

A Method to Enhance BOC Signal Reception Performance under Partial Band Interference

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Abstract—Traditionally, Global Navigation Satellite Systems (GNSS) have provided navigation services primarily in the L-band. However, with the rapid expansion of global and regional navigation satellite systems such as GPS, Galileo, GLONASS, BeiDou, QZSS, and NavIC, the demand for L-band channels has increased substantially. This surge has led to more inter-system interference, and certain portions of the L-band are now approaching spectral saturation. Consequently, risks of degraded signal quality, reduced positioning accuracy, and impaired system interoperability have become more significant. By contrast, the S-band remains relatively underutilized and is considered a promising candidate for mitigating interference from navigation satellite systems. Nevertheless, it is susceptible to adjacent-channel interference from services such as Wi-Fi, Locata, and other satellite systems. To address these challenges, this paper proposes an interference-robust signal processing technique to improve the reception performance of BOC (Binary Offset Carrier) signals under partial band interference.

Keywords—Interference Mitigation, Signal Processing, MRC

I. INTRODUCTION

Global Navigation Satellite Systems (GNSS) are critical for a wide range of applications, including navigation, positioning, precise time synchronization, geospatial information systems, weather monitoring, and Earth science research. GNSS has become a cornerstone of modern technological infrastructure, supporting both military and civilian domains. With the advancement of smartphones, autonomous vehicles, drones, unmanned systems, and smart cities, their importance continues to grow.

Traditionally, GNSS signals have been transmitted primarily in the L-band (1–2 GHz), which offers advantages such as high ionospheric penetration, low signal attenuation, and efficient receiver design. These properties have made the L-band the primary frequency band for GNSS. However, expansion of global and regional systems such as Galileo, GLONASS, BeiDou, QZSS, and NavIC has resulted in a substantial increase in channel demand. Consequently, inter-system interference has increased, and parts of the L-band are nearing saturation. This trend raises concerns about performance degradation and reduced interoperability among systems.

In this context, the need for alternative frequency bands has emerged to relieve L-band congestion and support new navigation services. Among these, the S-band (2–4 GHz) has

gained attention as a promising candidate due to its relatively low utilization and proximity to the L-band. The S-band is already used in regional navigation satellite systems (RNSS) such as China's BeiDou and India's IRNSS, and it is being actively discussed for use in next-generation GNSS.

Despite its advantages, the S-band RDSS (Radio Determination Satellite Service) band also presents challenges. As shown in Figure 1, it is adjacent to the ISM (Industrial, Scientific, and Medical) band, an unlicensed band used by technologies such as Wi-Fi and Bluetooth, as well as ground-based positioning systems like Locata. Furthermore, commercial services such as Globalstar already operate within the same band, introducing additional risks of interference to GNSS signal quality [1]. Mitigating both in-band and adjacent-band interference while ensuring robust receiver performance remains a key technical challenge. This study addresses these challenges by proposing a method to minimize the performance degradation of S-band navigation signals in the presence of interference.

This paper introduces an interference-robust signal processing technique to enhance the reception performance of BOC (Binary Offset Carrier) signals under partial-band interference. The proposed method applies adaptive weighting based on interference levels to optimize the signal-to-interference-plus-noise ratio (SINR). Simulation results show that the proposed approach maintains performance similar to conventional methods in interference-free scenarios, while significantly outperforming them under increasing interference. These results indicate strong robustness and improved reliability in practical applications.

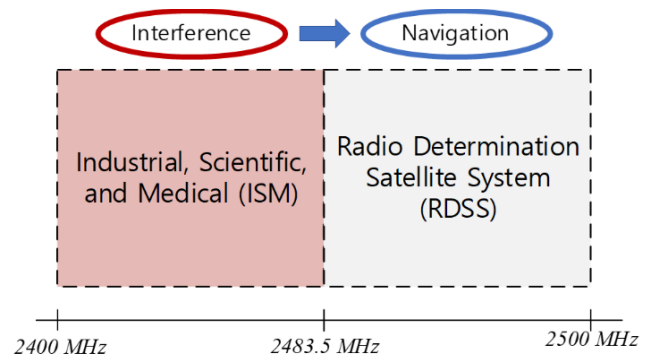


Fig. 1. Adjacent Band Interference between the ISM and RDSS Bands

II. SYSTEM MODEL & PROPOSED SCHEME

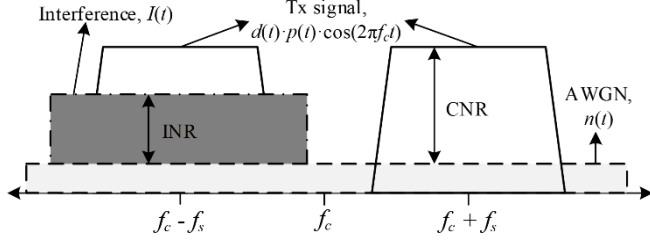


Fig. 2. The Boc Signal in the frequency domain

BOC modulation is commonly used in GNSS to improve navigation performance. The received BOC-modulated signal, $r(t)$, can be expressed as:

$$r(t) = d(t) \cdot p(t) \cdot \cos(2\pi f_c t + \theta) + n(t) + I(t) \quad (1)$$

where $d(t)$ is a data signal, $p(t)$ is a square-wave sub-carrier produced by a BOC modulation scheme, f_c is a carrier frequency, θ is a phase of the received signal, $n(t)$ is the additive white Gaussian noise (AWGN), and $I(t)$ is an interference signal. A unique characteristic of BOC signals is their split spectrum, in which the sub-carrier generates both upper sideband (USB) ($f_c + f_s$) and lower sideband (LSB) ($f_c - f_s$) components, symmetric about the center frequency. This frequency-splitting property allows for improved signal isolation and interference rejection in typical GNSS environments.

Figure 2 illustrates the frequency response of a BOC signal under partial interference, where interference is applied to either the USB or LSB. In particular, when considering interference from the ISM band, only the LSB is affected. The interference level is represented by the Interference-to-Noise Ratio (INR). The received signal can be rewritten as the sum of the USB and LSB components:

$$r(t) = r_{upper}(t) + r_{lower}(t) \quad (2)$$

To optimize the SINR, the receiver can apply weighting to the sidebands. The weighted signal $r_w(t)$ is then:

$$r_w(t) = w_1 \cdot r_{upper}(t) + w_2 \cdot r_{lower}(t) \quad (3)$$

Three weighting schemes are considered:

1. Equal Weighting: The conventional GNSS method applies equal weights to both sidebands.
2. Selection Scheme: Sets the weight of the more interfered sideband to zero, using only the cleaner side.
3. Maximal Ratio Combining (MRC): Optimizes SINR by assigning weights based on the inverse of the signal variance. The weights are calculated as:

$$w_1 = 1/\sigma_{upper}^2, w_2 = 1/\sigma_{lower}^2 \quad (4)$$

where σ_{upper}^2 and σ_{lower}^2 represent the variances of the USB and LSB components, respectively.

III. SIMULATION RESULTS

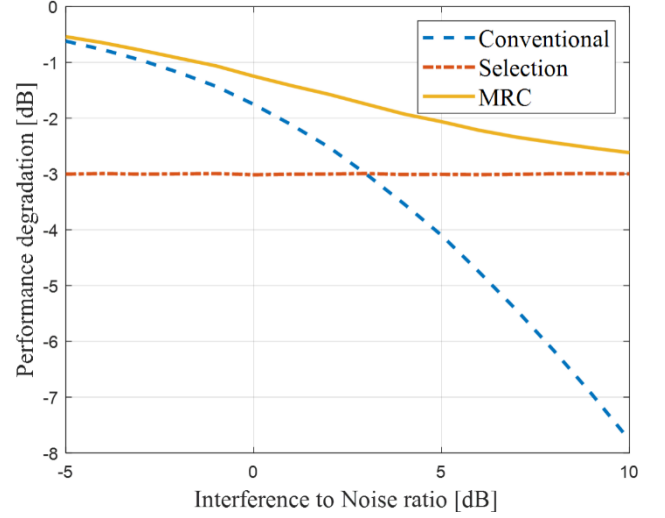


Fig. 3. Degradation of Reception Performance According to INR

The performance of the three techniques is evaluated and shown in Figure 3. The selection scheme consistently experiences a 3 dB loss due to using only one sideband. In low INR environments, both the conventional and MRC methods show similar degradation, with their performances expected to approach 0 dB loss as INR decreases toward $-\infty$. However, across all interference conditions, the MRC technique consistently outperforms the conventional method, with the performance gap widening as interference levels rise.

IV. CONCLUSION

This paper proposed a method to enhance BOC signal reception performance under partial band interference. Simulation results show that while the proposed method performs comparably to conventional techniques in interference-free environments, it achieves significant performance gains under interference. These gains become more pronounced as interference levels increase. These findings highlight the method's potential as a practical and robust solution for reliable GNSS signal reception in future S-band systems.

ACKNOWLEDGMENT

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