2.1 Setup for RF interference detection

This setup was carried out to find the presence of interference frequencies (Wi-Fi) in the intended NavIC S frequency band, 2492.028 MHz ± 8.25 MHz. The RF interference detection setup is depicted in Figure-2.

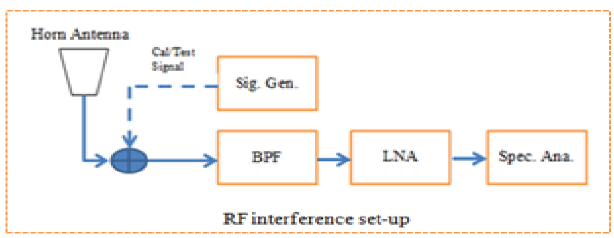

Figure-2: RF Interference detection setup

The details of the setup are explained below:

- Horn antenna was fixed on the top of Tripod with an antenna mount capable of rotating in azimuth and elevation axis. The connection diagram was made as per Figure-1.
- The RF chain was calibrated by computing
  - Chain Gain = LNA Gain - Cable Loss + Ant Gain - Other losses
  - System Sensitivity for measuring the minimum signal level = Noise floor at spectrum level – Chain Gain
- The Antenna mount azimuth axis was set to Zero by aligning it to the magnetic north by using a compass. The antenna elevation was set to 5deg.
- The azimuth axis was incremented in 30deg steps in clockwise direction from 0 to 360 deg. for completing one round measurement.
- Antenna was rotated manually (0°-360° in Azimuth) in steps of 30°, with fixed elevation angle of 5°.
- Spectrum plots were recorded with max hold position at each angle for 5-10 min interval.
- Whenever signal was observed above noise level, antenna was scanned around that region for signal maximization and the spectrum plots were recorded.
- Spectrum Analyzer settings to be used were for obtaining best tradeoff between minimum Noise floor and lesser sweep time.

2.2 NavIC Receiver setup

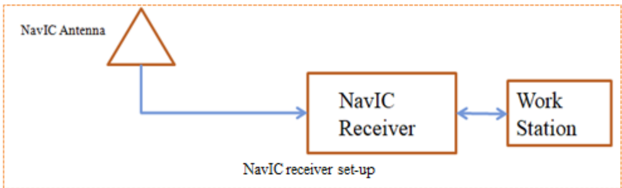

Figure-3: NavIC receiver set-up

Dual Band antenna (L5 and S band) was used to track NavIC Signals. The Antenna was made on through receiver and the receiver was configured in order to track NavIC satellites. The receiver's C/No was logged into workstation.

3. Observation

The spectrum plot in Figure-4 indicates the presence of a Wi-Fi signal near the NavIC antenna. The blue trace represents the Wi-Fi signal (maximum trace) detected by the spectrum analyzer. This interference led to degradation in the carrier-to-noise ratio (C/No) of the NavIC receiver resulting in complete loss of lock of signal channel at multiple times, as shown in Figure-5. The red trace represents the C/No of the S band, which experienced degradation and signal loss. In contrast, the green trace represents the C/No of the L5 band, which remained unaffected by the presence of the Wi-Fi signal.

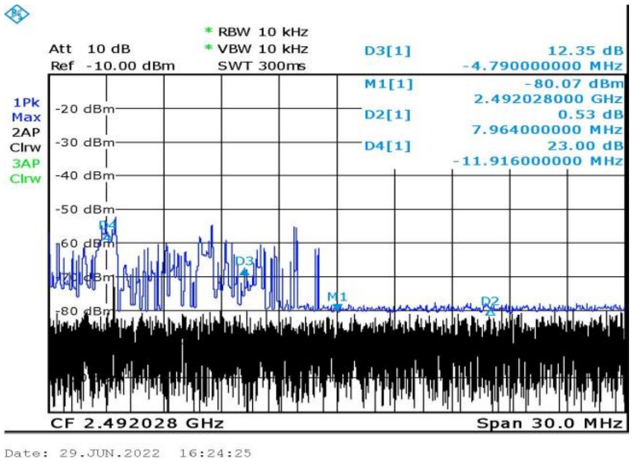

Figure-4: Wi-Fi signal presence near NavIC receiver

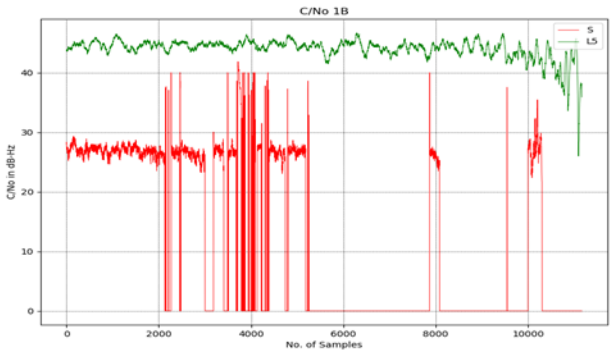

Figure-5: C/N0 degradation in S band of NavIC receiver

4. Conclusion

The interference from Wi-Fi signal was detected by both the experimental setups. The interference led to reduction in signal intensity. This reduction in C/No led to a complete loss of reception and tracking by the NavIC receiver, which is highly undesirable for its optimal operation. Therefore, efforts should be made to protect the S-band from interference by ISM band signals, such as Wi-Fi.

5. References

[1] Soualle, F. et al., Assessment on the use of S-band for combined navigation and communication. In Proceedings of the 24th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GNSS 2011), September 2011, pp. 1219– 1223.

[2] Dovis, F., GNSS Interference Threats and Counter Measures, Artech House, 2015, pp. 22–38.