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Editors

China Satellite Navigation Conference (CSNC) 2014 Proceedings: Volume II

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Preface

China's BDS Navigation Satellite System (BDS) has been independently developed, which is similar in principle to global positioning system (GPS) and compatible with other global satellite navigation systems (GNSS). The BDS will provide highly reliable and precise positioning, navigation and timing (PNT) services as well as short-message communication for all users under all-weather, all-time, and worldwide conditions.

China Satellite Navigation Conference (CSNC) is an open platform for academic exchanges in the field of satellite navigation. It aims to encourage technological innovation, accelerate GNSS engineering, and boost the development of the satellite navigation industry in China and in the world.

The 5th China Satellite Navigation Conference (CSNC 2014) is held on May 21–23, 2014, Nanjing, China. The theme of CSNC 2014 is BDS Application—Innovation, Integration and Sharing, which covers a wide range of activities, including technical seminars, academic exchange, forum, exhibition, lectures, as well as ION panel. The main topics are as:

1. BDS/GNSS Navigation Applications
2. Satellite Navigation Signal System, Compatibility and Interoperability
3. Precise Orbit Determination and Positioning
4. Atomic Clock Technique and Time-Frequency System
5. Satellite Navigation Augmentation and Integrity Monitoring
6. BDS/GNSS Test and Assessment Technology
7. BDS/GNSS User Terminal Technology
8. Satellite Navigation Models and Methods
9. Integrated Navigation and New Methods

The proceedings have 171 papers in nine topics of the conference, which were selected through a strict peer-review process from 479 papers presented at CSNC 2014.

We thank the contribution of each author and extend our gratitude to 165 referees and 36 session chairmen who are listed as members of an editorial board. The assistance of CNSC 2014's organizing committees and the Springer editorial office is highly appreciated.

Jiadong Sun

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Part I
Satellite Navigation Signal System, Compatibility and Interoperability

Chapter 1
The Research of the High-Altitude BDS Weak Signal Acquisition

Changyuan Wen, Fuzhan Yue, Yuehua Qiu and Ting Ke

Abstract Aiming at the application for High-Earth orbit spaceflight navigation, the paper is about the weak BDS signal acquisition on High-Earth orbit. First, this paper achieves the receiving power and Doppler-shift of the High-Earth orbit receiver by simulating the navigation signal characteristic which based on the STK (Satellite Tool Kit). In order to solve the problem of the secondary code witch modulated on BDS B1I and improve the acquisition sensibility, this paper analyses the autocorrelation characteristic of the data which modulated with the NH code, comes up with the resolution of using the alternate half-bit method by combining the coherent integration with the non-coherent integration. The result indicates that it can successfully acquire the −178 dBW BDS B1I signal under the mentioned method.

Keywords High-earth orbit · Weak signal acquisition · Coherent/Non-coherent · The alternate half-bit method · Neumann–Hoffman code searching

1.1 Introduction

High Earth Orbit (HEO) including Geostationary Orbit (GEO) and Highly Eccentric Earth Orbital (HEEO), are generally higher than the maximum height of its orbit 20,000 km. In recent years, in terms of land and sea communications, meteorological, educational applications, live television, disaster warning, HEO plays an important role. The high-altitude spacecraft navigation positioning and orbit determination has become one of the urgent needs to develop new technology. The satellite navigation system with the characteristics of global, all-weather,

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continuous and high precision has gradually become the principal means of navigation for positioning and orbit determination [1].

But due to high-altitude spacecraft orbital altitude higher than that of navigation constellation, needs to receive signals from the earth the other side of the navigation satellite receiver. Keeping out of the earth as well as propagation distance increasing lower the signal received power, which lead to reduce the presence of the available satellite, short duration of available navigation signals and weak receiving signal power by using the regular technology.

The NASA has a series of flight test for high-altitude GPS receiver application, developed such as the Pivot and the Navigator receiver for deep space exploration. High-altitude test shows that on high-altitude receiving power will be lower than the ordinary spaceborne receiver power more than 10 dB, doppler frequency shift in L1 band will be around 10 KHZ, the Navigator which uses 10 ms coherent integration when $C/N_0 = 25$ dB-Hz successful acquisition probability is only 50 %, larger deficiencies still exist for high-altitude applications [2]. The literature [3] studied the GNSS high-altitude satellite positioning related factors, but did not give a reasonable signal processing scheme .the literature [4] put forward navigation constellation with navigation signal constellation outside for locating scheme, but involved navigation constellation space redesign, implementation is difficult at present.

The above studies were all for the GPS orbit application, and domestic and foreign high-orbit applications are not seen on the BDS literature. This paper aiming high-altitude weak navigation signal with short duration carries out the high-orbit spacecraft BDS weak signal acquisition technology research.

1.2 BDS Navigation Signal Characteristics on High Earth Orbit

High-altitude navigation receiver needs to receive navigation signals from across the earth. Take GEO orbit for example, under the analysis of space geometric relationships between high-altitude with BDS MEO satellite constellation, and calculating the corresponding power link. Figure 1.1, the ε for BDS satellite antenna of unilateral coverage point of view, Angle φ for BDS satellite main beam unilateral, Angle θ for BDS satellite and earth tangent of unilateral. α for receiver and BDS satellite connection with the receiver to the Angle between the direction of the centre of the earth, β for receiver and BDS connect with BDS satellites pointing in the direction of the Angle between the direction of the center of the earth. In diagram of AC segment caused by earth sheltered, signal is not available.

Space navigation signal propagation link budget equation is:

$$P_R = P_T + G_T + G_R + 20\log\left(\frac{\lambda}{4\pi d}\right) - L_A \tag{1.1}$$