# Quasi-Zenith Satellite System
# Interface Specification
# Positioning Technology Verification Service
# (IS-QZSS-TV-002)

(December 19, 2018)

Cabinet Office

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## Revision History

| Rev. No. | Date | Page | Revisions |
|---|---|---|---|
| 001<br>Draft Edition | March 25, 2016 | | Draft edition |
| | July 12,2016 | - | Adds Disclaimer of Liability |
| 001 | April 13, 2018 | - | First release |
| 002 | December 19,2018 | 5 | ・Updates Minimum Signal Strength for QZS-3<br>・Corrects typographical error(L1S → L5S) in 3.1.8. |

“TBD” in this document is an abbreviation of “To be determined”. The items marked “TBD” have not been determined yet but will be determined in the future.

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# 1. Scope

This document describes the interface specifications of the positioning technology verification service (PTV) between the space segment of QZSS and the user segment. The interface specifications described herein include the signal characteristics and message specifications.

The content of system, service and availability are described in the applicable document (1) "PS-QZSS-001 Quasi-Zenith Satellite System Performance Standard".

# 2. Relevant Documents

## 2.1. Applicable Documents

The following documents constitute part of this document within the scope as defined in this document.

(1) PS-QZSS-001 Quasi-Zenith Satellite System Performance Standard

# 3. Signal Specifications

## 3.1. RF Characteristics

### 3.1.1. Signal Structure

The signal structure, PRN code characteristic and message characteristics are shown in Table 3.1-1, Table 3.1-2, and Table 3.1-3.

Table 3.1-1 Signal Structure

| Frequency Band | Signal Name | Modulation Method | PRN Code Name | Overlay Code Name | Message Name |
|---|---|---|---|---|---|
| L5 | L5S | QPSK | I5S | - | L5S |
| | | | Q5S | Neuman-Hoffman | - |

Table 3.1-2 PRN Code Characteristics

| PRN Code Name | Chip Rate | Length | Period | Overlay Code |
|---|---|---|---|---|
| I5S | 10.23 Mcps | 10,230 chips | 1 ms | - |
| Q5S | 10.23 Mcps | 10,230 chips | 1 ms | Neuman-Hoffman Length:20bits Period:1ms |

Table 3.1-3 Message Characteristics

| Message Name | Bit Rate | Symbol Rate | Period (Minimum Frame) | Encoding Method |
|---|---|---|---|---|
| L5S | 250 bps | 500 sps | 1 sec | CRC Convolutional code |

### 3.1.2. Frequency

The frequency band, nominal center frequency and occupied bandwidth of L5S signals are shown in Table 3.1-4.

However, the reference frequency ($f_0$) = 10.23 MHz is offset by the nominal $\Delta f/f_0$ = -5.399E-10 to compensate for the frequency difference between the ground surface and satellite orbit due to the relativistic effect. For this reason, the center frequency in the satellite orbit is not exactly precise. For example, the L5 band signal is offset by -0.6352Hz (nominal).

Table 3.1-4 Center Frequency and Occupied Bandwidth

| Frequency Band (Signal Name) | Nominal center frequency | Block II |
|---|---|---|
| L5 band (L5S) | 1176.45 MHz | 24.9 MHz<br>(±12.45 MHz) |

### 3.1.3. Modulation Method

#### 3.1.3.1. L5S

L5S signals are modulated by QPSK. The modulation method is shown in Figure 3.1-1.

L5S navigation messages and PRN codes are modulated by exclusive-OR (modulo 2 addition) and then modulated with L5 carrier waves by QPSK.

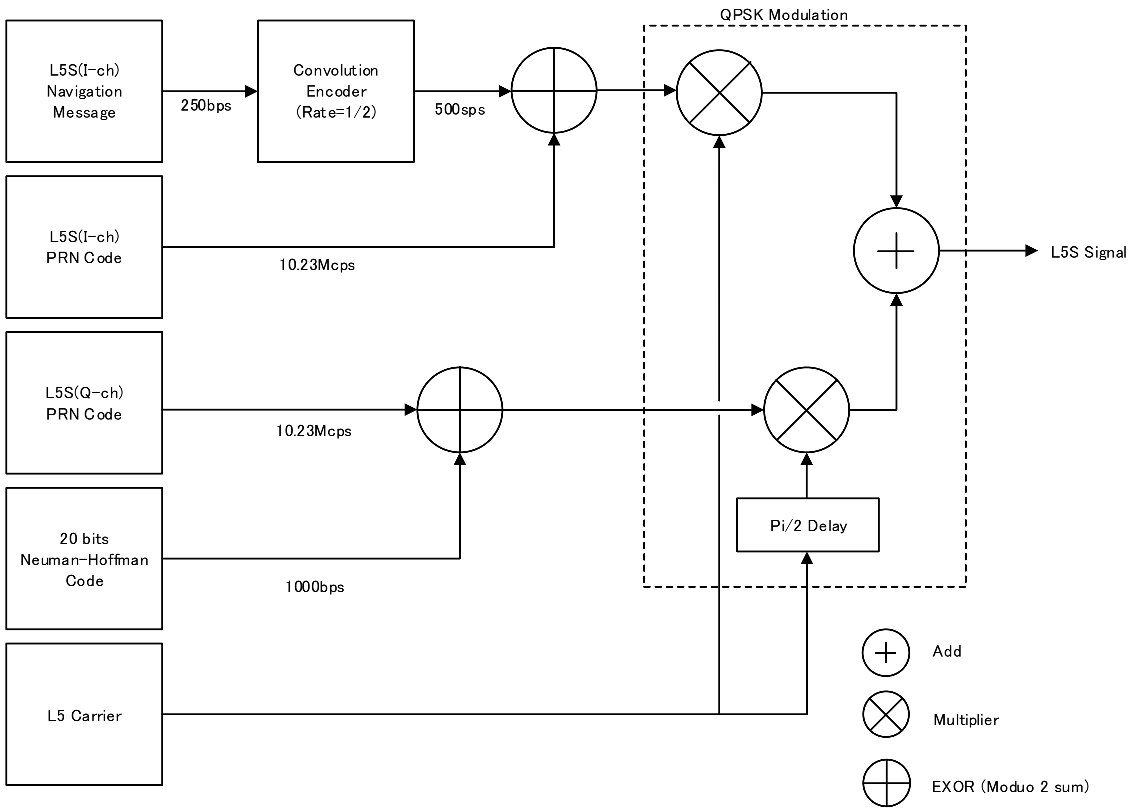


Figure 3.1-1 L5S Modulation

### 3.1.4. Correlation Loss

Correlation loss is defined as the energy ratio of carrier wave to output signals obtained by theoretically modulating the output signals by reverse diffusion.

The correlation loss values are as shown below:

- Block II: 1.0 dB or less

### 3.1.5. Carrier Phase Noise

For L5S signals, the spectral density of the phase noise of the unmodulated carrier wave before superposition of the PRN code and navigation message, shall be such that a phase-locked loop (PLL) with single-sided bandwidth of 10Hz will be able to track the carrier phase to the following values:

- Block II: 0.1 rad (RMS)

### 3.1.6. Spurious

For L5S signals, the spurious transmission of the unmodulated carrier wave before superposition of the PRN code and navigation message, shall be as follows:

- Block II: -40 dB or less

### 3.1.7. Phase Relationship within Signals

For L5 signals, the phase relationships between I-channel and Q-channel of L5S are shown in Figure 3.1-2.

The I-channel had 90° phase lag from the Q-channel. The accuracy is ± 5°.

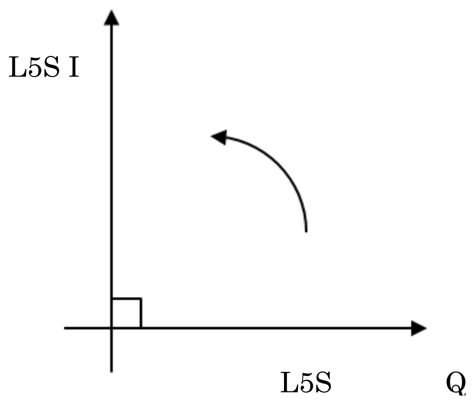


Figure 3.1-2 Phase relationship of L5S

### 3.1.8. Minimum Signal Strength

The minimum received power is measured at a ground-based isotropic antenna with a gain of 0dBi for circularly polarized wave reception, when L5S signals are received from a satellite with an elevation angle of 10° or more. The power is shown in Table 3.1-5.

Table 3.1-5 Minimum Signal Strength

| Signal Name | Block II |
|---|---|
| L5S | SV Number =3：-162.6dBW<br>Other SV Number：-157.0 dBW |

### 3.1.9. Polarization Property

L5S signals are right-hand circularly polarized.

At the center frequency of each signal, the axial ratio (power ratio of the long axis to short axis) of the ellipse of the circularly polarized wave is within the beam range ± 10° from the boresight direction and is shown in Table 3.1-6.

Table 3.1-6 Axial Ratio of the Ellipse of the Circularly Polarized Wave

| Signal Name | Block II |
|---|---|
| L5S | 2.0 dB or less |

### 3.1.10. Group Delay Property

#### 3.1.10.1. Group Delay Between Signals

L5S signals have, no group delay between signals.

#### 3.1.10.2. Group Delay Between Signals of the Same Frequency

L5S signals have no group delay between signals of same frequency

For L5S signals, no specifications are defined for the group delay between signals of the same frequencies.

### 3.1.11. PRN Code Jitter

The jitter with the PRN code zero-crossing interval shall be as follows:

- 2.0 ns or less (3σ).

For PRN codes, the average time difference between the rising edge and the falling edge shall be as follows:

- 1.0 ns or less

### 3.1.12. Code Carrier Coherence

(1) Short-term code carrier coherence

The short-term (less than 10 sec) difference between the code pseudo range rate and the Doppler frequency shall be less than 0.015 m/sec (1σ).

(2) Long-term code carrier coherence

The long-term (less than 100 sec) difference between the code phase pseudo range and the carrier phase pseudo range shall be less than 0.255 m (1σ).

(3) Short-term L1/L5 coherence

The short-term (less than 10 sec) difference between the L1 Doppler frequency and the L5 Doppler frequency shall be less than 0.015 m/sec (1σ).

(4) Long-term L1/L5 coherence

The long-term (less than 100 sec) difference between the L1 carrier phase pseudo range and the L5 carrier phase pseudo range shall be less than 0.255 m (1σ).

## 3.2. PRN Codes

### 3.2.1. PRN Number Assignment

The assignment of the PRN numbers by satellite categories are shown in Table 3.2-1.

Table 3.2-1 Assignment of PRN Number by satellite categories

| PRN Number (*1) | Satellite Category | Block Assignment | SV Number | Remarks |
|---|---|---|---|---|
| 196 | QZO | Block IIQ | 2 | |
| 197 | GEO | Block IIG | 3 | |
| 200 | QZO | Block IIQ | 4 | |

*1: There is a possibility that the code will be changed for a seven-QZS constellation in the future.

### 3.2.2. L5S Code

PRN codes of I5S and Q5S signals have 1ms in length at a chipping rate of 10.23Mbps, for total length of 10230 chips. In addition, Q5S has a Neuman-Hoffman (NH) code with a bit rate of 1kbps(cycle: 1ms) and a length of 20bits (20ms).The 20-bit NH code of Q5S is as follows:

1st Last

20-bit NH code = 0000 0100 1101 0100 1110

The PRN codes are generated as shown in Figure 3.2-1. The code pattern of each PRN number is generated with the XB code advance and the initial XB code state shown in Table 3.2-2.

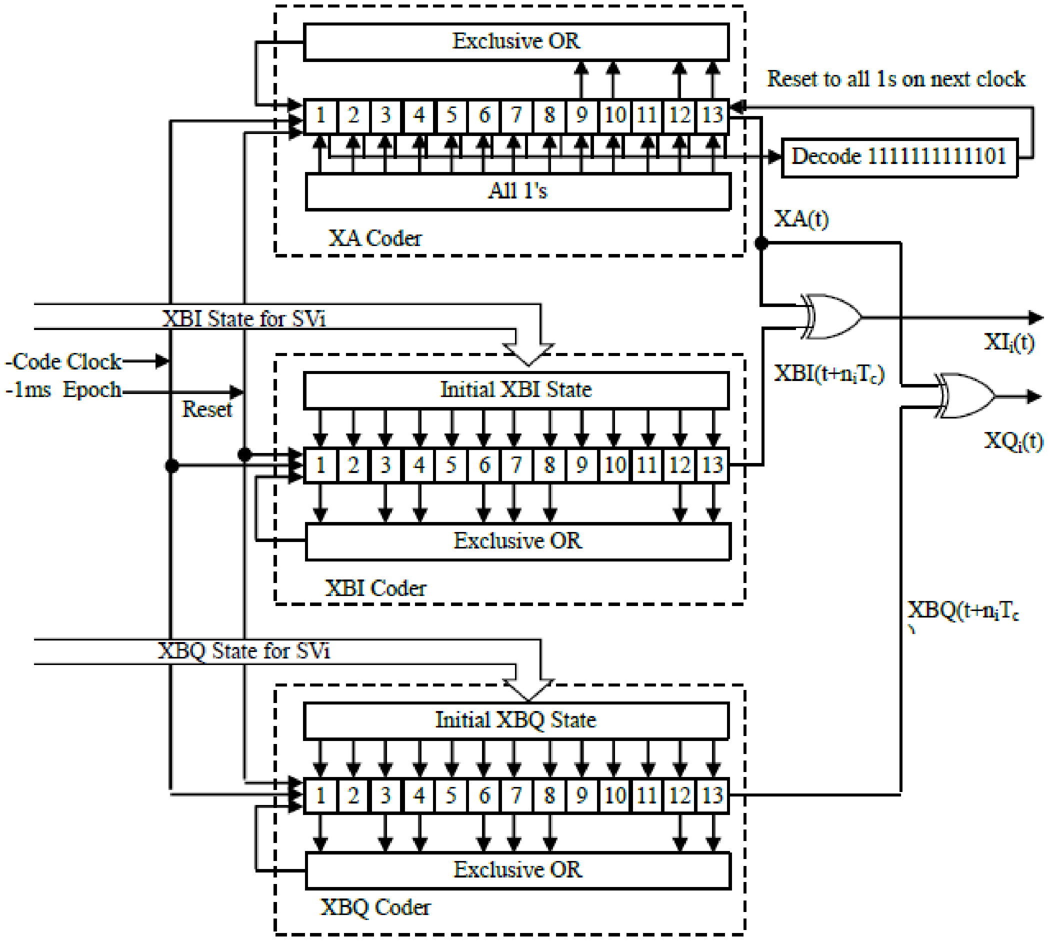


Figure 3.2-1 L5S Code Generator

Table 3.2-2 L5S PRN Code phase assignment

| PRN Number | XB Code Advance (Chips) | | Initial XB Code State | |
|---|---|---|---|---|
| | I5 | Q5 | I5 | Q5 |
| 196 | 0950 | 5182 | 1111101110001 | 0000100001100 |
| 197 | 5905 | 6606 | 0011111100001 | 0101000101101 |
| 200 | 3197 | 3115 | 0100001110110 | 0100011100110 |

### 3.2.3. Non-Standard Codes

L5S signals have no non-standard codes.

# 4. Message Specifications

## 4.1. L5S

### 4.1.1. Message Configuration

#### 4.1.1.1. Overview

Each message are transmitted by L5S signal consists of 250 bits shown in Figure 4.1-1. The single message is transmitted in one second (250bps).

Each message consist of 8-bit preamble (PAB),6-bit message type (MT), 212-bit data field (DATA FIELD) and a 24-bit CRC (CRC). The message transmission sequence is not specified, each message may be transmitted in one-second period..

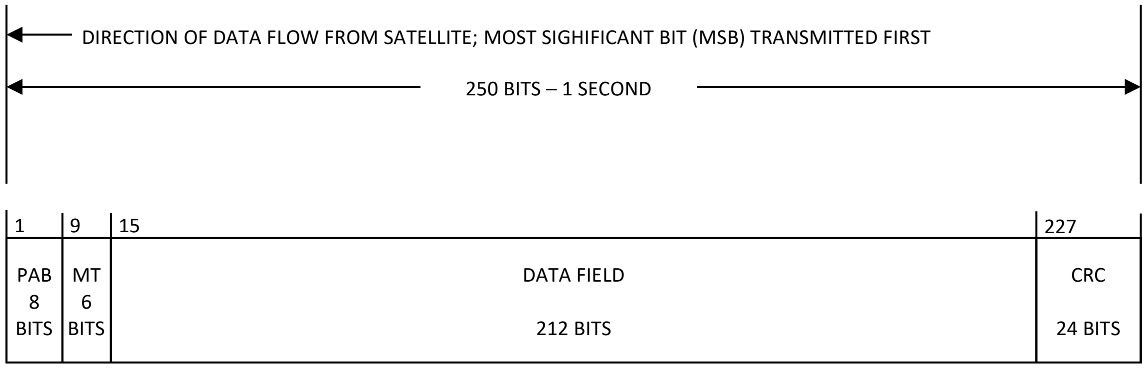


Figure 4.1-1 Message Block Format

#### 4.1.1.2. Timing

(1) Transmission Satellite

PTV message may be different for each satellite

(2) Transmission Interval

The transmission interval is dependent on the number of PTV users.

#### 4.1.1.3. Cyclic Redundancy Check (CRC)

The 24-bit CRC bit string is generated by the following generator polynomical g(X)

$$g(X) = X^{24} + X^{23} + X^{18} + X^{17} + X^{14} + X^{11} + X^{10} + X^{7} + X^{6} + X^{5} + X^{4} + X^{3} + X + 1$$

### 4.1.1.4. Forward Error Correction (FEC)

The bit string will be Forward Error Correction (FEC) encoded by a 1/2 rate convolutional code. 250-bps messages are encoded to 500-sps symbols. The convolutional coding will be constraint length 7, with a convolutional encoder logic arrangement as shown in Figure 4.1-2. The G1 symbol is selected on the output as the first half of a 4-millisecond data bit period and the G2 symbol is the second half.

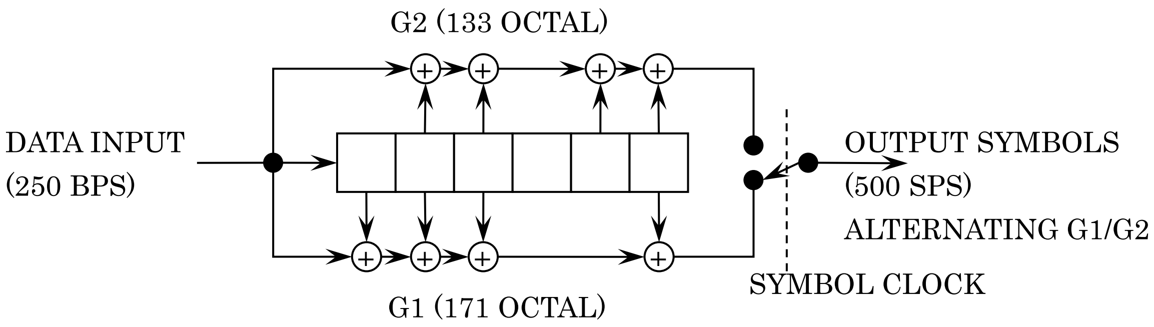


Figure 4.1-2 FEC method

### 4.1.2. Message Contents

#### 4.1.2.1. Overview

As described in Section 4.1.1.1. , each positioning technology verification message provided by the L5S signal consists of a preamble, a message type, a data field, and a CRC parity. Its message field shall be defined by the users of this service.

#### 4.1.2.2. Common Section

All message types contain the common parameters shown in Figure 4.1-3 and Table 4.1-1.

| 1 | 9 |
|---|---|
| PAB<br>8 BITS | MT<br>6 BITS |

Figure 4.1-3 Common Sections Format

Table 4.1-1 Parameter Definitions of Common Sections

| Parameter | Description | Effective Range | Number of Bits | LSB | Units |
|---|---|---|---|---|---|
| PAB | Preamble | - | 8 | - | - |
| MT | Message type | 0-63 | 6 | 1 | - |

(1) Preamble

The beginning of each message is the 8-bit preamble consists of the following three patterns repeated in sequence:

Pattern A: 01010011
Pattern B: 10011010
Pattern C: 11000110

The first bit in the "Pattern A" preamble is synchronous with the epoch of the 6-second L1C/A signal (signal for GPS and QZSS satellite positioning services) navigation message subframe "Pattern B" comes after "Pattern A". "Pattern C" comes after "Pattern B". After that, the sequence returns to "Pattern A".

FEC encoding is transformed for preambles in the same coding (See Section 4.1.1.4). Accordingly, while the preamble indicates the beginning of the message block, it cannot be used for signal acquisition prior to FEC decoding or for bit synchronization.

(2) Message type

Message type shall be defined by PTV users. However, Message type 63 shall be used as a null message.

#### 4.1.2.3. Message Type 63: Null Message

Figure 4.1-4 shows the data format and Table 4.1-2 shows its parameter definitions.

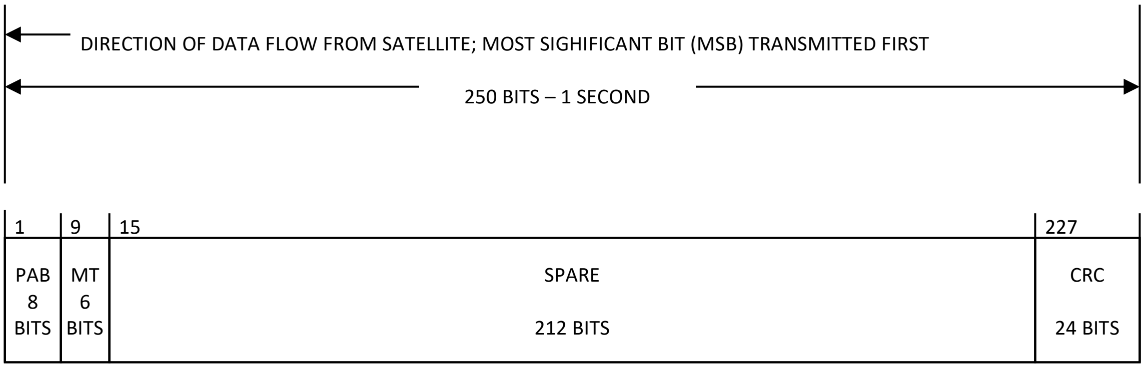


Figure 4.1-4 Message Type 63: Null Message Format

Table 4.1-2 Parameter Definitions

| Parameter | Description | Effective Range | Number of Bits | LSB | Units |
|---|---|---|---|---|---|
| - | PAB and MT (see 4.1.2.2. ) | - | - | - | - |
| Spare | Spare | - | 212 | 1 | - |
| - | CRC (see 4.1.1.3. ) | - | - | - | - |

(1) Spare

Fix to "0" for spare.