BeiDou Navigation Satellite System

Signal In Space

Interface Control Document

(Test Version)

China Satellite Navigation Office

December 2011

Content

1 Scope

The BeiDou Navigation Satellite System (hereinafter referred to as BeiDou system) has followed the development roadmap of starting with regional services first and expanding to global services later. A three-step development strategy has been taken. Phase I is BeiDou Navigation Satellite Demonstration System, which was been established in 2000. Phase II is BeiDou Navigation Satellite (regional) System to provide service for areas in China and its surrounding areas from 2012. Phase III is BeiDou Navigation Satellite System to be established completely and provide global service by 2020.

This interface document defines the specification related to B1 carrier signal between the space segment and the user segment of the BeiDou Navigation Satellite (regional) System.

2 System Overview

2.1 Space Constellation

The nominal constellation of BeiDou Navigation Satellite (regional) System is composed of fourteen satellites, including five Geostationary Earth Orbit (GEO) satellites and nine Non-Geostationary Earth Orbit (Non-GEO) satellites. The Non-GEO

satellites include four Medium Earth Orbit (MEO) satellites and five Inclined Geosynchronous Satellite Orbit (IGSO) satellites. The GEO satellites are positioned at 58.75°E, 80°E, 110.5°E, 140°E and 160°E respectively.

2.2 Coordinate System

The BeiDou system adopts the China Geodetic Coordinate System 2000 (CGCS2000), the definition of which is listed below:

The origin is located at the mass center of the Earth;

The Z-axis is in the direction of the IERS (International Earth Rotation Service) Reference Pole (IRP);

The X-axis is directed to the intersection of IERS Reference Meridian (IRM) and the plane passing through the origin and normal to the Z-axis;

The Y-axis, together with Z-axis and X-axis, constitutes a right handed orthogonal coordinate system.

The origin of the CGCS2000 is also the geometric center of the CGCS2000 ellipsoid, and the Z-axis is the rotation axis of the CGCS2000 ellipsoid. The parameters of the CGCS2000 ellipsoid are as follows:

Semi-major axis: $a = 6378137.0$ m

Geocentric gravitational constant (mass of the earth atmosphere

included): $GM = 398600.4418\times10^{9}\ m^3/s^2$

Flattening: $f = 1/298.257222101$

Rate of earth rotation: $\omega = 7.2921150\times10^{-5}$ rad/s

2.3 Time System

The BeiDou Time (BDT) System is a continuous timekeeping system, with its length of second being a SI second. BDT zero time-point started at 00:00 UTC on January 1st, 2006. BDT is synchronized with UTC in 100 nanoseconds (modulo one second).

3 B1 Signal Specifications

3.1 Signal Structure and Basic Characteristics

3.1.1 Signal Structure

The B1 signal is the sum of channel I and Q which are in phase quadrature of each other. The ranging code and navigation message is modulated on B1 carrier signal. The signal is composed of the carrier frequency, ranging code and navigation message.

The B1 signal is expressed as follows:

$$S^j = A_C C^j(t) D_C^j(t)\cos\left(2p\ ft + j_C^j\right) + A_P P^j(t) D_P^j(t)\sin\left(2p\ ft + j_P^j\right)$$

Where,

j: Satellite number

A_C: Amplitude of ranging code in channel I of carrier B1

A_P: Amplitude of ranging code in channel Q of carrier B1

C: Ranging code in channel I

P: Ranging code in channel Q

D_C: Data modulated on ranging code of channel I

D_P: Data modulated on ranging code of channel Q

f: B1 carrier frequency

j_C: Initial phase of channel I of carrier B1

j_P: Initial phase of channel Q of carrier B1

3.1.2 Basic Signal Characteristics

The basic characteristics and parameters of B1 signals are shown in Table 3-1.

Table 3-1 Basic characteristics and parameters of B1 signal

Carrier frequency	1561.098 MHz
Modulation	Quadrature Phase Shift Keying(QPSK)
Ranging code rate	Channel I: 2.046 Mcps
Ranging code length	Channel I: 2046 chips
Data rate	Channel I of GEO satellites: 500 bps
	Channel I of MEO/IGSO satellites: 50 bps Secondary code rate: 1 Kbps
Access mode	Code Division Multiple Access(CDMA)
Polarization	Right-Handed Circular Polarization(RHCP)

3.2 Signal Radio Frequency Characteristics

3.2.1 Carrier Frequency

The nominal frequency of B1 signal is 1561.098 MHz.

3.2.2 Satellite Signal Bandwidth and Out-band Suppression

(1) Bandwidth (1 dB): ±2.046 MHz,

Bandwidth (3 dB): ±8 MHz.

(2) Out-band suppression: no less than 15 dB on f_0 ±30 MHz, where f_0 is the carrier frequency of B1 signal.

3.2.3 Spurious

In-band spurious shall be at least 50 dB below the unmodulated carrier of B1 signal over the satellite signal bandwidth (1 dB).

3.2.4 Carrier Phase Noise

The phase noise spectral density of the unmodulated is as follows:

-60 dBc/Hz at f_0 ±10 Hz

-75 dBc/Hz at f_0 ±100 Hz

-80 dBc/Hz at f_0 ±1 kHz

-85 dBc/Hz at f_0 ±10 kHz

-95 dBc/Hz at f_0 ±100 kHz

where f_0 is the carrier frequency of B1 signal.

3.2.5 User-Received Signal Level

The minimum user-received signal power level is specified to be -163 dBW for channel I of B1 signal, which is measured at the output of a 0 dB circularly polarized receiving antenna (located near ground), when the satellite is above a 5-degree elevation angle.

3.2.6 Signal Coherence

The random jitter of the initial phase difference between the B1 carrier and the ranging code modulated on B1 carrier is less than 3°(1σ) (relative to the carrier).

3.3 B1 Ranging Code

The rate of the ranging code in channel I of carrier B1 is 2.046 Mcps, and the length is 2046 chips.

The ranging code in channel I of carrier B1 is a balanced Gold code truncating the last one chip. The Gold code is generated by means of Modulo-2 addition of G1 and G2 sequences which are respectively derived from two 11-bit linear shift registers.

The generator polynomials for G1 and G2 are as follows:

$G1(X)=1+X+X^7+X^8+X^9+X^{10}+X^{11}$

$G2(X)=1+X+X^2+X^3+X^4+X^5+X^8+X^9+X^{11}$

The initial phases of G1 and G2 are:

G1: 01010101010

G2: 01010101010

The ranging code generator of carrier B1 is shown in Figure 3-1.

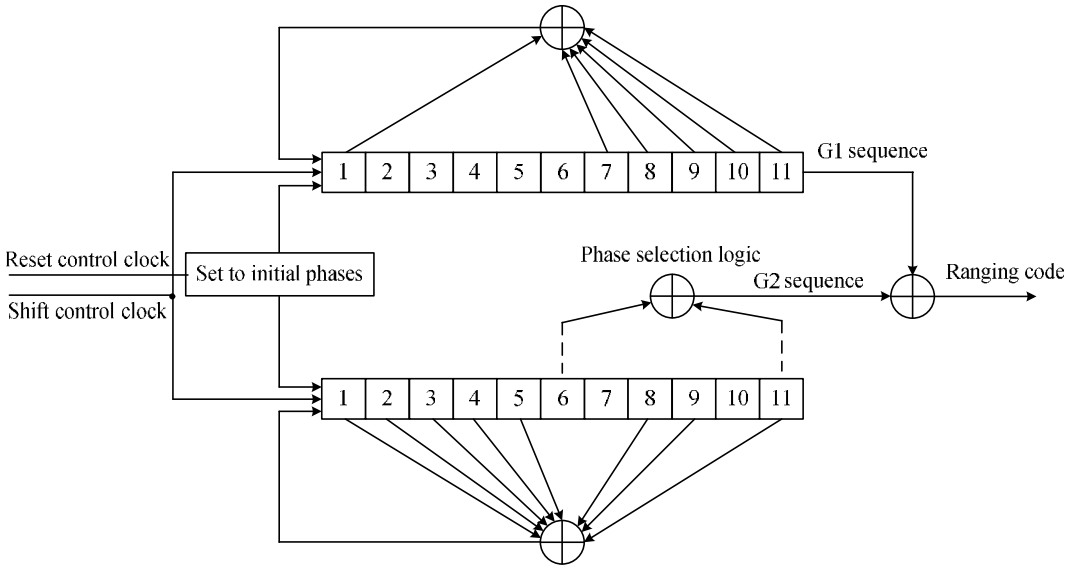

Figure 3-1 Ranging code generator of carrier B1

The different phase shift of G2 sequence is accomplished by respective tapping in the shift register generating G2 sequence. By means of Modulo-2 addition of G2 with different phase shift and G1, a ranging code in channel I is generated for each satellite.

The phase assignment of G2 sequence is shown in Table 3-2.

Table 3-2 Phase assignment of G2 sequence

No.	Satellite type	Ranging code number	Phase assignment of G2 sequence
1	GEO satellite	1	1 ⊕ 3
2	GEO satellite	2	1 ⊕ 4
3	GEO satellite	3	1 ⊕ 5
4	GEO satellite	4	1 ⊕ 6
5	GEO satellite	5	1 ⊕ 8
6	Non-GEO satellite	6	1 ⊕ 9
7	Non-GEO satellite	7	1 ⊕ 10
8	Non-GEO satellite	8	1 ⊕ 11
9	Non-GEO satellite	9	2 ⊕ 7
10	Non-GEO satellite	10	3 ⊕ 4
11	Non-GEO satellite	11	3 ⊕ 5
12	Non-GEO satellite	12	3 ⊕ 6
13	Non-GEO satellite	13	3 ⊕ 8
14	Non-GEO satellite	14	3 ⊕ 9
15	Non-GEO satellite	15	3 ⊕ 10
16	Non-GEO satellite	16	3 ⊕ 11
17	Non-GEO satellite	17	4 ⊕ 5
18	Non-GEO satellite	18	4 ⊕ 6
19	Non-GEO satellite	19	4 ⊕ 8
20	Non-GEO satellite	20	4 ⊕ 9
21	Non-GEO satellite	21	4 ⊕ 10
22	Non-GEO satellite	22	4 ⊕ 11

23	Non-GEO satellite	23	5 ⊕ 6
24	Non-GEO satellite	24	5 ⊕ 8
25	Non-GEO satellite	25	5 ⊕ 9
26	Non-GEO satellite	26	5 ⊕ 10
27	Non-GEO satellite	27	5 ⊕ 11
28	Non-GEO satellite	28	6 ⊕ 8
29	Non-GEO satellite	29	6 ⊕ 9
30	Non-GEO satellite	30	6 ⊕ 10
31	Non-GEO satellite	31	6 ⊕ 11
32	Non-GEO satellite	32	8 ⊕ 9
33	Non-GEO satellite	33	8 ⊕ 10
34	Non-GEO satellite	34	8 ⊕ 11
35	Non-GEO satellite	35	9 ⊕ 10
36	Non-GEO satellite	36	9 ⊕ 11
37	Non-GEO satellite	37	10 ⊕ 11