Quasi-Zenith Satellite System
Interface Specification
Satellite Positioning, Navigation and Timing Service
(IS-QZSS-PNT-005)

(October 24, 2022)

Cabinet Office

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Revision History

Rev.No.	Date	Page	Revisions
001 Draft Edition	March 25, 2016	-	Draft edition
	April 15, 2016	38	Correction of the explanation in Table 4.1.1-3 according to the IS-GPS-200
	July 12, 2016	-	Addition of Disclaimer of Liability
	January 17,2017	2,3,22,47,48,52,53,88,94,104,108 38	・Determination of the definition about the space vehicle number and the PRN Code number ・Correction of L1C/A default message in Table 3.1.1-1.
001	March 28,2017	-	First release
		43	・Correction of the explanation of Group delay between SV clock and L1C/A time.
		45	・Deletion of the explanation of the case the fit interval flag is "1".
		74	・Correction of WNop to RESERVED in Figure 4.2.2-5.
		85	・Correction of EOP Fit interval in Table 4.3.1-2
		94	・Correction of the explanatory note in Table 4.3.2-6. ・Corrects the explanation of PRN ID.
		104	・Correction of the explanatory note in Table 4.3.2-14.
		107	・Correction of Table 4.3.2-16 Parameters Defined Differently from GPS (CNAV(L2C,L5))
		108	・Correction of Table 4.3.2-17 Parameters Defined Differently from IS-QZSS-JAXA (CNAV(L2C,L5))
		111	・Correction of Table 5.4.1-2 Messages Contains Health and Alert Flags
002	January 23, 2018	52-53	・Addition of the parameter definitions of SV Configuration for LNAV.
		82	・Addition of the parameter definitions of SV Configuration for CNAV2.
		42	・Correction of the parameter for Code on L2

Rev.No.	Date	Page	Revisions
		99	・Correction of Japanese transcription in Figure 4.3.2-7.
		108	・Addition of the explanation of Almanac PRN ID.
		60	・ Modification of the validity period of Earth orientation parameter.
		88	・ Modification of the validity period of Earth orientation parameter.
003	November 5,2018	13	・Correction of the bitrate in Figure 3.1.3-6.
		18	・Modification of the minimum received power in Table 3.1.8-1.
		21	・Modification of the minimum received power in Table 3.1.15-1.
		38	・Addition of the page number and contents definitions for LNAV in Table 3.1.1-2.
		66	・Addition of the page number and contents definitions for CNAV2 in Table 4.2.2-2.
		90	・Addition of the message contents definitions for CNAV in Table 4.3.2-1.
004	January 25, 2021	1	・Update of the revision of reference documents.
		2,4,5,6,14,15,19,35,41,44,56,57,62,63,76,85,90,91,108,118,119	・Correction of misprints.
		3,6,7,8,15,16,37,39,41,50,118,119,120,125,126,130,135,138,143,144	・Change of the LNAV message name from LNAV(L1C/A) to LNAV(L1C/A, L1C/B).
		6,8,9,16,17,19,20,24,26,28,35,39,44,45,46,52,53,56,59,60,72,76,81,83,87,100,104,111,112,113,114,118,135,136	・Change in Tables, Figures and explanations with addition of the new signal “L1C/B”.
		22	・Addition of the QZSS SSV information.

Rev.No.	Date	Page	Revisions
		46	・Addition of the definition of 2MSBs of IODC.
		25	・Addition of the assignment of the PRN number of QZS1R, QZS05, QZS06, and QZS07.
		87, 113	・Addition of the differences about Earth orientation parameters from GPS.
		116	・Modification of the definition of Coordinate System.
		139	・Modification of the numerical formulas in Table 5.9.2-1.
		146	・Modification of the algorithm of Earth orientation parameters.
		75,78,95,101,104, 107,109	・Modification in Figure 4.2.2-4, 4.2.2-5, 4.3.2-2, 4.3.2-6, 4.3.2-8, 4.3.2-10 and 4.3.2-12.
005	October 24, 2022	-	・Deletion of IS-QZSS-JAXA from the reference documents.
		1,48,61,76, 73-74,79,90,98, 100,109,117,119, 134-135	・Update of the revision of the reference documents.
		8,23,30,39,43,53, 64,75,80-81,93, 98-100,102,105, 108,110-114,116, 123,133,135	・Correction of misprints.
		2,5	・Addition of the orbit definitions.
		2,5,39,43,64,71, 93,96	・Addition of the message ID for the QZNMA.
		6,8,12-13,17-18, 20-21,25,27,61, 74,78,89-90,108, 116,118-119,136, 138-139,141	・Addition of the Block III satellite specifications.
		21	・Correction of descriptions of the Block II satellite specifications.
		6,17,20,25-27	・Addition of information that Block III satellites do not broadcast the L2C signal.

Rev.No.	Date	Page	Revisions
		23-24	・Addition of the QZSS SSV information.
		27,30	・Update of the notations regarding non-standard code.
		39,64,93	・Modification of the maximum transmission interval regarding "Ionospheric(Japan area)".
		46-47,61,73-74, 76,89,98-99,118	・Addition of the Ephemeris status flag.
		131,141	・Modification of the ionosphere-free linear combinaions definition.
		141-142,144-145	・Modification of the TGD and ISC usage definition.
		148	・Clarification of Figure 5.9.3-1.

"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.

Table of Contents

1. Scope

This document describes the interface specifications of the satellite positioning, navigation and timing service (PNT) between the space segment of QZSS and the user segment. The interface specifications described herein include the signal characteristics, message specifications and user algorithms.

The content of system, service, accuracy, availability, continuity, integrity and other performance characteristics for users are described in the applicable document (1) "PS-QZSS QZSS Performance Standard."

2. Relevant Documents and Definition of Terms

2.1. Applicable Documents

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

(1) PS-QZSS QZSS Performance Standard
(2) IERS Technical Note 36 (IERS Conventions 2010)

2.2. Reference Documents

The reference documents are as follows:

(1) Global Positioning Systems Directorate Systems Engineering & Integration Interface Specification IS-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision N, approved on 6-JUN-2022

(2) Global Positioning Systems Directorate Systems Engineering & Integration Interface Specification IS-GPS-705, Navstar GPS Space Segment/User Segment L5 Interfaces, Revision J, approved on 7-JUN-2022

(3) Global Positioning Systems Directorate Systems Engineering & Integration Interface Specification IS-GPS-800, Navstar GPS Space Segment/User Segment L1C Interfaces, Revision J, approved on 6-JUN-2022

(4) Obsolete

2.3. Definition of Terms

Terms	Definitions
alert	See Section 5.4.1 If a service stops due to an error occurring in the GNSS system, an alert notifies the user that the service is not available.
almanac	See Section 4.1.2.6.2(2) Reduced-precision parameter of the satellite orbit and the SV clock
almanac reference week	See Section 4.1.2.6.3(2) Reference week number of almanac orbital information
anti-spoof	See Section 4.1.2.2(6) Protection against spoofing
carrier phase noise	Phase noise characteristics for the carrier waves of a PNT signal
code characteristics	See Section 3.1.1 Code characteristics for the spread spectrum signal of a PNT signal
code jitter	See Section 3.1.11 A PNT signal is transmitted using a spread spectrum signal. Code jitter is the time jitter of the spread spectrum code width.
ephemeris	See Section 4.1.2.4(2) The trajectory in the Earth-Centered, Earth-Fixed (ECEF) coordinates for each fit interval.
epoch	Reference time for ephemeris
GEO	Geostationary Orbits
fit interval	Available period since the ephemeris epoch.
health	See Section 5.4.1 Health condition of each PNT signal
navigation message	Message transmitted by a satellite in a PNT signal. The messages are ephemeris, almanac, SV clock and satellite health.
overlay code	See Section 3.2.3.2 Code that is overlaid on a PRN code. Also known as secondary code (L1CP, L5I and L5Q).
PRN ID	See Section 4.3.2.2(2) The number of the 6LSBs of the PRN number.
QGEO	The small inclined geosynchronous orbit with a slight eccentricity.
QZNMA	QZNMA is the message data for the Navigation Message Authentication generated by the QZSS.
QZO	The inclined geosynchronous orbit with a slight eccentricity called quasi-zenith orbit.
ranging code	See Section 3.2.3.1 Code used to calculate the pseudo range between the satellite and the user

Terms	Definitions
SIS-URE	Range error due to the orbit and clock of a satellite without errors due to propagation (ionospheric delay, tropospheric delay, etc.) and user's environment (multipass, receiver noise, etc.).
special messages	See Section 4.1.2.6.4(1) The text message in a navigation message. The message can contain information not related to positioning. This is a string composed of eight-bit ASCII characters.
SV clock	See Section 5.5.1 Clock used in a satellite
SV clock offset	Offset between the GNSS system clock and the SV clock
SV ID	Space vehicle ID. The information to identify the message of subframe 4 and 5 in LNAV(L1C/A, L1C/B).
SV number	The number of space vehicle
telemetry word	See Section 4.1.2.2 Unit of navigation message
text message	See Section 4.3.2.6(1) The text message in a navigation message. The message can contain information not related to positioning. This is a string composed of eight-bit ASCII characters.
Time-of-week	GPS time is calculated by the week number and the week time. The week time is counted from UT 0:00 on Sunday.
week changeover	The changeover is occurred at end/start of time of week at UT 0:00 on Sunday.
week number	See Section 4.1.2.3(1) GPS time is calculated by the week number and the week time. The week number is counted from January 6th, 1980.

2.4. Abbreviations

-A-

AODO	Age of Data Offset
A-S	Anti-Spoof

-B-

BOC	Binary Offset Carrier
bps	bits per second
BPSK	Binary phase-shift keying

-C-

CNAV	Civil Navigation
CPS	Chips per Second
CRC	Cyclic Redundancy Check

-D-

-E-

ECEF	Earth Center Earth Fixed
ECI	Earth Centerd Inertial
EOP	Earth Orientation Parameters
ERD	Estimated Range Deviation
EXOR	Exclusive or

-F-

FEC	Forward Error Correction

-G-

GEO	Geostationary Orbits
GGTO	time offset between GPST and GNSST
GPS	Global Positioning System
GPST	GPS Time

-H-

HMI	Hazardous Mis- leading Information
HOW	Hand Over Word

-I-

IERS	International Earth Rotation and Reference Systems Service
IODC	Issue of Data Clock
IODE	Issue of Data Ephemeris
ISC	Inter Signal Correction
ISF	Integrity Status Flag
ITOW	Interval Time of week
ITRF	International Terrestrial Reference Frame
ITRS	International Terrestrial Reference System

-J-

-K-

-L-

LDPC	Low Density Parity Check
LNAV	Legacy NAVigation
LSB	Least Significant Bit

-M-

MSB	Most Significant Bit

-N-

NH Code	Neuman-Hoffman Code
NICT	National Institute of Information and Communications Technology
NMCT	Navigation Message Correction Table
NTE	Not-To-Exceed

-O-

-P-

PLL	Phase Locked Loop
PRN	Pseudorandom Noise

-Q-

QGEO	Quasi-Geostationary Orbits
QPSK	Quadrature Phase Shift Keying
QZNMA	Quasi-Zenith Satellite Navigation Message Authentication
QZO	Quasi-Zenith Orbits
QZS	Quasi-Zenith Satellite
QZSS	Quasi-Zenith Satellite System
QZSST	QZSS Time

-R-

RF	Radio Frequency
RMS	Root Mean Square

-S-

SAS	Signal Authentication Service
sc/s	semi-circle par second
SF	Subframe
SIS	Signal-In-Space
SIS-URE	Signal-In-Space User Range Error
sps	symbols par second
SV	Space Vehicle

-T-

TAI	International Atomic Time
TGD	Timing Group Delay
TLM Word	Telemetry Word
TMBOC	Time Multiplex BOC
TOI	Time of Interval
TOW	Time of week
TTA	Time-To-Alert

-U-

URA	User Range Accuracy
USNO	United States Naval Observatory
UT1	Universal Time1
UTC	Coordinated Universal Time

-V-

-W-

-X-

xor	exclusive or

-Y-

-Z-

3. Signal Specifications

3.1. RF Characteristics

3.1.1. Signal Structure

The signal structure, PRN code characteristics and message characteristics are as shown in Table 3.1.1-1, Table 3.1.1-2 and Table 3.1.1-3.

Table 3.1.1-1 Signal Structure

Frequency band	Signal name	Modulation method	PRN code name	Overlay code name	Message name
L1	L1C/A (*1)	BPSK	C/A	-	LNAV(L1C/A, L1C/B)
	L1C/B (*1)	BOC (Block IIA and III) (*2)			
	L1C	BOC (Block I) TMBOC (Block II and III)	L1CP	L1CO	-
		BOC	L1CD	-	CNAV2(L1C)
L2	L2C	BPSK(Block I and II) (*3)	L2CL	-	-
			L2CM	-	CNAV(L2C)
L5	L5	QPSK	I5	Neuman -Hoffman	CNAV(L5)
			Q5	Neuman -Hoffman	-

*1: L1C/A can be switched to L1C/B for Block IIA and III satellite. Current status on which of L1C/A or L1C/B signal is transmitted is found in LNAV SV health shown in Section 4.1.2.3(4) as well as described on the following QZSS website.

https://sys.qzss.go.jp/dod/en/constellation.html

*2: Definition of Block IIA is given in Section 3.2.1.

*3: Two signals are time-division multiplexed into one channel for each chip.

Table 3.1.1-2 PRN Code Characteristics

PRN code name	Chip rate	Length	Period	Overlay Code
C/A	1.023 Mcps	1023 chips	1 ms	-
L1CP	1.023 Mcps	10230 chips	10 ms	L1CO Length: 1800 bits Period: 18 s
L1CD	1.023 Mcps	10230 chips	10 ms	-
L2CL	0.5115 Mcps	767250 chips	1.5 s	-
L2CM	0.5115 Mcps	10230 chips	20 ms	-
I5	10.23 Mcps	10230 chips	1 ms	Neuman-Hoffman Length: 10 bits Period: 10 ms
Q5	10.23 Mcps	10230 chips	1 ms	Neuman-Hoffman Length: 20 bits Period: 20 ms

Table 3.1.1-3 Message Characteristics

Message Name	Bit Rate	Symbol Rate	Period (Minimum Frame)	Encoding method
LNAV(L1C/A, L1C/B)	50 bps	-	6 s	Hamming Code
CNAV2(L1C)	Approx. 50 bps	100 sps	18 s	CRC BCH, LDPC Interleave
CNAV(L2C)	25 bps	50 sps	12 s	CRC Convolutional code
CNAV(L5)	50 bps	100 sps	6 s	CRC Convolutional code

3.1.2. Frequency

The frequency band, nominal carrier frequency and occupied bandwidth are as shown in Table 3.1.2-1.

However, the nominal 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 effects. For this reason, the carrier frequency in the satellite orbit differs in a precise sense. For example, the L1 band signal is offset by -0.8506 Hz (nominal).

Table 3.1.2-1 Carrier Frequency and Occupied Bandwidth

Frequency band	Nominal carrier frequency	Block I	Block II	Block III
L1 band	1575.42 MHz (=154 × f_0)	24.0 MHz (±12.0 MHz)	30.69 MHz (±15.345 MHz)	30.69 MHz (±15.345 MHz)
L2 band	1227.60 MHz (=120 × f_0)	24.0 MHz (±12.0 MHz)	30.69 MHz (±15.345 MHz)	-
L5 band	1176.45 MHz (=115 × f_0)	24.9 MHz (±12.45 MHz)	24.0 MHz (±12.00 MHz)	24.0 MHz (±12.00 MHz)

3.1.3. Modulation Methods

3.1.3.1. L1C/A and L1C/B

(1) L1C/A

L1C/A signals are modulated by BPSK. The modulation method is shown in Figure 3.1.3-1(a).

LNAV(L1C/A, L1C/B) messages and C/A PRN codes are modulated by exclusive-or (modulo-2 addition) and then multiplied with the L1 carrier waves and BPSK modulated.

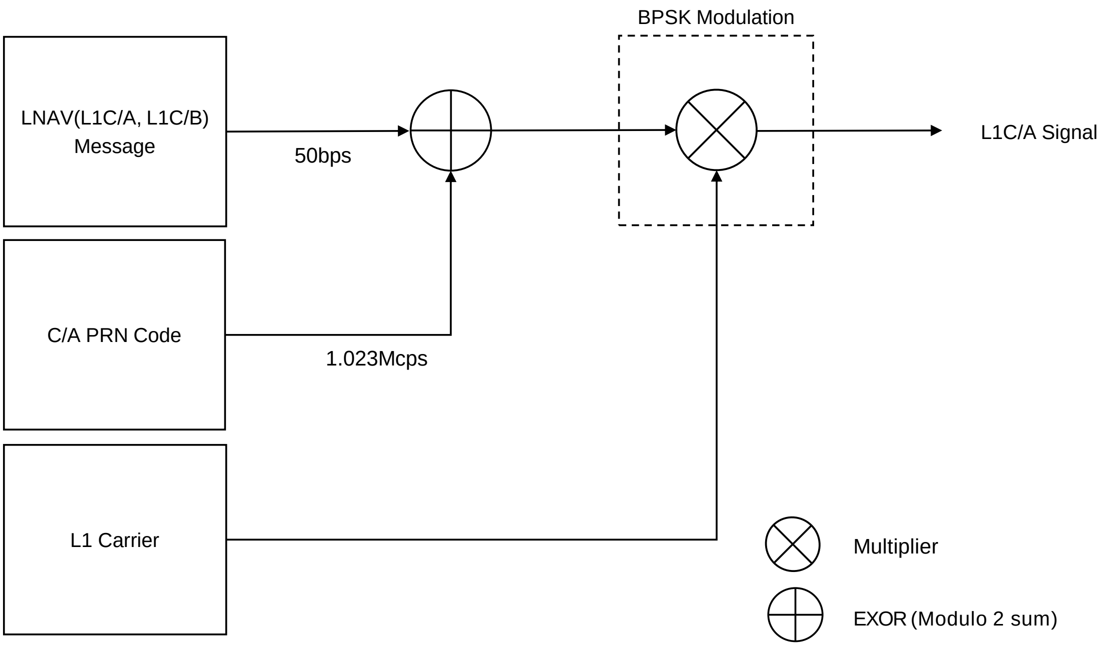


Figure 3.1.3-1(a) L1C/A Modulation

(b) L1C/B

L1C/B signals are modulated by Binary Offset Carrier (BOC) modulation technique. The modulation method is shown in Figure 3.1.3-1(b).

LNAV(L1C/A, L1C/B) messages, C/A PRN codes, and BOC sub-carrier waves are modulated by exclusive-or (modulo-2 addition) and then multiplied with the L1 carrier waves and BPSK modulated. Here, the BOC sub-carrier wave is a 1.023 MHz square wave of "1010...", beginning with a logical value of 1.

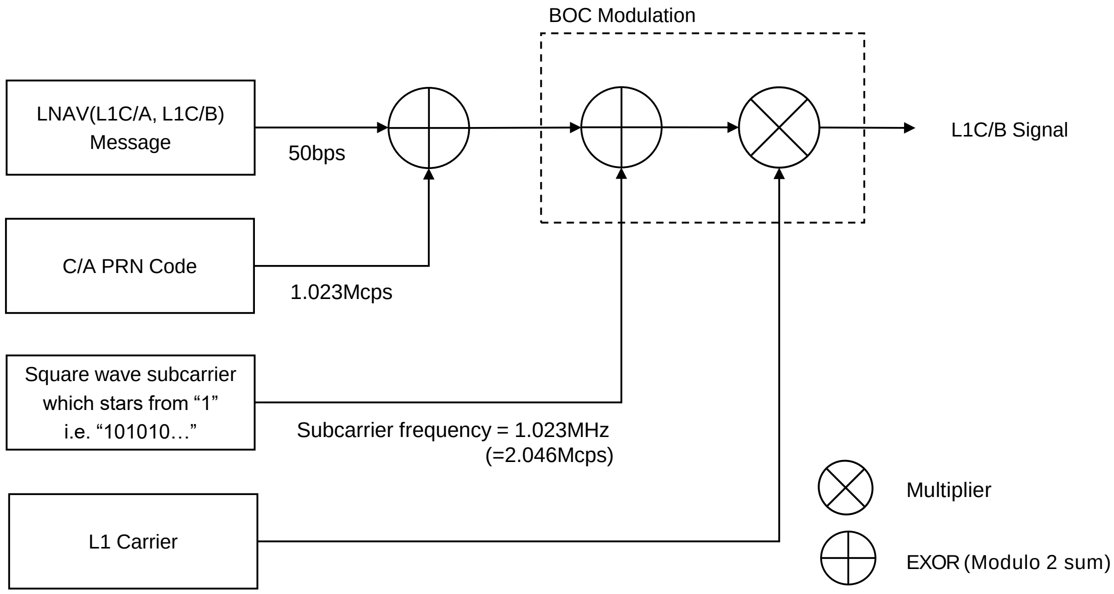


Figure 3.1.3-1(b) L1C/B Modulation

3.1.3.2. L1C

(1) L1CD

L1CD signal containing navigation messages is modulated on the L1 RF carrier using a Binary Offset Carrier (BOC) modulation technique. The modulation methods are shown in Figure 3.1.3-2.

L1CD signals are generated by subjecting coded L1C navigation messages, L1CD PRN codes and BOC sub-carriers to an exclusive-or operation (modulo-2 addition) and then multiplying them by L1 carrier waves. Here, the BOC sub-carrier wave is modulated by a 1.023MHz square wave of "1010...", beginning with a logical value of 1.

Like L1CD, the signals modulated by BOC at a sub-carrier wave of 1.023 MHz and a PRN code chipping rate of 1.023 Mcps are referred to as BOC (1,1).

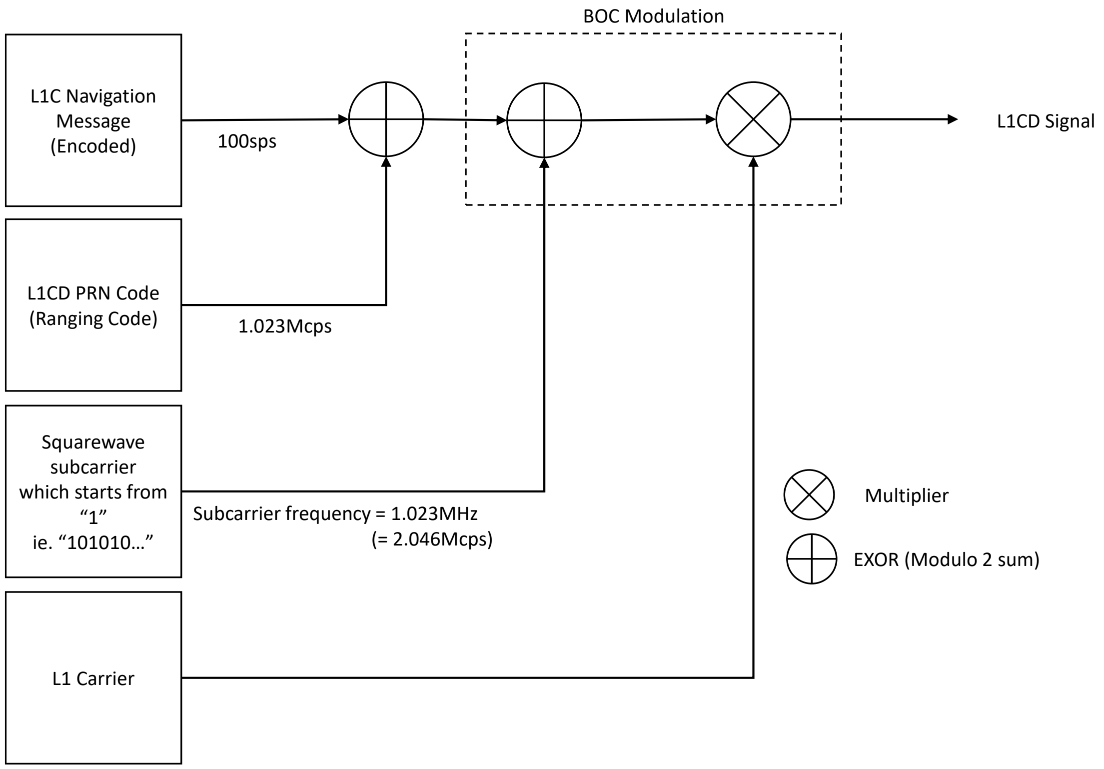


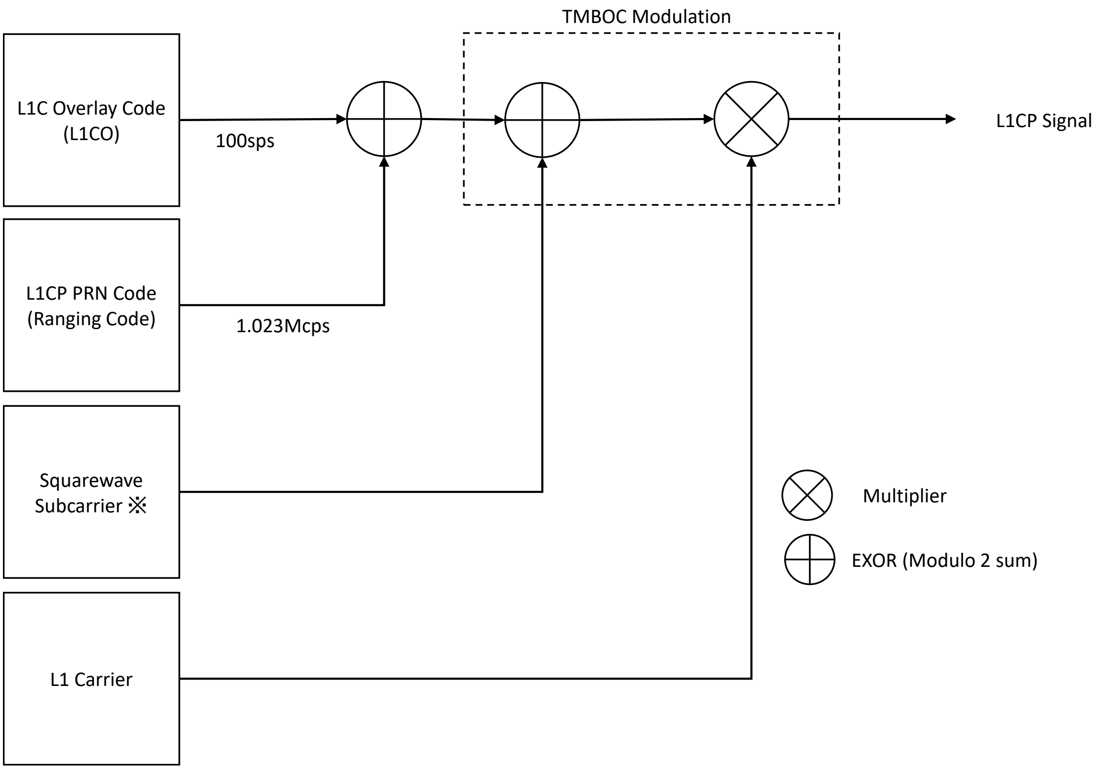
Figure 3.1.3-2 L1CD Modulation

(2) L1CP

L1CP signal (Block I) is modulated on the L1 RF carrier using a BOC, and L1CP signal (Block II and III) is modulated on the L1 RF carrier using a Time Multiplex BOC (TMBOC) modulation technique.

The modulation methods are shown in Figure 3.1.3-3.

L1CP signals are generated by modulating L1CD PRN codes and L1C overlay codes by exclusive-or, and then modulating them with TMBOC sub-carrier waves and L1 carrier waves.



*: The modulation method differs between BOC and TMBOC. For details, refer to the text.

Figure 3.1.3-3 L1CP Modulation

Here, TMBOC technique uses a mixture BOC (1,1) spreading symbols and BOC (6,1) spreading symbols, where each BOC (6,1) spreading symbol consists of 6 cycles of a "6 x 1.023 MHz" squarewave, defined as binary 10101010101010 (1=binary bit value), with total duration 1/1.023 ms.

For L1CP signals with 10230 chips, which is equivalent to 1 bit (10 ms) of overlay code L1CO, as shown in Figure 3.1.3-4, the 0th, 4th, 6th, and 29th chips of every 33 chips (the serial number: 0, 4, 6, 29, 33, 37, 39, 62, …, 10197, 10201, 10203, 10226 in the case of 0 to 10229) are modulated by BOC (6,1), and the other chips are modulated by BOC (1,1).

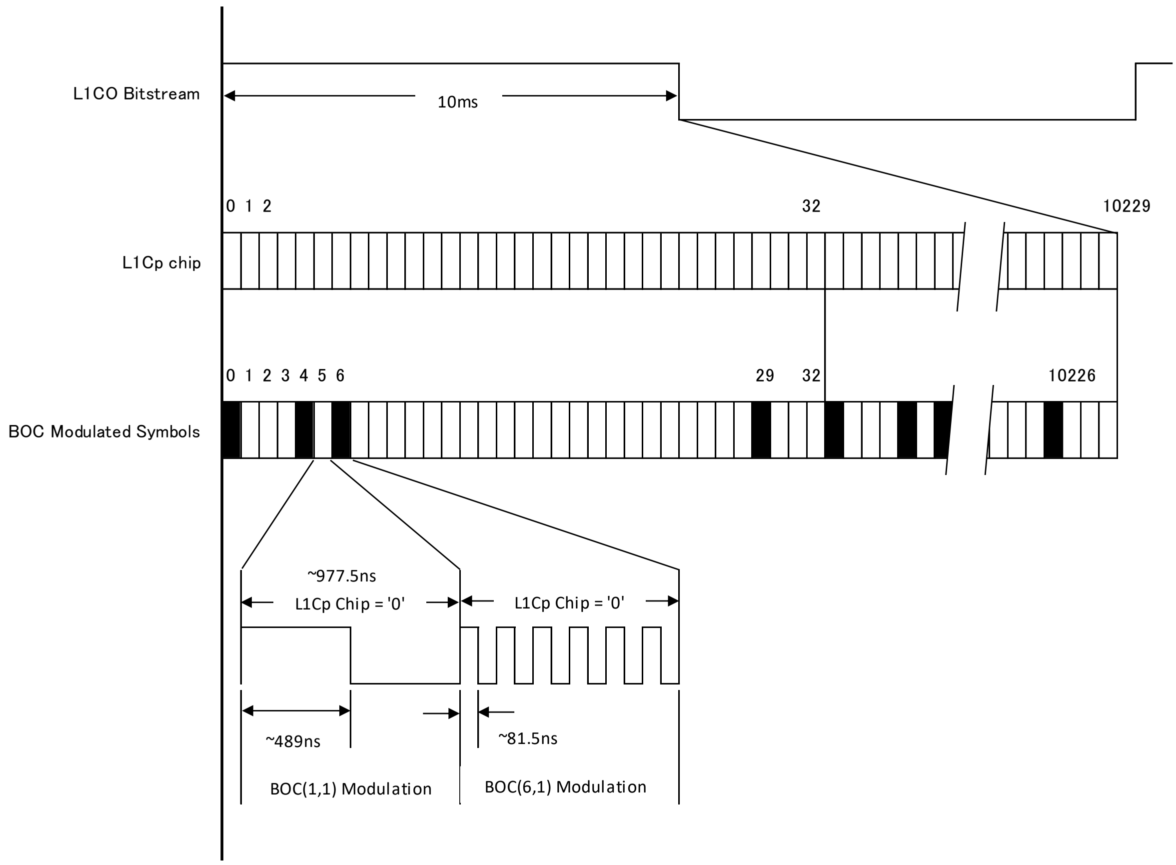


Figure 3.1.3-4 TMBOC Modulation of L1CP (Block II and III)

3.1.3.3. L2C

L2CM (include L2C navigation messages) and L2CL are time-division multiplexed with each chip and then BPSK modulated to obtain the L2C signal. The modulation method is shown in Figure 3.1.3-5.

L2C navigation messages with a data rate of 25 bps are convolutional coded at a coding rate of 1/2 into the messages with a data rate of 50 sps, which are then modulated by exclusive-or with L2CM signals at 511.5 kcps. L2CM and L2CL codes are alternately switched and time-division multiplexed at a frequency of 1.023 MHz.

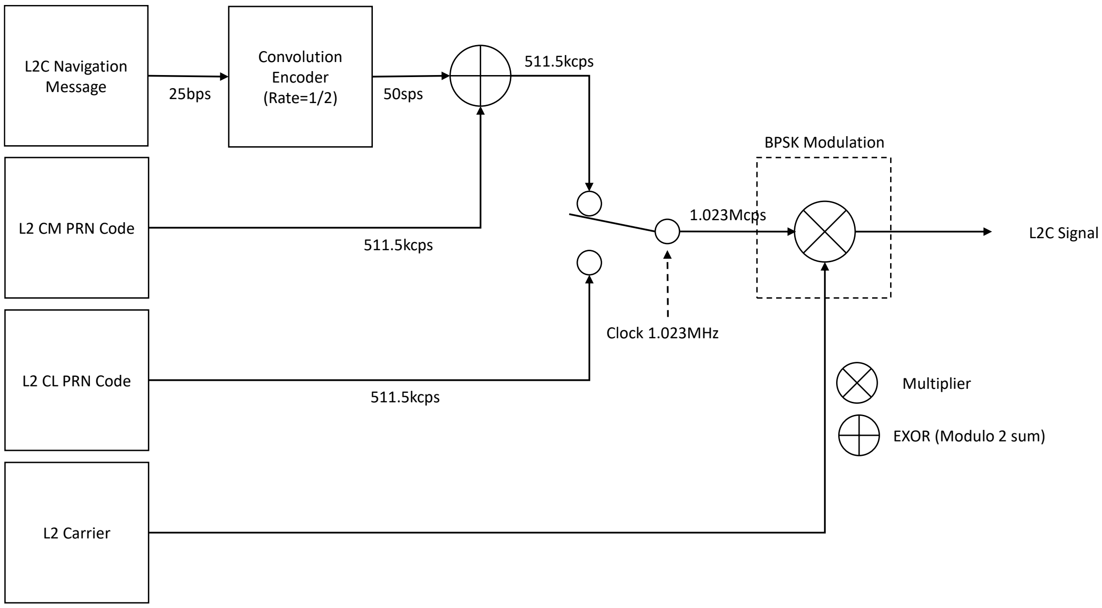


Figure 3.1.3-5 L2C Modulation

3.1.3.4. L5

L5I (include L5 navigation messages) and L5Q are modulated by QPSK. The modulation method is shown in Figure 3.1.3-6.

L5 navigation messages with a data rate of 50 bps are convolutional coded at a coding rate of 1/2 into the messages with a data rate of 100 sps, which are then modulated by exclusive-or with I5 PRN code and 10-bit Neuman-Hoffman code. On the other hand, Q5 PRN code is modulated by exclusive-or with 20-bit Neuman-Hoffman code at 100 bps. I5 and Q5 are modulated by QPSK so that Q5 lags behind I5 by 90°.

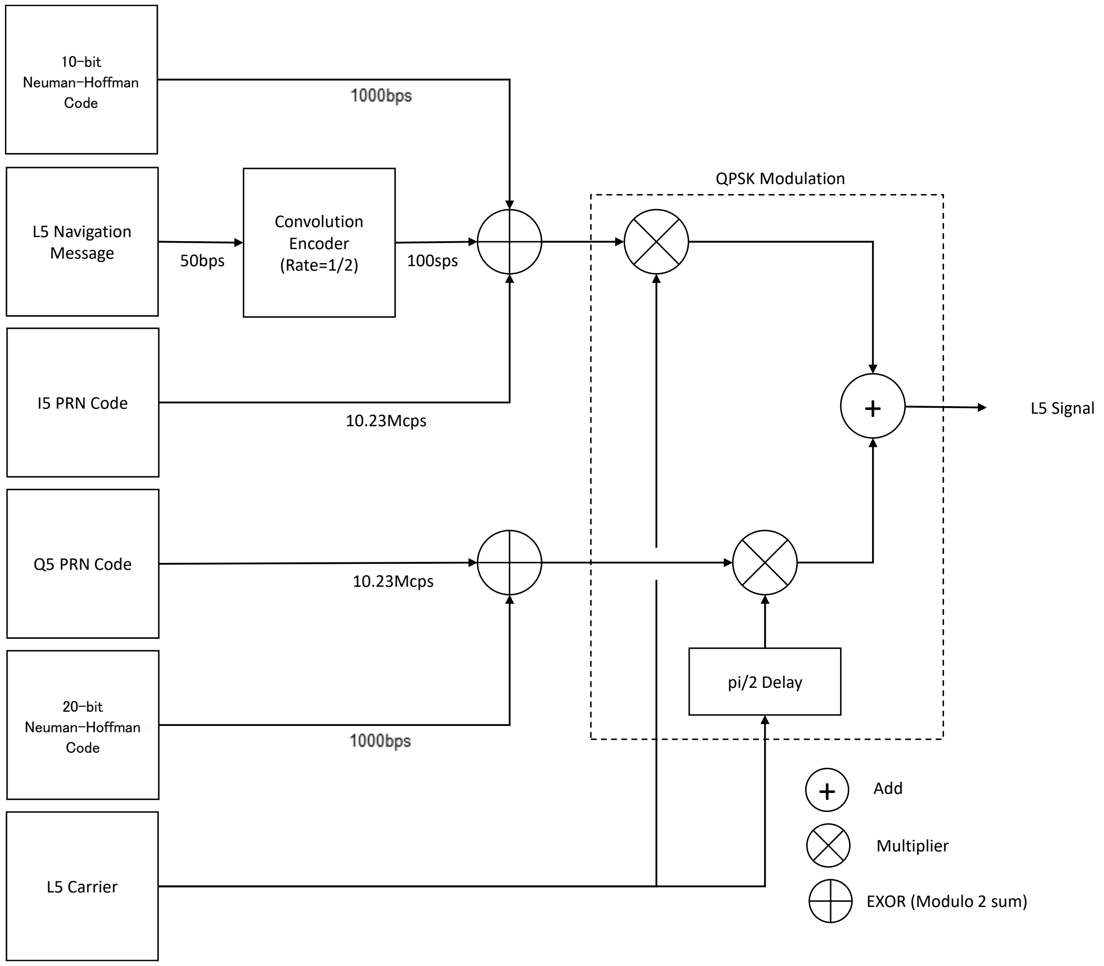


Figure 3.1.3-6 L5 Modulation

3.1.3.5. Signal Timing

As shown in Figure 3.1.3-7 and Figure 3.1.3-8, the leading end of all the PRN codes, navigation messages, and overlay codes are synchronized at the end/start of every week.

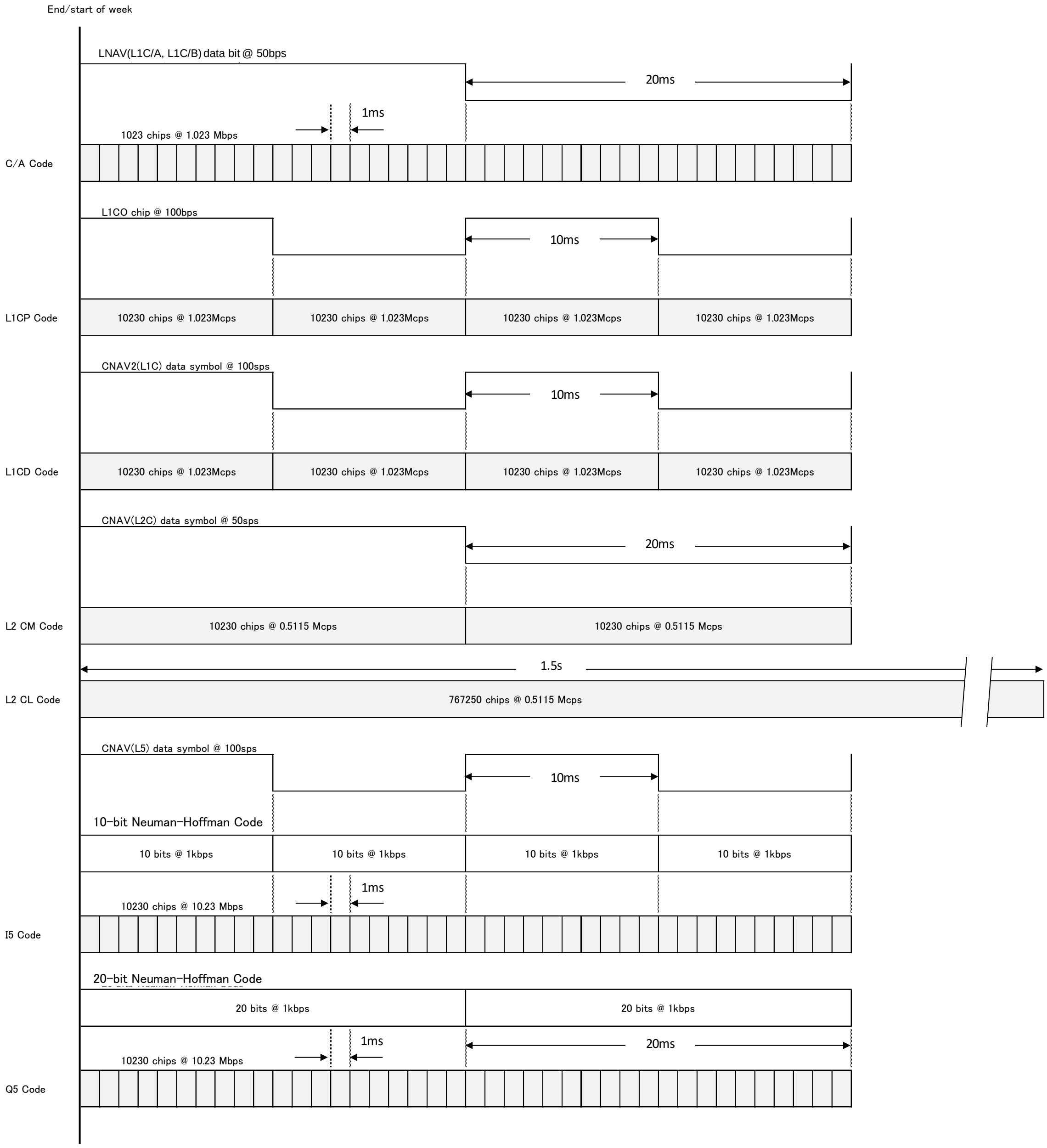


Figure 3.1.3-7 PRN Code and Navigation Message Data Bit Timing

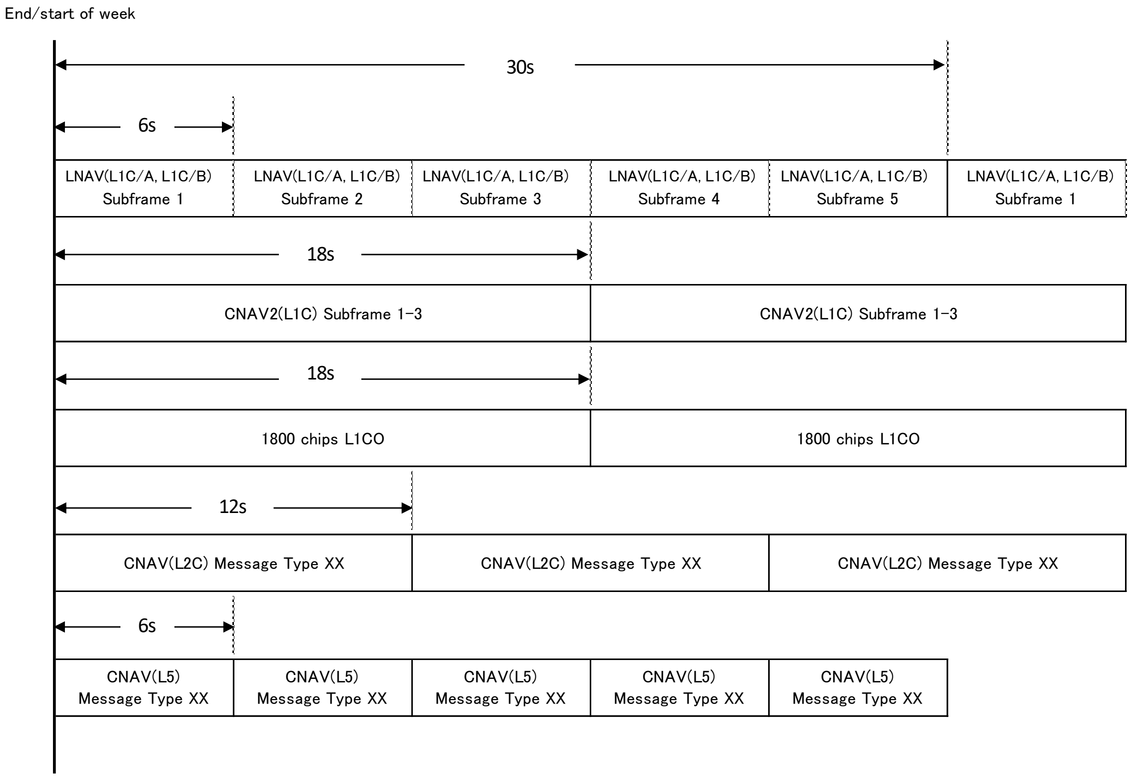


Figure 3.1.3-8 Navigation Message Timing

3.1.4. Correlation Loss

The correlation loss is defined as the difference between the signal power received in the bandwidth defined in 3.1.2. (excluding signal combining loss) and the signal power recovered in an ideal correlation receiver of the same bandwidth using an exact replica of the waveform within an ideal sharp-cutoff filter bandwidth, whose bandwidth corresponds to that specified in 3.1.2. and whose phase is linear over that bandwidth.

The total allowable correlation loss due to SV modulation and filtering imperfections, which is a function of signal, shall be as follows:

- Block I: 0.6 dB or less
- Block II and III:
  - L1C/A: 0.3 dB or less
  - L1C/B: 0.3 dB or less (*1)
  - L1C: 0.2 dB or less
  - L2C: 0.3 dB or less (*2)
  - L5: 0.6 dB or less

*1: Transmitted from Block IIA and III satellite.

*2: Not transmitted from Block III satellite.

3.1.5. Carrier Phase Noise

The phase noise spectral density of the unmodulated carrier shall be such that a phase locked loop (PLL) of 10 Hz one-sided noise bandwidth shall be able to track the carrier to the following values:

- Block I: 0.1 rad (RMS)
- Block II and III: 0.035 rad (RMS)

3.1.6. Spurious

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

- Block I: -40 dB or less
- Block II and III: -40 dB or less

3.1.7. Phase Relationship within Signals

3.1.7.1. L1

For L1 signals, the phase relationships between L1CD, L1CP, and L1C/A (or L1C/B) are shown in Table 3.1.7-1 and Figure 3.1.7-1:

Table 3.1.7-1 Phase relationships

	Carrier wave	Phase lag	accuracy
Block I	L1CD and L1C/A	same phase	± 5°
	L1CP and L1C/A	90° phase lag	± 5°
	L1CP and L1CD	90° phase lag	± 5°
Block II and III	L1CD and L1C/A (or L1C/B)	90° phase lag	± 5°
	L1CP and L1C/A (or L1C/B)	90° phase lag	± 5°
	L1CP and L1CD	same phase	± 5°

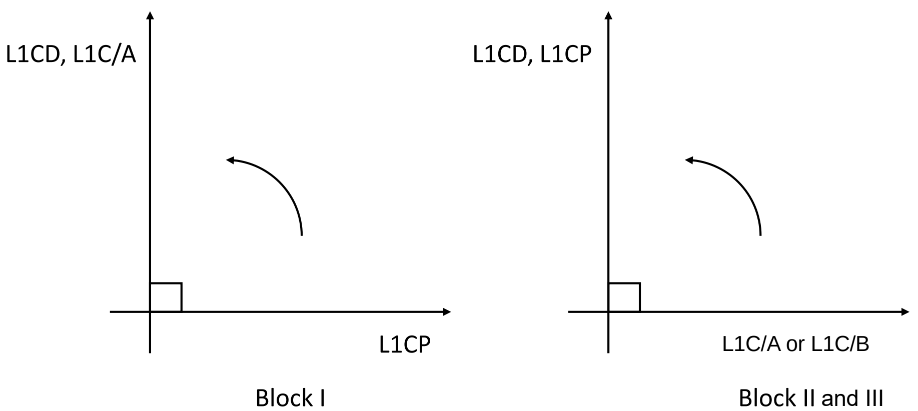


Figure 3.1.7-1 Phase Relationship of L1

3.1.7.2. L2

L2 signals have no phase relationships because they are modulated by BPSK.

3.1.7.3. L5

I5 leads Q5 by 90°. The accuracy is ± 5°.

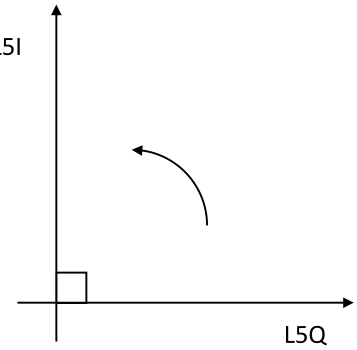


Figure 3.1.7-2 Phase Relationship of L5

3.1.8. Minimum Received Power

The minimum received power is measured at a ground-based isotropic antenna with a gain of 0dBi for circularly polarized wave reception, when PNT signals are received from a satellite with an elevation angle of 10 degrees or more. The power is shown in Table 3.1.8-1.

Table 3.1.8-1 Minimum Received Power

Signal Name	Block I	Block II and III
L1C/A	-158.5 dBW	SV ID =7: -164.0 dBW Other SV IDs: -158.5 dBW
L1C/B	-	-158.5 dBW (for Block IIA-Q and III) (*1)
L1C	L1CD: -163.0 dBW L1CP: -158.25 dBW	SV ID =7: L1CD: -167.2 dBW L1CP: -162.4 dBW OtherSV IDs: L1CD: -163.0 dBW L1CP: -158.25 dBW
L2C	-160.0 dBW (Sum of L2CL and L2CM)	-158.5 dBW (Sum of L2CL and L2CM)(*2)
L5	I5: -157.9 dBW Q5: -157.9 dBW	I5: -157.0 dBW Q5: -157.0 dBW

*1: Definition of Block IIA-Q and III is given in Section 3.2.1.
*2: Not transmitted from Block III satellite.

3.1.9. Polarization Characteristics

All PNT signals are right-hand circularly polarized.

At the carrier 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 3.1.9-1.

Table 3.1.9-1 Axial Ratio of the Ellipse of the Circularly Polarized Wave

Frequency Band	Block I	Block II	Block III
L1 band	1.0 dB or less	1.0 dB or less	1.0 dB or less
L2 band	2.0 dB or less	2.0 dB or less	-
L5 band	2.0 dB or less	2.0 dB or less	2.0 dB or less

3.1.10. Group Delay Property

3.1.10.1. Group Delay between Signals

At the antenna phase center of a satellite, the absolute values of the group delay (PRN code phase difference) between the L1 signal and L2 signal, and between the L1 signal and L5 (I5 or Q5) signal are shown in Table 3.1.10-1.

Table 3.1.10-1 Group Delay between Signals

Signal Name	Block I	Block II	Block III
L1-L2	25 ns or less	25 ns or less	-
L1-L5	20 ns or less	20 ns or less	20 ns or less

The variations within any day are shown in Table 3.1.10-2.

Table 3.1.10-2 Variations of Group Delay between Signals

Block I	Block II and III
2 ns or less (3σ)	0.6 ns or less (95%)

3.1.10.2. Group Delay between Signals of Same Frequency

At the antenna phase center of a satellite, the absolute values of group delay between any pair of L1C/A (or L1C/B), L1CD, and L1CP, and between I5 and Q5, are shown in Table 3.1.10-3.

Table 3.1.10-3 Absolute Value of Group Delay between Signals of Same Frequency

Block I	Block II and III
Not specified	10 ns or less

The variations within any day are shown in Table 3.1.10-4.

Table 3.1.10-4 Variations of the Group Delay between Signals of Same Frequency

Block I	Block II and III
Not specified	1.0 ns or less (95%)

3.1.11. PRN Code Jitter

The code jitter is the time jitter of the spread spectrum code width.

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

At the antenna output end of a satellite, the variation of the difference between the carrier wave phase and PRN code phase shall be as follows:

1.2 ns or less

3.1.13. Antenna Phase Center Characteristics

In an off-Nadir angle range of 0 to 9 degrees, the phase variation of the antenna phase center at L1, L2 and L5 frequency signals shall be as follows:

within ±18°.

3.1.14. Characteristics for Space Service Volume Users

3.1.14.1. Minimum Signal Strength

For Space service volume (SSV) users, the information about the minimum received signal power obtained by a space user at GEO and the off-boresight angle of L1, L2 and L5 frequency signals are shown in Table 3.1.14-1. Each minimum received signal power is calculated based on transmission antenna EIRPs and radiation patterns measured on the ground. A free-space path loss (FSPL) is obtained from the distance between the apogee of each QZSS and the point at the intersection of GEO orbit with the edge of the simple conic RF pattern, whose cone half angle is defined as the reference off-boresight angle.

Table 3.1.14-1 QZSS SSV information

Parameters		Value	
Satellite	Signals	Minimum received signal power at GEO (*2)	Reference off-boresight angle
QZS-1 (*1)	L1C/A	-185.3 dBW	22 deg
	L1C	-188.3 dBW	22 deg
	L2C	-188.7 dBW	24 deg
	L5	-180.7 dBW	24 deg
QZS-2	L1C/A	-184.1 dBW	22 deg
	L1C(L1CD)	-187.3 dBW	22 deg
	L1C(L1CP)	-182.5 dBW	22 deg
	L2C	-181.8 dBW	23 deg
	L5	-177.4 dBW	25 deg
QZS-3	L1C/A	-184.4 dBW	19 deg
	L1C(L1CD)	-187.6 dBW	19 deg
	L1C(L1CP)	-182.8 dBW	19 deg
	L2C	-180.2 dBW	25 deg
	L5	-180.6 dBW	22 deg
QZS-4	L1C/A or L1C/B	-184.3 dBW	22 deg
	L1C(L1CD)	-187.5 dBW	22 deg
	L1C(L1CP)	-182.7 dBW	22 deg
	L2C	-182.0 dBW	23 deg
	L5	-177.8 dBW	25 deg
QZS-1R	L1C/A or L1C/B	-181.7 dBW	18 deg
	L1C(L1CD)	-184.9 dBW	18 deg
	L1C(L1CP)	-180.1 dBW	18 deg
	L2C	-183.0 dBW	22 deg
	L5	-181.9 dBW	22 deg

Parameters		Value	
QZS-5	L1C/A or L1C/B	TBD	TBD
	L1C(L1CD)	TBD	TBD
	L1C(L1CP)	TBD	TBD
	L5	TBD	TBD
QZS-6	L1C/A or L1C/B	TBD	TBD
	L1C(L1CD)	TBD	TBD
	L1C(L1CP)	TBD	TBD
	L5	TBD	TBD
QZS-7	L1C/A or L1C/B	TBD	TBD
	L1C(L1CD)	TBD	TBD
	L1C(L1CP)	TBD	TBD
	L5	TBD	TBD

*1: Reference: The Interoperable Global Navigation Satellite Systems Space Service Volume, UNITED NATIONS, Vienna, 2018

*2: Assuming a 0 dBi user antenna.

3.1.14.2. Group Delay

TBD

3.1.15. (Reference) Comparison of RF Characteristics between GPS and QZSS

The comparison of the RF characteristics between GPS and QZSS is shown in Table 3.1.15-1.

Table 3.1.15-1 Comparison of RF Characteristics between GPS and QZSS

No.	Item	GPS (Reference document (1),(2),(3))	QZSS
1	Correlation loss	■ L1C/A, L2C IIR, IIRM, IIF: 0.6 dB III, IIIF: 0.3 dB ■ L1C 0.2 dB ■ L5 0.6 dB	■ L1C/A, L2C Block I: 0.6 dB Block II and III: 0.3dB(*1) ■ L1C/B Block IIA and III: 0.3dB ■ L1C Block I: 0.6 dB Block II and III: 0.2dB ■ L5 0.6 dB
2	Carrier phase noise	■ L1C/A, L2C, L5 0.1 rad (RMS) ■ L1C 0.035 rad (RMS)	■ L1C/A,L1C,L2C,L5 Block I: 0.1 rad (RMS) Block II and III: 0.035 rad (RMS)(*1) ■ L1C/B Block IIA and III: 0.035 rad (RMS)
3	Spurious	-40 dBc	-40 dBc
4	Phase relationship	±100 mrad (5.73 deg)	±5 deg
5	Minimum received power	■ L1C/A -158.5 dBW ■ L1CD/L1CP -163.0/-158.25 dBW ■ L2C IIRM, IIF: -160.0 dBW III, IIIF: -158.5 dBW ■ L5I/L5Q IIF: -157.9/-157.9 dBW III, IIIF: -157.0/-157.0 dBW	■ L1C/A -164.0 dBW(SVID = 7) -158.5 dBW(Other SVIDs) ■ L1C/B Block IIA and III:-158.5 dBW ■ L1CD/L1CP -167.2/-162.4 dBW (SVID = 7) -163.0/-158.25 dBW (Other SVIDs) ■ L2C Block I: -160.0 dBW Block II: -158.5 dBW ■ L5I/L5Q Block I: -157.9/-157.9 dBW Block II and III: -157.0/-157.0 dBW
6	Polarization characteristics	■ L1 1.8 dB ■ L2 2.2 dB ■ L5 2.4 dB	■ L1 1.0 dB ■ L2, L5 2.0 dB(*1)
7	Absolute group delay between signals of different frequencies	L1-L2: 15.0 ns L1-L5: 30.0 ns	L1-L2: 25 ns(*1) L1-L5: 20 ns
8	Variation of group delay between signals of different frequencies	3.0 ns (95%)	Block I: 2.0 ns(3σ) Block II and III: 0.6 ns (95%)
9	Absolute group delay between signals of same frequency	10 ns	Block I: Not specified Block II and III: 10 ns
10	Variation of group delay between signals of same frequency	1.0 ns (95%)	Block I: Not specified Block II and III: 1.0 ns (95%)

No.	Item	GPS (Reference document (1),(2),(3))	QZSS
11	PRN code jitter	Not specified	2.0 ns (3σ)
12	Code carrier coherence	Not specified	1.2 ns
13	Antenna phase center characteristics	Not specified	±18°

*1: Not transmitted L2 band signal from Block III satellite.

3.2. PRN Codes

3.2.1. PRN Number Assignment

The assignment of the PRN numbers by satellite categories are shown in Table 3.2.1-1.

Table 3.2.1-1 Assignment of the PRN Numbers by Satellite Categories

PRN number		Satellite category	Block Assignment	SV Number	SV ID (*2)	Remarks
L1C/A L1C L2C L5	L1C/B					
193	-	QZO	Block I-Q	1	1	QZS01
194	-	QZO	Block II-Q	2	2	QZS02
195	-	QZO	Block II-Q	4	3	QZS04
196	203(*4)	QZO	Block IIA-Q (*3)	5	4	QZS1R
197(*5)	204(*4)	QZO	Block III-Q	6	5	QZS05
198		-	-	-	-	Used as a non-standard code (*1)
199	-	GEO	Block II-G	3	7	QZS03
200(*5)	205(*4)	GEO	Block III-G	7	8	QZS06
201(*5)	206(*4)	QGEO	Block III-G	8	9	QZS07
202		-	-	-	-	Used as a non-standard code (*1)

*1: There is a possibility that the code is used by users in the future.

*2: The information to identify PRN number about QZS almanac in the message of subframe 4 and 5 in LNAV(L1C/A, L1C/B) . For details, see Section 4.1.2.7.

*3: The Block of PRN number 196 is assigned “IIA” or “IIA-Q” in order to distinguish it from other Block II satellites. In this IS-QZSS-PNT, Block II basically includes Block IIA unless otherwise indicated.

*4: L1C/A and L1C/B signals are exclusively transmitted.

*5: Not transmitted L2C signal from Block III satellite.

3.2.2. C/A Codes

The C/A PRN code which is used by both the L1C/A and L1C/B signals has 1ms in length at a chipping rate of 1.023 Mbps, for total length of 1023 chips. The PRN codes are generated as shown in Figure 3.2.2-1, Figure 3.2.2-2, and Figure 3.2.2-3. The PRN code sequence is identified by “G2 Delay” and “Initial G2 Setting” in Table 3.2.2-1.

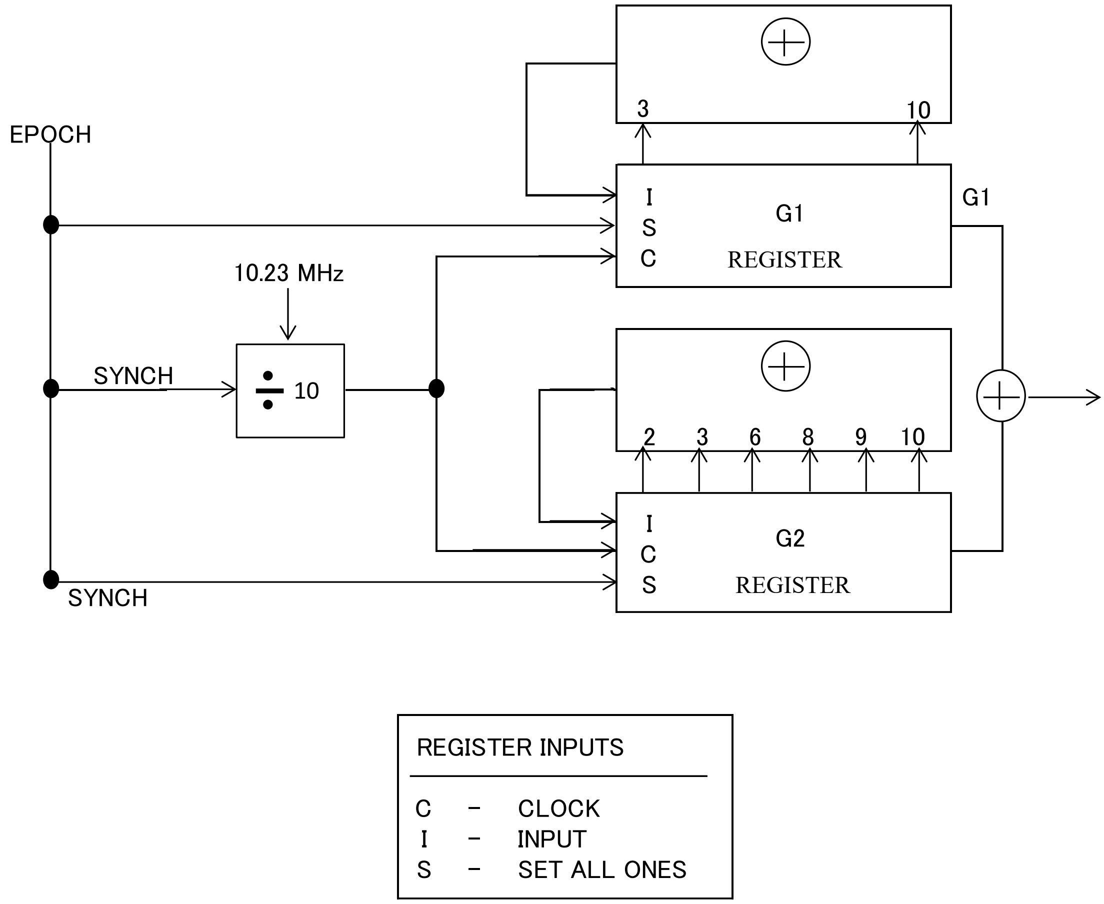


Figure 3.2.2-1 C/A PRN Code Generator

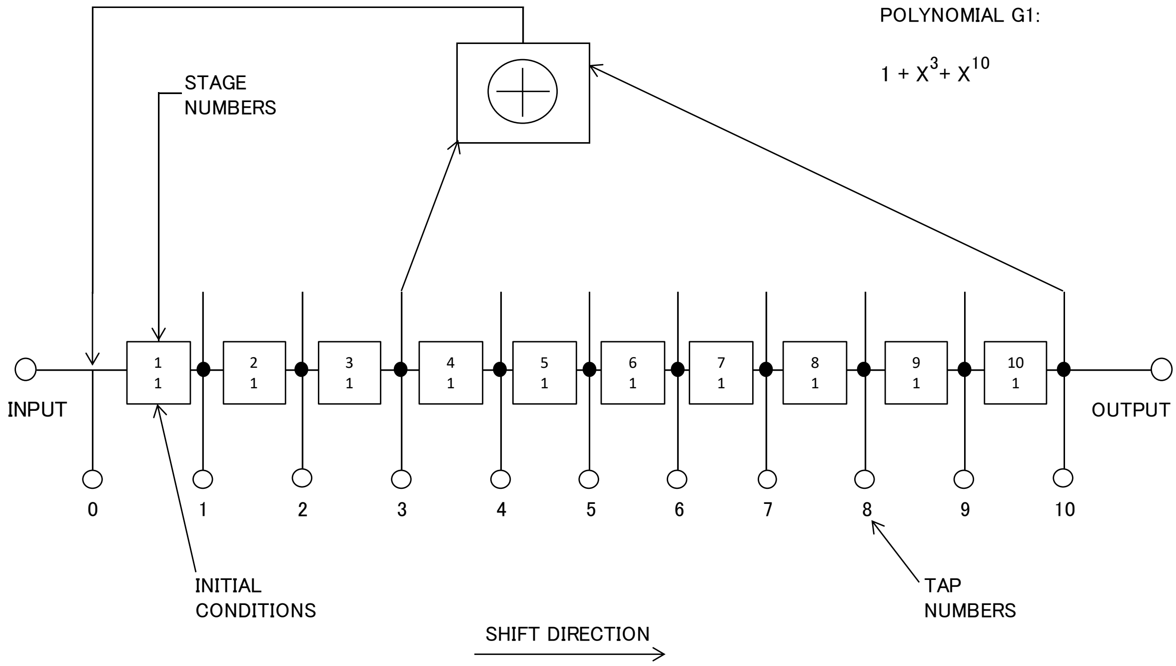


Figure 3.2.2-2 G1 Shift Register

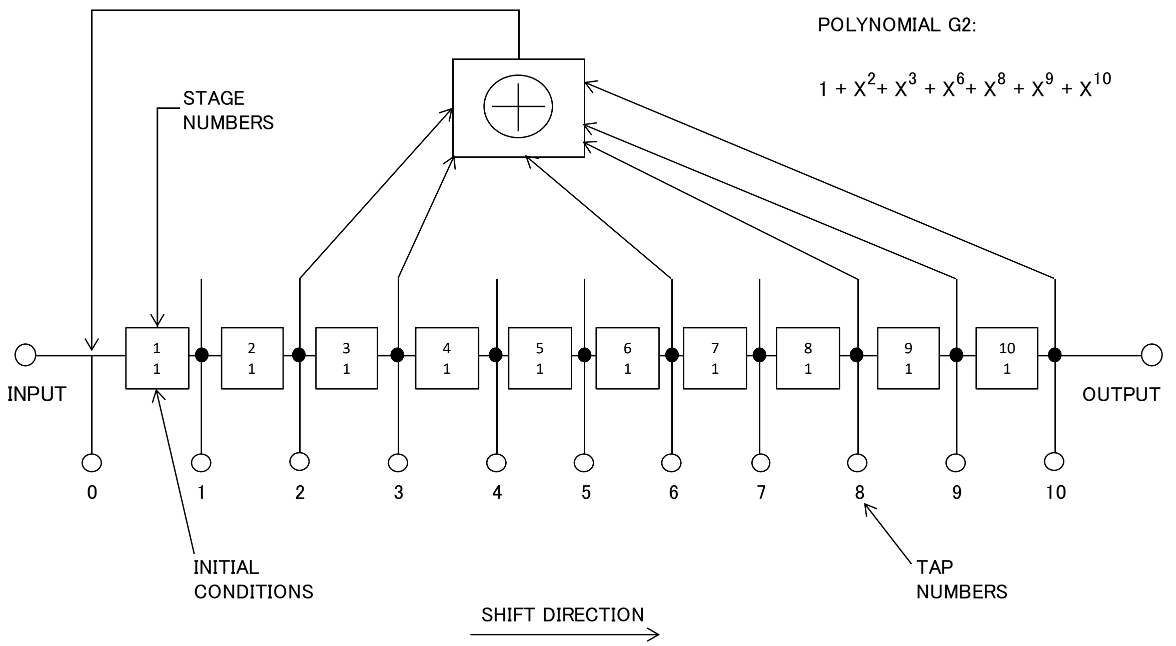


Figure 3.2.2-3 G2 Shift Register

Table 3.2.2-1 C/A PRN Code Phase Assignments

PRN Number	G2 Delay (Chips)	Initial G2 Setting (Octal)	First 10 chips (Octal)	Remarks
193	339	1050	0727	L1C/A
194	208	1607	0170	L1C/A
195	711	1747	0030	L1C/A
196	189	1305	0472	L1C/A
197	263	0540	1237	L1C/A
198	537	1363	0414	(non-standard code)
199	663	0727	1050	L1C/A
200	942	0147	1630	L1C/A
201	173	1206	0571	L1C/A
202	900	1045	0732	(non-standard code)
203	30	0476	1301	L1C/B
204	500	0604	1173	L1C/B
205	935	1757	0020	L1C/B
206	556	1330	0447	L1C/B

3.2.3. L1C Codes

The ranging codes of L1CD and L1CP have 10ms in length at a chipping rate of 1.023 Mbps, for total length of 10230 chips. L1CP has also an overlay code with 18s in length at a rate of 100 bps, for total length of 1800 bits in addition to the ranging code.

3.2.3.1. Ranging Code

The ranging code is the code used to calculate the pseudo range between the satellite and the user. Both L1CP and L1CD are constructed using the same method. Each ranging code is the Weil code of 10230 chips to be generated with the Weil index and the insertion index corresponding to the PRN code from the Legendre sequence of 10223 chips and a 7-bit expansion sequence as shown in Figure 3.2.3-1.

The Weil index and the insertion index corresponding to each PRN number are as shown in Table 3.2.3-1.

The Legendre sequence with 10223 chips, L(t), for t=0,…,10222, is defined as follows:

- L(0) = 0
- L(t) = 1, If there exists an integer "x" such that "t" is a congruent to "x^2" modulo 10223;
- L(t) = 0, If there exists no integer "x" such that "t" is a congruent to "x^2" modulo 10223.

The above Legendre sequence is used to construct the unique length-10223 sequence used for each ranging code. This sequence, called a Weil-code, is the exclusive-or of L(t) and a shift of L(t). A Weil-code W(t;w) is specified by Weil Index "w", ranging from 1 to 5111, which represents the shift of L(t) and is defined as follows:

W(t;w) = L(t) xor L((t+w) modulo 10223) for t=0 to 10222

A PRN code of 10230 chips is generated by inserting the 7-bit expansion sequence "0110100" at the location corresponding to the insertion index for the Weil code of 10223 chips.

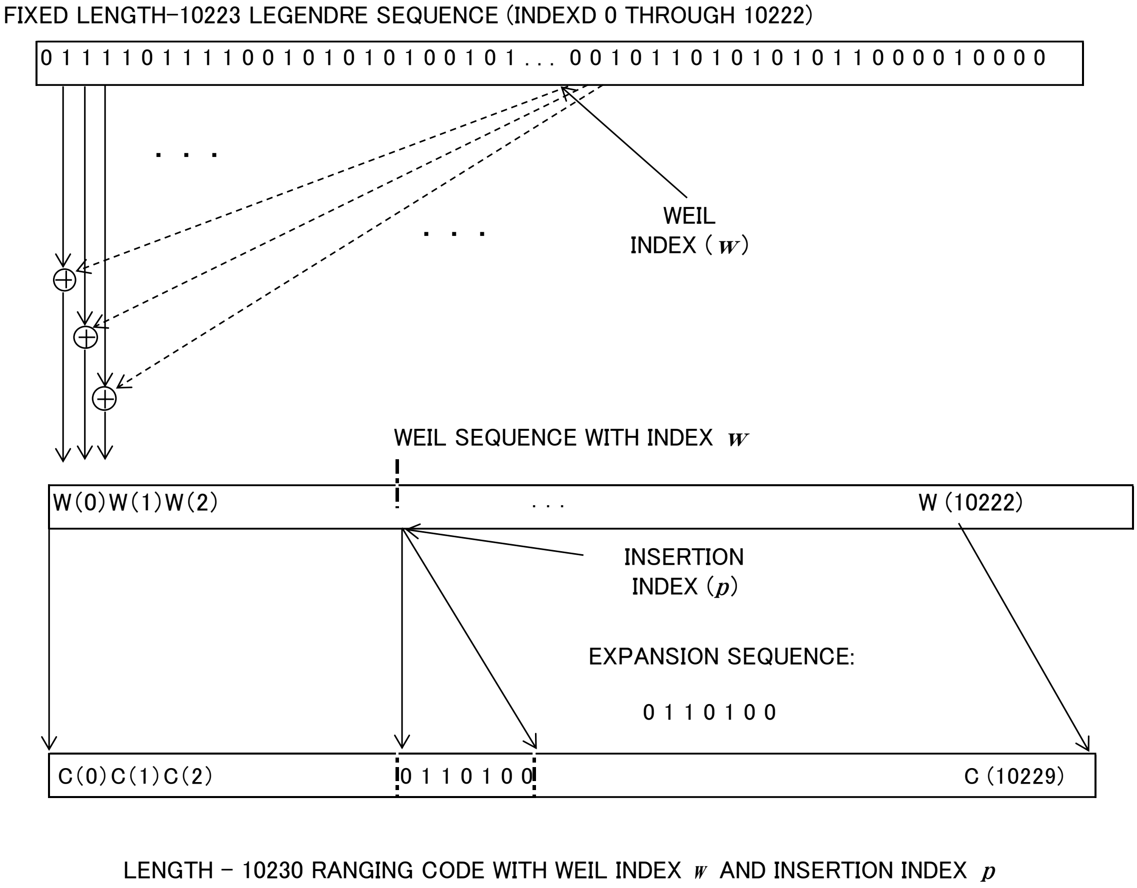


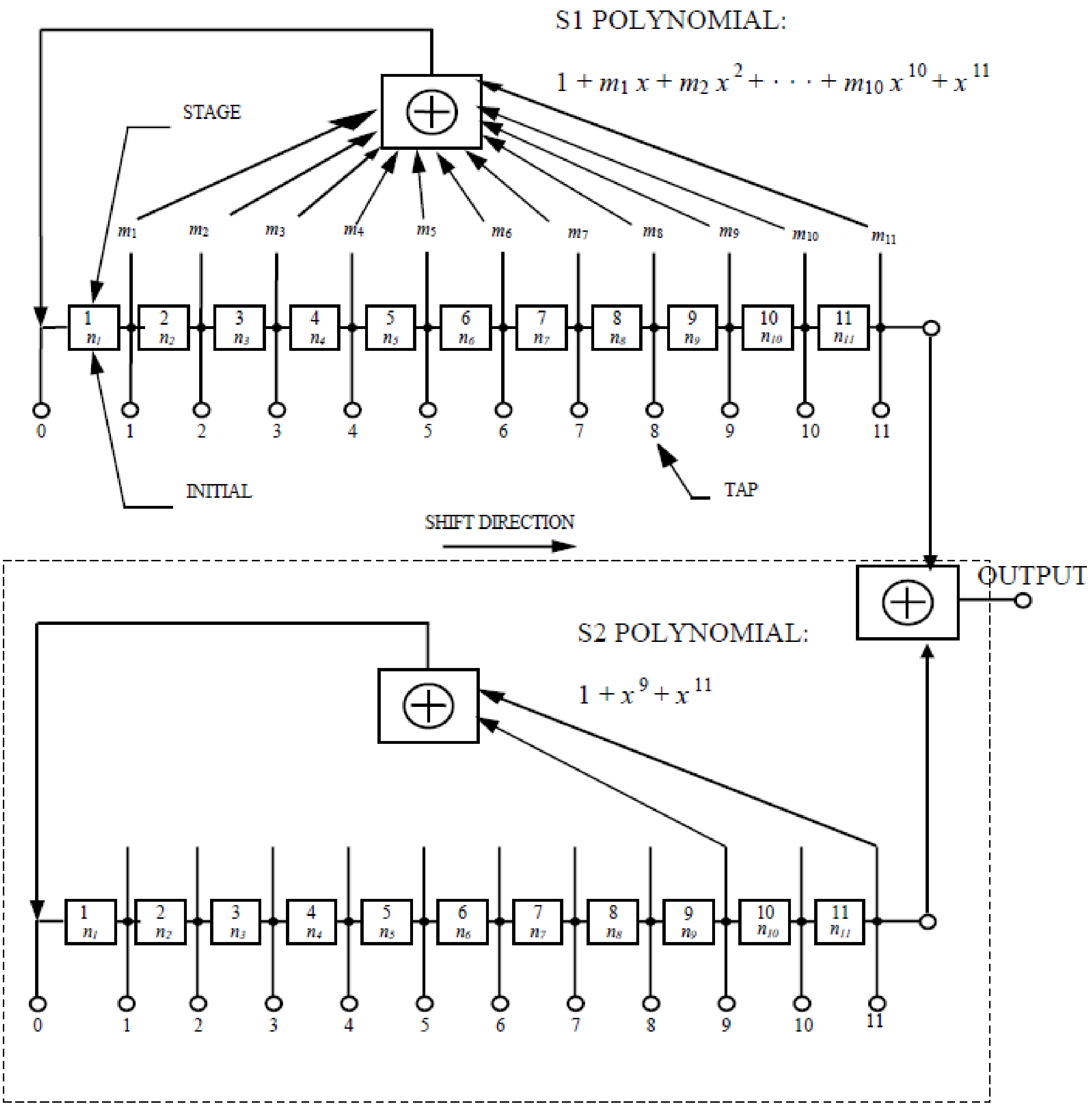
Figure 3.2.3-1 L1CP and L1CD Ranging Code Generation

Table 3.2.3-1 L1C PRN Code Assignments

PRN number	L1CP				L1CD			
	Weil Index	Insertion Index	First 24 Chips (Octal)	Last 24 Chips (Octal)	Weil Index	Insertion Index	First 24 Chips (Octal)	Last 24 Chips (Octal)
193	4311	9864	70670250	11640746	4834	9753	54420241	43473502
194	5024	9753	24737373	51661203	4456	4799	75476311	32402217
195	4352	9859	04467202	15610600	4056	10126	50612163	43454074
196	4678	328	02551300	70117174	3804	241	77772455	06321507
197	5034	1	32252546	77615261	3672	1245	03320402	22101365
198	5085	4733	10121331	22447126	4205	1274	20225612	67251717
199	3646	164	10537634	65022442	3348	1456	55426411	02047657
200	4868	135	32014275	41243522	4152	9967	70477545	43352227
201	3668	174	13126037	56605536	3883	235	71116442	04471535
202	4211	132	60700561	13020736	3473	512	42077151	62510717

3.2.3.2. Overlay Codes

The overlay code is the code that is overlaid on a primary code (PRN code). Overlay code is applied to the L1CP, L5I, and L5Q signals. The overlay code of L1CO, the ranging code of L1CP added modulo 2, is the head 1800-bit of the 2047-bit code generated according to Figure 3.2.3-2. The polynomial coefficient corresponding to each PRN number and the initial value of shift register are as shown in Table 3.2.3-2.



Note: S1 polynomial coefficients and initial conditions are given in Table 3.2.3-2.
MSB of initial condition given in Table 3.2.3-2 is in stage 11.
The first bit of the output is the MSB of the output sequence.
For S1 polynomial, m_{11} is equal to "1".

Figure 3.2.3-2 L1C Overlay Code Generator

Table 3.2.3-2 L1C Overlay Code Assignments

PRN Number	S1 Polynomial Coefficient	Initial S1 Value (Octal)	Initial S2 Value (Octal)	First 11 Symbols (Octal)	Last 11 Symbols (Octal)
193	5403	0500	3261	3761	1676
194	5403	0254	1760	1534	1620
195	5403	3445	0430	3075	2340
196	5403	2542	3477	1135	3477
197	5403	1257	1676	0421	3241
198	6501	0211	1636	1427	3011
199	6501	0534	2411	2125	0674
200	6501	1420	1473	0053	1746
201	6501	3401	2266	1667	1110
202	6501	0714	2104	2610	1415

3.2.4. L2C Codes

L2C consists of L2CM and L2CL, and PRN codes of L2CM and L2CL are generated using the same code generator polynomial each clocked at 511.5kbps. L2CM PRN codes is reset after 10230 chips resulting in a code period of 20ms, and L2CL PRN codes is reset after 767250 chips resulting in a code period of 1.5s. Each PRN code is time-division multiplexed with each chip in the order of L2CM and L2CL as shown in Figure 3.2.4-1, and L2C code becomes the 1.023 Mcps code.

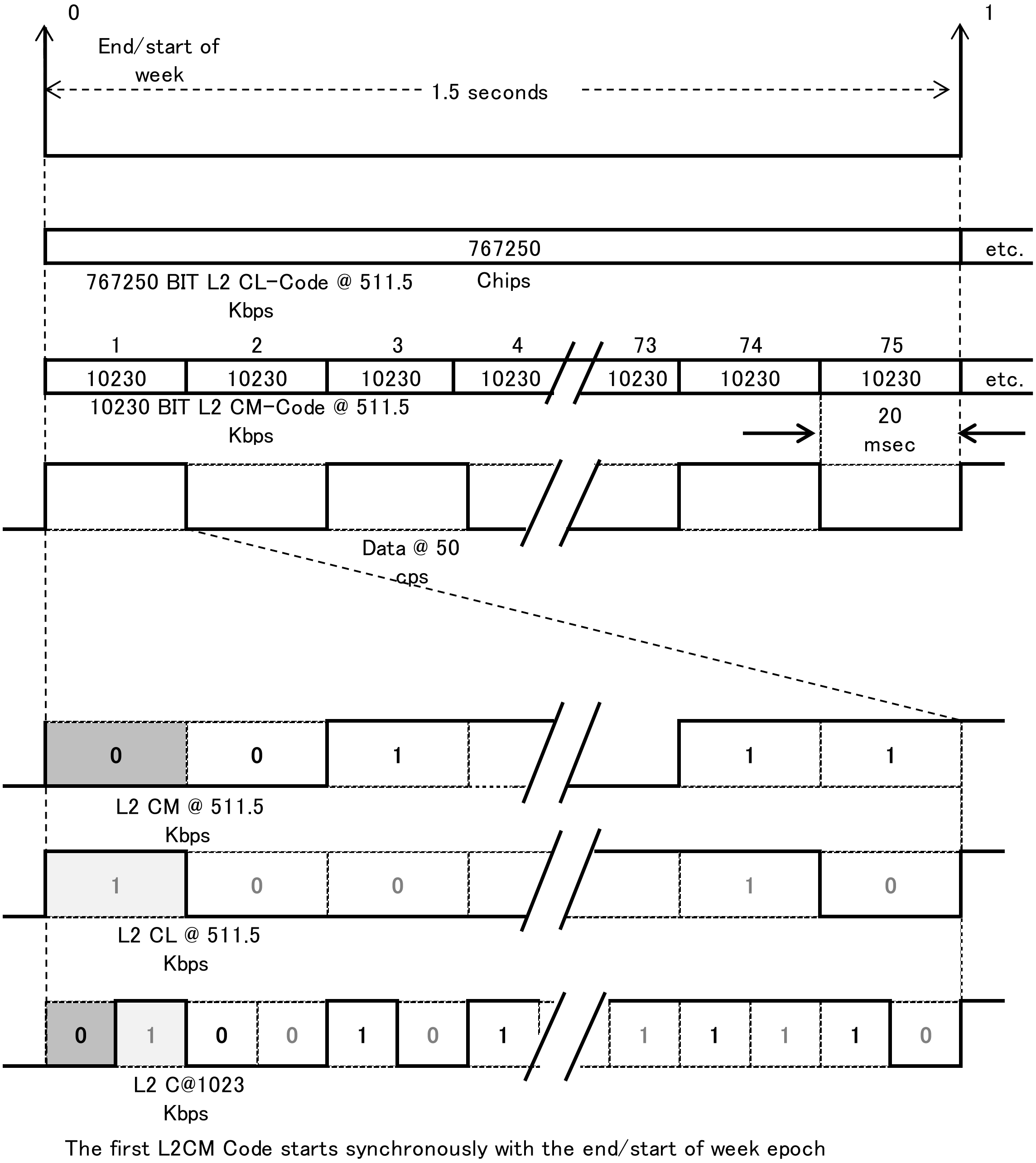


Figure 3.2.4-1 L2C Timing

PRN codes of L2CM and L2CL are generated using the same polynomial as shown in Figure 3.2.4-2, and the code pattern corresponding to each PRN number is generated based on the initial shift register value shown in Table 3.2.4-1.

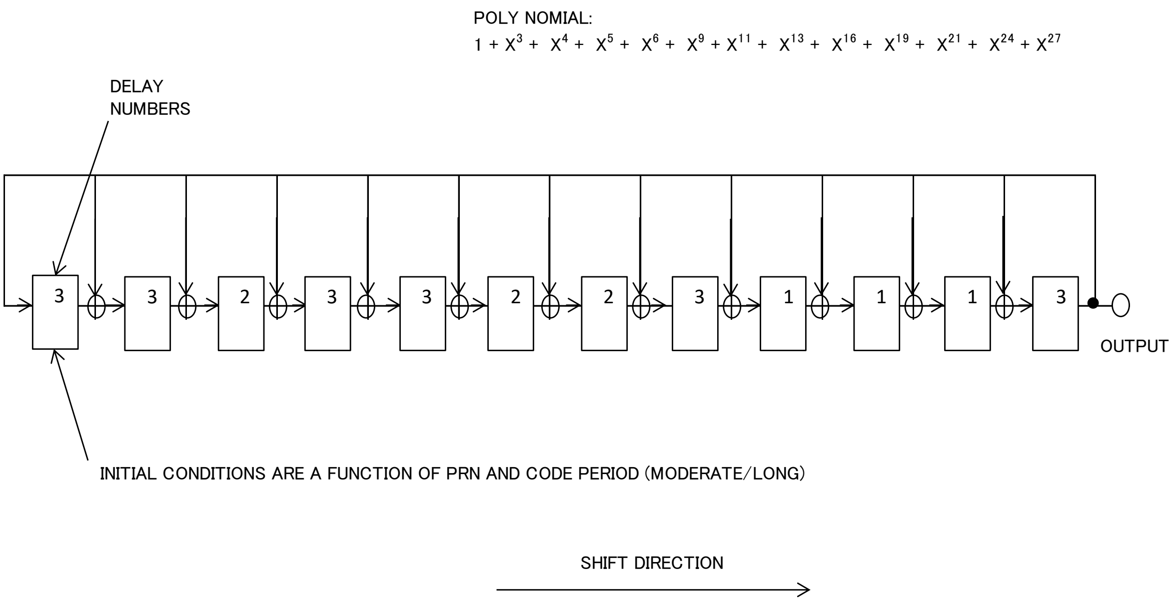


Figure 3.2.4-2 L2C Shift Register

Table 3.2.4-1 L2C PRN Code Assignments

PRN Number	Initial Shift Register Value (Octal)		Final Shift Register Value (Octal)	
	L2CM	L2CL	L2CM	L2CL
193	204244652	235525312	415505547	722043377
194	202133131	507056307	705146647	240751052
195	714351204	221720061	006215430	375674043
196	657127260	520470122	371216176	166677056
197	130567507	603764120	645502771	123055362
198	670517677	145604016	455175106	707017665
199	607275514	051237167	127161032	437503241
200	045413633	033326347	470332401	275605155
201	212645405	534627074	252026355	376333266
202	613700455	645230164	113771472	467523556

3.2.5. L5 Codes

PRN codes of I5 and Q5 signals have 1ms in length at a chipping rate of 10.23Mbps, for total length of 10230 chips. In addition, I5 has a Neuman-Hoffman (NH) code with a bit rate of 1kbps (cycle: 1ms) and a length of 10bits (10ms), and Q5 has a NH code with a bit rate of 1kbps (cycle: 1ms) and a length of 20bits (20ms).The 10-bit and 20-bit NH codes of I5 and Q5 are as follows:

1st Last

10-bit NH code = 0000 1101 01

1st Last

20-bit NH code = 0000 0100 1101 0100 1110

Each PRN code is generated as shown in Figure 3.2.5-1. XA is an 8190 length code, with an initial condition of all 1's, that is short cycled 1-chip before its natural conclusion and restarted to run over a period of 1ms (synchronized with the C/A code) for a total of 10230 chips.

XBI and XBQ are 8191 length codes that are not short cycled.

They are restarted at their natural completion and run over a period of 1ms (synchronized with the XA code) for a total of 10230 chips.

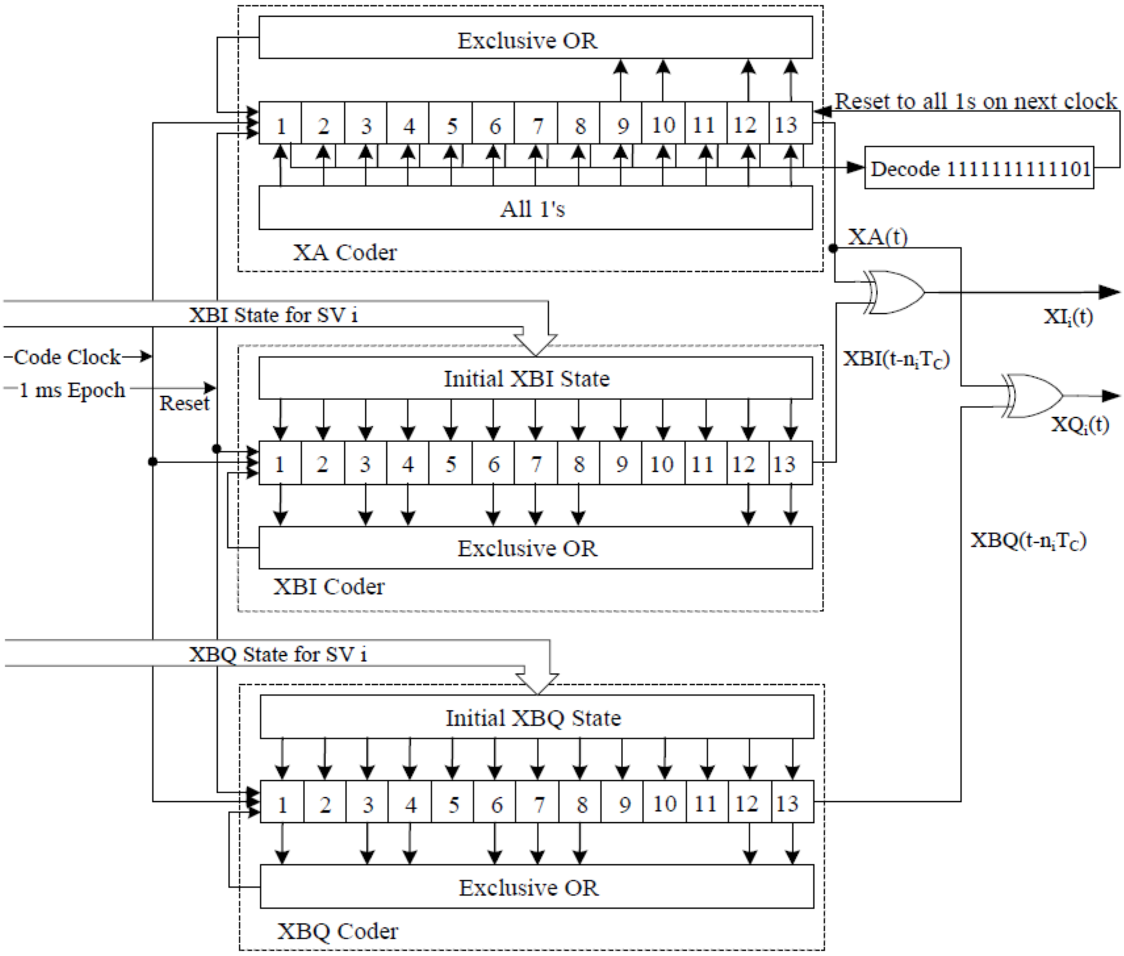


Figure 3.2.5-1 L5 PRN Code Generator

The code pattern of each PRN number is generated by the XB shift register advances and the initial XB code state as shown in Table 3.2.5-1.

Table 3.2.5-1 L5 PRN Code Assignments

PRN Number	XB Code Advancement (Chips)		XB Code Initial Value (Binary)	
	I5	Q5	I5	Q5
193	5836	4757	0110000101110	1001110000111
194	0926	0427	0110010011111	0110100111010
195	6086	5452	1000111001100	0110001100110
196	0950	5182	1111101110001	0000100001100
197	5905	6606	0011111100001	0101000101101
198	3240	6531	0000001110001	1000001010111
199	6675	4268	1010110100100	0011001110001
200	3197	3115	0100001110110	0100011100110
201	1555	6835	0111110100011	0100101100101
202	3589	862	0001111001011	1110001010111

3.2.6. Non-Standard Codes

The non-standard codes are used in case of system errors. Users cannot use them for satellite positioning.

4. Message Specifications

4.1. LNAV(L1C/A, L1C/B)

4.1.1. Message Configuration

4.1.1.1. Timing

(1) Message Patterns

At the beginning of the week, the message pattern is reset.

The message pattern of subframe 4 and subframe 5 is based on a transmission pattern table.

(2) Update Timing

Each navigation message may be updated at a different timing with each satellite and each signal.

(3) Transmission Cycle

Table 4.1.1-1shows maximum transmission intervals.

Table 4.1.1-1 Maximum Transmission Intervals

Message data	Subframe	Data ID	SV ID	Maximum Transmission Interval (seconds)	Remarks
SV clock	SF1	-	-	30	
Ephemeris	SF2&3	-	-	30	
Group delay	SF1	-	-	30	
QZS almanac	SF4 or 5	3	1-10	600	
QZS almanac epoch and health	SF4 or 5	3	51	60	
Special messages	SF4 or 5	3	55	-	Not specified
Ionospheric (wide area) and UTC parameters	SF4 or 5	3	56	60	
QZNMA	SF4 or 5	3	60	(*1)	
Ionospheric (Japan area) and UTC parameters	SF4 or 5	3	61	720	

*1: To be specified in "IS-QZSS-SAS"

(4) Update interval and Fit Interval

Table 4.1.1-2 shows the nominal update intervals, fit intervals and validity period in the difference between the epoch and current time of the various parameters.

Table 4.1.1-2 Update Interval and Fit Intervals

Parameter	Update interval	Fit interval	Validity Period (*1)
SV clock	1 hour (*2)	2 hours	2 hours
Ephemeris	1 hour (*2)	2 hours	2 hours
URA	1 hour	Not applicable because time information indicating the epoch is not included.	
Group delay	1 day	Not applicable because time information indicating the epoch is not included.	
Almanac	1 day	6 days	144 hours
Ionospheric parameter (wide area)	1 hour	Not applicable because time information indicating the epoch is not included.	
Ionospheric parameter (Japan area)	1 hour	Not applicable because time information indicating the epoch is not included.	
UTC parameter	1 day	6 days	144 hours

*1: The validity periods are twice the absolute value of the difference between the current time (t) and the epochs (t_o) as follows:

SV clock epoch t_{oc}: $|t - t_{oc}|$

Ephemeris epoch t_{oe}: $|t - t_{oe}|$

Almanac epoch t_{oa}: $|t - t_{oa}|$

UTC parameter epoch t_{ot}: $|t - t_{ot}|$

*2: The update interval is a nominal value, and users should detect the update of the clock and ephemeris parameter by IODC and IODE.

4.1.1.2. Overview

LNAV(L1C/A, L1C/B) messages, which are transmitted by L1C/A or L1C/B signals, consist of 5 subframes, 1 subframe is 10 words, as shown in Figure 4.1.1-1.

Each word consists of 24-bit data and 6-bit parity.

"Word 1" of each subframe is a telemetry word (TLM) including a preamble, and "Word 2" of each subframe is a hand-over word (HOW).

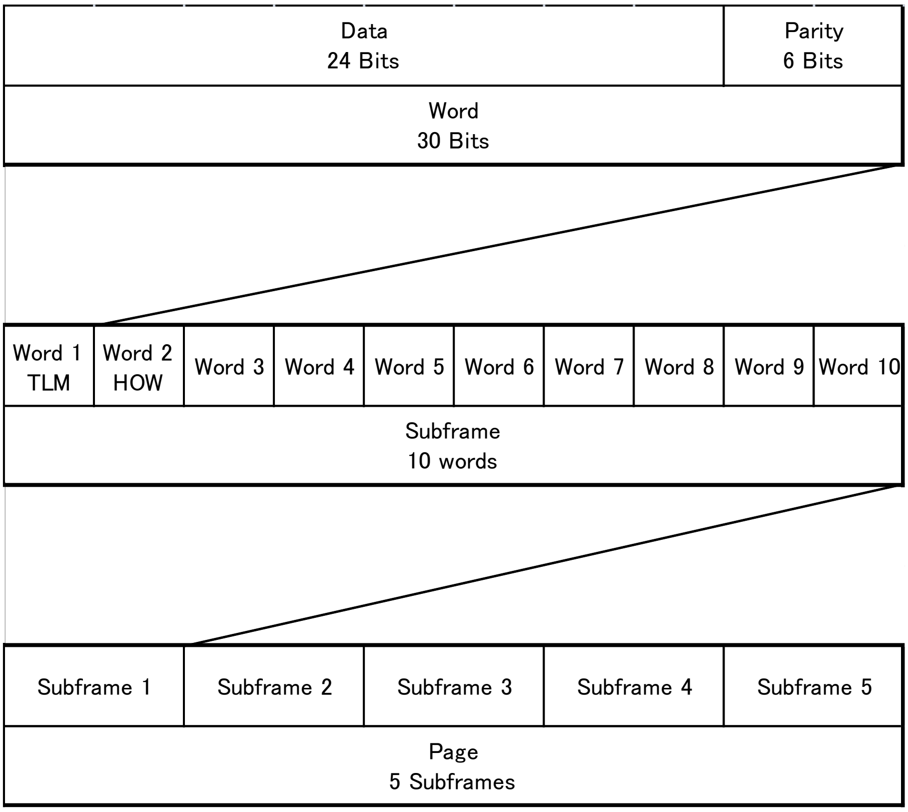


Figure 4.1.1-1 LNAV(L1C/A, L1C/B) Message Configuration

4.1.1.3. Parity

The 6-bit parity bits located at the end of the 30-bit word is a (32, 26) hamming code. The encoding method is shown in Table 4.1.1-3.

Table 4.1.1-3 Satellite Parity Encoding Method

$$D_1 = d_1 \oplus D_{30}^*$$
$$D_2 = d_2 \oplus D_{30}^*$$
$$D_3 = d_3 \oplus D_{30}^*$$
$$\vdots$$
$$D_{24} = d_{24} \oplus D_{30}^*$$
$$D_{25} = D_{29}^* \oplus d_1 \oplus d_2 \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_{10} \oplus d_{11} \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{17} \oplus d_{18} \oplus d_{20} \oplus d_{23}$$
$$D_{26} = D_{30}^* \oplus d_2 \oplus d_3 \oplus d_4 \oplus d_6 \oplus d_7 \oplus d_{11} \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{18} \oplus d_{19} \oplus d_{21} \oplus d_{24}$$
$$D_{27} = D_{29}^* \oplus d_1 \oplus d_3 \oplus d_4 \oplus d_5 \oplus d_7 \oplus d_8 \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{19} \oplus d_{20} \oplus d_{22}$$
$$D_{28} = D_{30}^* \oplus d_2 \oplus d_4 \oplus d_5 \oplus d_6 \oplus d_8 \oplus d_9 \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{17} \oplus d_{20} \oplus d_{21} \oplus d_{23}$$
$$D_{29} = D_{30}^* \oplus d_1 \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_7 \oplus d_9 \oplus d_{10} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{17} \oplus d_{18} \oplus d_{21} \oplus d_{22} \oplus d_{24}$$
$$D_{30} = D_{29}^* \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_8 \oplus d_9 \oplus d_{10} \oplus d_{11} \oplus d_{13} \oplus d_{15} \oplus d_{19} \oplus d_{22} \oplus d_{23} \oplus d_{24}$$

where

- $d_1, d_2, \ldots, d_{24}$: Source data bits
- Symbol* : Last 2 bits of the previous word of the subframe
- $D_{25}, D_{26}, \ldots, D_{30}$: Computed parity bits
- $D_1, D_2, \ldots, D_{30}$: Data bits transmitted by the SV
- $\oplus$: “Modulo-2” or “exclusive-or” operation

4.1.1.4. Default Message

When the system detects an error, the default message shown in Table 4.1.1-4 may be transmitted.

Table 4.1.1-4 Default message

Item	Description
Word 1	Normal TLM message
Word 2	Appropriate TOW count and subframe ID The alert flag is "1".
Word 3 to 9	1010101010 1010101010 1010000000(B)
Word 10	1010101010 1010101010 1000000000(B)

4.1.1.5. Invalid Message

When the system detects an error, an error message in which all bits are 0 may be transmitted.

4.1.2. Message Content

4.1.2.1. Overview

The content shown in Table 4.1.2-1 are stored in each subframe of the LNAV(L1C/A, L1C/B) message. Subframes 4 and 5 store different content depending on the SV ID and data ID contained in Word 3. The content of SV ID and data ID are shown in Table 4.1.2-2.

Table 4.1.2-1 LNAV(L1C/A, L1C/B) Message Content

Subframe No.	Description
Subframe 1	SV clock parameter
Subframe 2	Ephemeris
Subframe 3	
Subframe 4	As per Table 4.1.2-2
Subframe 5	

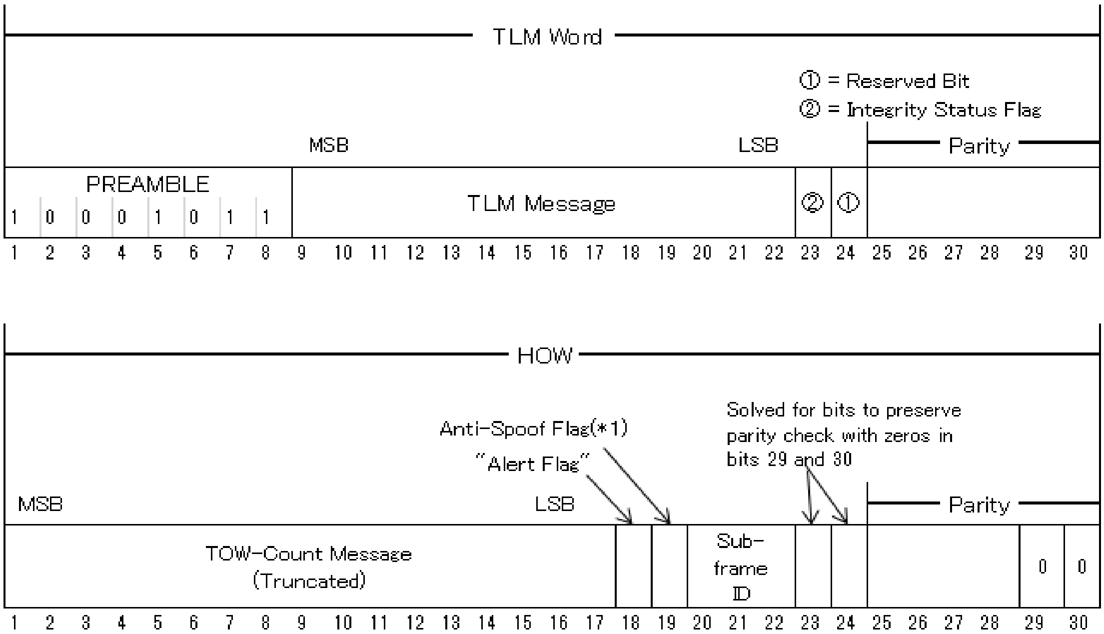
Table 4.1.2-2 SV ID and Data ID List

Data ID	SV ID	Description
3	0	Test mode(*)
	1 to 10	QZS almanac
	51	QZS almanac epoch and health
	55	Special messages
	56	Ionospheric parameter (Wide area) and UTC parameter
	60	QZNMA
	61	Ionospheric parameter (Japan area) and UTC parameter

(*): SV ID 0 indicates that LNAV(L1C/A, L1C/B) signal of the QZS is in test mode. When receiving SV ID 0, the user should not use that subframes.

4.1.2.2. TLM and HOW

Word 1 and Word 2 of each subframe use a common TLM and HOW for every subframe. The bit assignment for the TLM and HOW are shown in Figure 4.1.2-1, and the definitions of each parameter are shown in Table 4.1.2-3.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-1 TLM and HOW Formats

Table 4.1.2-3 Parameter Definitions

Parameter	Description	Effective Range	Number of Bits	LSB	Units
Preamble	Preamble	10001011(B)	8	-	-
TLM Message	Telemetry message	For system	14	-	-
Integrity Status Flag	Integrity status flag	0-1	1	-	-
TOW Count Message	Time-of-week count message	0-604794	17	6	sec
Alert Flag	Alert flag	0-1	1	-	-
Anti-Spoof Flag	Anti-spoof flag (*1)	0	1	-	-
Subframe ID	Subframe ID	1-5	3	1	-

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(1) Preamble

Fix to "10001011" (B).

(2) TLM message

This is undefined because it is used by the system.

(3) Integrity status flag (ISF)

This is the integrity assurance level of the signal.

The definition is shown in Section 5.4.2.

(4) TOW count message

This is the time of week at the start of the next following subframe.

(5) Alert flag

This informs the user that the signal cannot be used due to increase of the user range error or occurrence of other error.

For details, see Section 5.4.1.

(6) Anti-spoof flag

This is the flag of the protection against spoofing.

This is always "0" because it is not used in QZSS.

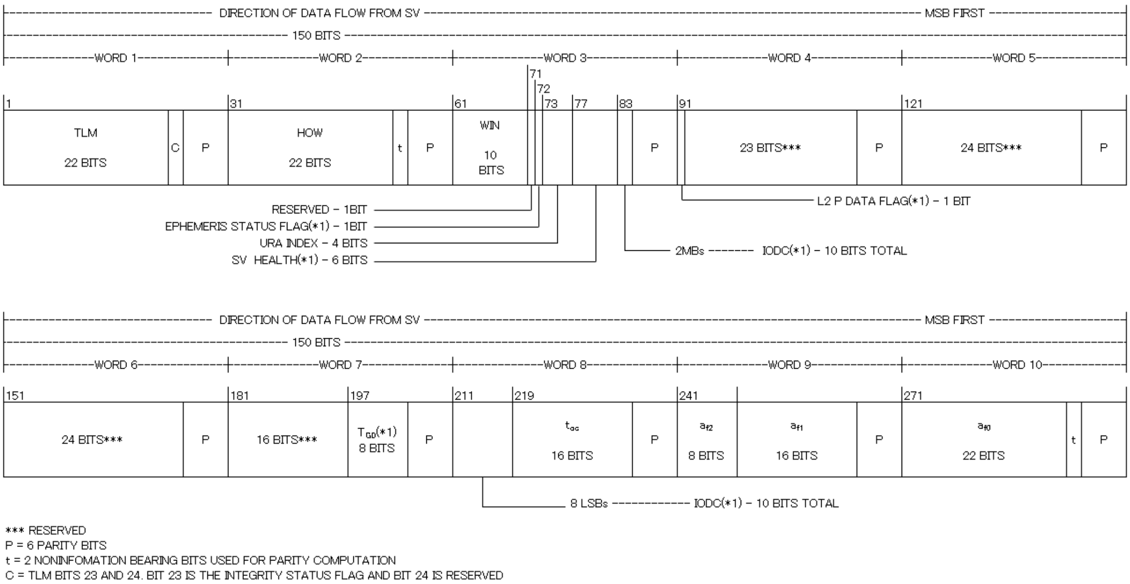
This parameter is defined differently from GPS. For details, see Section 4.1.2.7.

(7) Subframe ID

This is the subframe number. The range is from 1 to 5.

4.1.2.3. Subframe 1 (SV Clock)

Figure 4.1.2-2 shows the data format of subframe 1 and Table 4.1.2-4 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-2 Subframe 1 Format

Table 4.1.2-4 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameter (See Table 4.1.2-3)		-	-	-	-
WN	Week number		0-1023	10	1	weeks
Ephemeris Status Flag	Indicating the status of ephemeris(*1)		0-1	1	-	-
URA INDEX	User range accuracy index		0-15	4	-	-
SV health	SV health (*1)		-	6	-	-
IODC	Issue of Data, Clock (*1)		0-1023	10	-	-
L2P data flag	L2P code data flag (*1)		0-1	1	-	-
T_{GD}	Group delay between SV clock and L1C/A (or L1C/B)(*1)		**	8*	2^{-31}	sec
t_{oc}	SV clock parameter	Epoch of SV clock (time of week)	0-604784	16	2^{+4}	sec
a_{f0}		SV clock bias correction coefficient	**	22*	2^{-31}	sec
a_{f1}		SV clock drift correction coefficient	**	16*	2^{-43}	sec/sec
a_{f2}		SV clock drift rate correction coefficient	**	8*	2^{-55}	sec/sec^2
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(1) Week number

In GPS, time is expressed in the format of week number and week time. Week number is counted from January 6th, 1980. This is 10-bit binary data (0-1024) that shall be modulo 1024 of each QZSS week number. QZSS week number increases at the start of every week epoch.

(2) Ephemeris Status Flag

The flag indicates when the ephemeris as well as SV clock parameter were uploaded.

"0": within an hour

"1": more than an hour ago

This is defined differently from GPS. For details, see Section 4.1.2.7.

(3) User range accuracy (URA) INDEX

This is the RMS value of the maximum SIS range error in the validity period of each SV clock and ephemeris. When the URA is updated, IODE is also incremented in the same as the ephemeris.

The definition and user algorithm are shown in Section 5.4.3.

(4) SV health

This consists of the 1MSB health and the 5LSBs health. The 1-bit health is the SV health of L1C/A or L1C/B and the 5-bit health is the SV health of all PNT signals including L1C/A, L1C/B, L1C, L2C, and L5. Because the L1C/A and L1C/B signals are exclusively transmitted, the L1C/B Health will be 1 when the L1C/A signal is transmitted. On the contrary, the L1C/A Health will be 1 when the L1C/B signal is transmitted.The 5-bit health parameter is defined differently from GPS. For details, see Sections 4.1.2.7.

Table 4.1.2-5-1 and Table 4.1.2-5-2 show the definitions of each health. For details, see in Section 5.4.1.

When the SV health is updated, IODE is also incremented in the same as the ephemeris.

Table 4.1.2-5-1 Definitions of 1-bit Health

Bit Location	Name	Target Signal
1st bit (MSB)	L1 Health	L1C/A or L1C/B

Table 4.1.2-5-2 Definitions of 5-bit Health

Bit Location	Name	Target Signal
1st bit (MSB)	L1C/A Health	L1C/A
2nd bit	L2 Health	L2C
3rd bit	L5 Health	L5
4th bit	L1C Health	L1C
5th bit (LSB)	L1C/B Health	L1C/B

(5) Issue of Data, Clock (IODC)

This is the issue number of the SV clock parameter. 2 MSBs of IODC indicate fit intervals is as shown in Table 4.1.2-6.Users can detect the update of the SV clock parameter by IODC.

This is defined differently from GPS. For details, see Section 4.1.2.7.

Table 4.1.2-6 Definition of 2MSBs of IODC

2 MSBs of IODC(binary)	Fit intervals(minutes)
00	15
01	30
10	60
11	120

(6) L2P data flag

Fixed to "1".

This is defined differently from GPS. For details, see Section 4.1.2.7.

(7) Group delay between SV clock and L1C/A (or L1C/B) time

This is one of the group delay parameters. The definition and user algorithm are shown in Section 5.8.

This is defined differently from GPS. For details, see Section 4.1.2.7.

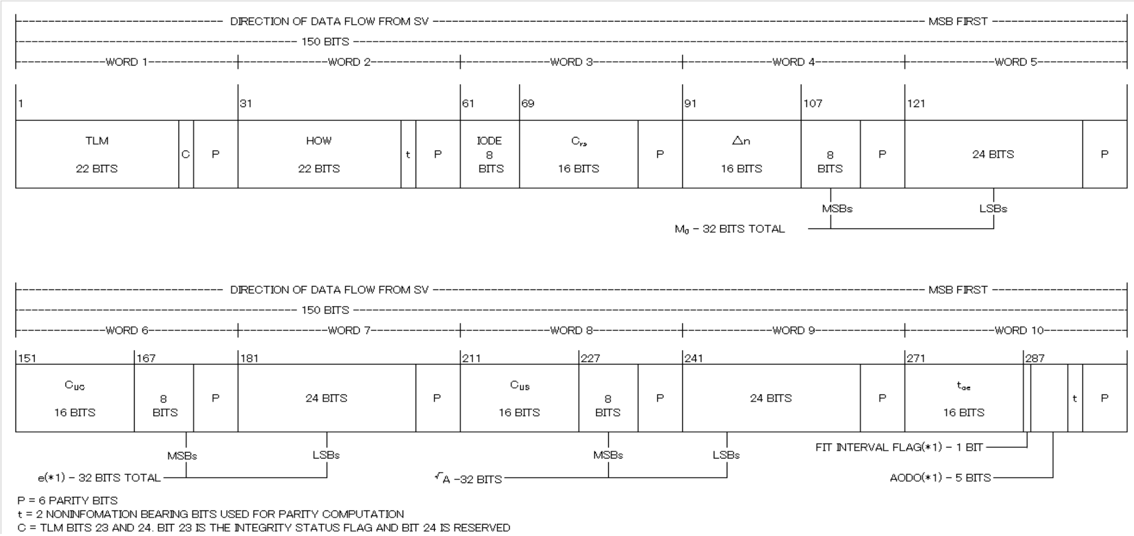
(8) SV clock parameter

These are used to correct the SV clock offset defined by the pseudo range of each signal by the user.

The definition and user algorithm are shown in Section 5.5.

4.1.2.4. Subframe 2 (Ephemeris 1)

Figure 4.1.2-3 shows the data format of subframe 2 and Table 4.1.2-7 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-3 Subframe 2 Format

Table 4.1.2-7 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameter (See Table 4.1.2-3.)		-	-	-	-
IODE	Issue of data, ephemeris		0-255	8	-	-
Crs	Ephemeris	Amplitude of the sine harmonic correction term to the orbit radius	**	16*	2^{-5}	m
Δn		Mean motion difference from computed value	**	16*	2^{-43}	semi-circle/sec
M_0		Mean anomaly at reference time	**	32*	2^{-31}	semi-circle
Cuc		Amplitude of the cosine harmonic correction term to the argument of latitude	**	16*	2^{-29}	rad
e		Eccentricity (*1)	**	32	2^{-33}	-
Cus		Amplitude of the sine harmonic correction term to the argument of latitude	**	16*	2^{-29}	rad
$\sqrt{A}$		Square root of the semi-major axis	**	32	2^{-19}	$m^{1/2}$
t_{oe}		Reference time ephemeris	0-604784	16	2^{+4}	sec
FIT INTERVAL FLAG	Fit interval flag (*1)		0-1	1	-	-
AODO	Age of data offset (Navigation message correction table effective period) (*1)		0-27000	5	900	sec
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(1) Issue of data, ephemeris (IODE)

This is the issue number of the ephemeris parameter. Users can detect the update of the ephemeris parameter by IODE. The IODE is consistent with the 8LSBs of the IODC (10 bits). The IODE is contained in subframes 2 and 3, and when these three values are not the same, it indicates that subframes 1, 2 and 3 are not data sets issued at the same time, and thus the user needs to collect the same sets.

The following rules apply to IODE and IODC of different data sets:

(a) IODC is different from other IODC in the previous 2 days.
(b) IODE is different from other IODE in the previous 6 hours.

(2) Ephemeris

These are the trajectory in the Earth-Centered, Earth-Fixed (ECEF) coordinates for each fit interval.

The user algorithm is shown in Section 5.6.

This is defined differently from GPS. For details, see Section 4.1.2.7.

(3) Fit interval flag

This is the fit interval period of the ephemeris.

"0": 2 hours

"1": Greater than 2 hours

This is always “0” in QZSS because the fit interval period of the ephemeris is 2 hours as shown in Table 4.1.1-2.

This is defined differently from GPS. For details, see Section 4.1.2.7.

(4) Age of data offset (AODO)

Because this system does not transmit any navigation message correction tables, AODO is fixed to "11111"(B).

This is defined differently from GPS. For details, see Section 4.1.2.7.

4.1.2.5. Subframe 3 (Ephemeris 2)

Figure 4.1.2-4 shows the data format of subframe 3 and Table 4.1.2-8 shows its parameter definitions.

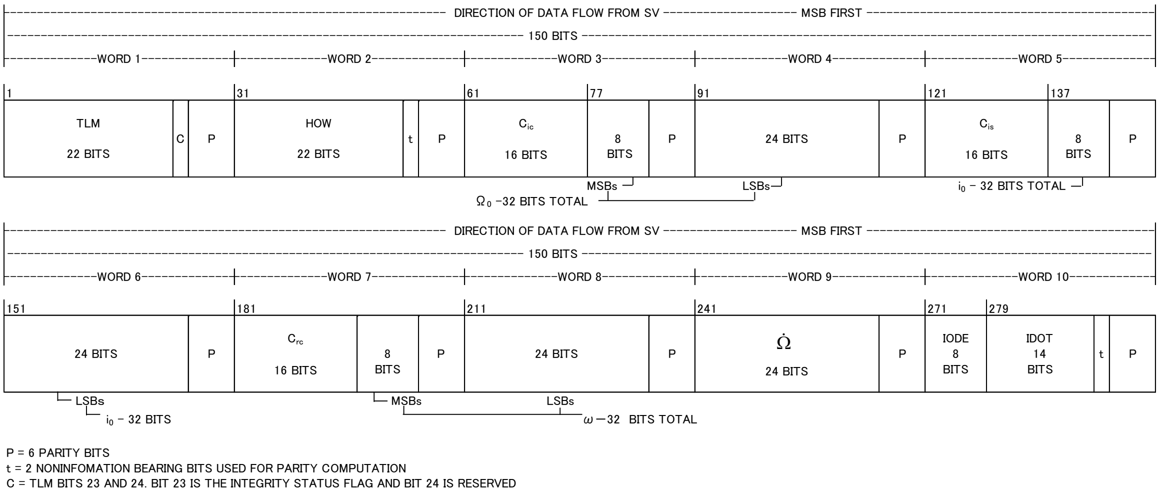


Figure 4.1.2-4 Subframe 3 Format

Table 4.1.2-8 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameter (See Table 4.1.2-3)		-	-	-	-
Cic	Ephemeris	Amplitude of the cosine harmonic correction term to the angle of inclination	**	16*	2^{-29}	rad
Ω_0		Longitude of ascending node of orbit plane at weekly epoch	**	32*	2^{-31}	semi-circle
Cis		Amplitude of the sine harmonic correction term to the angle of inclination	**	16*	2^{-29}	rad
i_0		Inclination angle at reference time	**	32*	2^{-31}	semi-circle
Crc		Amplitude of the cosine harmonic correction term to the orbit radius	**	16*	2^{-5}	m
ω		Argument of perigee	**	32*	2^{-31}	semi-circle
$\dot{\Omega}$		Rate of right ascension	**	24*	2^{-43}	semi-circle/sec
IODE	Issue of data ,ephemeris		0-255	8	-	-
$\dot{I}$ IDOT	Ephemeris	Rate of inclination angle	**	14*	2^{-43}	semi-circle/sec

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.

(1) Issue of data, ephemeris (IODE)

See, section 4.1.2.4. (1) .

(2) Ephemeris

See, section 4.1.2.4. (2) .

4.1.2.6. Subframes 4 and 5

4.1.2.6.1. Overview

Subframes 4 and 5 identify by data ID and SV ID in 8MSBs of Word 3 shown in Figure 4.1.2-5 and Table 4.1.2-9.

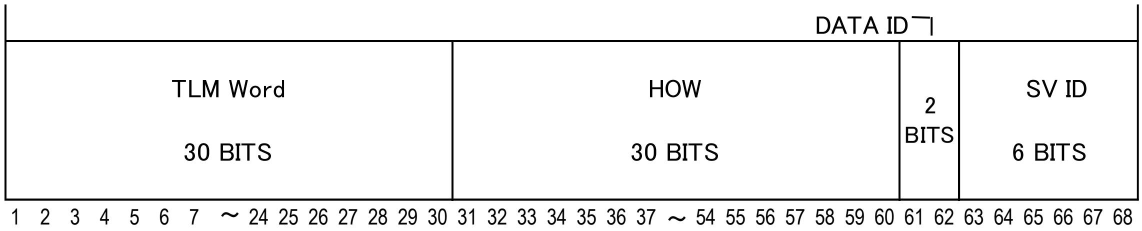


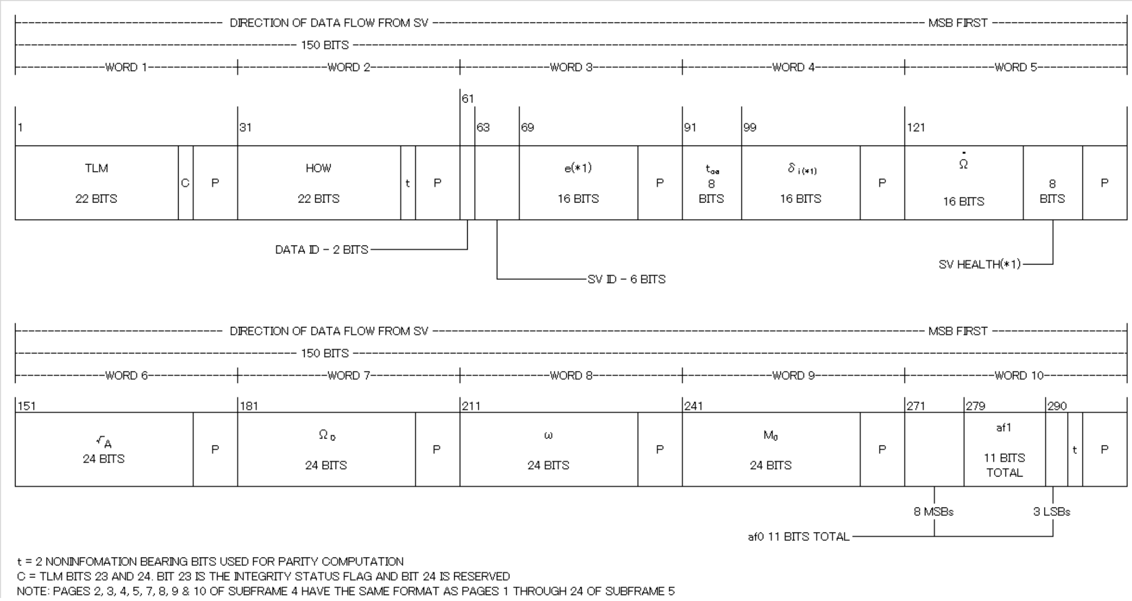
Figure 4.1.2-5 Common Section of Subframes 4 and 5 Format

Table 4.1.2-9 Parameter Definitions

Parameter	Description	Effective Range	Number of Bits	LSB	Units
-	TLM and HOW parameters (See Table 4.1.2-3.)	-	-	-	-
DATA ID	Data ID	0-3	2	1	-
SV ID	Space vehicle ID. The information to identify the message of subframe 4 and 5 in LNAV(L1C/A, L1C/B)	0-63	6	1	-

4.1.2.6.2. QZS Almanac (Data ID = "3", SV ID = 1 to 10)

Figure 4.1.2-6 shows the data format and Table 4.1.2-10 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-6 QZS Almanac Format

Table 4.1.2-10 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameters (See Table 4.1.2-3)		-	-	-	-
DATA ID	Data ID (See Table 4.1.2-9)		3	2	1	-
SV ID	PRN number ID (See Table 4.1.2-9)		1-10	6	1	-
t_{oa}	Almanac	Almanac reference time of week	0-602112	8	2^{+12}	sec
e		Difference from reference eccentricity (*1)	**	16	2^{-21}	-
δ_i		Difference from reference angle of inclination (*1)	**	16*	2^{-19}	semi-circle
$\dot{\Omega}$		Rate of right ascension	**	16*	2^{-38}	semi-circle/sec
SV HEALTH	SV health (*1)		-	8	-	-
$\sqrt{A}$	Almanac	Square root of the semi-major axis	**	24	2^{-11}	$m^{1/2}$
Ω_0		Longitude of ascending node of orbit plane at weekly epoch	**	24*	2^{-23}	semi-circle
ω		Argument of perigee	**	24*	2^{-23}	semi-circle
M_0		Mean anomaly at reference time	**	24*	2^{-23}	semi-circle
a_{f0}		SV clock bias correction coefficient	**	11*	2^{-20}	sec
a_{f1}		SV clock drift correction coefficient	**	11*	2^{-38}	sec/sec
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(1) SV health

This consists of the 3MSBs health and the 5LSBs health as shown in Table 4.1.2-11.

The 3-bit health is shown in Section 5.4.1. The 5-bit health is defined differently from GPS. For details, see Section 4.1.2.7.

Because the SV health is uploaded with the latest almanac, it may not be consistent with the real SV health. For the same reason, it may not be consistent with the SV health of subframe 1.

Table 4.1.2-11 QZS Almanac SV Health Definitions

Bit Position	Name	Target Signal
1st to 3rd bits (MSB)	3-bit health	L1C/A or L1C/B
4th to 8th bits (LSB)	5-bit health	L1C/A, L2C, L5, L1C and L1C/B

(2) Almanac

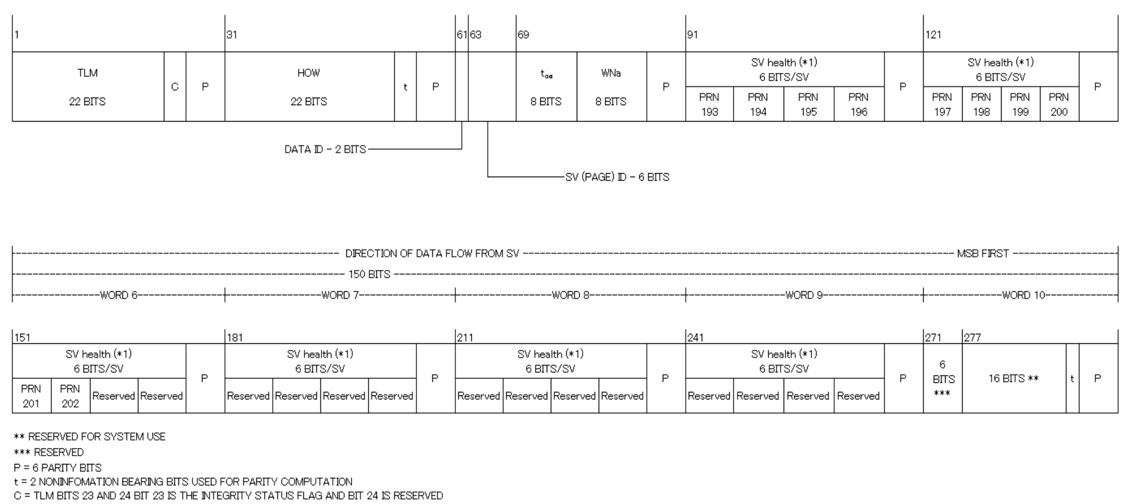
This is a reduced-precision parameter of the satellite orbit and the SV clock. The almanac data is fitted in a period of 6 days, and is updated every 1 day.

The user algorithm is shown in Section 5.7.1.

This parameter is defined differently from GPS. For details, see Section 4.1.2.7.

4.1.2.6.3. QZS Almanac Epoch and Health (Data ID = "3", SV ID = 51)

Figure 4.1.2-7 shows the data format andTable 4.1.2-12 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-7 QZS Almanac Epoch and Health Format

Table 4.1.2-12 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameters (See Table 4.1.2-3.)		-	-	-	-
DATA ID	Data ID (See Table 4.1.2-9.)		3	2	1	-
SV ID	PRN number ID (See Table 4.1.2-9.)		51	6	1	-
t_{oa}	Almanac reference time of week		0-602112	8	2^{+12}	sec
WN_a	Almanac reference week		**	8	1	weeks
SV health	SV health (*1)	PRN193	-	6	-	-
		PRN194	-	6	-	-
		PRN195	-	6	-	-
		PRN196 or 203(*2)	-	6	-	-
		PRN197 or 204(*2)	-	6	-	-
		PRN198	-	6	-	-
		PRN199	-	6	-	-
		PRN200 or 205(*2)	-	6	-	-
		PRN201 or 206(*2)	-	6	-	-
		PRN202	-	6	-	-
		Reserved	-	84	-	-
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(*2) The PRN code differs between L1C/A signal and L1C/B signal.

(1) Almanac reference time of week

This is the almanac reference time of week.

The definition and user algorithm are shown in Section 5.7.1.

(2) Almanac reference week

This is the reference week number of almanac orbital information.

The definition and user algorithm are shown in Section 5.7.1.

(3) SV health

See Sections 4.1.2.3. (4) .

Because the SV health is uploaded with the latest almanac, it may not be consistent with the real health. For the same reason, it may not be consistent with the SV health data of subframe 1.

4.1.2.6.4. Special Messages (Data ID = "3", SV ID = 55)

Figure 4.1.2-8 shows the data format and Table 4.1.2-13 shows its parameter definitions.

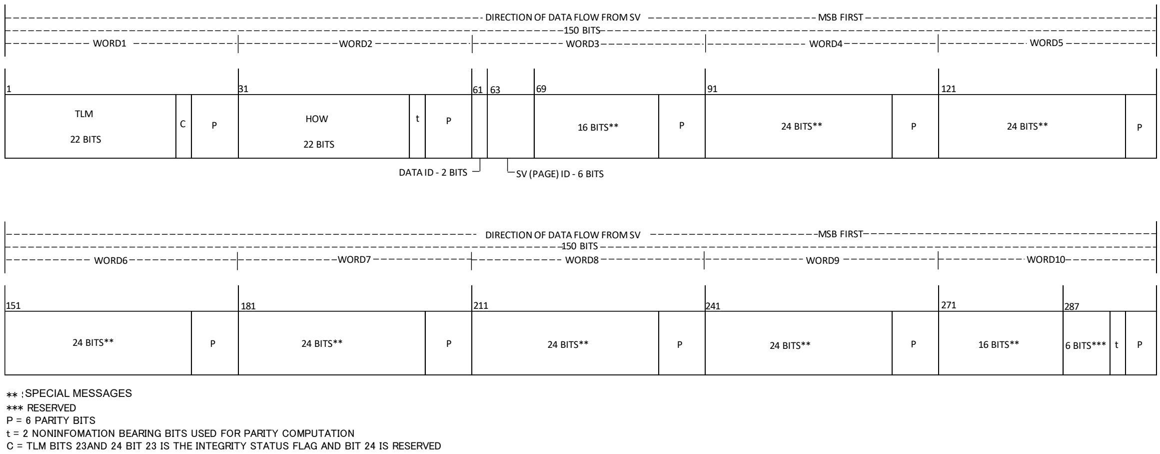


Figure 4.1.2-8 Special Messages Format

Table 4.1.2-13 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameters (See Table 4.1.2-3.)	-	-	-	-
Data ID	Data ID (See Table 4.1.2-9.)	3	2	1	-
SV ID	PRN number ID (See Table 4.1.2-9.)	55	6	1	-
-	Special messages	-	176	-	-
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

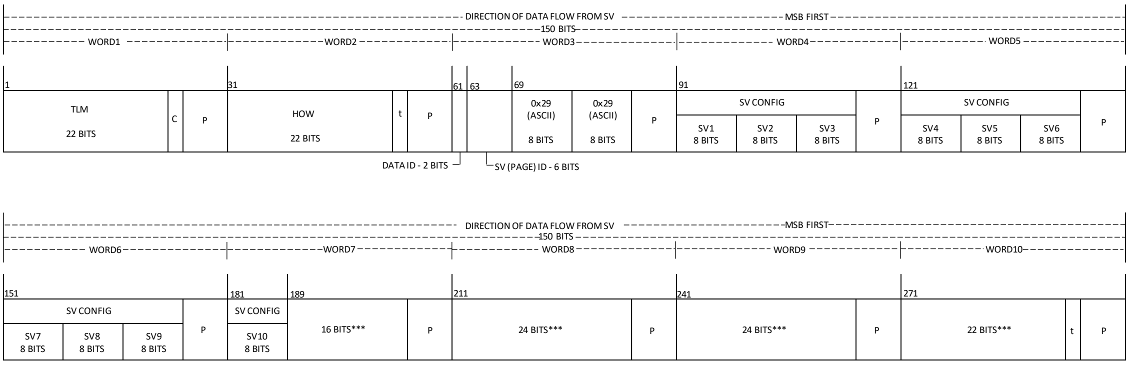
(1) Special messages

Specially defined message transmitted in a navigation message. Special messages can contain information not related to positioning. Special messages are strings composed of 22 eight-bit ASCII characters.

In case that the 16 bits field of WORD3 is 0x2929(0010100100101001), SV Configuration information is broadcasted on and after WORD4.

For details, refer to the following Figure and Table.

Parameter definitions of SV Configuration



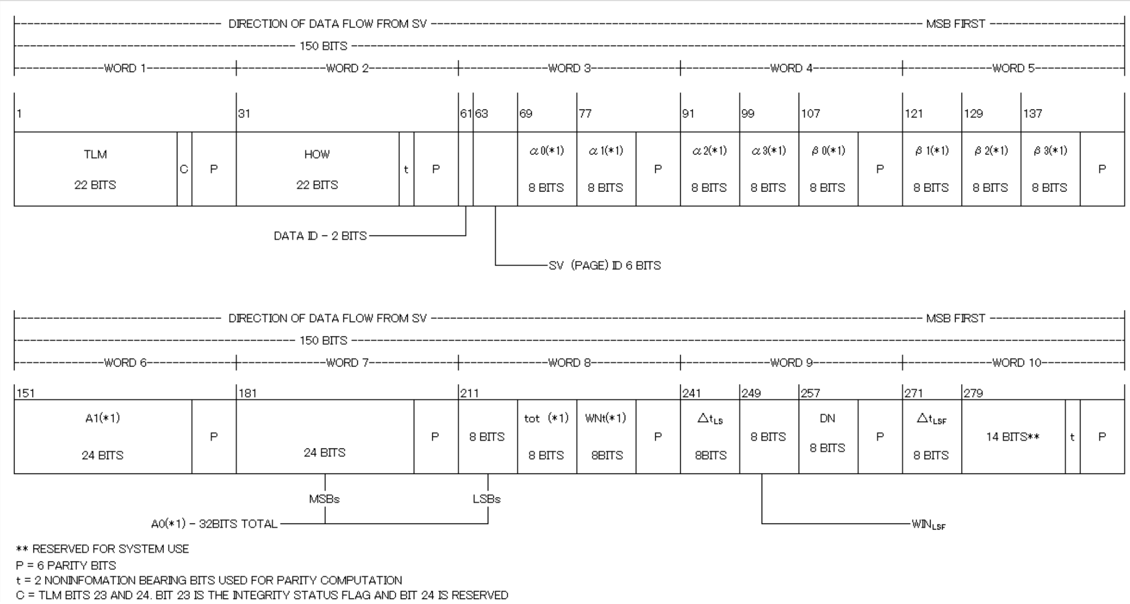
*** RESERVED
P = 6 PARITY BITS
t = 2 NONINFOMATION BEARING BITS USED FOR PARITY COMPUTATION
C = TLM BITS 23AND 24 BIT 23 IS THE INTEGRITY STATUS FLAG AND BIT 24 IS RESERVED

Field		Parameter	Value
WORD3	8BITS	1st CHARACTER	0010100100101001: SV Configuration
	8BITS	2nd CHARACTER	Other combinations: Special Messages
WORD4	8BITS	SV Configuration (PRN193)	01100000:No satellite configuration
	8BITS	SV Configuration (PRN194)	01100001:Block I
	8BITS	SV Configuration (PRN195)	01100010:Block II
WORD5	8BITS	SV Configuration (PRN196 or 203)*1	01100011:Block III
	8BITS	SV Configuration (PRN197 or 204)*1	01100100~01101110: Reserved
	8BITS	SV Configuration (PRN198)	01101111:not in PNT Service
WORD6	8BITS	SV Configuration (PRN199)	
	8BITS	SV Configuration (PRN200 or 205)*1	
	8BITS	SV Configuration (PRN201 or 206)*1	
WORD7	8BITS	SV Configuration (PRN202)	
	16BITS	Reserved	
WORD8	24BITS	Reserved	
WORD9	24BITS	Reserved	
WORD10	22BITS	Reserved	

*1: The PRN code differs between L1C/A signal and L1C/B signal.

4.1.2.6.5. Ionospheric (Wide Area) and UTC Parameters (Data ID = 3, SV ID = 56)

Figure 4.1.2-9 shows the data format and Table 4.1.2-14 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

Figure 4.1.2-9 Ionospheric and UTC Parameters Format

Table 4.1.2-14 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	TLM and HOW parameters (See Table 4.1.2-3.)		-	-	-	-
Data ID	Data ID (See Table 4.1.2-9.)		3	2	1	-
SV ID	PRN number ID (See Table 4.1.2-9.)		56	6	1	-
α_0	Ionospheric parameter (*1)		**	8*	2^{-30}	sec
α_1			**	8*	2^{-27}	sec/semi-circle
α_2			**	8*	2^{-24}	sec/semi-circle^2
α_3			**	8*	2^{-24}	sec/semi-circle^3
β_0			**	8*	2^{+11}	sec
β_1			**	8*	2^{+14}	sec/semi-circle
β_2			**	8*	2^{+16}	sec/semi-circle^2
β_3			**	8*	2^{+16}	sec/semi-circle^3
A_0	UTC parameter	Bias coefficient between UTC and QZSS (*1)	**	32*	2^{-30}	sec
A_1		Drift coefficient between UTC and QZSS (*1)	**	24*	2^{-50}	sec/sec
Δt_{LS}		Current or past leap second count	**	8*	1	sec
t_{ot}		Epoch of UTC Parameter (Time data reference Time of Week) (*1)	0-602112	8	2^{+12}	sec
WN_t		UTC reference week number (*1)	**	8	1	weeks
WN_{LSF}		Leap second reference week number	**	8	1	weeks
DN		Leap second reference day number	1-7	8	1	days
Δt_{LSF}		Current or future leap second count	**	8*	1	sec

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.1.2.7.

(1) Ionospheric parameter

This is used to calculate the ionospheric delay for single frequency users.

The parameters can be used in the wide area shown in Section 5.9.3.

The user algorithm is shown in Section 5.9.

This is defined differently from GPS. For details, see Section 4.1.2.7.

(2) UTC parameter

This is related to the modulo 1 second offset between QZSST and UTC (NICT), as well as to the leap second.

The user algorithm is shown in Section 5.12.

This is defined differently from GPS. For details, see Section 4.1.2.7.

4.1.2.6.6. Ionospheric (Japan area) and UTC Parameters (Data ID = 3, SV ID = 61)

Ionospheric (Japan area) and UTC parameters are same as a definition of ionospheric (Wide area) and UTC parameters. See Section 4.1.2.6.5. The ionospheric (Japan area) parameters can be used in the Japan area shown in Section 5.9.3.

4.1.2.7. (Reference) Differences from GPS

Table 4.1.2-15 shows parameters that are defined differently from GPS definitions specified in the reference document (1) of Section 2.2.

Table 4.1.2-15 Parameters Defined Differently from GPS (LNAV(L1C/A))

Subframe	Page *1	Parameter	GPS	QZSS
common	common	Anti-Spoof Flag	Anti-spoof flag "0": Anti-spoof OFF "1": Anti-spoof ON	Unused Fixed to "0"
1	-	EPHEMERIS STATUS FLAG	C/A OR P ON L2 L2 code identification "0": spare "1": P code "2": L1C/A code	Indicating the status of ephemeris "0": within an hour "1": more than an hour ago
		L2P DATA FLAG	Presence of L2P code message "0": L2P message ON "1": L2P message OFF	Unused Fixed to "1"
		5-bit health	L1 and L2 health	L1C/A, L2, L5, L1C and L1C/B health
		IODC	The issue number of the data set, Clock. The period without using the same value is undefined.	The issue number of the data set, Clock. The period without using the same value is 2 days.
		TGD	Group delay between SV clock and L1P (Y)	Group delay between SV clock and L1C/A (or L1C/B)
2	-	Ephemeris (e)	Eccentricity of ephemeris	
			Upper limit of parameter range of 0.03	Parameter range is not restricted.
		FIT INTERVAL FLAG	Fit interval flag	
			"0": 4 hours "1": more than 4 hours	"0": 2 hours "1": more than 2 hours
		AODO	Offset time when NMCT data is used	Unused Fixed to "11111"(B)
4	13	NMCT	Navigation message correction table	Not transmitted.
	18	Ionospheric parameter (α_0, α_1, α_2, α_3, β_0, β_1, β_2, β_3)	The target area	
			The entire globe.	Wide area Japan area
		UTC parameter (A_0, A_1, t_{ot}, WN_t)	Relationship between UTC (USNO) and GPST	Relationship between UTC (NICT) and QZSST
4,5	Subframe 4 : Pages 2–5, 7–10	Almanac (e)	Eccentricity	Difference from reference eccentricity (e_{REF}) eREF=0.06[-](QZO) eREF=0[-](GEO/QGEO)
	Subframe 5 : Pages 1–24	Almanac (δi)	Difference from reference angle of inclination (i_0) i_0 = 0.3[semi-circles]	Difference from reference angle of inclination (i_{REF}) i_{REF} = 0.25 [semi-circles] (QZO) i_{REF} = 0 [semi-circles] (GEO/QGEO)
5	25	5-bit health	L1 and L2 health	L1C/A, L2, L5, L1C and L1C/B health

*1: The pages number of subframe 4 and 5 depend on the definition of GPS.

4.1.2.8. (Delete)

4.2. CNAV2(L1C)

4.2.1. Message Configuration

4.2.1.1. Overview

CNAV2(L1C) messages, which are transmitted by L1CD signal, consist of 3 subframes as shown in Figure 4.2.1-1.

Subframe 1 is the epoch count for 18 seconds from the start of current ITOW epoch as a 9-bit Time of Interval (TOI) count.

Subframe 2 is the clock and ephemeris.

Subframe 3 is one of the messages by the page number. It shall be transmitted by the variable transmission pattern.

Subframe 1 is BCH encoded, and subframes 2 and 3 are encoded by LDPC (Low Density Parity Check) and are subjected to interleaving. Subframes 1, 2 and 3 are an 1800-bit (18-second) message in total.

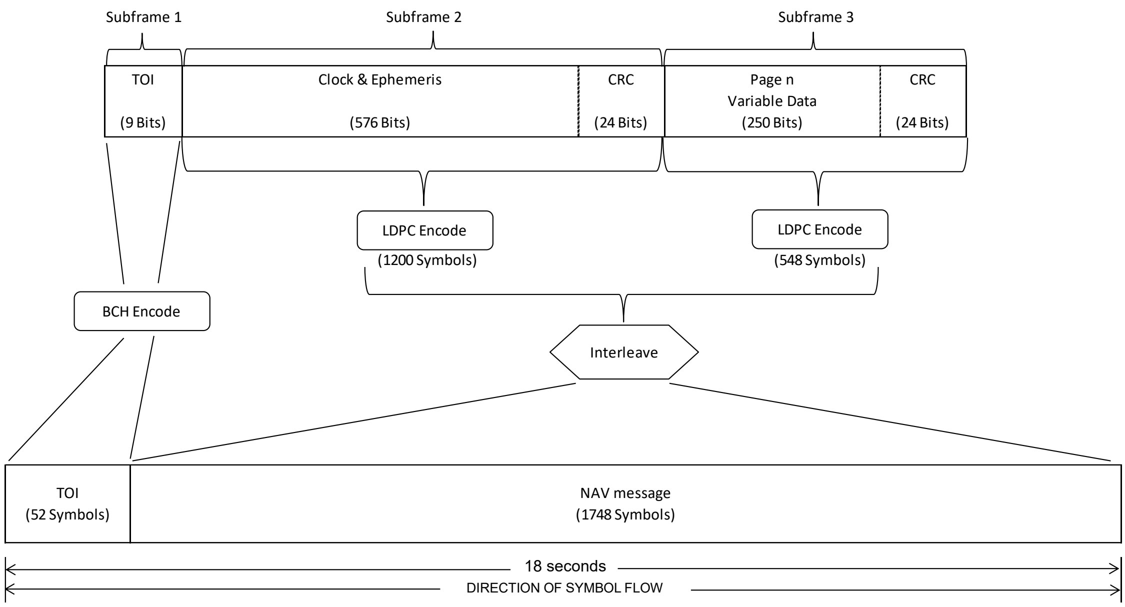


Figure 4.2.1-1 CNAV2(L1C) Message Configuration

4.2.1.2. Timing

(1) Message Patterns

At the beginning of the week, the message pattern is reset.

(2) Update Timing

Each navigation message may be updated at a different timing with each satellite and signal.

(3) Transmission Cycle

Table 4.2.1-1 shows maximum transmission intervals.

Table 4.2.1-1 Maximum Transmission Intervals

Message data	Subframe	Page	Maximum Transmission Interval (seconds)	Remarks
SV clock	SF2	-	18	
Ephemeris	SF2	-	18	
ISC	SF2	-	18	
UTC parameter and ionospheric parameter (wide area)	SF3	Page 1	144	
GGTO and earth orientation parameter	SF3	Page 2	144	
QZS reduced almanac	SF3	Page 3	600(*1)	
QZS Midi almanac	SF3	Page 4	3600(*1)	
Text message	SF3	Page 6	-	Not specified
QZNMA	SF3	Page 60	(*2)	
UTC parameter and ionospheric parameter (Japan area)	SF3	Page 61	720	

*1: Maximum interval when the message is transmitted

*2: To be specified in "IS-QZSS-SAS"

(4) Update interval and Fit Interval

Table 4.2.1-2 shows the nominal update intervals, fit intervals and validity periods in the difference between the epoch and current time of various parameters.

Table 4.2.1-2 Update Interval and Fit Intervals

Parameter	Update Interval	Fit Interval	Validity Period (*1)
SV clock	1 hour (*2)	2 hours	2 hours
Ephemeris	1 hour (*2)	2 hours	2 hours
Elevation-dependent URA	1 hour	Not applicable because time information indicating the epoch is not included.	
Non-elevation-dependent URA	1 hour	2 hours	2 hours
Group delay	1 day	Not applicable because time information indicating the epoch is not included.	
Reduced almanac	1 day	6 days	144 hours
Midi almanac	1 day	6 days	144 hours
Ionospheric parameter (wide area)	1 hour	Not applicable because time information indicating the epoch is not included.	
Ionospheric parameter (Japan area)	1 hour	Not applicable because time information indicating the epoch is not included.	
Earth orientation parameter	1 hour (*3)	2 hours	12 hours
UTC parameter	1 day	6 days	144 hours
GGTO	1 day	6 days	144 hours

*1: The validity periods are twice the absolute value of the differences between the current time (t) and the epochs (t_o) as follows:

SV clock and ephemeris epoch t_{oe} :$|t - t_{oe}|$
Non-elevation-dependent URA epoch t_{op} :$|t - t_{op}|$
Reduced almanac epoch t_{oa} :$|t - t_{oa}|$
Midi almanac epoch t_{oa} :$|t - t_{oa}|$
Earth orientation parameter epoch t_{EOP} :$|t - t_{EOP}|$
UTC parameter epoch t_{ot} :$|t - t_{ot}|$
GGTO epoch t_{GGTO} :$|t - t_{GGTO}|$

*2: The update interval is a nominal value, and users should detect the update of the clock and ephemeris parameter by toe.

*3: The update interval is a nominal value.

4.2.1.3. TOI Data Encoding

9 bits of TOI data are channel encoded using BCH (51, 8) code. The 8 Least Significant Bits (LSBs-the rightmost bits) of 9-bit TOI data are encoded using the generator polynomial of 763 (octal). This code generator is conceptually shown in Figure 3.2.3-2 using an 8-stage linear shift register generator. TOI data bits 1 to 8 (8 LSBs) are loaded into the generator, Most Significant Bit (MSB) first, as initial conditions of the registers, which is then shifted 51 times to generate 51 encoded symbols. The ninth bit of TOI data (MSB) shall be modulo 2 added to the 51 encoded symbols and it shall also be appended as MSB of the 52 symbols TOI message. The first output symbol of the generator (after modulo 2 added to the ninth bit of TOI data) shall be the 2nd MSB of the 52 symbols TOI message.

Figure 4.2.1-2 shows a schematic of the 8-stage linear shift register generator used for code generation.

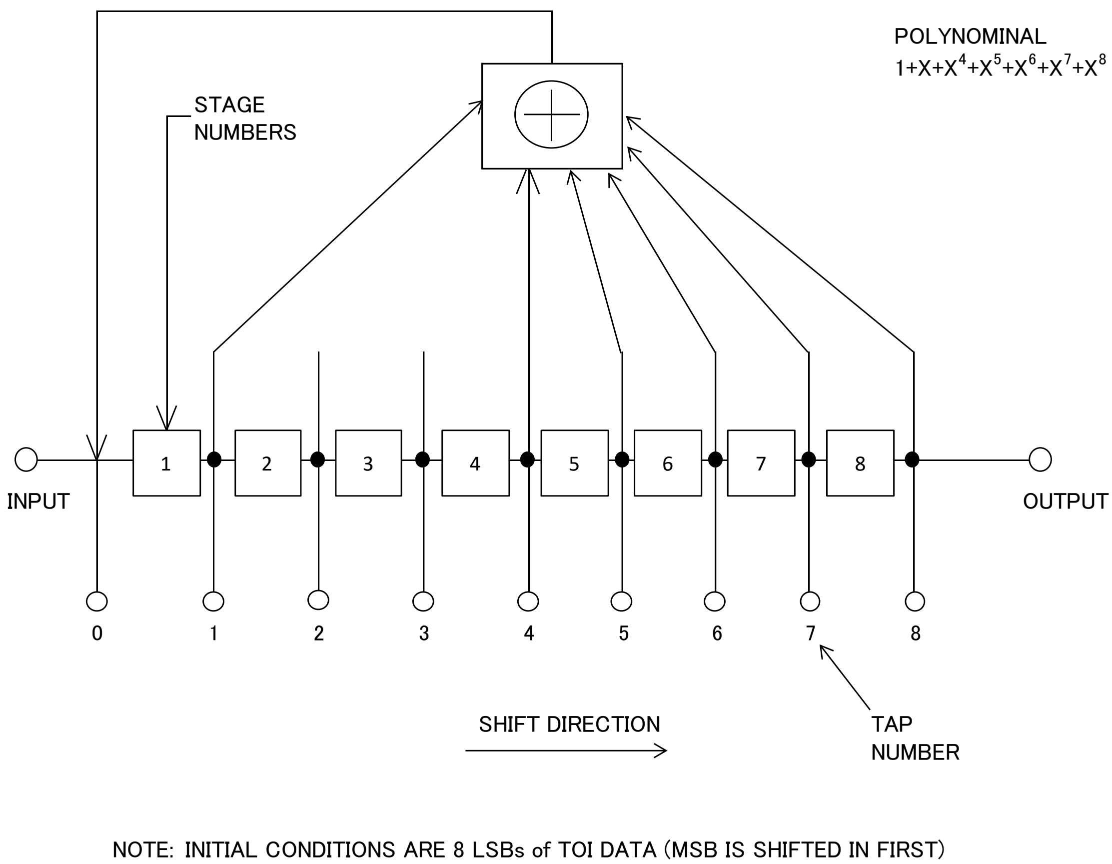


Figure 4.2.1-2 TOI Data Encoding

4.2.1.4. Cyclic Redundancy Check (CRC)

The 24-bit CRC bit string ($p_1, p_2, \cdots p_{24}$) is generated by the following generator polynomial g(X) from the message bit string ($m_1, m_2, \cdots m_k$):

$$g(X) = \sum_{i=0}^{24} g_i X^i$$

g_i are as follows when "CRC-24Q", Qualcomm 24-bit CRC.

i = 0,1,3,4,5,6,7,10,11,14,17,18,23,24: $g_i = 1$,
i = 2,8,9,12,13,15,16,19,20,21,22: $g_i = 0$.

g(X) can be rewritten as follows.

$$g(X) = (1 + X)p(X)$$

Here, $p(X)$ is the following primitive polynomial:

$$p(X) = X^{23} + X^{17} + X^{13} + X^{12} + X^{11} + X^{9} + X^{8} + X^{7} + X^{5} + X^{3} + 1$$

By expressing the information bit string $m(X)$ as follows,

$$m(X) = m_k + m_{k-1}X + m_{k-2}X^2 + \cdots + m_1 X^{k-1}$$

and when dividing $m(X)X^{24}$ by $g(X)$, the remainder is polynomial $R(X)$ which becomes smaller than a degree of 24. The CRC bit p_i (i=1∼24) is the coefficient of X^{24-i} of $R(X)$.

4.2.1.5. Low Density Parity Check (LDPC) Code

The data of subframe 2 and subframe 3 are separately encoded by LDPC codes with an encoding rate of 1/2. Subframe 2 has a total of 600 bits consisting of 576 bits for the clock and ephemeris and 24 bits for the CRC. Subframe 3 has a total of 274 bits consisting of 250 bits for variable data and 24 bits for the CRC. After LDPC encoding, subframe 2 has 1200 symbols and subframe 3 has 548 symbols.

The LDPC encoding structure is based on a parity-check matrix H(m, n). For subframe 2, m = 600, and n = 1200, and for subframe 3, m = 274, and n = 548. H(m, n) is consists of 6 submatrices A, B, T, C, D and E as shown in Figure 4.2.1-3. Each element of H(m, n) is either "0" or "1."

Tables 6-1 to 6-6 define the coordinates of elements with a value of "1" in each of the submatrices A, B, C, D, E and T, respectively, for subframe 2. Tables 6-7 to 6-16 define the coordinates of elements with a value of "1" in each of the submatrices A, B, C, D, E, and T, respectively, for subframe 3.

The inverse matrix of T is not described in this document, but T can be easily obtained because it is a lower triangular matrix.

The LDPC is encoded by the submatrices A, B, C, D, E and T as follows:

$$p_1^t = \phi^{-1}(-ET^{1}A + C)s^t$$

$$p_2^t = -T^{-1}(As^t + Bp_1^t)$$

However,

$$\phi = -ET^{-1}B + D$$

s : Data of subframes 2 and 3

$[\ ]^t$: Transpose matrix

Each element of matrix p_1 and p_2 is modulo 2 number.

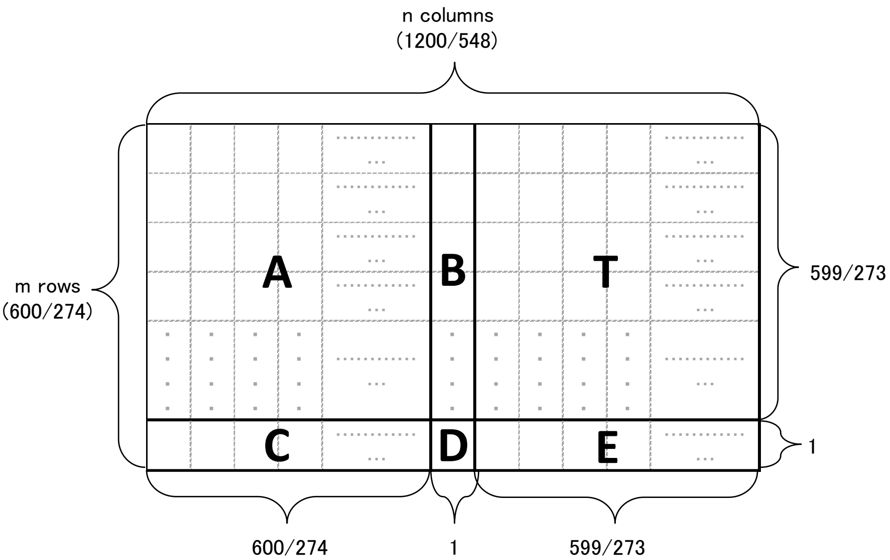


Figure 4.2.1-3 Low Density Parity Check (LDPC) Code Matrix

4.2.1.6. Interleaving

Interleaving is the transformation method the 1748 symbols encoded by LDPC from subframes 2 and 3 are transformed as a two-dimensional array of 38 rows and 46 columns as in Figure 4.2.1-4.

These symbols are written from left to right starting at Row 1. These symbols are sequentially read out of the array from top to bottom starting at Column 1.

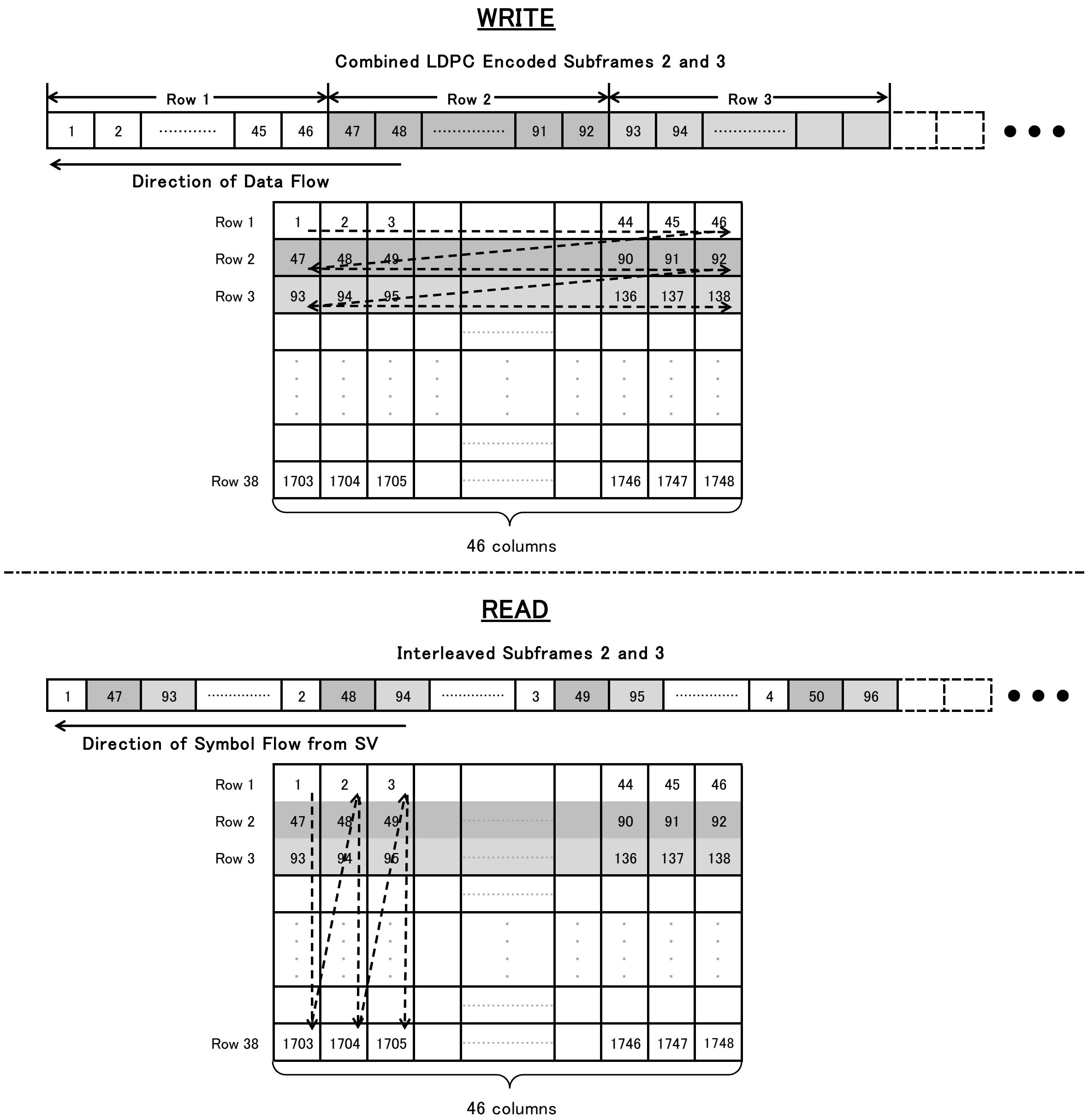


Figure 4.2.1-4 Interleaving

4.2.1.7. Default Message

When the system detects an error, the default message shown in Table 4.2.1-3 may be transmitted.

Table 4.2.1-3 Default message

Item	Description
Subframe 1	Appropriate TOI
Subframe 2	L1C health is "1" Appropriate WN and ITOW For the others, alternating "1" and "0" Appropriate CRC
Subframe 3	The page number is "0" Appropriate PRN For the others, alternating "1" and "0" Appropriate CRC

4.2.1.8. Invalid Message

When the system detects an error, an error message in which all bits are 0 may be transmitted.

4.2.2. Message Content

4.2.2.1. Overview

The content shown in Table 4.2.2-1 are stored in each subframe of the CNAV2(L1C) message. The content of the page are shown in Table 4.2.2-2.

Table 4.2.2-1 CNAV2(L1C) Message Content

Subframe No.	Description
Subframe 1	Time of Interval
Subframe 2	Clock and ephemeris
Subframe 3	As per Table 4.2.2-2

Table 4.2.2-2 Correspondence between the Page Number and Content

Page No.	Description
0	Test mode(*)
1	UTC parameter and ionospheric parameter (wide area)
2	GGTO and earth orientation parameter
3	QZS reduced almanac
4	QZS Midi almanac
6	Text message
60	QZNMA
61	UTC parameter and ionospheric parameter (Japan area)

(*): Page No.0 indicates that CNAV2(L1C) signal of the QZS is in test mode. When receiving Page No.0, the user should not use that subframes.

4.2.2.2. Subframe 1

Figure 4.2.2-1 shows the data format of subframe 1 and Table 4.2.2-3 shows its parameter definitions.

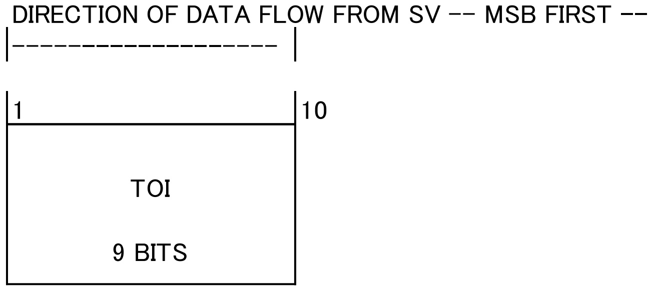


Figure 4.2.2-1 Subframe 1 Format

Table 4.2.2-3 Parameter Definitions

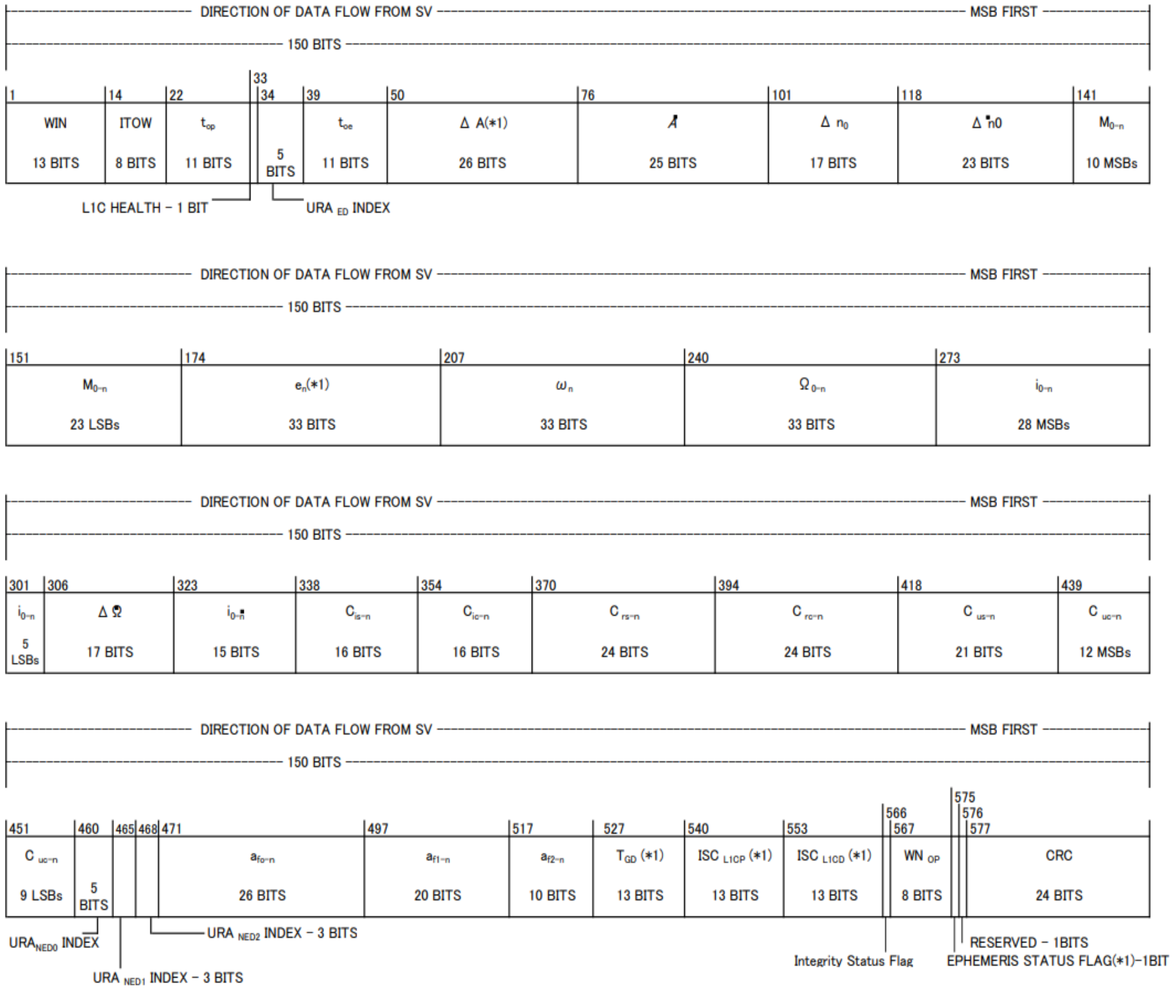
Parameter	Description	Effective range	Number of Bits	LSB	Units
TOI	Time Of Interval Count	0-7182	9	18	s

(1) TOI count

This is the number of next 18-second message epochs since the start of 2-hour ITOW epoch. The TOI count range is from 0 to 399. The start of the 2-hour ITOW epoch is synchronized with the start of subframe 1 and TOI count is “1”. The TOI count is nominally the same on all QZSs.

4.2.2.3. Subframe 2

Figure 4.2.2-2 shows the data format of subframe 2, and Table 4.2.2-4 show its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

Figure 4.2.2-2 Subframe 2 Format

Table 4.2.2-4 Parameter Definitions

Parameter	Description			Effective Range**	Number of Bits	LSB	Units
WN	Week number			0-8191	13	1	weeks
ITOW	Interval time of week			0-83	8	-	-
t_{op}	Data predict time of week			0-604500	11	300	sec
L1C health	L1C health			0-1	1	-	-
URA_{ED}Index	Elevation Dependent URA index			-16-15	5*	-	-
t_{oe}	Ephemeris /clock data reference time of week			0-604500	11	300	sec
ΔA	Ephemeris	Semi-major axis difference at reference time (*1)		**	26*	2^{-9}	m
$\dot{A}$		Change rate in semi-major axis		**	25*	2^{-21}	m/sec
Δn_0		Mean motion difference from computed value at reference time		**	17*	2^{-44}	semi-circle/sec
$\Delta \dot{n}_0$		Rate of mean motion difference from computed value		**	23*	2^{-57}	semi-circle/sec^2
M_{0-n}		Mean anomaly at reference time		**	33*	2^{-32}	semi-circle
e_n		Eccentricity (*1)		**	33	2^{-34}	-
ω_n		Argument of perigee		**	33*	2^{-32}	semi-circle
Ω_{0-n}		Longitude of ascending node of orbit plane at weekly epoch		**	33*	2^{-32}	semi-circle
i_{0-n}		Inclination angle at reference time		**	33*	2^{-32}	semi-circle
$\Delta\dot{\Omega}$		Rate of right ascension difference		**	17*	2^{-44}	semi-circle/sec
IDOT		Rate of inclination angle		**	15*	2^{-44}	semi-circle/sec
C_{is-n}		Amplitude of the sine harmonic correction term to the angle of inclination		**	16*	2^{-30}	rad
C_{ic-n}		Amplitude of the cosine harmonic correction term to the angle of inclination		**	16*	2^{-30}	rad
C_{rs-n}		Amplitude of the sine correction term to the orbit radius		**	24*	2^{-8}	m
C_{rc-n}		Amplitude of the cosine correction term to the orbit radius		**	24*	2^{-8}	m
C_{us-n}		Amplitude of the sine harmonic correction term to the argument of latitude		**	21*	2^{-30}	rad
C_{uc-n}		Amplitude of the cosine harmonic correction term to the argument of latitude		**	21*	2^{-30}	rad
URA_{NED0}Index	Non elevation dependent URA		Index	-	5*	-	-
URA_{NED1}Index			Change index	-	3	-	-
URA_{NED2}Index			Change rate index	-	3	-	-
a_{f0-n}	SV clock	Bias correction coefficient		**	26*	2^{-35}	sec
a_{f1-n}		Drift correction coefficient		**	20*	2^{-48}	sec/sec
a_{f2-n}		Drift rate correction coefficient		**	10*	2^{-60}	sec/sec^2
T_{GD}	Group delay (*1)	Between SV clock and L1C/A***		**	13*	2^{-35}	sec
ISC_{L1CP}		Between L1C/A*** and L1CP		**	13*	2^{-35}	sec
ISC_{L1CD}		Between L1C/A*** and L1CD		**	13*	2^{-35}	sec
ISF	Integrity status flag			-	1	-	-
WN_{op}	Data predict week number			**	8	1	weeks
Ephemeris Status Flag	Indicating the status of ephemeris(*1)			0-1	1	-	-

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.
(***) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

(1) Week number

In GPS, time is expressed in the format of week number and week time. Week number is counted from January 6th, 1980. This is 13-bit binary data (0-8191) that shall be modulo 8192 of each QZSS week number. QZSS week number increases at the start of every week epoch.

(2) Interval time of week (ITOW)

This is a 2-hour epoch starting from the beginning of the GPS week. The range is 0 to 83.

As shown in Figure 4.2.2-3, the time-of-week calculated based on TOI and ITOW (ITOW × 7,200 + TOI × 18) is not always consistent with the start time of the next message (different values are found every 2 hours).

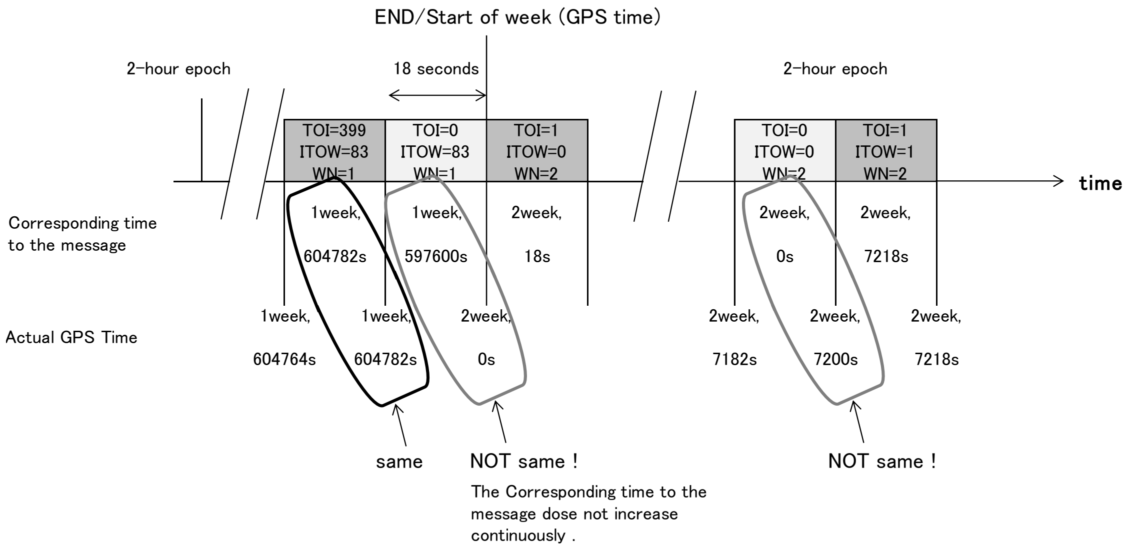


Figure 4.2.2-3 ITOW

(3) Data predict time of week

This is the epoch time of week of the state estimate utilized for prediction of satellite quasi-Keplerian ephemeris parameters.

(4) L1C health

This is the health of L1C.

The definition and user algorithm are shown in Section 5.8.2.

(5) Elevation Dependent URA index

This is the RMS value of the SIS range error at the worst case location and at the maximum time in the effective time period of ephemeris of the same set.

The definition and user algorithm are shown in Section 5.4.3.

(6) Ephemeris / Clock data reference time of week

This is the epoch for the Ephemeris and Clock data.

The user algorithm is shown in Section 5.6.

(7) Ephemeris

This is the trajectory in the Earth-Centered, Earth-Fixed (ECEF) coordinates for each fit interval.

The user algorithm is shown in Section 5.6.

These parameters are defined differently from GPS. For details, see Section 4.2.2.5.

(8) Non elevation dependent URA

This is the RMS values of the worst SIS range errors within the effective period of the SV clock.

The definition and user algorithm are shown in Section 5.4.3.

(9) SV clock

This is the SV clock offset.

The definition and user algorithm are shown in Section 5.5.

For the epoch of the clock parameter, the epoch of the ephemeris t_{oe} (see above (6)) is used.

(10) Group delay

These are the parameters for single-frequency users who use L1C. The definition and user algorithms are shown in Section 5.8.

This is defined differently from GPS. For details, see Section 4.2.2.5.

(11) Integrity status flag (ISF)

This is the integrity assurance level of the signal, see Section 5.4.2.

(12) Data predict week number

This is the week number of the state estimate utilized for the prediction of satellite quasi-Keplerian ephemeris parameters.

(13) Ephemeris Status Flag

The flag indicates when the ephemeris as well as SV clock parameter were uploaded.

"0": within an hour

"1": more than an hour ago

This is defined differently from GPS. For details, see Section 4.2.2.5.

4.2.2.4. Subframe 3

4.2.2.4.1. Overview

Subframe 3 identifies by page number. Every subframe 3 contains a PRN number and page number.

4.2.2.4.2. Page 1 (UTC Parameters and Ionospheric Parameters (Wide Area))

Figure 4.2.2-4 shows the data format and Table 4.2.2-5 shows its parameter definitions.

DIRECTION OF DATA FLOW FROM SV — MSB FIRST

150 BITS

1	9	15	31	44	51	59	75	88	101	105	113	121	129	137	145
PRN	Page No	A0-n(*1)	A1-n(*1)	A2-n (*1)	ΔtLS	tot (*1)	WNt(*1)	WNLSF	DN	ΔtLSF	α0(*1)	α1(*1)	α2(*1)	α3(*1)	β0 (*1)
8 BITS	6 BITS	16 BITS	13 BITS	7 BITS	8 BITS	16 BITS	13 BITS	13 BITS	4 BITS	8 BITS	8 BITS	8 BITS	8 BITS	8 BITS	6 MSBs

DIRECTION OF DATA FLOW FROM SV — MSB FIRST

124 BITS

151	153	161	169	177	190	203	216	229	251 — 274
β0 - 2 LSBs	β1 (*1)	β2 (*1)	β3 (*1)	ISC_L1CA(*1)	ISC_L2C(*1)	ISC_L5I5(*1)	ISC_L5Q5(*1)	RESERVED	CRC
	8 BITS	8 BITS	8 BITS	13 BITS	13 BITS	13 BITS	13 BITS	22 BITS	24 BITS

NOTE: Broadcast sequence of subframe 3 pages is a variable and, as such, users must not expect a fixed pattern of page sequence.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

Figure 4.2.2-4 Subframe 3, Page 1:UTC Parameters and Ionospheric Parameters (Wide Area) Format

Table 4.2.2-5 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
PRN	PRN number for the satellite transmitting the message		193-202	8	1	-
Page No	Page number of the relevant page		1	6	1	-
A_{0-n}	UTC parameter (*1)	Bias coefficient of QZSST relative to UTC(NICT)	**	16*	2^{-35}	sec
A_{1-n}		Drift coefficient of QZSST relative to UTC(NICT)	**	13*	2^{-51}	sec/sec
A_{2-n}		Drift rate coefficient of QZSST relative to UTC(NICT)	**	7*	2^{-68}	sec/sec^2
Δt_{LS}		Current or past leap second count	**	8*	1	sec
t_{ot}		Epoch of UTC Parameter (Time data reference Time of Week)	0-604784	16	2^{+4}	sec
WN_{ot}		Time data reference week number	**	13	1	weeks
WN_{LSF}		Leap second reference week number	**	13	1	weeks
DN		Leap second reference day number	**	4	1	days
Δt_{LSF}		Current or future (updated) leap second count	**	8*	1	sec
α_0	Ionospheric parameter (*1)		**	8*	2^{-30}	sec
α_1			**	8*	2^{-27}	sec/semi-circle
α_2			**	8*	2^{-24}	$sec/semi\text{-}circle^2$
α_3			**	8*	2^{-24}	$sec/semi\text{-}circle^3$
β_0			**	8*	2^{+11}	sec
β_1			**	8*	2^{+14}	semi-circle/sec
β_2			**	8*	2^{+16}	$sec/semi\text{-}circle^2$
β_3			**	8*	2^{+16}	$sec/semi\text{-}circle^3$
$ISC_{L1C/A}$	Group delay (*1)	Between L1C/A*** and L1C/A*** (fixed to "0.0")	**	13*	2^{-35}	sec
ISC_{L2C}		Between L1C/A*** and L2C	**	13*	2^{-35}	sec
ISC_{L5I5}		Between L1C/A*** and L5I5	**	13*	2^{-35}	sec
ISC_{L5Q5}		Between L1C/A*** and L5Q5	**	13*	2^{-35}	sec

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.
(***) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

(1) PRN

This is the PRN number for the satellite transmitting the message.

(2) Page No

This is the page number of the relevant page.

(3) UTC parameter

These are modulo 1 second offset between QZSST and UTC (NICT).

The definition and user algorithms are shown in Section 5.12.

These are defined differently from GPS. For details, see Section 4.2.2.5.

(4) Ionospheric parameter

These are used by the user who only uses L1C to calculate the ionospheric delay.

The parameters can be used in the wide area shown in Section 5.9.3.

The user algorithm is shown in Section 5.9.

This is defined differently from GPS. For details, see Section 4.2.2.5.

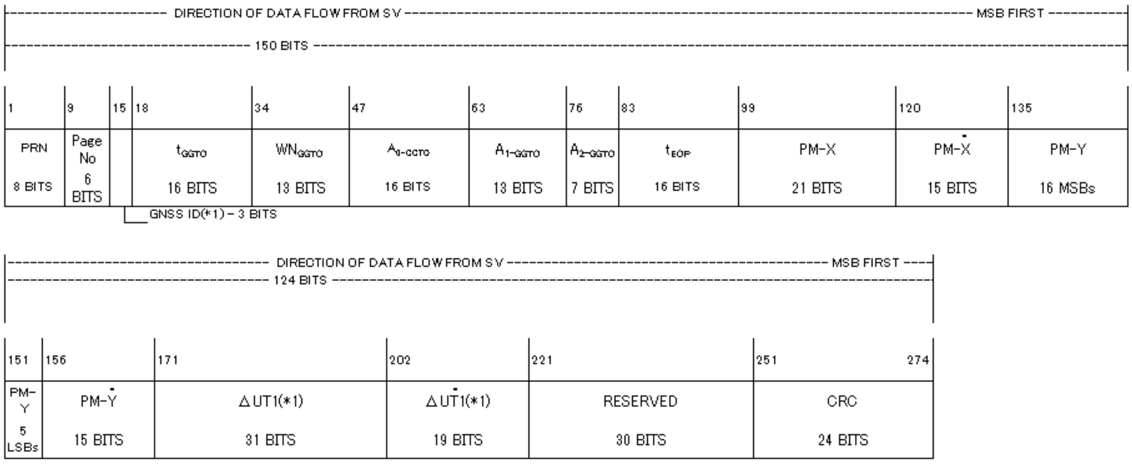
(5) Group delay

These are the parameters for dual-frequency users who use L1/L2 and L1/L5. The definition and user algorithm are shown in Section 5.8.

These parameters are defined differently from GPS. For details, see Section 4.2.2.5.

4.2.2.4.3. Page 2 (GGTO and Earth Orientation Parameter)

Figure 4.2.2-5 shows the data format of page 2, and Table 4.2.2-6 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

Figure 4.2.2-5 Subframe 3, Page 2: GGTO and EOP Format

Table 4.2.2-6 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
PRN	PRN number for the satellite transmitting the message		193-202	8	1	-
Page No	Page number of the relevant page		2	6	1	-
GNSS ID	GNSS Type ID(*1)		-	3	-	-
t_{GGTO}	GGTO parameter (*1)	Time data reference Time of Week	0-604784	16	2^{+4}	sec
WN_{GGTO}		Time data reference Week Number	**	13	1	weeks
A_{0GGTO}		Bias coefficient of QZSS time scale relative to GNSS time scale	**	16*	2^{-35}	sec
A_{1GGTO}		Drift coefficient of QZSS time scale relative to GNSS time scale	**	13*	2^{-51}	sec/sec
A_{2GGTO}		Drift rate coefficient of QZSS time scale relative to GNSS time scale	**	7*	2^{-68}	sec/sec^2
t_{EOP}	Earth orientation parameter	Earth orientation parameter data reference time	0-604784	16	2^{+4}	sec
PM_X		X-axis polar motion value at reference time	+/-1	21*	2^{-20}	arc-sec
PM_$\dot{X}$		X-axis polar motion drift at reference time	+/-7.8125e-3	15*	2^{-21}	arc-sec/day
PM_Y		Y-axis polar motion value at reference time	+/-1	21*	2^{-20}	arc-sec
PM_$\dot{Y}$		Y-axis polar motion drift at reference time	+/-7.8125e-3	15*	2^{-21}	arc-sec/day
ΔUT1(*1)		UT1-UTC Difference at Reference Time	+/-64	31*	2^{-24}	sec
$\Delta U\dot{T}1$(*1)		Rate of UT1-UTC Difference at Reference Time	+/-7.8125e-3	19*	2^{-25}	sec/day
(*) Indicates numbers expressed in two's complement with the MSB used as a signed bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

(1) PRN

This is the PRN number for the satellite transmitting the message.

(2) Page No

This is the page number of the relevant page.

(3) GNSS ID

This is the GNSS ID for GGTO.

These are defined differently from GPS. For details, see Section 4.2.2.5.

0: Data unusable

1: Galileo

2: GLONASS

3: GPS

4 to 7: Spare

(4) GPS/GNSS time offset (GGTO) parameter

These are time offset (GGTO) between GPS and GNSS.

The definition and user algorithm are shown in Section 5.11.

These are defined differently from GPS. For details, see Section 4.2.2.5.

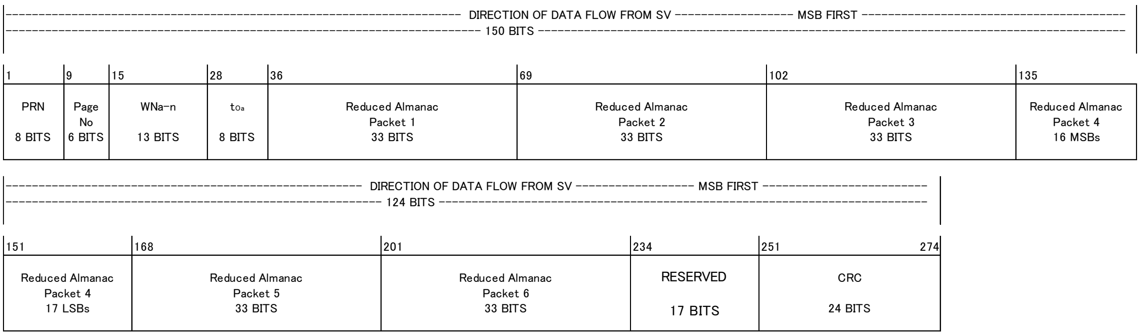
(5) Earth orientation parameter (EOP)

These are used to transform ECEF coordinates to ECI coordinates.

The definition and user algorithm are shown in Section 5.13.

4.2.2.4.4. Page 3 (QZS Reduced Almanac)

Figure 4.2.2-6 shows the data format of page 3 and Table 4.2.2-7 shows its parameter definitions.



NOTE: Broadcast sequence of subframe 3 pages is a variable and, as such, users must not expect a fixed pattern of page sequence.

Figure 4.2.2-6 Subframe 3, Page 3: Reduced Almanac Format

Table 4.2.2-7 Parameter Definitions

Parameter	Description	Effective Range	Number of Bits	LSB	Units
PRN	PRN number for the satellite transmitting the message	193-202	8	1	-
Page No	Page number of the relevant page	3	6	1	-
WN_{a-n}	Almanac reference week	0-8191	13	1	weeks
t_{oa}	Almanac reference time of week	0-602112	8	2^{+12}	sec
-	Reduced almanac packet 1	-	33	-	-
-	Reduced almanac packet 2	-	33	-	-
-	Reduced almanac packet 3	-	33	-	-
-	Reduced almanac packet 4	-	33	-	-
-	Reduced almanac packet 5	-	33	-	-
-	Reduced almanac packet 6	-	33	-	-

(1) PRN

This is the PRN number for the satellite transmitting the message.

(2) Page No

This is the page number of the relevant page.

(3) Almanac reference week

This is the reference week number of almanac orbital information.

The definition and user algorithm are shown in Section 5.7.2.2.

(4) Almanac reference time of week

This is the almanac reference time of week.

The definition and user algorithm are shown in Section 5.7.2.2.

(5) Reduced almanac packet

This is a reduced almanac of each QZS.

Figure 4.2.2-7 shows the data format and Table 4.2.2-8 shows its parameter definitions.

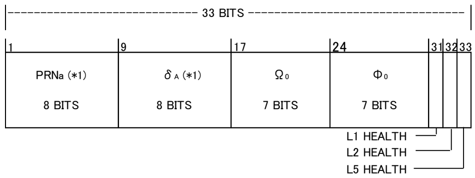


Figure 4.2.2-7 Reduced Almanac Packet Format

Table 4.2.2-8 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
PRN_a	PRN number	193-202	8	1	-
δ_A	Difference from nominal semi-major axis (*1)	**	8*	2^{+9}	m
Ω_0	Longitude of ascending node of orbit plane at weekly epoch	**	7*	2^{-6}	semi-circle
Φ_0	Argument of latitude at reference time	**	7*	2^{-6}	semi-circle
L1/L2/L5 health	L1/L2/L5 health	-	3	-	-
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

(6) PRN number

This is a PRN number indicated by the satellite.

If data are invalid, set to "0".

(7) Reduced almanac data

These are low-accuracy orbit parameters of QZS.

Their definition and user algorithm are shown in Section 5.7.2.2.

These are defined differently from GPS. For details, see Section 4.2.2.5.

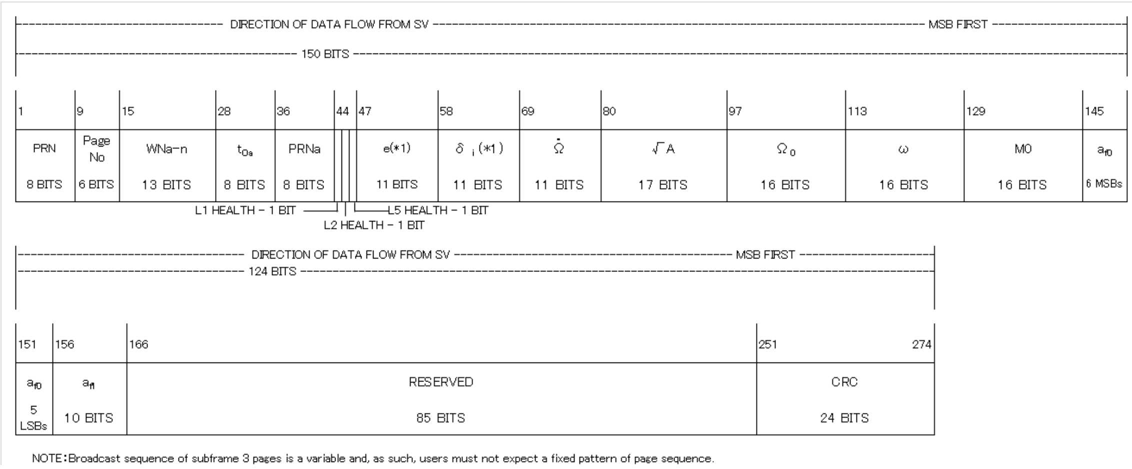
(8) L1/L2/L5 health

This is the health of the L1, L2, and L5 signals from the satellite that corresponds to the PRN number. Since the PRN numbers for the L1C/B signal are not included in the PRN number defined in (6), the health of the L1C/B signal is notified by the L1 health of the PRN number from 193 to 202 that defines the signal of the satellite transmitting the L1C/B signal.

The definitions and user algorithm are shown in Section 5.4.1.

4.2.2.4.5. Page 4 (QZS Midi Almanac)

Figure 4.2.2-8 shows the data format of page 4, and Table 4.2.2-9 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

Figure 4.2.2-8 Subframe 3, Page 4: Midi Almanac Format

Table 4.2.2-9 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
PRN	PRN number for the satellite transmitting the message		193-202	8	1	-
Page No	Page number of the relevant page		4	6	1	-
WN_{a-n}	Midi almanac	Almanac reference week	0-8191	13	1	weeks
t_{oa}		Almanac reference time of week	0-602112	8	2^{+12}	sec
PRN_a	PRN number for almanac		**	8	1	-
L1/L2/L5 health	L1/L2/L5 health		-	3	-	-
e	Midi almanac (*1)	Difference from reference eccentricity	**	11	2^{-16}	-
δ_i		Difference from reference angle of inclination	**	11*	2^{-14}	semi-circle
$\dot{\Omega}$		Rate of right ascension	**	11*	2^{-33}	semi-circle/sec
$\sqrt{A}$		Square root of the semi-major axis	**	17	2^{-4}	$m^{1/2}$
Ω_0		Longitude of ascending node of orbit plane at weekly epoch	**	16*	2^{-15}	semi-circle
ω		Argument of perigee	**	16*	2^{-15}	semi-circle
M_0		Mean anomaly at reference time	**	16*	2^{-15}	semi-circle
a_{f0}		SV clock bias correction coefficient	**	11*	2^{-20}	sec
a_{f1}		SV clock drift correction coefficient	**	10*	2^{-37}	sec/sec

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.2.2.5.

(1) PRN

This is the PRN number for the satellite transmitting the message.

(2) Page No

This is the page number of the relevant page.

(3) PRN number for almanac

This is a PRN number indicated by the relevant almanac. If data are invalid, set to “0”.

(4) L1/L2/L5 health

This is the health of the L1, L2, and L5 signals from the satellite that corresponds to the PRN number. Since the PRN numbers for the L1C/B signal are not included in the PRN number for almanac defined in (3), the health of the L1C/B signal is notified by the L1 health of the PRN number from 193 to 202 that defines the signal of the satellite transmitting the L1C/B signal.

The definition and user algorithm are shown in Section 5.4.1.

(5) Midi almanac

These are low-accuracy satellite orbit and the SV clock.

The definition and user algorithm are shown in Section 5.7.2.1.

These are defined differently from GPS. For details, see Section 4.2.2.5.

4.2.2.4.6. Page 6 (Text Message)

Figure 4.2.2-9 shows the data format of page 6, and Table 4.2.2-10 shows its parameter definitions.

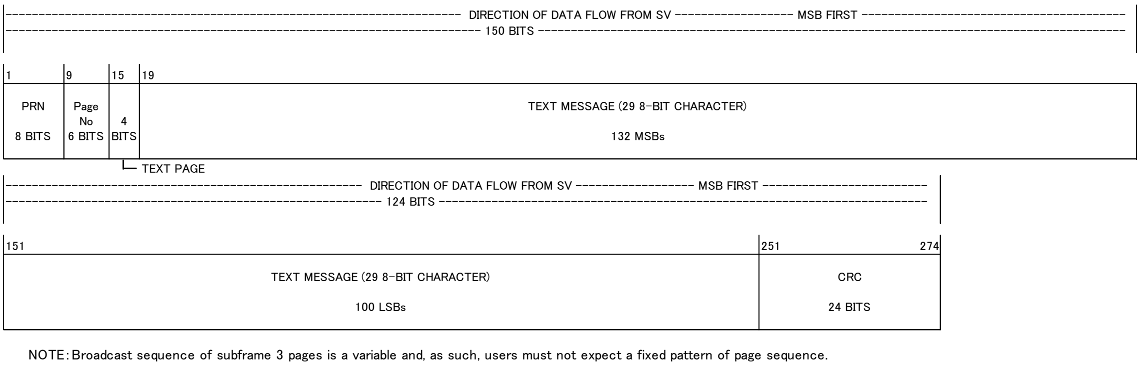


Figure 4.2.2-9 Subframe 3, Page 6: Text Message Format

Table 4.2.2-10 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
PRN	PRN number for the satellite transmitting the message	193-202	8	1	-
Page No	Page number of the relevant page	6	6	1	-
Text Page	Text page	0-15	4	1	-
Text Message	Text message	-	232	-	-
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

(1) PRN

This is the PRN number for the satellite transmitting the message.

(2) Page No

This is the page number of the relevant page.

(3) Text page

This is the page number of the text message.

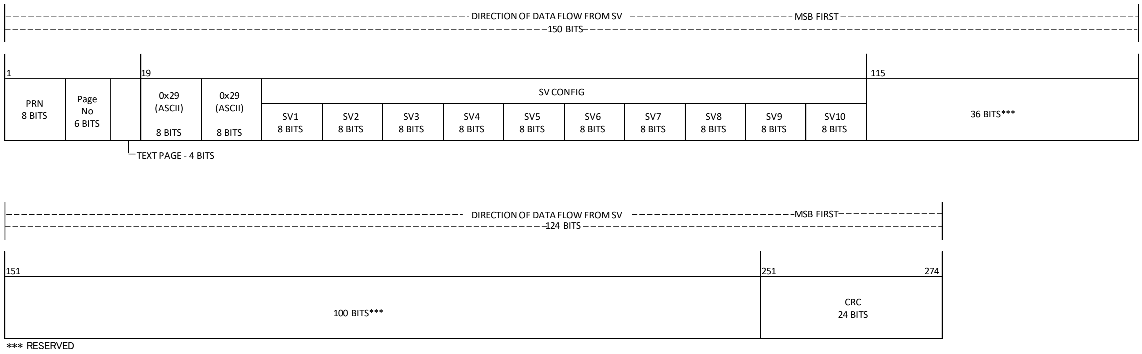
(4) Text message

Text data message transmitted in a navigation message. A text message can contain information not related to positioning. Text messages are currently not used for any specific purpose. This is a string composed of 29 eight-bit ASCII characters.

In case that the 4 bits field of Text Page is 0x0(0000) and the upper 16 bits field of Text message is 0x2929(0010100100101001), SV Configuration information is broadcasted on and after the 17 bits of Text message.

For details, refer to the following Figure and Table.

Parameter definitions of SV Configuration



Field		Parameter	Value
Text Page	4BITS	Text Page	0000
Text Message	8BITS	1st CHARACTER	0010100100101001: SV Configuration Other combinations: Text Messages
	8BITS	2nd CHARACTER	
	8BITS	SV Configuration (PRN193)	01100000:No satellite configuration 01100001:Block I 01100010:Block II 01100011:Block III 01100100~01101110: Reserved 01101111:not in PNT Service
	8BITS	SV Configuration (PRN194)	
	8BITS	SV Configuration (PRN195)	
	8BITS	SV Configuration (PRN196)	
	8BITS	SV Configuration (PRN197)	
	8BITS	SV Configuration (PRN198)	
	8BITS	SV Configuration (PRN199)	
	8BITS	SV Configuration (PRN200)	
	8BITS	SV Configuration (PRN201)	
	8BITS	SV Configuration (PRN202)	
	36BITS	Reserved	
	100BITS	Reserved	

4.2.2.4.7. Page 61 (UTC Parameter and Ionospheric Parameter (Japan area))

Ionospheric (Japan area) and UTC parameters is same as a definition of Ionospheric (Wide area) and UTC parameters.

See Section 4.2.2.4.2.

The Ionospheric (Japan area) parameters can be used in the Japan area shown in Section 5.9.3.

4.2.2.5. (Reference) Differences from GPS

Table 4.2.2-11 shows parameters that are defined differently from GPS definitions specified in Section 2.2 of Reference Document (3).

Table 4.2.2-11 Parameters Defined Differently from GPS (CNAV2(L1C))

Sub frame	Page	Parameter	GPS	QZSS
2	-	Ephemeris (ΔA)	Difference from reference semi-major axis (A_{REF})	
			A_{REF} = 26 559 710 [m]	A_{REF} = 42 164 200 [m]
		Ephemeris (e_n)	Eccentricity of ephemeris	
			Upper limit of parameter range of 0.03	Parameter range is not restricted.
		T_{GD}	Group delay between SV clock and L1P (Y) time	Group delay between SV clock and L1C/A* time
		ISC_{L1CP}	Group delay between L1P (Y) and L1CP	Group delay between L1C/A* and L1CP
		ISC_{L1CD}	Group delay between L1P (Y) and L1CD	Group delay between L1C/A* and L1CD
		EPHEMERIS STATUS FLAG	Reserved	Indicating the status of ephemeris "0": within an hour "1": more than an hour ago
3	1	UTC parameter (A_{0-n}, A_{1-n}, A_{2-n}, t_{ot}, WN_t)	Relationship between UTC (USNO) and GPST	Relationship between UTC (NICT) and QZSST
		Ionospheric parameter (α_0, α_1, α_2, α_3, β_0, β_1, β_2, β_3)	The target area	
			The entire globe	Wide area (In addition, the target area is "Japan area" in page 61.)
		$ISC_{L1C/A}$	Group delay between L1P (Y) and L1C/A	Group delay between L1C/A* and L1C/A*
		ISC_{L2C}	Group delay between L1P (Y) and L2C	Group delay between L1C/A* and L2C
		ISC_{L5I5}	Group delay between L1P (Y) and L5I5	Group delay between L1C/A* and L5I5
		ISC_{L5Q5}	Group delay between L1P (Y) and L5Q5	Group delay between L1C/A* and L5IQ
	2	GNSS time offset	Relationship between GPST and other GNSS time	Relationship between QZSST and other GNSS time
		GNSS ID	ID of GNSS indicated by the GNSS time offset parameter	
			"0": N/A "1": Galileo "2": GLONASS "3 to 7": spare	"0": N/A "1": Galileo "2": GLONASS "3": GPS "4 to 7": spare
		Earth orientation parameter	ΔUTGPS: UT1-GPS $\Delta U\dot{T}GPS$: Rate of UT1-GPS LSB of ΔUTGPS is equal to 2^{-23}.	ΔUT1: UT1-UTC $\Delta U\dot{T}1$: Rate of UT1-UTC LSB of ΔUT1 is equal to 2^{-24}.
	3	Reduced almanac (δA)	Difference from reference semi-major axis (A_{REF})	
			A_{REF} = 26 559 710 [m]	A_{REF} = 42 164 200 [m]
		Precondition for reduced almanac (e)	Eccentricity	
			e = 0 [-]	e = 0.075 [-] (QZO) GEO/QGEO: Same as left
		Precondition for reduced almanac (i)	Angle of orbit inclination	
			i = 55 [deg]	i = 43 [deg] (QZO) i = 0 [deg] (GEO/QGEO)
		Precondition for reduced almanac ($\dot{\Omega}$)	Rate of time change of right ascension of ascending node	
			$\dot{\Omega}$= -2.6 × 10^{-9} [sc/s]	$\dot{\Omega}$= -8.7 × 10^{-10} [sc/s] (QZO) $\dot{\Omega}$= 0 [sc/s] (GEO/QGEO)

Sub frame	Page	Parameter	GPS	QZSS
		Precondition for reduced almanac (ω)	Argument of perigee ω = 0 [deg]	 ω = 270 [deg] (QZO) GEO/QGEO: Same as left
	4	Midi almanac (e)	Eccentricity	Difference from reference eccentricity (e_{REF}) e_{REF} = 0.06 [-] (QZO) e_{REF} = 0 [-] (GEO/QGEO)
		Midi almanac (δi)	Difference from reference angle of inclination (i_0) i_0 = 0.3 [semi-circles]	Difference from reference angle of inclination (i_{REF}) i_{REF} = 0.25 [semi-circles] (QZO) i_{REF} = 0 [semi-circles] (GEO/QGEO)
	5	Correction data	Ephemeris correction data and clock correction data	Not transmitted.
	6	Text	Text message	Not transmitted.
	7	SV Configuration	3-bit SV Configuration	Not transmitted.
	8	Integrity Support Message (ISM)	ISM Parameters	Not transmitted.

(*) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

4.2.2.6. (Delete)

4.3. CNAV(L2C,L5)

4.3.1. Message Configuration

4.3.1.1. Overview

Each CNAV(L2C,L5) message to be transmitted by L2CM and L5I consists of 300 bits as shown in Figure 4.3.1-1, and a single message is transmitted in 12 seconds (25 bps) on L2C and 6 seconds (50 bps) on L5.

Each message consists of 8-bit preamble, 6-bit PRN ID, 6-bit type ID, 17-bit TOW count, 1-bit alert flag, 238-bit message and 24-bit CRC. The messages are encoded by forward error correction (FEC) at 1/2 encoding rate.

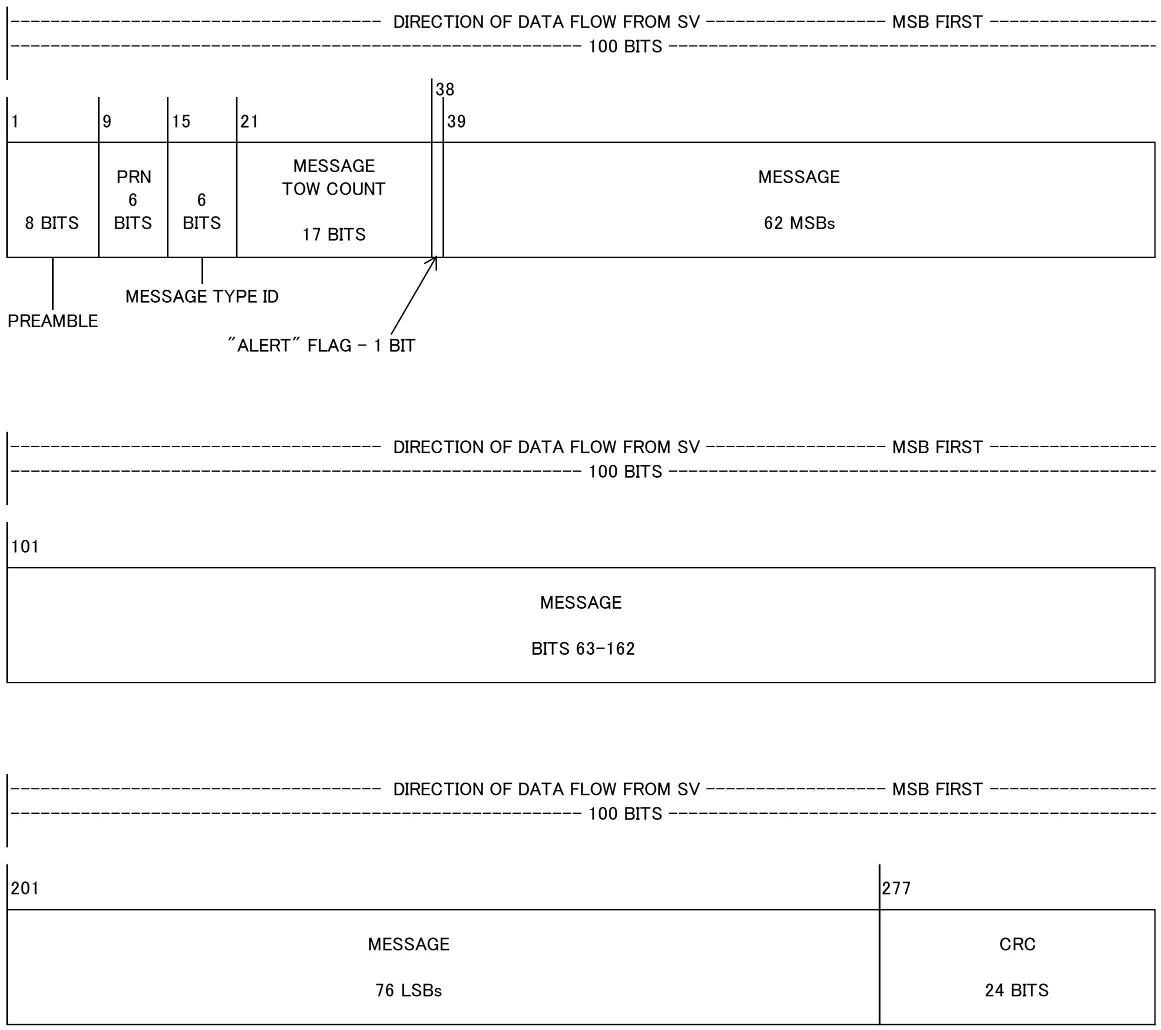


Figure 4.3.1-1 CNAV(L2C,L5) Message Configuration

4.3.1.2. Timing

(1) Message pattern

At the beginning of the week, the message pattern is reset.

(2) Update timing

Each navigation message may be updated at a different timing with each satellite and each signal.

(3) Transmission Cycle

Table 4.3.1-1 shows maximum transmission intervals.

Table 4.3.1-1 Maximum Transmission Intervals

Message Data	Format (Message Type ID)	Maximum Transmission Interval of L2C (seconds)	Maximum Transmission Interval of L5 (seconds)	Remarks
SV clock	Types 30 to 37, 61	48	24	
Ephemeris	Types 10 and 11	48	24	
Group delay	Type 30	288	144	
Ionospheric parameter (wide area)	Type 30	288	144	
Ionospheric parameter (Japan area)	Type 61	288	720	
QZS reduced almanac	Type 12 or 31	1200(*1)	600(*1)	
QZS Midi almanac	Type 37	7200(*1)	3600(*1)	
Earth orientation parameter	Type 32	1800	900	
UTC parameter	Type 33	288	144	
GGTO	Type 35	288	144	
Text message	Type 15	-	-	Not specified
QZNMA	Type 60	-	(*2)	

*1: Maximum interval when this message is transmitted

*2: To be specified in detail as data in "IS-QZSS-SAS". QZNMA applies to L5 signal only.

(4) Update interval and Fit interval

Table 4.3.1-2 shows the nominal update intervals, fit intervals, and validity periods in the difference between the epoch and current time of various parameters.

Table 4.3.1-2 Update Interval and Fit Intervals

Parameter	Update Interval	Fit Interval	Validity Period (*1)
SV clock	1 hour (*2)	2 hours	2 hours
Ephemeris	1 hour (*2)	2 hours	2 hours
Elevation-dependent URA	1 hour	Not applicable because time information indicating the epoch is not included.	
Non-elevation-dependent URA	1 hour	2 hours	2 hours
Group delay	1 day	Not applicable because time information indicating the epoch is not included.	
Reduced almanac	1 day	6 days	144 hours
Midi almanac	1 day	6 days	144 hours
Ionospheric parameter (wide area)	1 hour	Not applicable because time information indicating the epoch is not included.	
Ionospheric parameter (Japan area)	1 hour	Not applicable because time information indicating the epoch is not included.	
Earth orientation parameter	1 hour (*3)	2 hours	12 hours
UTC parameter	1 day	6 days	144 hours
GGTO	1 day	6 days	144 hours

*1: The validity periods are twice the absolute value of the differences between the current time (t) and the epochs (t_o) as follows:

SV clock epoch t_{oc}	:$\lvert t - t_{oc}\rvert$
Ephemeris epoch t_{oe}	:$\lvert t - t_{oe}\rvert$
Non-elevation-dependent URA epoch t_{op}	:$\lvert t - t_{op}\rvert$
Reduced almanac epoch t_{oa}	:$\lvert t - t_{oa}\rvert$
Midi almanac epoch t_{oa}	:$\lvert t - t_{oa}\rvert$
Earth orientation parameter epoch t_{EOP}	:$\lvert t - t_{EOP}\rvert$
UTC parameter epoch t_{ot}	:$\lvert t - t_{ot}\rvert$
GGTO epoch t_{GGTO}	:$\lvert t - t_{GGTO}\rvert$

*2: The update interval is a nominal value, and users should detect the update of the clock and ephemeris parameter by toc and toe.

*3: The update interval is a nominal value.

4.3.1.3. Cyclic Redundancy Check (CRC)

See, Section 4.2.1.4.

4.3.1.4. Forward Error Correction (FEC)

The CNAV(L2C,L5) bit string will become a Forward Error Correction (FEC) encoded by a convolution code with an encoding rate of 1/2 rate. 25-bps L2C messages are encoded to 50sps symbols and 50-bps L5 messages are encoded to 100sps symbols. The convolutional coding will be constraint length 7, with a convolutional encoder logic arrangement as shown in Figure 4.3.1-2. The G1 symbol is selected on the output as the first half of a 40-millisecond data bit period (25 bps) with L2C and of a 20-millisecond data bit period (50 bps) with L5.

The beginning of the first symbol that contains any information about the first bit of a message will be synchronized, in SV clock, to the end/start of the week of QZSST.

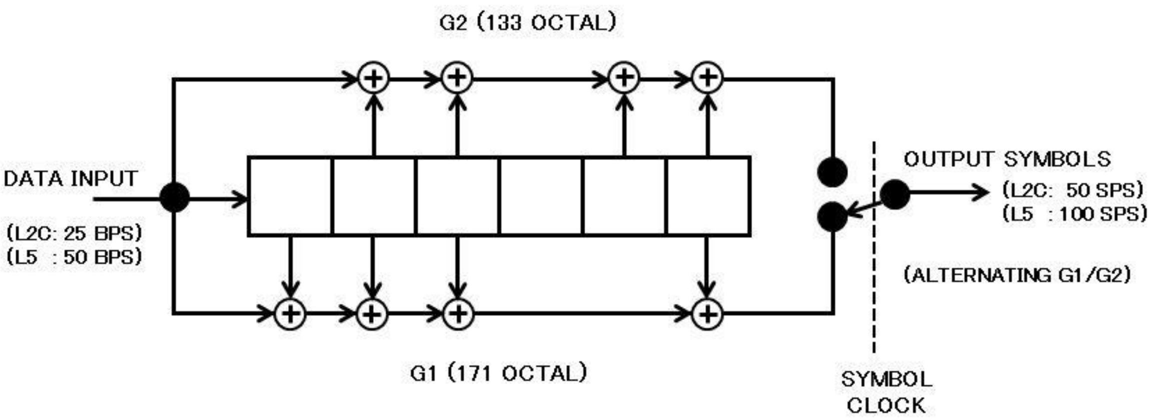


Figure 4.3.1-2 Convolutional Encoder

4.3.1.5. Default message

When the system detects an error, the default message shown in Table 4.3.1-3 may be transmitted.

Table 4.3.1-3 Default message

Item	Description
Preamble	appropriate Preamble
PRN	appropriate PRN
Type ID	"0"
TOW count	appropriate TOW count
Alert flag	"1"
Message	alternating "1" and "0"
CRC	appropriate CRC

4.3.1.6. Invalid Message

When the system detects an error, an error message in which all bits are 0 may be transmitted.

4.3.2. Message Content

4.3.2.1. Overview

The content shown in Table 4.3.2-1 are stored in each message type of CNAV(L2C,L5) message.

Table 4.3.2-1 CNAV(L2C,L5) Message Content

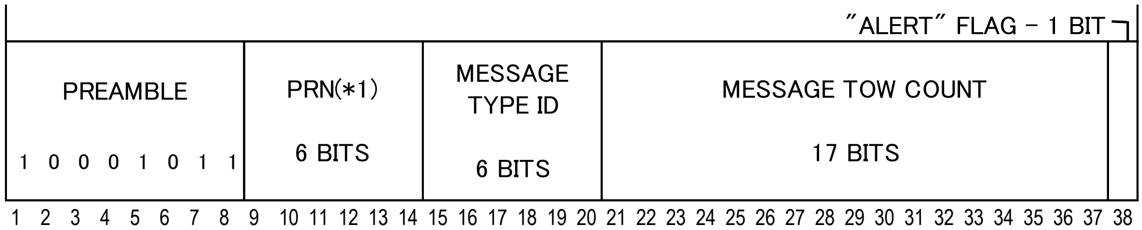
Message Type ID	Description
0	Test mode(*1)
10	Ephemeris 1
11	Ephemeris 2
12	QZS reduced almanac
15	Text message
30	SV clock, ionospheric parameter (wide area) and ISC
31	SV clock and QZS reduced almanac
32	SV clock and earth orientation parameter
33	SV clock and UTC parameter
35	SV clock and GGTO
37	SV clock and QZS Midi almanac
60	QZNMA(*2)
61	SV clock, ionospheric parameter (Japan area) and ISC

(*1): Message Type 0 indicates that CNAV (L2C,L5) signal of the QZS is in test mode. When receiving Message Type 0, the user should not use that messages.

(*2): QZNMA applies to L5 signal only.

4.3.2.2. Common Section

All message types of CNAV(L2C,L5) navigation messages contain the common parameters shown in Figure 4.3.2-1 and Table 4.3.2-2.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-1 Common Sections of CNAV(L2C,L5) Messages Format

Table 4.3.2-2 Parameter Definitions

Parameter	Description	Effective Range	Number of Bits	LSB	Units
Preamble	Preamble	-	8	-	-
PRN	PRN ID (*1)	1-10	6	1	-
Message Type ID	Message type ID	0-63	6	1	-
Message TOW Count	Message time-of-week count	0-604794	17	6	sec
Alert Flag	Alert flag	0-1	1	-	-

*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) Preamble

Fix to “10001011”(B).

(2) PRN ID

The PRN number information is indicated by the 6LSBs of the PRN number. This is defined differently from GPS. For details, see Section 4.3.2.15.

(3) Message type ID

This is the type ID of the message.

(4) Message TOW count

This is the time of week at the end of the message.

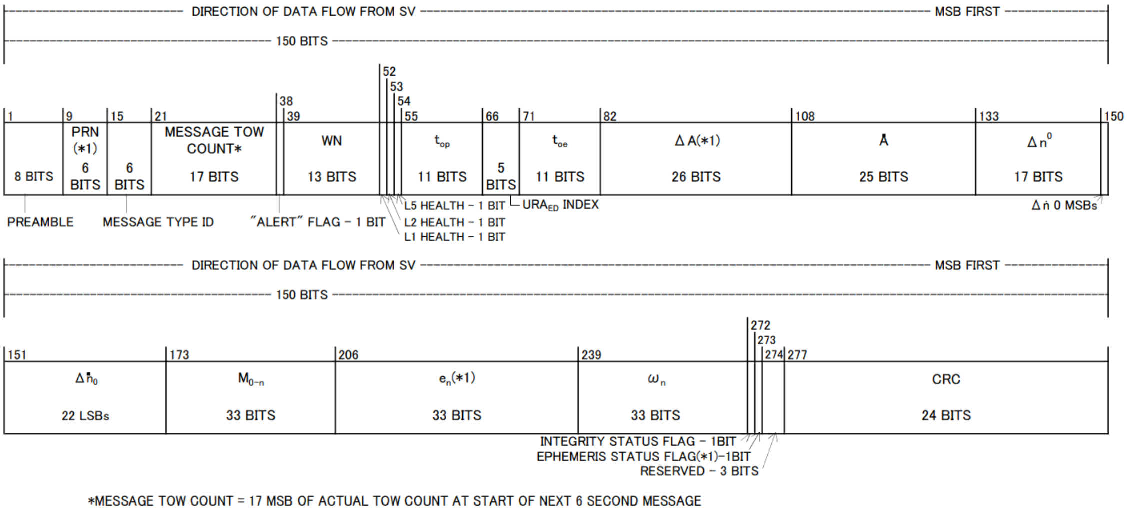
(5) Alert flag

This informs the user that the signal cannot be used due to increase of the user range error or occurrence of other error.

For details, see Section 5.4.1.

4.3.2.3. Message Type 10 (Ephemeris 1)

Figure 4.3.2-2 shows the data format of message type 10, and Table 4.3.2-3 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-2 Message Type 10: Ephemeris 1 Format

Table 4.3.2-3 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	Common section of CNAV(L2C,L5) (See Table 4.3.2-2)		-	38	-	-
WN	Week number		0-8191	13	1	weeks
Signal health (L1/L2/L5)	L1/L2/L5 health		-	3	1	-
t_{op}	Data predict time of week		0-604500	11	300	seconds
URA_{ED} Index	Elevation dependent URA index		-16-15	5*	-	-
t_{oe}	Ephemeris	Ephemeris data reference time of week	0-604500	11	300	seconds
ΔA		Semi-major axis difference at reference time (*1)	**	26*	2^{-9}	meters
$\dot{A}$		Change rate in semi-major axis	**	25*	2^{-21}	meters/sec
Δn_0		Mean motion difference from computed value at reference time	**	17*	2^{-44}	semi-circles/sec
$\Delta \dot{n}_0$		Rate of mean motion difference from computed value	**	23*	2^{-57}	semi-circles/sec^2
M_{0-n}		Mean anomaly at reference time	**	33*	2^{-32}	semi-circles
e_n		Eccentricity (*1)	**	33	2^{-34}	dimensionless
ω_n		Argument of perigee	**	33*	2^{-32}	semi-circles
ISF	Integrity status flag		0-1	1	-	-
Ephemeris Status Flag	Indicating the status of ephemeris(*1)		0-1	1	-	-
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) Week number

In GPS, time is expressed in the format of week number and week time. Week number is counted from January 6th, 1980. This is 13-bit binary data (0-8191) that shall be modulo 8192 of each QZSS week number. QZSS week number increases at the start of every week epoch.

(2) Signal health (L1/L2/L5)

This is the health of L1, L2 and L5.

The definitions and user algorithms are shown in Section 5.4.1.

(3) Data predict time of week

This is the epoch time of week of the state estimate utilized for the prediction of satellite quasi-Keplerian ephemeris parameters.

(4) Elevation dependent URA index

This is the RMS value of the SIS range error for the worst case location and at the maximum time in the effective time period of the ephemeris of the same set.

The definition and user algorithm are shown in Section 5.4.3.

(5) Ephemeris

These are the trajectory in the Earth-Centered, Earth-Fixed (ECEF) coordinates for each fit interval.

The user algorithm is shown in Section 5.6.

These are defined differently from GPS. For details, see Section 4.3.2.15.

(6) Integrity status flag (ISF)

This is the integrity assurance level of the signal.

The definition is shown in Section 5.4.2.

(7) Ephemeris Status Flag

The flag indicates when the ephemeris as well as SV clock parameter were uploaded.is generated.

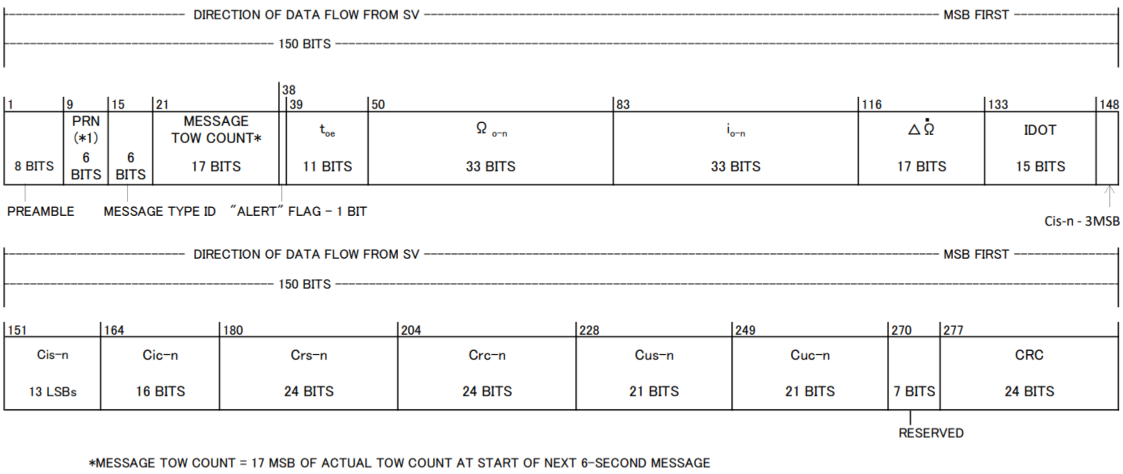
"0": within an hour

"1": more than an hour ago

This is defined differently from GPS. For details, see Section 4.3.2.15.

4.3.2.4. Message Type 11 (Ephemeris 2)

Figure 4.3.2-3 shows the data format of message type 11, and Table 4.3.2-4 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-3 Message Type 11: Ephemeris 2 Format

Table 4.3.2-4 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	Common section of CNAV(L2C,L5) (See Table 4.3.2-2)		-	38	-	-
t_{oe}	Ephemeris	Ephemeris data reference time of week	0-604500	11	300	seconds
Ω_{0-n}	Ephemeris	Longitude of ascending node of orbit plane at weekly epoch	**	33*	2^{-32}	semi-circles
i_{0-n}	Ephemeris	Inclination angle at reference time	**	33*	2^{-32}	semi-circles
$\Delta\dot{\Omega}$	Ephemeris	Rate of right ascension difference	**	17*	2^{-44}	semi-circles/sec
IDOT	Ephemeris	Rate of inclination angle	**	15*	2^{-44}	semi-circles/sec
C_{is-n}	Ephemeris	Amplitude of the sine harmonic correction term to the angle of inclination	**	16*	2^{-30}	radians
C_{ic-n}	Ephemeris	Amplitude of cosine harmonic correction term to the angle of inclination	**	16*	2^{-30}	radians
C_{rs-n}	Ephemeris	Amplitude of the sine correction term to the orbit radius	**	24*	2^{-8}	meters
C_{rc-n}	Ephemeris	Amplitude of the cosine correction term to the orbit radius	**	24*	2^{-8}	meters
C_{us-n}	Ephemeris	Amplitude of the sine harmonic correction term to the argument of latitude	**	21*	2^{-30}	radians
C_{uc-n}	Ephemeris	Amplitude of the cosine harmonic correction term to the argument of latitude	**	21*	2^{-30}	radians
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

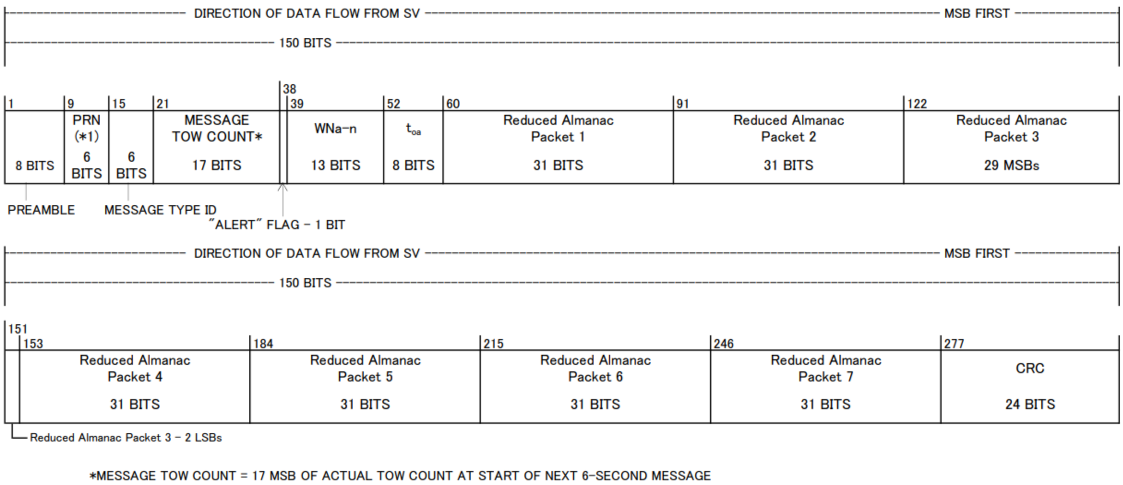
(1) Ephemeris

These are the trajectory in the Earth-Centered, Earth-Fixed (ECEF) coordinates for each fit interval.

The user algorithm is shown in Section 5.6.

4.3.2.5. Message Type 12 (QZS Reduced Almanac)

Figure 4.3.2-4 shows the data format of message type 12, and Table 4.3.2-5 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-4 Message Type 12: Reduced Almanac Format

Table 4.3.2-5 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	Common section of CNAV(L2C,L5) (See Table 4.3.2-2)	-	38	-	-
WN_{a-n}	Almanac reference week	0-8191	13	1	weeks
t_{oa}	Almanac reference time of week	0-602112	8	2^{12}	seconds
-	Reduced almanac packet 1	-	31	-	-
-	Reduced almanac packet 2	-	31	-	-
-	Reduced almanac packet 3	-	31	-	-
-	Reduced almanac packet 4	-	31	-	-
-	Reduced almanac packet 5	-	31	-	-
-	Reduced almanac packet 6	-	31	-	-
-	Reduced almanac packet 7	-	31	-	-
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

(1) Almanac reference week

This is the reference week number of almanac orbital information.

The definition and user algorithm are shown in Section 5.7.2.2.

(2) Almanac reference time of week

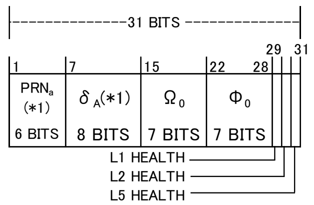
This is the almanac reference time of week.

The definition and user algorithm are shown in Section 5.7.2.2.

(3) Reduced almanac packet

Reduced almanac packets 1 to 7 contain reduced almanacs for QZSs.

Figure 4.3.2-5 shows the data format of each reduced almanac packet, and Table 4.3.2-6 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-5 Reduced Almanac Packet Format

Table 4.3.2-6 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
PRN_a	PRN ID (*1)		1-10	6	-	-
δ_A	Reduced almanac data	Difference from nominal semi-major axis (*1)	**	8*	2^{+9}	m
Ω_0		Longitude of ascending node of orbit plane at weekly epoch	**	7*	2^{-6}	semi-circle
Φ_0		Argument of latitude at reference time	**	7*	2^{-6}	semi-circle
L1/L2/L5 health	L1/L2/L5 health		-	3	-	-
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(a) PRN ID

This is the number of the 6LSBs of the PRN number of QZS.

If data are invalid, set to “0”.

This is defined differently from GPS. For details, see Section 4.3.2.15.

(b) L1/L2/L5 health

This is the health of the L1, L2 and L5 signals from the satellite that corresponds to the PRN number. Since the PRN numbers for the L1C/B signal are not included in the PRN ID defined in (a), the health of the L1C/B signal is notified by the L1 health of the PRN number from 193 to 202 that defines the signal of the satellite transmitting the L1C/B signal.

The definition and user algorithm are shown in Section 5.4.1.

(c) Reduced almanac data

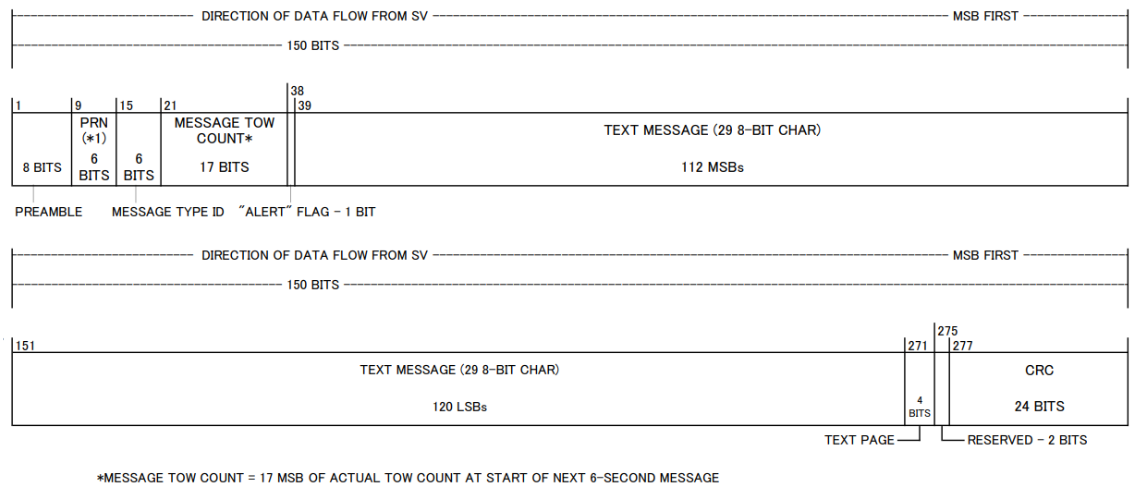
These are low-accuracy orbit parameters of QZS.

Their definition and user algorithms are shown in Section 5.7.2.2.

These are defined differently from GPS. For details, see Section 4.3.2.15.

4.3.2.6. Message Type 15 (Text Message)

Figure 4.3.2-6 shows the data format of message type 15, and Table 4.3.2-7 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-6 Message Type 15: Text Message Format

Table 4.3.2-7 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	Common section of CNAV(L2C,L5) (See Table 4.3.2-2)	-	38	-	-
Text Message	Text message in 29 ASCII characters	-	232	-	-
Text Page	Text page	-	4	-	-
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

(1) Text message

Text data message transmitted in a navigation message. A text message can contain information not related to positioning. Text messages are currently not used for any specific purpose. This is a string composed of 29 eight-bit ASCII characters.

(2) Text page

This is the page number of the text message.

4.3.2.7. Common to Message Types 30 to 37 and 61 (SV Clock Parameters)

Message types 30 to 37 and 61 contain SV clock parameters. Figure 4.3.2-7 shows the data format, and Table 4.3.2-8 shows the SV clock parameter definitions.

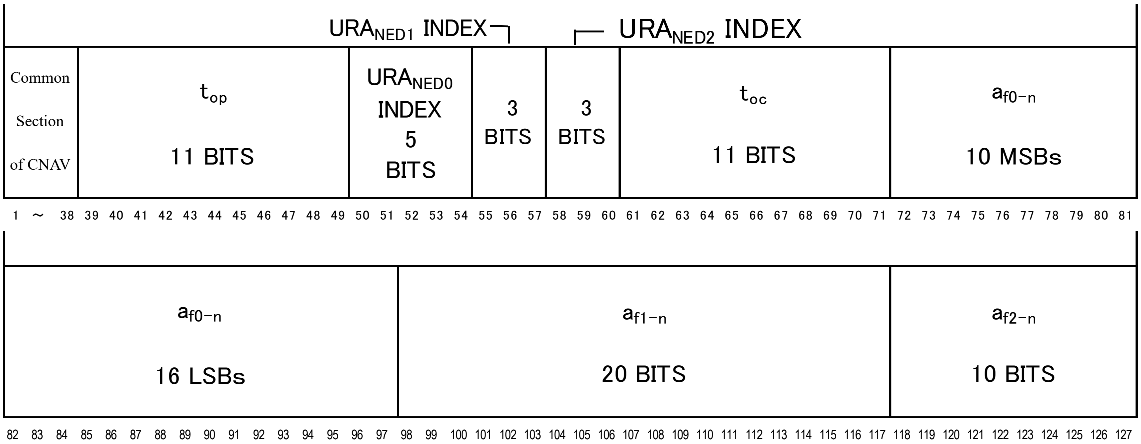


Figure 4.3.2-7 SV Clock Parameter Format

Table 4.3.2-8 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	Common section of CNAV(L2C,L5) (See Table 4.3.2-2)	-	-	-	-
t_{op}	Data predict time of week	0-604500	11	300	seconds
URA_{NED0} Index	Non-elevation-dependent URA index (0 order)	-	5*	-	-
URA_{NED1} Index	Non-elevation-dependent URA index (1st order)	-	3	-	-
URA_{NED2} Index	Non-elevation-dependent URA index (2nd order)	-	3	-	-
t_{oc}	SV clock parameter (clock data reference time of week)	0-604500	11	300	seconds
a_{f0-n}	SV clock parameter (bias correction coefficient)	**	26*	2^{-35}	seconds
a_{f1-n}	SV clock parameter (drift correction coefficient)	**	20*	2^{-48}	sec/sec
a_{f2-n}	SV clock parameter (drift rate correction coefficient)	**	10*	2^{-60}	sec/sec^2

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.

(1) Data predict time of week

This is the epoch time of week of the state estimate utilized for the prediction of satellite quasi-Keplerian ephemeris parameters.

(2) Non-elevation-dependent URA index

This is the RMS values of the worst SIS range errors within the effective period of the SV clock.

The definition and user algorithm are shown in Section 5.4.3.

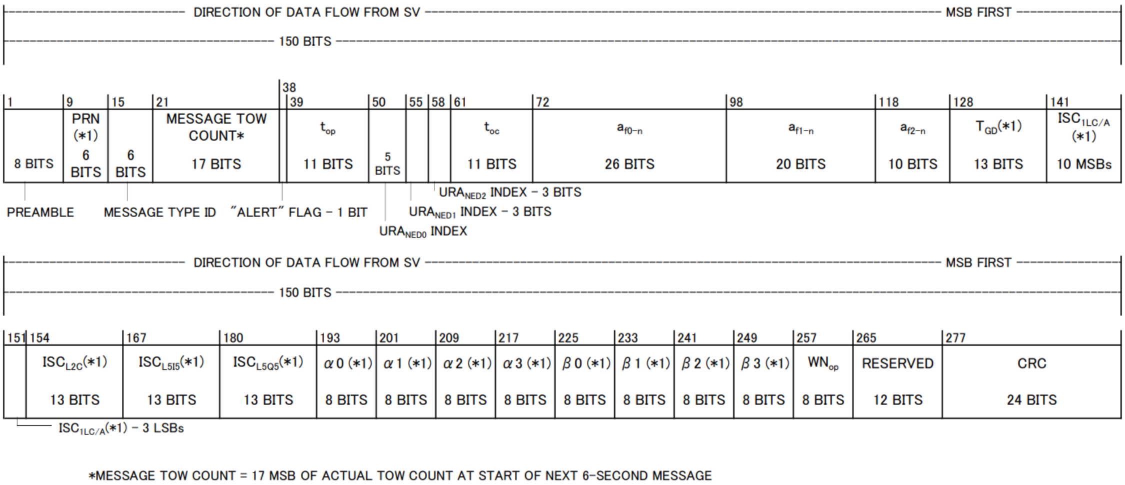
(3) SV clock parameter

These are used to correct the SV clock offset by the user.

The definition and user algorithm are shown in Section 5.5.

4.3.2.8. Message Type 30 (Clock, Ionospheric (Wide Area) and Group Delay Differential Correction Parameters)

Figure 4.3.2-8 shows the data format of message type 30, and Table 4.3.2-9 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-8 Message Type 30: Clock, IONO, and Group Delay Format

Table 4.3.2-9 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)		-	-	-	-
T_{GD}	Group delay correction parameter for group delay between SV clock and L1C/A*** (*1)		**	13*	2^{-35}	sec
$ISC_{L1C/A}$	Inter-signal correction parameter for group delay(*1)	Between L1C/A*** and L1C/A*** (fixed to "0.0")	**	13*	2^{-35}	sec
ISC_{L2C}		Between L1C/A*** and L2C	**	13*	2^{-35}	sec
ISC_{L5I5}		Between L1C/A*** and L5I5	**	13*	2^{-35}	sec
ISC_{L5Q5}		Between L1C/A*** and L5Q5	**	13*	2^{-35}	sec
α_0	Ionospheric parameter (*1)		**	8*	2^{-30}	sec
α_1			**	8*	2^{-27}	sec/semi-circle
α_2			**	8*	2^{-24}	sec/semi-circle^2
α_3			**	8*	2^{-24}	sec/semi-circle^3
β_0			**	8*	2^{+11}	sec
β_1			**	8*	2^{+14}	sec/semi-circle
β_2			**	8*	2^{+16}	sec/semi-circle^2
β_3			**	8*	2^{+16}	sec/semi-circle^3
WN_{op}	Data predict week number			8	1	weeks

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.
(***) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) Group delay correction parameter

These are the parameters for single-frequency users who use L2C or L5. The definition and user algorithms are shown in Section 5.8.

These are defined differently from GPS. For details, see Section 4.3.2.15.

(2) Ionospheric parameter

These are used by user who only uses L2C or L5 to calculate the ionospheric delay.

The parameters can be used in the wide area shown in Section 5.9.3.

The user algorithm is shown in Section 5.9.

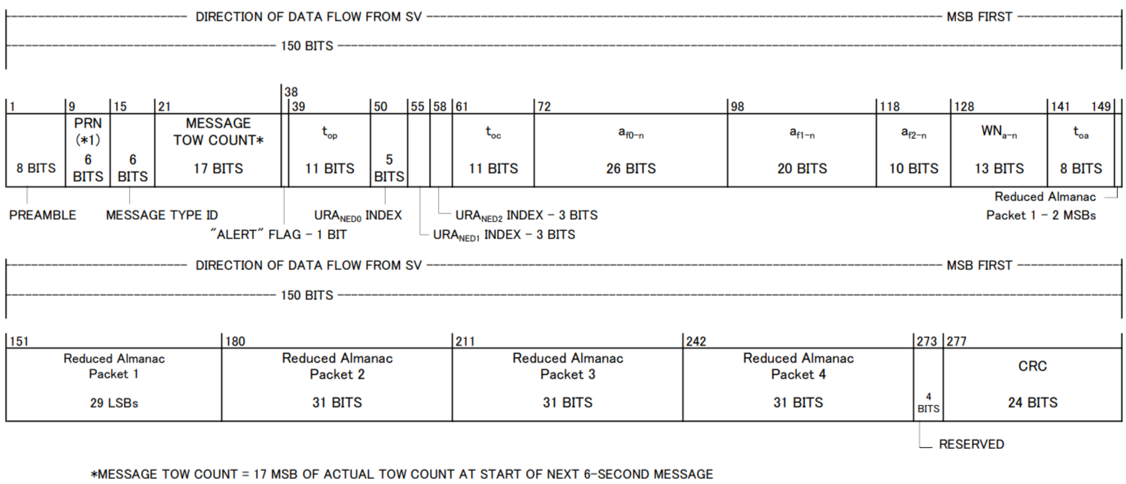
This is defined differently from GPS. For details, see Section 4.3.2.15.

(3) Data predict week number

This is the week number of the state estimate utilized for the prediction of satellite quasi-Keplerian ephemeris parameters.

4.3.2.9. Message Type 31 (Clock and Reduced Almanac)

Figure 4.3.2-9 shows the data format of message type 31, and Table 4.3.2-10 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-9 Message Type 31: Clock and Reduced Almanac Format

Table 4.3.2-10 Parameter Definitions

Parameter	Description	Effective Range	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)	-	-	-	-
WN_{a-n}	Almanac reference week	0-8191	13	1	weeks
t_{oa}	Almanac reference time of week	602112	8	2^{12}	seconds
-	Reduced almanac packet 1	-	31	-	-
-	Reduced almanac packet 2	-	31	-	-
-	Reduced almanac packet 3	-	31	-	-
-	Reduced almanac packet 4	-	31	-	-

(1) Almanac reference week

This is the reference week number of almanac orbital information.

The definition and user algorithm are shown in Section 5.7.2.2.

(2) Almanac reference time of week

This is the almanac reference time of week.

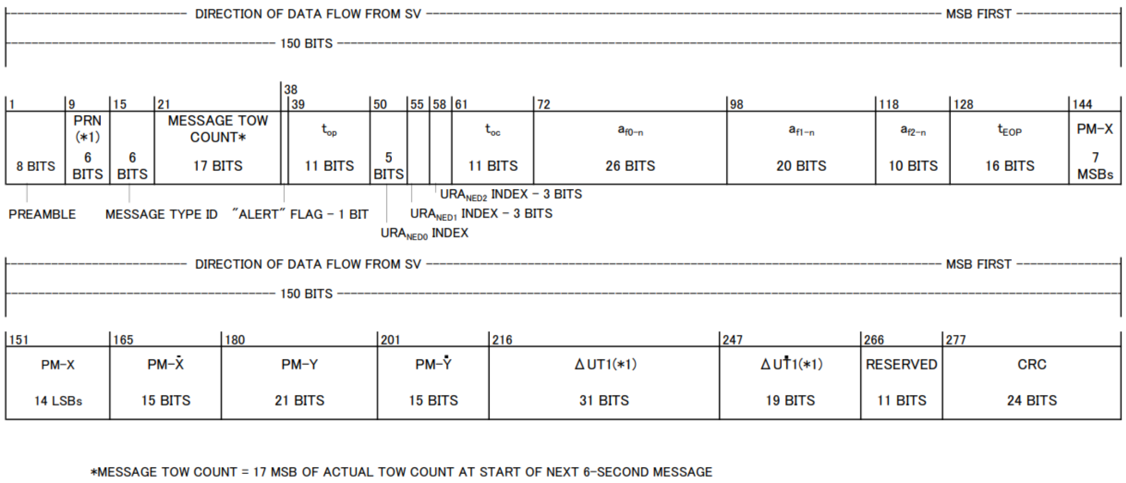
The definition and user algorithm are shown in Section 5.7.2.2.

(3) Reduced almanac packet

These are the same as that in Section 4.3.2.5. (3) .

4.3.2.10. Message Type 32 (Clock and Earth Orientation Parameter (EOP))

Figure 4.3.2-10 shows the data format of message type 32, and Table 4.3.2-11 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-10 Message Type 32: Clock and EOP Format

Table 4.3.2-11 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)	-	-	-	-
t_{EOP}	Earth orientation parameter data reference time (Epoch of earth orientation parameter)	0-604784	16	2^4	seconds
PM_X	Earth orientation parameter (X-axis polar motion value at reference time)	+/-1	21*	2^{-20}	arc-seconds
PM_Ẋ	Earth orientation parameter (X-axis polar motion drift at reference time)	+/-7.8125e-3	15*	2^{-21}	arc-seconds/day
PM_Y	Earth orientation parameter (Y-axis polar motion value at reference time)	+/-1	21*	2^{-20}	arc-seconds
PM_Ẏ	Earth orientation parameter (Y-axis polar motion drift at reference time)	+/-7.8125e-3	15*	2^{-21}	arc-seconds/day
ΔUT1(*1)	Earth orientation parameter (UT1-UTC Difference at Reference Time)	+/-64	31*	2^{-24}	seconds
ΔUṪ1(*1)	Earth orientation parameter (Rate of UT1-UTC Difference at Reference Time)	+/-7.8125e-3	19*	2^{-25}	seconds/day
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit. (**) Ω_{0-n} is the right ascension angle in the week epoch (Ω_{0-w}) that is transmitted as the rate of right ascension when referenced.					

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

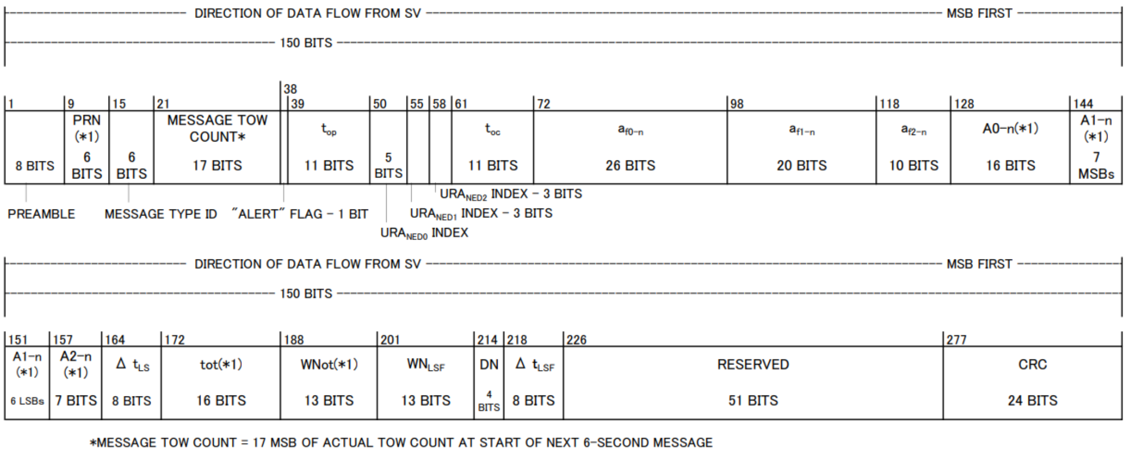
(1) Earth orientation parameter (EOP)

These are used to transform ECEF coordinates to ECI coordinates.

The definition and user algorithm are shown in Section 5.13.

4.3.2.11. Message Type 33 (Clock and UTC Parameters)

Figure 4.3.2-11 shows the data format of message type 33, and Table 4.3.2-12 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-11 Message Type 33: Clock and UTC Format

Table 4.3.2-12 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)		-	-	-	-
A_{0-n}	UTC parameter	Bias coefficient of QZSSTe relative to UTC(NICT) (*1)	**	16*	2^{-35}	seconds
A_{1-n}		Drift coefficient of QZSSTe relative to UTC(NICT) (*1)	**	13*	2^{-51}	sec/sec
A_{2-n}		Drift rate coefficient of QZSST relative to UTC(NICT) (*1)	**	7*	2^{-68}	sec/sec^2
Δt_{LS}		Current or past leap second count	**	8*	1	seconds
t_{ot}		Epoch of UTC Parameter (Time data reference Time of Week) (*1)	0-604784	16	2^{+4}	seconds
WN_{ot}		Time data reference week number (*1)	**	13	1	weeks
WN_{LSF}		Leap second reference week number	**	13	1	weeks
DN		Leap second reference day number	**	4**	1	days
Δt_{LSF}		Current or future leap second count	**	8*	1	seconds

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) UTC parameter

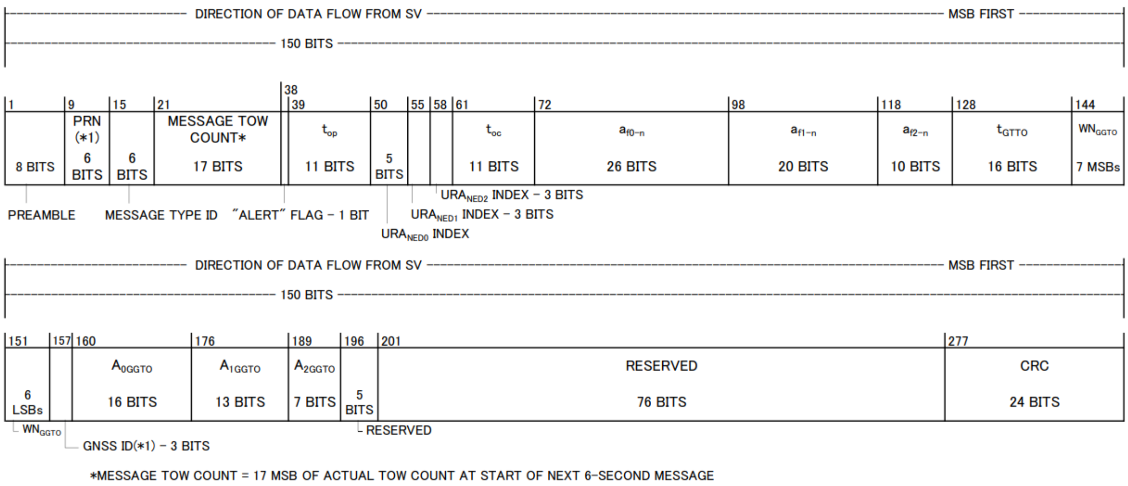
These are modulo 1 second offset between QZSST and UTC (NICT).

The definition and user algorithm are shown in Section 5.12.

These are defined differently from GPS. For details, see Section 4.3.2.15.

4.3.2.12. Message Type 35 (Clock and QZSS/GNSS Time Offset)

Figure 4.3.2-12 shows the data format of message type 35, and Table 4.3.2-13 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-12 Message Type 35: Clock and GGTO Format

Table 4.3.2-13 Parameter Definitions

Parameter	Description	Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)	-	-	-	-
t_{GGTO}	Time data reference Time of Week	604784	16	2^{4}	seconds
WN_{GGTO}	Time data reference Week Number	**	13	1	weeks
GNSS ID	GNSS Type ID (*1)	-	3	-	see text
A_{0GGTO}	Bias coefficient of GPS time scale relative to GNSS time scale	**	16*	2^{-35}	seconds
A_{1GGTO}	Drift coefficient of GPS time scale relative to GNSS time scale	**	13*	2^{-51}	sec/sec
A_{2GGTO}	Drift rate correction coefficient of GPS time scale relative to GNSS time scale	**	7*	2^{-68}	sec/sec^{2}
(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.					
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.					

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) GPS/GNSS time offset (GGTO)

These are time offset (GGTO) between GPS and GNSS.

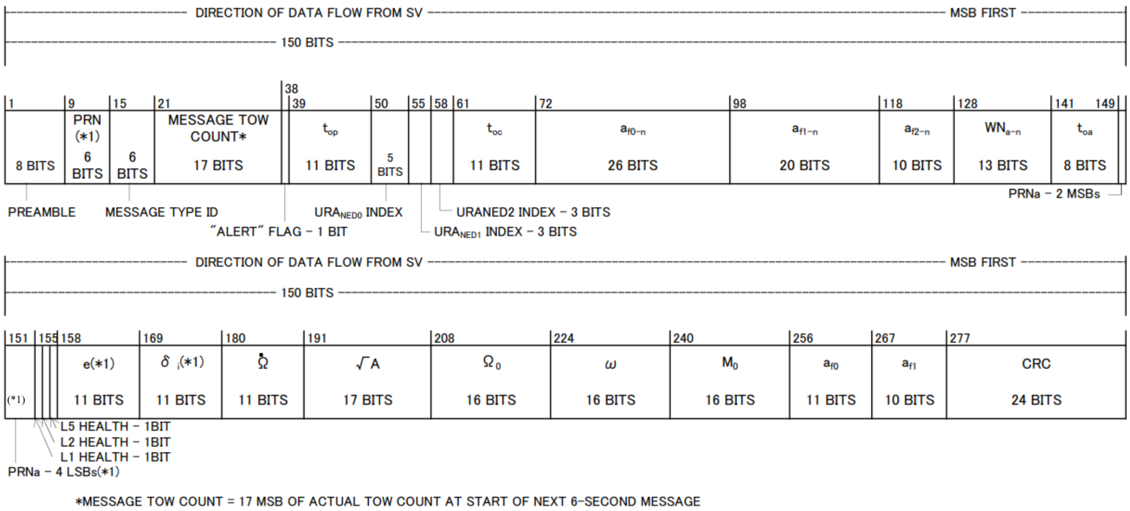
The definition and user algorithms are shown in Section 5.11.

However, this parameter is fixed to "0". Because there are no difference between QZSST and GPST by system operation.

These are defined differently from GPS. For details, see Section 4.3.2.15.

4.3.2.13. Message Type 37 (Clock and Midi Almanac)

Figure 4.3.2-13 shows the data format of message type 37, and Table 4.3.2-14 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-13 Message Type 37: Clock and Midi Almanac Format

Table 4.3.2-14 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)		-	-	-	-
WN_{a-n}	Midi almanac	Epoch of almanac (week number)	0-8191	13	1	weeks
t_{oa}		Epoch of almanac (time of week)	0-602112	8	2^{+12}	sec
PRN_a	Almanac PRN ID(*1)		**	6	1	-
L1/L2/L5 health	L1/L2/L5 health		-	3	-	-
e	Midi almanac	Difference from reference eccentricity (*1)	**	11	2^{-16}	-
δ_i		Difference from reference angle of orbit inclination (*1)	**	11*	2^{-14}	semi-circle
$\dot{\Omega}$		Rate of right ascension	**	11*	2^{-33}	semi-circle/sec
$\sqrt{A}$		Square root of the semi-major axis	**	17	2^{-4}	$m^{1/2}$
Ω_0		Longitude of ascending node of orbit plane at weekly epoch	**	16*	2^{-15}	semi-circle
ω		Argument of perigee	**	16*	2^{-15}	semi-circle
M_0		Mean anomaly at reference time	**	16*	2^{-15}	semi-circle
a_{f0}		SV clock bias correction coefficient	**	11*	2^{-20}	sec
a_{f1}		SV clock drift correction coefficient	**	10*	2^{-37}	sec/sec
(*) Indicates numbers expressed in two's complement with the MSB used as a signed bit. (**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.						

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) Midi almanac

These are low-accuracy satellite orbit and SV clock.

The definition and user algorithm are shown in Section 5.7.2.1.

These are defined differently from GPS. For details, see Section 4.3.2.15.

(2) Almanac PRN ID

This is the number of the 6LSBs of the PRN number of QZS.

If data are invalid, set to “0”.

This is defined differently from GPS. For details, see Section 4.3.2.15.

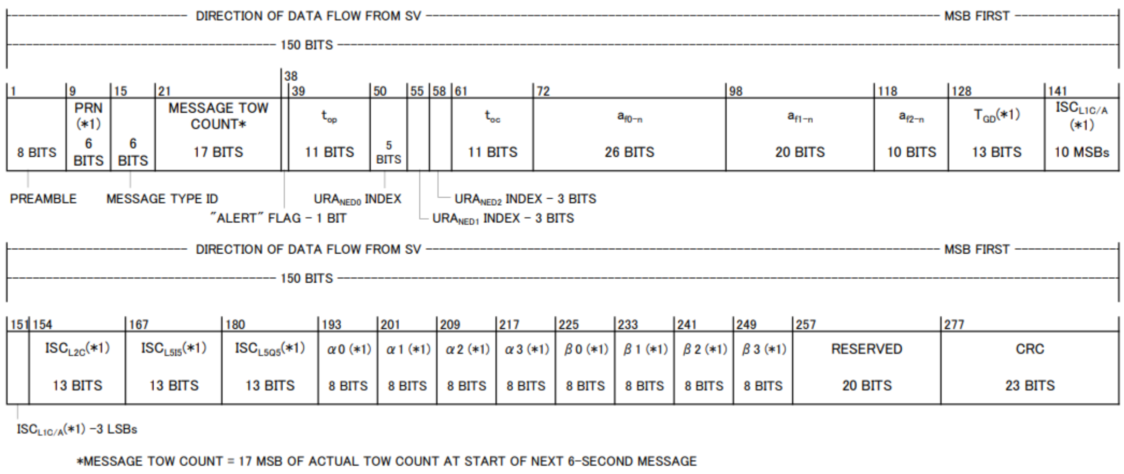
(3) L1/L2/L5 health

This is the health of the L1, L2 and L5 signals from the satellite that corresponds to the PRN number. Since the PRN numbers for the L1C/B signal are not included in the Almanac PRN ID defined in (2), the health of the L1C/B signal is notified by the L1 health of the PRN number from 193 to 202 that defines the signal of the satellite transmitting the L1C/B signal.

The definition and user algorithm are shown in Section 5.4.1.

4.3.2.14. Message Type 61 (Clock, Ionospheric (Japan area) and Group Delay Differential Correction Parameters)

Figure 4.3.2-14 shows the data format of message type 61, and Table 4.3.2-15 shows its parameter definitions.



(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

Figure 4.3.2-14 Message Type 61: Clock, IONO and Group Delay Format

Table 4.3.2-15 Parameter Definitions

Parameter	Description		Effective Range**	Number of Bits	LSB	Units
-	SV clock parameter (See Table 4.3.2-8)		-	-	-	-
T_{GD}	Group delay correction parameter for group delay between SV clock and L1C/A*** (*1)		**	13*	2^{-35}	sec
$ISC_{L1C/A}$	Inter-signal correction parameter for group delay (*1)	Between L1C/A*** and L1C/A*** (fixed to "0.0")	**	13*	2^{-35}	sec
ISC_{L2C}		Between L1C/A*** and L2C	**	13*	2^{-35}	sec
ISC_{L5I5}		Between L1C/A*** and L5I5	**	13*	2^{-35}	sec
ISC_{L5Q5}		Between L1C/A*** and L5Q5	**	13*	2^{-35}	sec
α_0	Ionospheric parameter (*1)		**	8*	2^{-30}	sec
α_1			**	8*	2^{-27}	sec/semi-circle
α_2			**	8*	2^{-24}	sec/semi-circle^2
α_3			**	8*	2^{-24}	sec/semi-circle^3
β_0			**	8*	2^{+11}	sec
β_1			**	8*	2^{+14}	sec/semi-circle
β_2			**	8*	2^{+16}	sec/semi-circle^2
β_3			**	8*	2^{+16}	sec/semi-circle^3

(*) Indicates numbers expressed in two's complement with the MSB used as a sign bit.
(**) Indicates that the maximum range expressed by the number of bits and the LSB is the effective range of that item.
(***) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

(*1) This parameter is defined differently from that for GPS. For details, see Section 4.3.2.15.

(1) Group delay correction parameter

These are the parameters for single-frequency users who use L2C or L5. The definition and user algorithms are shown in Section 5.8.

These are defined differently from GPS. For details, see Section 4.3.2.15.

(2) Ionospheric parameters

These are used by user who only uses the L2C or L5 to calculate the ionospheric delay.

The parameters can be used in the wide area shown in Section 5.9.3.

The user algorithm is shown in Section 5.9.

These are defined differently from GPS For details, see Section 4.3.2.15.

4.3.2.15. (Reference) Differences from GPS

Table 4.3.2-16 show parameters that are defined differently from GPS definitions specified in Section 2.2 of Reference Documents (1) and (2).

Table 4.3.2-16 Parameters Defined Differently from GPS (CNAV(L2C,L5))

Message Type	Parameter	GPS	QZSS
common	PRN	PRN number of GPS	PRN ID of QZS
10	Ephemeris (ΔA)	Difference from reference semi-major axis (A_{REF})	
		A_{REF} = 26 559 710 [m]	A_{REF} = 42 164 200 [m]
	Ephemeris (e_n)	Eccentricity of ephemeris Upper limit of parameter range of 0.03	Eccentricity of ephemeris Parameter range is not restricted.
	Ephemeris Status Flag	L2C Phasing Phase relationship between L2C and L2P	Indicating the status of ephemeris "0": within an hour "1": more than an hour ago
30	TGD	Group delay between SV clock and L1P (Y) time	Group delay between SV clock and L1C/A* time
	$ISC_{L1C/A}$	Group delay between L1P (Y) and L1C/A	Group delay between L1C/A* and L1C/A*
	ISC_{L2C}	Group delay between L1P (Y) and L2C	Group delay between L1C/A* and L2C
	ISC_{L5I5}	Group delay between L1P (Y) and L5I5	Group delay between L1C/A* and L5I5
	ISC_{L5Q5}	Group delay between L1P (Y) and L5Q5	Group delay between L1C/A* and L5IQ
	Ionospheric parameter (α_0, α_1, α_2, α_3, β_0, β_1, β_2, β_3)	The target area	
		The entire globe	Wide area (In addition, the target area is "Japan area" in Message Type 61.)
12, 31 37	PRNa	PRN number of GPS	PRN ID of QZS
12 31	Reduced almanac (δA)	Difference from reference semi-major axis (A_{REF})	
		A_{REF} = 26 559 710 [m]	A_{REF} = 42 164 200 [m]
	Precondition for reduced almanac (e)	Eccentricity	
		e = 0 [-]	e = 0.075 [-] (QZO) GEO/QGEO: Same as left
	Precondition for reduced almanac (i)	Angle of orbit inclination	
		i = 55 [deg]	i = 43 [deg] (QZO) i = 0 [deg] (GEO/QGEO)
	Precondition for reduced almanac ($\dot{\Omega}$)	Rate of time change of right ascension of ascending node	
		$\dot{\Omega}$= -2.6 × 10^{-9} [sc/s]	$\dot{\Omega}$= -8.7 × 10^{-10} [sc/s] (QZO) $\dot{\Omega}$= 0 [sc/s] (GEO/QGEO)
	Precondition for reduced almanac (ω)	Argument of perigee	
		ω = 0 [deg]	ω = 270 [deg] (QZO) GEO/QGEO: Same as left
32	Earth Orientation Parameter	ΔUTGPS: UT1-GPS $\Delta \dot{UT}$GPS: Rate of UT1-GPS LSB of ΔUTGPS is equal to 2^{-23}.	ΔUT1: UT1-UTC $\Delta \dot{UT}$1: Rate of UT1-UTC LSB of ΔUT1 is equal to 2^{-24}.
33	UTC parameter (A_{0-n}, A_{1-n}, A_{2-n}, t_{ot}, WN_t)	Relationship between UTC (USNO) and GPST	Relationship between UTC (NICT) and QZSST
35	GNSS time offset	Relationship between GPS time and other GNSS time	Relationship between QZSS time and other GNSS time
	GNSS ID	ID of GNSS indicated by GNSS time offset parameter	
		"0": N/A "1": Galileo "2": GLONASS "3 to 7": spare	"0": N/A "1": Galileo "2": GLONASS "3": GPS "4 to 7": spare
37	Midi almanac (e)	Eccentricity	Difference from reference eccentricity (e_{REF}) e_{REF} = 0.06 [-] (QZO) e_{REF} = 0 [-] (GEO/QGEO)
	Midi almanac (δi)	Difference from reference angle of inclination (i_0) i_0 = 0.3 [semi-circles]	Difference from reference angle of inclination (i_{REF}) i_{REF} = 0.25 [semi-circles] (QZO) i_{REF} = 0 [semi-circles] (GEO/QGEO)

Message Type	Parameter	GPS	QZSS
34 13 14	Correction data	SV clock correction data and ephemeris correction data	Not transmitted.
40	Integrity Support Message (ISM)	ISM Parameters	Not transmitted.

(*) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

4.3.2.16. (Delete)

5. User Algorithms

5.1. Time System

The PNT time system shall is the QZSS time system (QZSST) shown below.

(1) Definitions

(a) Length of 1 second

The length of 1 second in QZSST shall be identical to the International Atomic Time (TAI).

(b) Offset between QZSST and TAI

QZSST shall be delayed from TAI by 19 seconds.

(c) Starting point of week number for QZSST

The starting point of the week number for QZSST shall be the same as the GPS time system (GPST), which is 0:00 am (UTC) on January 6, 1980.

(2) Navigation message reference time

The parameters relating to time such as the SV clock parameter, mean motion and UTC parameters shall all be based on QZSST.

5.2. Coordinate System

The PNT coordinate system is defined as follows.

< Definitions >

- Origin: Mass center of the earth
- Z-axis: the IERS Reference north pole
- X-axis: Intersection of the IERS Reference Meridian (IRM) and the equatorial plane
- Y-axis: Completes a right-handed, Earth-centered, Earth-Fixed (ECEF) orthogonal coordinate system

< Realizations >

- The positions of monitor stations are managed by being applied the PNT reference coordinate system stipulated by IERS. The offset of the PNT reference coordinate system relative to ITRF should be within 2 cm (95%). The applied version of ITRF is published at the Survice Support Information page (https://qzss.go.jp/en/technical/dod/pnt/index.html) on the QZSS website.

5.3. Constants

5.3.1. Speed of Light

c = 299792458 [m/s].

5.3.2. Circular Constant

π = 3.1415926535898.

5.3.3. Angular Velocity of the Earth's Rotation

$\dot{\Omega}_e$ = 7.2921151467 × 10^{-5} [rad/s].

5.3.4. Earth's Gravitational Constant

μ = 3.986005 × 10^{14} [m^3/s^2].

5.3.5. Semi-Circle

1 [semi-circle] = π [rad] (defined in Section 5.3.2)

5.4. Health and Integrity

5.4.1. Health and Alert Flag

The health flags indicate the health condition of each signal. The alert flags indicate the health condition of the transmit signals. If any of these signals is "1", the user can not use the signals. These conditions are shown in Section 4.4.1 of Applicable Document (1) "PS-QZSS".

Table 5.4.1-1 shows the types and definitions of the health and alert flags. Table 5.4.1-2 shows the messages contains health and alert flag.

There are two types of health: almanac health and ephemeris health. The almanac health has a low cycle update, and the ephemeris health has a high cycle update. Accordingly, in some cases, the almanac health may not match the current signal condition and the ephemeris health. Therefore, we recommend that you use the ephemeris health when there is a difference between the almanac health and the ephemeris health.

Table 5.4.1-1 Types and Definitions of Health and Alert Flags

Item	Number of Bits	Definitions
Alert Flag	1	One-bit flag of the alert condition
3bit Health	3	Three-bit flag of the health condition of L1C/A or L1C/B
L1C/A Health	1	One-bit flag of the health condition of L1C/A
L1C/B Health	1	One-bit flag of the health condition of L1C/B
L1 Health	1	One-bit flag of the health condition of L1C/A or L1C/B
L2 Health	1	One-bit flag of the health condition of L2C
L5 Health	1	One-bit flag of the health condition of L5
L1C Health	1	One-bit flag of the health condition of L1C

Table 5.4.1-2 Messages Contains Health and Alert Flags

Item	LNAV(L1C/A, L1C/B)	CNAV(L2C,L5)	CNAV2(L1C)
Alert Flag	All subframes	All message types	-
3bit Health	Almanac(Subframe 4 or 5, Data ID="3",SV ID =1 to 10)	-	-
L1C/A Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	-	-
L1C/B Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	-	-
L1 Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	Ephemeris Midi Almanac Reduced Almanac	Midi Almanac Reduced Almanac
L2 Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	Ephemeris Midi Almanac Reduced Almanac	Midi Almanac Reduced Almanac
L5 Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	Ephemeris Midi Almanac Reduced Almanac	Midi Almanac Reduced Almanac
L1C Health	SV Clock (Subframe 1) Almanac(Subframe 4 or 5)	-	Ephemeris

The 3-bit health included only with the LNAV(L1C/A, L1C/B) almanac is the condition of L1C/A or L1C/B in more detail, and bits definitions are shown in Table 5.4.1-3.

Table 5.4.1-3 3bit Health Definitions

1st bit	2nd bit	3rd bit	Description
0	0	0	All data are healthy.
0	0	1	Parity error
0	1	0	TLM/HOW format error (except TOW error)
0	1	1	TOW error
1	0	0	Subframe 1, 2, or 3 is erroneous. (except TLM and HOW errors)
1	0	1	Subframe 4 or 5 is erroneous. (except TLM and HOW errors)
1	1	0	Any of the subframe data is erroneous. (except TLM and HOW errors)
1	1	1	Any of the subframe data including TLM/HOW is erroneous.

5.4.2. Integrity Status Flag

The integrity status flag (ISF) of LNAV(L1C/A, L1C/B), CNAV2(L1C), and CNAV(L2C,L5) indicates the integrity assurance level as follows.

[If ISF is ON ("1")]

- NTE (Not-To-Exceed Tolerance) = 5.73 × URA (defined in Section 5.4.3)
- TTA = 5.2 sec
- HMI probability (*) = 1×10^{-8}/h or less

[If ISF is OFF ("0")]

- NTE = 4.42 × URA
- TTA = 5.2 sec
- HMI probability (*) = 1×10^{-5}/h or less

(*) Probability that the SIS-URE exceeds NTE without an alarm within the TTA time

5.4.3. URA Index

The URA index indicates the user range accuracy (URA) of the satellite.

The URA index parameter definition differs among LNAV(L1C/A, L1C/B), CNAV2(L1C) and CNAV(L2C,L5) as below.

5.4.3.1. LNAV(L1C/A, L1C/B)

URA value of LNAV(L1C/A, L1C/B) indicates the RMS value of the worst and the maximum SIS range errors in the effective period of the clock and ephemeris of the same set. When URA of LNAV(L1C/A, L1C/B) is updated, IODE is also incremented.

The URA includes the SIS component of the user range error as follows. Note that it does not include the ionospheric model error for a single frequency user:

- Satellite clock error
- Ephemeris error
- TGD/ISC error

Table 5.4.3-1 shows the URA parameter.

Table 5.4.3-1 URA Parameter of LNAV(L1C/A, L1C/B)

Parameter	Description	Units
URA INDEX	URA index	-

The relationship between URA value and URA index is as shown in Table 5.4.3-2.

Table 5.4.3-2 URA Indexes

URA Index	URA value[m]
0	0.00 < URA ≤ 2.40
1	2.40 < URA ≤ 3.40
2	3.40 < URA ≤ 4.85
3	4.85 < URA ≤ 6.85
4	6.85 < URA ≤ 9.65
5	9.65 < URA ≤ 13.65
6	13.65 < URA ≤ 24.00
7	24.00 < URA ≤ 48.00
8	48.00 < URA ≤ 96.00
9	96.00 < URA ≤ 192.00
10	192.00 < URA ≤ 384.00
11	384.00 < URA ≤ 768.00
12	768.00 < URA ≤ 1536.00
13	1536.00 < URA ≤ 3072.00
14	3072.00 < URA ≤ 6144.00
15	6144.00 < URA or invalid

If each URA index is "Ui," the nominal URA value X[m] is calculated by following equations:

If $0 \le Ui \le 6$, then $X = 2^{(1+Ui/2)}$
If $6 \le Ui \le 15$, then $X = 2^{(Ui-2)}$

Ui = 15 shall indicate the absence of an accuracy prediction and shall advise the standard positioning service user to use that SV at his own risk.
Also, if Ui = 1, 3 or 5, X is rounded to 2.8m, 5.7m or 11.3 m, respectively.

5.4.3.2. CNAV2(L1C) and CNAV(L2C,L5)

URA value of CNAV2(L1C) and CNAV(L2C,L5) consists of the elevation-dependent URA"URA_{ED}" and the non-elevation-dependent URA "URA_{NED}" defined as below.
The URA at time "t" and elevation angle "El" is calculated by the following equation:

$$URA(t, El) = \sqrt{\left(URA_{ED} \cdot \sin(El + 90[\mathrm{deg}])\right)^2 + \left(URA_{NED}(t)\right)^2}\ [m]$$

5.4.3.2.1. Elevation-dependent URA

$URA_{ED}$of CNAV2(L1C) and CNAV(L2C,L5) is the RMS value of the worst and the maximum SIS range error in the effective period of the ephemeris of the same set.
URA_{ED} includes the SIS component of the user range error as follows. Note that it does not include the ionospheric model error for a single frequency user.

- Ephemeris error

Table 5.4.3-3 shows URA_{ED} parameters.

Table 5.4.3-3 Elevation-dependent URA Parameter

Parameter	Description	Units
URA_{ED} Index	Elevation-dependent URA index	-

The relationship between the URA value and URA index is as shown in Table 5.4.3-4.

Table 5.4.3-4 Elevation-dependent URA Indexes (1/2)

URA Index	URA value(m)
15	6144.00 < URA or there is no prediction value
14	3072.00 < URA ≤ 6144.00
13	1536.00 < URA ≤ 3072.00
12	768.00 < URA ≤ 1536.00
11	384.00 < URA ≤ 768.00
10	192.00 < URA ≤ 384.00
9	96.00 < URA ≤ 192.00
8	48.00 < URA ≤ 96.00
7	24.00 < URA ≤ 48.00
6	13.65 < URA ≤ 24.00
5	9.65 < URA ≤ 13.65
4	6.85 < URA ≤ 9.65
3	4.85 < URA ≤ 6.85
2	3.40 < URA ≤ 4.85
1	2.40 < URA ≤ 3.40
0	1.70 < URA ≤ 2.40
-1	1.20 < URA ≤ 1.70
-2	0.85 < URA ≤ 1.20
-3	0.60 < URA ≤ 0.85
-4	0.43 < URA ≤ 0.60
-5	0.30 < URA ≤ 0.43
-6	0.21 < URA ≤ 0.30
-7	0.15 < URA ≤ 0.21
-8	0.11 < URA ≤ 0.15
-9	0.08 < URA ≤ 0.11
-10	0.06 < URA ≤ 0.08
-11	0.04 < URA ≤ 0.06
-12	0.03 < URA ≤ 0.04
-13	0.02 < URA ≤ 0.03
-14	0.01 < URA ≤ 0.02
-15	URA ≤ 0.01
-16	There is no prediction value.

If each URA index is "Ui," the nominal URA value X(m) obtained from it is calculated by the following equation:

If $0 \le Ui \le 6$, then $X = 2^{(1+Ui/2)}$
If $6 \le Ui \le 15$, then $X = 2^{(Ui-2)}$

Ui = -16 or Ui = 15 shall indicate the absence of an accuracy prediction and shall advise the standard positioning service user to use that SV at his own risk.

Also, if N = 1, 3, or 5, X is rounded to 2.8m, 5.7m, or 11.3 m, respectively.

5.4.3.2.2. Non-elevation-dependent URA

URA_{NED} of CNAV2(L1C) and CNAV(L2C,L5) is the RMS value of the worst and the maximum SIS range errors in the effective time period of the SV clock of the same set.

URA_{NED} includes the SIS component of the user range error as follows:

- Satellite clock error (single frequency and dual frequency users)
- TGD/ISC error (single frequency and dual frequency users)

Table 5.4.3-5 shows the URA_{NED} parameters.

Table 5.4.3-5 Non-elevation-dependent URA Parameters

Parameter	Description	Units
WN_{op}	Data predict week number	seconds
t_{op}	Data predict time of week	seconds
URA_{NED0}Index	Non-elevation-dependent (NED) accuracy index	-
URA_{NED1}Index	NED accuracy change index	-
URA_{NED2}Index	NED accuracy change rate index	-

URA_{NED} at a time "t" is calculated by the following equation:

If $t - t_{op} + 604800*(WN - WN_{op}) \leqq 93600$ [s],

Then, $URA_{NED}(t) = URA_{NED0} + URA_{NED1}(t - t_{OP} + 604800*(WN - WN_{OP}))$[m]

and

If $t - t_{op} + 604800*(WN - WN_{op}) > 93600$ [s],

Then, $URA_{NED}(t) = URA_{NED0} + URA_{NED1}(t - t_{OP} + 604800*(WN - WN_{OP}))$
$+ URA_{NED2}(t - t_{OP} + 604800*(WN - WN_{OP}) - 93600)^2$ [m]

Here, the relationship between URA_{NED0}Index and URA_{NED0} value is the same as shown in Table 5.4.3-4.

The relationship between URA_{NED1}Index and URA_{NED1} is shown in the following equations:

$$URA_{NED1} = \frac{1}{2^N}\ [m/s]$$

Where, N = 14 + URA_{NED1}Index

The relationship between URA_{NED2}Index and URA_{NED2} is shown in the following equations:

$$URA_{NED2} = \frac{1}{2^N}\ [m/s^2]$$

Where, N = 28 + URA_{NED1}Index

5.5. Satellite Clock Correction Using the SV Clock Parameters

This is the same calculation for LNAV(L1C/A, L1C/B), CNAV2(L1C) and CNAV(L2C,L5).

5.5.1. Parameter Definition

Table 5.5.1-1 shows the SV clock parameters. Table 5.5.1-2 shows the constant for calculation.

Table 5.5.1-1 SV Clock Parameters

Parameter	Description	Units
t_{oc}	Clock data referencing time of week	seconds
a_{f0-n}	SV clock bias correction coefficient	seconds
a_{f1-n}	SV clock drift correction coefficient	sec/sec
a_{f2-n}	SV clock drift rate correction coefficient	sec/sec^2

Table 5.5.1-2 Constant

Constant	Description	Units
F	$F = \frac{-2\sqrt{\mu}}{c^2} = -4.442807633 \times 10^{-10}$	$[\frac{s}{\sqrt{m}}]$

5.5.2. Algorithm

Table 5.5.2-1 shows the SV clock offset calculation algorithms.

Table 5.5.2-1 SV Clock Offset Calculation Algorithms

$\Delta t_r = Fe\sqrt{A}\sin E_k$	Correction term required due to the relativistic effect [s] The orbit parameters are obtained from the ephemeris parameter.
$\Delta t_{SV} = a_{f0} + a_{f1}(t - t_{oc}) + a_{f2}(t - t_{oc})^2 + \Delta t_r$	SV clock offset [s]

Note that the relationship among QZSST, SV clock, and SV clock offset is shown below:

$$t_{QZSST} = t_{SV} - \Delta t_{SV}$$

5.6. Satellite Position Using the Ephemeris

This is the difference calculation for LNAV(L1C/A, L1C/B), CNAV2(L1C) and CNAV(L2C, L5) shown below.

Here, satellite position means the antenna phase center of a satellite in the pseudo range of the ionosphere-free linear combinations of the dual-frequency signals shown in Table 5.6-1, expressed by the coordinate system defined in Section 5.2.

The definition changes from L1C/A(or L1C/B) and L2C to L1CP and L5Q5 because L2C is abolished at Block III Satellite. However, in order to avoid burdening users who have been using dual frequency L1C/A(or L1C/B) and L2C for some time with this change, LNAV in Block I and Block II remains L1C/A(or L1C/B) and L2C.

The pseudo range of the ionosphere-free linear combinations are defined in Section 5.10.

Table 5.6-1 Signals for the ionosphere-free linear combinations

Message	Pseudo Range	
	Block I and Block II	Block III
LNAV	L1C/A(or L1C/B) and L2C	L1CP and L5Q5
CNAV2	L1CP and L5Q5	L1CP and L5Q5
CNAV		

5.6.1. LNAV(L1C/A, L1C/B)

5.6.1.1. Parameter Definition

Table 5.6.1-1 shows the ephemeris parameters for LNAV(L1C/A, L1C/B). Table 5.6.1-2 shows the constants for calculation.

Table 5.6.1-1 LNAV(L1C/A, L1C/B) Ephemeris Parameters

Parameter	Description	Units	
t_{oe}	Ephemeris data reference time of week	sec	
$\sqrt{A}$	Square root of the semi-major axis	$m^{1/2}$	
Δn	Mean motion difference from computed value	semi-circle/sec	
M_0	Mean anomaly in epoch	semi-circle	
e	Eccentricity	-	
ω	Argument of perigee	semi-circle	
Ω_0	Longitude of ascending node of orbit plane at weekly epoch	semi-circle	
$\dot{\Omega}$	Rate of right ascension	semi-circle/sec	
i0	Inclination angle at reference time	semi-circle	
$\dot{I}$	Rate of change of angle of inclination	semi-circle/sec	
Cis	Amplitude of the sine harmonic correction term to the angle of inclination	rad	
Cic	Amplitude of the cosine harmonic correction term to the angle of inclination	rad	
Crs	Amplitude of the sine harmonic correction term to the orbit radius	m	
Crc	Amplitude of the cosine harmonic correction term to the orbit radius	m	
Cus	Amplitude of the sine harmonic correction term to the argument of latitude	rad	
Cuc	Amplitude of the cosine harmonic correction term to the argument of latitude	rad	

Table 5.6.1-2 Constants

Constant	Description	Units
μ	Earth's gravitational constant (described in Section 5.3.4.)	$[m^3/s^2]$
$\dot{\Omega}_e$	Angular velocity of the earth's rotation (described in Section 5.3.3.)	[rad/s]

5.6.1.2. Algorithms

Table 5.6.1-3 shows the satellite position calculation algorithms.

Table 5.6.1-3 Satellite Position Calculation Algorithms

$A = \left(\sqrt{A}\right)^2$	Semi-major axis [m]
$n_0 = \sqrt{\frac{\mu}{A^3}}$	Mean motion [rad/s]
$t_k = t - t_{0e}$	Elapsed time from ephemeris epoch [s]
$n = n_0 + \Delta n$	Correction of mean motion [rad/s]
$M_k = M_0 + n t_k$	Mean anomaly [rad]
$M_k = E_k - e \sin E_k$	Calculation of eccentric anomaly by Kepler's Equation [rad]
$v_k = \tan^{-1}\left\{\frac{\sqrt{1-e^2}\sin E_k}{\cos E_k - e}\right\}$	True anomaly [rad]
$\Phi_k = \nu_k + \omega$	Argument of latitude [rad]
$\delta u_k = c_{us}\sin 2\phi_k + c_{uc}\cos 2\phi_k$	Second harmonic perturbation for argument of latitude correction [rad]
$\delta r_k = c_{rs}\sin 2\phi_k + c_{rc}\cos 2\phi_k$	Second harmonic perturbation for radius correction harmonic [m]
$\delta i_k = c_{is}\sin 2\phi_k + c_{ic}\cos 2\phi_k$	Second harmonic perturbation for inclination angle correction [rad]
$u_k = \Phi_k + \delta u_k$	Correction of argument of latitude [rad]
$r_k = A(1 - e \cos E_k) + \delta r_k$	Correction of radius [m]
$i_k = i_0 + \delta i_k + (\dot{I}) t_k$	Correction of inclination angle [rad]
$x_k' = r_k \cos u_k$ $y_k' = r_k \sin u_k$	Position in orbital plane [m]
$\Omega_k = \Omega_0 + (\dot{\Omega} - \dot{\Omega}_e) t_k - \dot{\Omega}_e t_{oe}$	Correction of longitude of ascending node [rad]
$x_k = x_k' \cos\Omega_k - y_k' \cos i_k \sin\Omega_k$ $y_k = x_k' \sin\Omega_k + y_k' \cos i_k \cos\Omega_k$ $z_k = y_k' \sin i_k$	Satellite position in earth-fixed coordinate system [m]

5.6.2. CNAV2(L1C) and CNAV(L2C,L5)

5.6.2.1. Parameter Definition

Table 5.6.2-1 shows the ephemeris parameters for CNAV2(L1C) and CNAV(L2C,L5). Table 5.6.2-2 shows the constants for calculations.

Table 5.6.2-1 CNAV2(L1C) and CNAV(L2C,L5) Ephemeris Parameters

Parameter	Description	Units
t_{oe}	Ephemeris data reference time of week	sec
ΔA	Difference from reference semi-major axis	m
$\dot{A}$	Rate of change of reference semi-major axis	m/sec
Δn	Mean motion difference from computed value	semi-circle/sec
$\Delta \dot{n}$	Rate of change of mean motion difference from computed value	semi-circle/sec^2
M_{0-n}	Mean anomaly in epoch	semi-circle
e_n	Eccentricity	-
ω_n	Argument of perigee	semi-circle
Ω_{0-n}	Longitude of ascending node of orbit plane at weekly epoch	semi-circle
$\Delta\dot{\Omega}$	Rate of right ascension difference	semi-circle/sec
i_{0-n}	Inclination angle at reference time	semi-circle
IDOT	Rate of change of angle of inclination	semi-circle/sec
C_{is-n}	Amplitude of the sine harmonic correction term to the angle of inclination	rad
C_{ic-n}	Amplitude of the cosine harmonic correction term to the angle of inclination	rad
C_{rs-n}	Amplitude of the sine correction term to the orbit radius	m
C_{rc-n}	Amplitude of the cosine correction term to the orbit radius	m
C_{us-n}	Amplitude of the sine harmonic correction term to the argument of latitude	rad
C_{uc-n}	Amplitude of the cosine harmonic correction term to the argument of latitude	rad

Table 5.6.2-2 Constants

Constant	Description	Units
μ	Earth's gravitational constant (described in Section 5.3.4.)	[m^3/s^2]
$\dot{\Omega}_e$	Angular velocity of the earth's rotation (described in Section 5.3.3.)	[rad/s]
A_{REF}	Reference semi-major axis $A_{REF} = 42164200$	[m]
$\dot{\Omega}_{REF}$	Rate of reference right ascension $\dot{\Omega}_{REF} = -2.6 \times 10^{-9}$	[semi-circle/sec]

5.6.2.2. Algorithms

Table 5.6.2-3 shows the satellite position calculation algorithms.

Table 5.6.2-3 Satellite Position Calculation Algorithms

$A_0 = A_{REF} + \Delta A$	Semi-major axis at reference time [m]
$A_k = A_0 + (\dot{A})t_k$	Semi-major axis [m]
$n_0 = \sqrt{\dfrac{\mu}{A_0^3}}$	Mean motion [rad/s]
$t_k = t - t_{0e}$	Elapsed time from ephemeris epoch [s]
$\Delta n_A = \Delta n_0 + 1/2 \Delta \dot{n}_0 t_k$	Correction value of mean motion [rad/s]
$n_A = n_0 + \Delta n_A$	Correction of mean motion [rad/s]
$M_k = M_0 + n_A t_k$	Mean anomaly [rad]
$M_k = E_k - e_n \sin E_k$	Calculation of eccentric anomaly by Kepler's Equation [rad]
$v_k = \tan^{-1}\left\{\dfrac{\sqrt{1-e_n^2}\sin E_k}{\cos E_k - e_n}\right\}$	True anomaly [rad]
$\Phi_k = \nu_k + \omega$	Argument of latitude [rad]
$\delta u_k = c_{us\text{-}n}\sin 2\phi_k + c_{uc\text{-}n}\cos 2\phi_k$	Second harmonic perturbation for argument of latitude correction [rad]
$\delta r_k = c_{rs\text{-}n}\sin 2\phi_k + c_{rc\text{-}n}\cos 2\phi_k$	Second harmonic perturbation for radius correction [m]
$\delta i_k = c_{is\text{-}n}\sin 2\phi_k + c_{ic\text{-}n}\cos 2\phi_k$	Second harmonic perturbation for inclination angle correction [rad]
$u_k = \Phi_k + \delta u_k$	Correction of argument of latitude [rad]
$r_k = A_k(1 - e_n \cos E_k) + \delta r_k$	Correction of semi-major axis [m]
$i_k = i_{0\text{-}n} + \delta i_k + (IDOT)t_k$	Correction of angle of inclination [rad]
$x_k' = r_k \cos u_k$ $y_k' = r_k \sin u_k$	Positions in orbital plane [m]
$\dot{\Omega} = \dot{\Omega}_{REF} + \Delta\dot{\Omega}$	Rate of right ascension [rad/s]
$\Omega_k = \Omega_{0\text{-}n} + (\dot{\Omega} - \dot{\Omega}_e)t_k - \dot{\Omega}_e t_{oe}$	Correction of longitude of ascending node [rad]
$x_k = x_k' \cos\Omega_k - y_k' \cos i_k \sin\Omega_k$ $y_k = x_k' \sin\Omega_k + y_k' \cos i_k \cos\Omega_k$ $z_k = y_k' \sin i_k$	Satellite position in earth-fixed coordinate system [m]

5.7. Satellite Position Using the Almanac

5.7.1. LNAV(L1C/A, L1C/B)

5.7.1.1. Parameter Definitions

Table 5.7.1-1 shows the almanac parameters for LNAV(L1C/A, L1C/B). Table 5.7.1-2 shows the constants for calculations.

Table 5.7.1-1 Almanac Parameters

Parameter	Description	Units
WN_a	Almanac reference week	Weeks
t_{oa}	Almanac reference time of week	sec
e	Difference from reference eccentricity (*)	-
δ_i	Difference from reference angle of inclination (*)	semi-circle
$\dot{\Omega}$	Rate of right ascension	semi-circle/sec
$\sqrt{A}$	Square root of the semi-major axis	$m^{1/2}$
Ω_0	Longitude of ascending node of orbit plane at weekly epoch	semi-circle
ω	Argument of perigee	semi-circle
M_0	Mean anomaly in epoch	semi-circle
a_{f0}	SV clock bias correction coefficient	sec
a_{f1}	SV clock drift correction coefficient	sec/sec

*: The definitions are shown in Table 5.7.1-3.

Table 5.7.1-2 Constants

Constant	Description	Units
μ	Earth's gravitational constant (described in Section 5.3.4)	$[m^3/s^2]$
$\dot{\Omega}_e$	Angular velocity of the earth's rotation (described in Section 5.3.3)	[rad/s]

5.7.1.2. Algorithms

The satellite positions shall be calculated using the algorithms shown in Table 5.6.1-3. The parameters for the algorithms are shown in Table 5.7.1-3 and Table 5.7.1-4

Table 5.7.1-3 Almanac Parameters for Satellite

Parameter	QZO Satellite	GEO/QGEO Satellite
e [-]	Difference from $e_{REF} = 0.06$	Difference from $e_{REF} = 0$
δ_i [semi-circles]	Difference from $i_{REF} = 0.25$	Difference from $i_{REF} = 0$

Table 5.7.1-4 Settings for Satellite Position Using the Almanac

Parameter	Description	Units
t_{oe}	From almanac parameter t_{oa}	sec
$\sqrt{A}$	From almanac parameter	$m^{1/2}$
Δn	0 (zero)	semi-circle/sec
M_0	From almanac parameter	semi-circle
e	From almanac parameter ($e = e_{REF} + e$)	-
ω	From almanac parameter	semi-circle
Ω_0	From almanac parameter	semi-circle
$\dot{\Omega}$	From almanac parameter	semi-circle/sec
i0	From almanac parameter ($i0 = i_{REF} + \delta_i$)	semi-circle
$\dot{i}$	0 (zero)	semi-circle/sec
Cis	0 (zero)	rad
Cic	0 (zero)	rad
Crs	0 (zero)	m
Crc	0 (zero)	m
Cus	0 (zero)	rad
Cuc	0 (zero)	rad

The SV clock offsets shall be calculated using the algorithms shown in Table 5.5.2-1. The parameters for the algorithms are shown in Table 5.7.1-5

Table 5.7.1-5 SV Clock Parameters for Almanac

Item	Description	Units
t_{oc}	From almanac parameter t_{oa}	seconds
a_{f0-n}	From almanac parameter	seconds
a_{f1-n}	From almanac parameter	sec/sec
a_{f2-n}	0 (zero)	sec/sec^2

5.7.2. CNAV2(L1C) and CNAV(L2C,L5)

5.7.2.1. Midi Almanac

5.7.2.1.1. Parameter Definitions

Table 5.7.2-1 shows the Midi almanac parameters for CNAV2(L1C) and CNAV(L2C,L5). Table 5.7.2-2 and Table 5.7.2-3 show the constants for calculations.

Table 5.7.2-1 Midi Almanac Parameters

Parameter	Description	Units
WN_{a-n}	Almanac reference week	weeks
t_{oa}	Almanac reference time of week	sec
e	Difference from reference eccentricity	-
δ_i	Difference from reference angle of inclination	semi-circle
$\dot{\Omega}$	Rate of right ascension	semi-circle/sec
$\sqrt{A}$	Square root of the semi-major axis	$m^{1/2}$
Ω_0	Longitude of ascending node of orbit plane at weekly epoch	semi-circle
ω	Argument of perigee	semi-circle
M_0	Mean anomaly in epoch	semi-circle
a_{f0}	SV clock bias correction coefficient	sec
a_{f1}	SV clock drift correction coefficient	sec/sec

Table 5.7.2-2 Constants

Constant	Description	Units
μ	Earth's gravitational constant (described in Section 5.3.4)	$[m^3/s^2]$
$\dot{\Omega}_e$	Angular velocity of the earth's rotation (described in Section 5.3.3)	[rad/s]

Table 5.7.2-3 Midi Almanac Parameters for Satellite

Parameter	QZO Satellite	GEO/QGEO Satellite
e [-]	Difference from $e_{REF} = 0.06$	Difference from $e_{REF} = 0$
δ_i [semi-circles]	Difference from $i_{REF} = 0.25$	Difference from $i_{REF} = 0$

5.7.2.1.2. Algorithms

The Midi almanac algorithms are the same as those shown in Section 5.7.1.2.

5.7.2.2. Reduced Almanac

5.7.2.2.1. Parameter Definitions

Table 5.7.2-4 shows the reduced almanac parameters for CNAV2(L1C) and CNAV(L2C,L5). Table 5.7.2-5 and Table 5.7.2-6 show the constants for calculations.

The SV clock parameter is not included in the reduced almanac.

Table 5.7.2-4 Reduced Almanac Parameters

Parameter	Description	Units
WN_{a-n}	Almanac reference week	weeks
t_{oa}	Almanac reference time of week	sec
δ_A	Difference from nominal semi-major axis	m
Ω_0	Longitude of ascending node of orbit plane at weekly epoch	semi-circle
Φ_0	Argument of latitude at reference time	semi-circle

Table 5.7.2-5 Constants

Parameter	Description	Units
μ	Earth's gravitational constant (described in Section 5.3.4.)	$[m^3/s^2]$
$\dot{\Omega}_e$	Angular velocity of the earth's rotation (described in Section 5.3.3.)	[rad/s]
A_{REF}	Reference semi-major axis $A_{REF} = 42164200$	m

Table 5.7.2-6 Reduced Almanac Parameters for Satellite

Parameter	QZO Satellite	GEO/QGEO Satellite
e [-]	$e=0.075$	$e=0$
i [semi-circles]	$i=0.2389$ (= 43 [deg])	$i=0.0$ (= 0 [deg])
$\dot{\Omega}$ [semi-circles/s]	$\dot{\Omega}=-8.7\times 0^{-10}$	$\dot{\Omega}=0$
ω_{REF} [semi-circles]	$\omega_{REF}=-0.5$ (= 270 [deg])	$\omega_{REF}=0$ (= 0 [deg])

5.7.2.2.2. Algorithms

Table 5.7.2-7 shows the satellite position calculation algorithms that are based on the reduced almanac.

Table 5.7.2-7 Satellite Position Calculation Algorithms

$A_0 = A_{REF} + \delta_A$	Semi-major axis [m]
$n_0 = \sqrt{\dfrac{\mu}{A_0^{\ 3}}}$	Mean motion [rad/s]
$t_k = t - t_{oa}$	Elapsed time from almanac epoch [s]
$M_0 = \Phi_0 - \omega_{REF}$	Mean anomaly in almanac epoch [rad]
$M_k = M_0 + n_0 t_k$	Mean anomaly [rad]
$M_k = E_k - e\sin E_k$	Calculation of eccentric anomaly by Kepler's Equation [rad]
$v_k = \tan^{-1}\left\{\dfrac{\sqrt{1-e^2}\sin E_k}{\cos E_k - e}\right\}$	True anomaly [rad]
$u_k = v_k + \omega_{REF}$	Argument of latitude [rad]
$r_k = A_0(1 - e\cos E_k)$	Correction of radius [m]
$x_k' = r_k \cos u_k$ $y_k' = r_k \sin u_k$	Position in orbital plane [m]
$\Omega_k = \Omega_0 + (\dot{\Omega} - \dot{\Omega}_e)t_k - \dot{\Omega}_e t_{oa}$	Correction of longitude of ascending node [rad]
$x_k = x_k'\cos\Omega_k - y_k'\cos i\sin\Omega_k$ $y_k = x_k'\sin\Omega_k + y_k'\cos i\cos\Omega_k$ $z_k = y_k'\sin i$	Satellite position in earth-fixed coordinate system [m]

5.8. Satellite Clock Correction Using Group Delay Differential Correction Parameters

5.8.1. Parameter Definition

Table 5.8.1-1 shows the group delay parameters for LNAV(L1C/A, L1C/B), CNAV2(L1C) and CNAV(L2C,L5).

Using these group delay parameters, the SV clock of each signal is calculated from the SV clock defined by the pseudo range of the ionosphere-free linear combination of L1C/A and L2C in LNAV in Block I and II, L1CP and L5Q5 for the rest. For details, see Section 5.6.

The group delay parameters shall be a value applied to the measured pseudo range in a receiver that has an ideal correlator with a bandwidth of 20.46 MHz and a correlator width of 97.75 ns.

Table 5.8.1-1 Navigation Messages (Group Delay Parameters)

Parameter	Description	Units
T_{GD}	Group delay between SV clock and L1C/A*	sec
$ISC_{L1C/A}$	Inter-signal correction for group delay between L1C/A* and L1C/A* (fixed to "0")	sec
ISC_{L2C}	Inter-signal correction for group delay between L1C/A* and L2C	sec
ISC_{L5I5}	Inter-signal correction for group delay between L1C/A* and L5I5	sec
ISC_{L5Q5}	Inter-signal correction for group delay between L1C/A* and L5Q5	sec
ISC_{L1CP}	Inter-signal correction for group delay between L1C/A* and L1CP	sec
ISC_{L1CD}	Inter-signal correction for group delay between L1C/A* and L1CD	sec

(*) Indicates that L1C/A can be switched to L1C/B for Block IIA and III satellite.

In QZSS, because T_{GD} is the group delay between the SV clock and L1C/A (or L1C/B). The relationship between T_{GD} and ISC_{L2C} of LNAV in Block I and Block II is as follows:

$$T_{GD} = \frac{1}{1-\gamma_{12}} ISC_{L2C}$$

$$\begin{aligned} ISC_{L2C} &= (\Delta t_{SV})_{L2C} - (\Delta t_{SV})_{L1C/A} \\ &= t_{L2C} - t_{L1C/A} \end{aligned}$$

Where, $(\Delta t_{SV})_{L2C}$, $(\Delta t_{SV})_{L1C/A}$: SV clock offset [s] of L2C and L1C/A

t_{L2C}, $t_{L1C/A}$: SV clock [s] of L2C and L1C/A

$$\gamma_{12} = \left(\frac{f_{L1}}{f_{L2}}\right)^2 = \left(\frac{1575.42}{1227.6}\right)^2$$

For CNAV / CNAV2 in all blocks and LNAV after Block III, the relationship between T_{GD}, ISC_{L1CP} and ISC_{L5Q5} is as follows:

$$T_{GD} = \frac{ISC_{L5Q5} - \gamma_{15} ISC_{L1CP}}{1 - \gamma_{15}}$$

$$\begin{aligned} ISC_{L1CP} &= (\Delta t_{sv})_{L1CP} - (\Delta t_{sv})_{L1C/A} \\ &= t_{L1CP} - t_{L1C/A} \end{aligned}$$

$$\begin{aligned} ISC_{L5Q5} &= (\Delta t_{sv})_{L5Q5} - (\Delta t_{sv})_{L1C/A} \\ &= t_{L5Q5} - t_{L1C/A} \end{aligned}$$

Where, $(\Delta t_{SV})_{L1CP}$, $(\Delta t_{SV})_{L5Q5}$, $(\Delta t_{SV})_{L1C/A}$: SV clock offset [s] of L1CP, L5Q5 and L1C/A
t_{L1CP}, t_{L5Q5}, $t_{L1C/A}$: SV clock [s] of L1CP, L5Q5 and L1C/A

$$\gamma_{15} = \left(\frac{f_{L1}}{f_{L5}}\right)^2 = \left(\frac{1575.42}{1176.45}\right)^2$$

5.8.2. Algorithms

The algorithms represent the relationship between the SV clock and the SV clock offset.

Single frequency users of L1C/A shall use the following equation to calculate the SV clock offset. Note $ISC_{L1C/A} = 0$.

$$\left(\Delta t_{SV}\right)_{L1C/A} = \Delta t_{SV} - T_{GD} + ISC_{L1C/A} = \Delta t_{SV} - T_{GD}$$

Single frequency users of L1C shall use the following equations to calculate the SV clock offset:

$$\left(\Delta t_{SV}\right)_{L1CP} = \Delta t_{SV} - T_{GD} + ISC_{L1CP}$$

$$\left(\Delta t_{SV}\right)_{L1CD} = \Delta t_{SV} - T_{GD} + ISC_{L1CD}$$

Single frequency users of L2C shall use the following equation to calculate the SV clock offset:

$$\left(\Delta t_{SV}\right)_{L2C} = \Delta t_{SV} - T_{GD} + ISC_{L2C}$$

Single frequency users of L5 shall use the following equation to calculate the SV clock offset:

$$\left(\Delta t_{SV}\right)_{L5I5} = \Delta t_{SV} - T_{GD} + ISC_{L5I5}$$

$$\left(\Delta t_{SV}\right)_{L5Q5} = \Delta t_{SV} - T_{GD} + ISC_{L5Q5}$$

Dual frequency users of L1C/A (or L1C/B) and L2C shall use the following equation to calculate the SV clock offset:

$$(\Delta t_{sv})_{L1C/A-L2C} = \Delta t_{sv} - T_{GD} + \frac{ISC_{L2C}}{1-\gamma_{12}}$$

Here, when LNAV is used for Block I and II, the following relationship can be used,

$$(\Delta t_{SV})_{L1C/A-L2C} = \Delta t_{SV}$$

Dual frequency users of L1C/A (or L1C/B) and L5 shall use the following equations to calculate the SV clock offset:

$$(\Delta t_{SV})_{L1C/A-L5I5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5I5}}{1-\gamma_{15}}$$

$$(\Delta t_{SV})_{L1C/A-L5Q5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5Q5}}{1-\gamma_{15}}$$

Where,

$$\gamma_{15} = \left(\frac{f_{L1}}{f_{L5}}\right)^2 = \left(\frac{1575.42}{1176.45}\right)^2$$

Dual frequency users of L1C and L2C shall use the following equations to calculate the SV clock offset:

$$(\Delta t_{SV})_{L1CP-L2C} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L2C} - \gamma_{12} ISC_{L1CP}}{1-\gamma_{12}}$$

Here, using LNAV in Block I and II is as follows,

$$= \Delta t_{SV} - \frac{\gamma_{12} ISC_{L1CP}}{1-\gamma_{12}}$$

$$(\Delta t_{SV})_{L1CD-L2C} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L2C} - \gamma_{12} ISC_{L1CD}}{1-\gamma_{12}}$$

Here, using LNAV in Block I and II is as follows,

$$= \Delta t_{SV} - \frac{\gamma_{12} ISC_{L1CD}}{1-\gamma_{12}}$$

Dual frequency users of L1C and L5 shall use the following equations to calculate the SV clock offset:

$$(\Delta t_{SV})_{L1CP-L5I5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5I5} - \gamma_{15} ISC_{L1CP}}{1-\gamma_{15}}$$

$$(\Delta t_{SV})_{L1CD-L5I5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5I5} - \gamma_{15} ISC_{L1CD}}{1-\gamma_{15}}$$

$$(\Delta t_{SV})_{L1CP-L5Q5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5Q5} - \gamma_{15} ISC_{L1CP}}{1-\gamma_{15}}$$

$$(\Delta t_{SV})_{L1CD-L5Q5} = \Delta t_{SV} - T_{GD} + \frac{ISC_{L5Q5} - \gamma_{15} ISC_{L1CD}}{1-\gamma_{15}}$$

Here, when CNAV / CNAV2 is used the following relationship can be used,

$$(\Delta t_{sv})_{L1CP-L5Q5} = \Delta t_{sv}$$

5.9. Ionospheric Delay Correction Using Ionospheric Parameters

5.9.1. Parameter Definition

Table 5.9.1-1 shows the ionospheric parameters of LNAV(L1C/A, L1C/B), CNAV2(L1C) and CNAV(L2C,L5). In addition, Table 5.9.1-2 shows the other parameters for calculations. Note that the elevation angle, azimuthal angle, latitude, and longitude are calculated using a spheroid that has a semimajor axis of 6,378,137 m and an oblateness of 298.257223563.

Table 5.9.1-1 Ionospheric Parameters

Parameter	Description	Units
α_0	Ionospheric parameter	sec
α_1	Ionospheric parameter	sec/semi-circle
α_2	Ionospheric parameter	sec/semi-circle^2
α_3	Ionospheric parameter	sec/semi-circle^3
β_0	Ionospheric parameter	sec
β_1	Ionospheric parameter	sec/semi-circle
β_2	Ionospheric parameter	sec/semi-circle^2
β_3	Ionospheric parameter	sec/semi-circle^3

Table 5.9.1-2 Other Parameters

Parameter	Description	Units
E	Elevation angle viewed from user	[semi-circles]
A	Azimuthal angle of satellite viewed from user (with north as 0 and the clockwise direction as positive)	[semi-circles]
ϕ_u	Latitude of user	[semi-circles]
λ_u	Longitude of user	[semi-circles]
t_{QZSST}	QZSS time calculated by receiver	[s]

5.9.2. Algorithms

Table 5.9.2-1 shows the L1 ionospheric delay correction calculation algorithms that are based on the ionospheric parameters. T_{iono} is the delay amount at the L1 frequency. When this algorithm is used for the L2 signal and L5 signal, transform by the following equations:

$$(T_{iono})_{L2} = \frac{f_{L1}^2}{f_{L2}^2} T_{iono} \quad \text{[s]}, \qquad (T_{iono})_{L5} = \frac{f_{L1}^2}{f_{L5}^2} T_{iono} \quad \text{[s]}$$

where, f_{L1}, f_{L2}, f_{L5}: Frequencies [Hz] of L1, L2, and L5

Table 5.9.2-1 L1 Ionospheric Delay Correction Calculation Algorithms

$\psi = \dfrac{0.0137}{E+0.11} - 0.022$	Earth's central angle between the user position and the earth projection of ionospheric intersection point [semi-circles]
$\phi_i = \begin{cases} \phi_u + \psi\cos A, & \lvert\phi_i\rvert \leqq 0.416 \\ +0.416, & \phi_i > +0.416 \\ -0.416, & \phi_i < -0.416 \end{cases}$	Latitude of the earth projection of the ionospheric pierce point [semi-circles]
$\lambda_i = \lambda_u + \dfrac{\psi \sin A}{\cos \phi_i}$	Longitude of the ionospheric pierce point [semi-circles]
$\phi_m = \phi_i + 0.064\cos(\lambda_i - 1.617)$	Magnetic latitude of ionospheric pierce point (Average ionospheric altitude of 350 km is assumed.) [semi-circles]
$t = 4.32\times10^4 \lambda_i + t_{QZSST}$ where, $0 \leqq t < 86400$ [s]. If $t \geqq 86400$, subtract 86400 [s]. If $t < 0$, add 86400 [s].	Local time [s]
$PER = \begin{cases} \sum_{n=0}^{3} \beta_n \phi_m^n, & PER \geqq 72000 \\ 72000, & PER < 72000 \end{cases}$	Phase [s]
$x = \dfrac{2\pi(t-50400)}{PER}$	Phase [rad]
$AMP = \begin{cases} \sum_{n=0}^{3} \alpha_n \phi_m^n, & AMP \geqq 0 \\ 0, & AMP < 0 \end{cases}$	Amplitude [s]
$F = 1.0 + 16.0(0.53 - E)^3$	Obliquity factor [-]
$T_{iono} = \begin{cases} F * \left[5.0*10^{-9} + (AMP)\left\{1 - \dfrac{x^2}{2} + \dfrac{x^4}{24}\right\}\right], & \lvert x\rvert < 1.57 \\ F * \left(5.0*10^{-9}\right), & \lvert x\rvert \geq 1.57 \end{cases}$	L1 ionospheric delay [s]

5.9.3. Applicable Area

There are two types of ionospheric parameters: Wide area and Japan area. The areas shall be shown in Figure 5.9.3-1 and Table 5.9.3-1.

The ionospheric parameter for each area can only be used in the target area. Therefore, it must not be used in the other area.

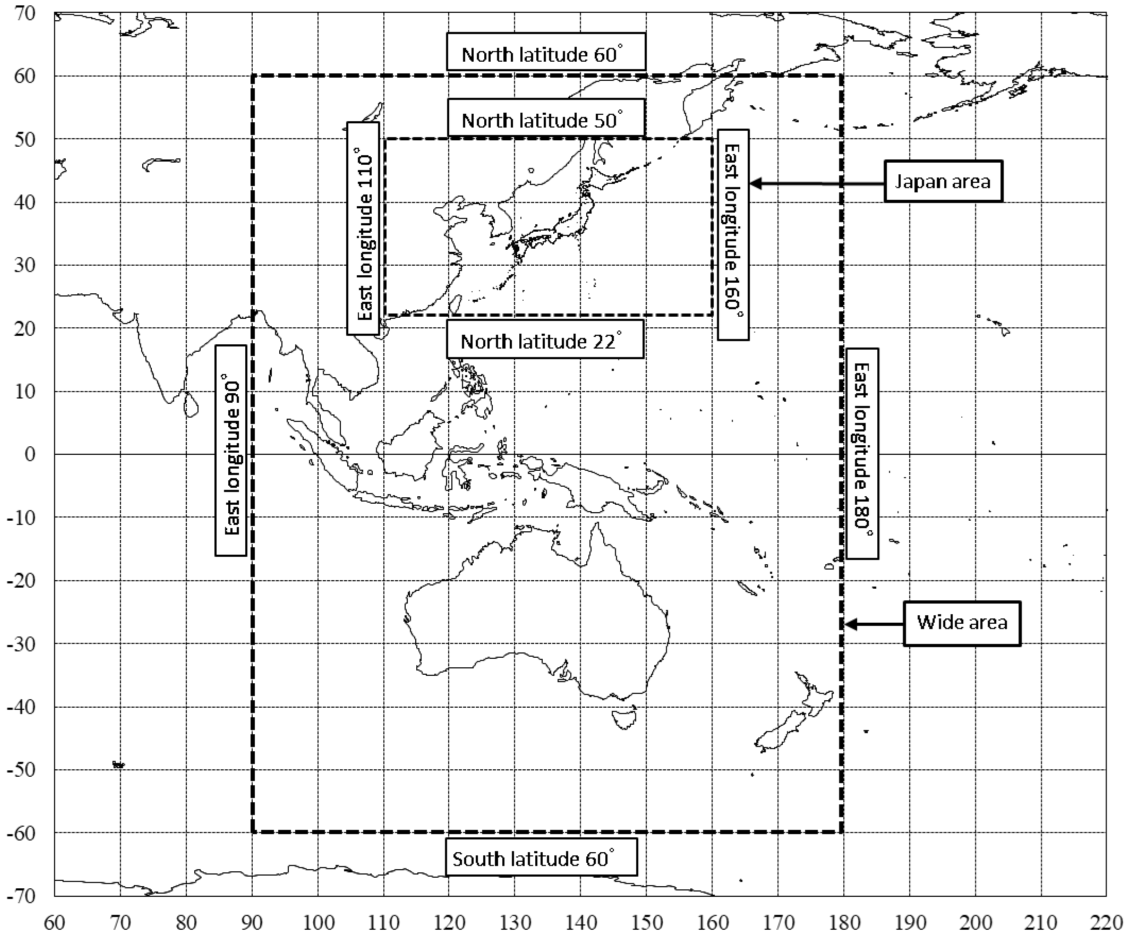


Figure 5.9.3-1 Target Areas of Ionospheric Parameters

Table 5.9.3-1 Boundary Lines of Target Areas

Azimuth Direction	Wide Area	Japan Area
North	North latitude 60°	North latitude 50°
South	South latitude 60°	North latitude 22°
West	East longitude 90°	East longitude 110°
East	East longitude 180°	East longitude 160°

5.10. Ionospheric Delay Correction Using Dual Frequency Observation

Users who correct ionospheric delays using dual frequency observation shall be the pseudo range of the ionosphere-free linear combination using the following equation.

Dual frequency users of L1 and L2 shall use the following equation:

$$PR_{L1x-L2x} = \frac{PR_{L2x} - \gamma_{12} PR_{L1x}}{1 - \gamma_{12}}$$

where,

$$\gamma_{12} = \left(\frac{f_{L1}}{f_{L2}} \right)^2 = \left(\frac{1575.42}{1227.6} \right)^2$$

$PR_{L1x\text{-}L2x}$: Pseudo range after ionospheric delay correction

PR_{L1x} : Pseudo range measured by the PRN code (C/A, L1CP, L1CD) of the L1 frequency

PR_{L2x} : Pseudo range measured by the PRN code (L2CM, L2CL) of the L2 frequency

Dual frequency users of L1 and L5 shall use the following equation:

$$PR_{L1x-L5x} = \frac{PR_{L5x} - \gamma_{15} PR_{L1x}}{1 - \gamma_{15}}$$

where,

$$\gamma_{15} = \left(\frac{f_{L1}}{f_{L5}} \right)^2 = \left(\frac{1575.42}{1176.45} \right)^2$$

$PR_{L1x\text{-}L5x}$: Pseudo range after ionospheric delay correction

PR_{L5x} : Pseudo range measured by the PRN code (I5, Q5) of the L5 frequency

5.11. GNSS Time Offset Correction

5.11.1. Parameter Definition

Table 5.11.1-1 shows the GNSS time offset parameters for CNAV2(L1C) and CNAV(L2C,L5).

Table 5.11.1-1 GNSS Time Offset Parameters

Parameter	Description	Units
t_{GGTO}	Time data reference Time of Week	sec
WN_{GGTO}	Time data reference Week Number	weeks
A_{0GGTO}	Bias coefficient of QZSS time scale relative to GNSS time scale	sec
A_{1GGTO}	Drift coefficient of QZSS time scale relative to GNSS time scale	sec/sec
A_{2GGTO}	Drift rate coefficient of QZSS time relative to GNSS time scale	sec/sec^2
GNSS ID	GNSS Type ID	-

5.11.2. Algorithm

The algorithm to transform from QZSST to another GNSS time is shown in Table 5.11.2-1.

Table 5.11.2-1 Calculation Algorithm

$t_{GNSS} = t_{QZSST} - (A_{0GGTO} + A_1\left(t_{QZSST} - t_{GGTO} + 604800(WN - WN_{GGTO})\right) + A_{2GGTO}\left(t_{QZSST} - t_{GGTO} + 604800(WN - WN_{GGTO})\right)^2)$	Another GNSS time [s]

5.12. UTC Offset Correction

5.12.1. Parameter Definition

Table 5.12.1-1 shows the UTC parameters of LNAV(L1C/A, L1C/B), and Table 5.12.1-2 shows those of CNAV2(L1C) and CNAV(L2C,L5). Here, the UTC parameters of QZSS are the value of UTC(NICT).

Table 5.12.1-1 LNAV(L1C/A, L1C/B) UTC Parameters

Parameter	Description	Units
A_0	Bias coefficient of QZSS time scale relative to UTC time scale	sec
A_1	Drift coefficient of QZSS time scale relative to UTC time scale	sec/sec
Δt_{LS}	Current or past leap second count	sec
t_{ot}	Epoch of UTC parameter (time data reference time of week)	sec
WN_t	Modulo-256 expression of UTC reference week number	weeks
WN_{LSF}	Modulo-256 expression of leap second reference week number (*1)	weeks
DN	Leap second reference day number (*2)	days
Δt_{LSF}	Current or future leap second count	sec

Table 5.12.1-2 CNAV2(L1C) and CNAV(L2C,L5) UTC Parameters

Parameter	Description	Units
A_{0-n}	Bias coefficient of QZSS time scale relative to UTC time scale	sec
A_{1-n}	Drift coefficient of QZSS time scale relative to UTC time scale	sec/sec
A_{2-n}	Drift rate correction coefficient of QZSS time scale relative to UTC time scale	sec/sec^2
Δt_{LS}	Current or past leap second count	sec
t_{ot}	Epoch of UTC parameter (time data reference time of week)	sec
WN_{ot}	Time data reference week number	weeks
WN_{LSF}	Leap second reference week number	weeks
DN	Leap second reference day number (*2)	days
Δt_{LSF}	Current or future leap second count	sec

*1: The value of WN_{LSF}, which is the modulo-256 expression of the leap second reference week number, is managed so that the absolute value of the difference between the untruncated WN defined in Section 4.1.2.3 and WN_{LSF} values shall not exceed 127 in order to enable the leap second reference week number to be determined uniquely when Δt_{LS} and Δt_{LSF} are not equal.

*2: The leap second reference day number DN means that the leap second is inserted at the end of the day indicated by DN. Note that a value of "1" indicates the first day from the week end/start of the week.

5.12.2. UTC Offset Calculation Algorithm

The UTS offset calculation algorithm indicates an algorithm that uses the UTC parameter to transform from QZSS time t_{QZSST} to UTC t_{UTC}. The transform algorithm from QZSS time to UTC uses different calculation methods depending on the relationship between the user's current time and the leap second update timing indicated by WN_{LSF} and DN, and these calculation methods are classified into three case types.

(1) When the user's current time is 6 hours or more before the leap second update timing indicated by WN_{LSF} and DN

The relationship between UTC [s] and QZSS time [s] is shown in the following equation:

$$t_{UTC} = (t_{QZSST} - \Delta t_{UTC}) \text{ [mod 86400][s]}$$

Here, Δt_{UTC} is calculated by the algorithm shown in Table 5.12.2-1

Table 5.12.2-1 UTC Offset Calculation Algorithm

For LNAV(L1C/A, L1C/B): $\Delta t_{UTC} = \Delta t_{LS} + A_0 + A_1(t_{QZSST} - t_{ot} + 604800(WN - WN_t))$ Note: Because WN_t is a modulo-256 expression, an integral multiple of 256 shall be added in order to match the current week.
For CNAV2(L1C) and CNAV(L2C,L5): $\Delta t_{UTC} = \Delta t_{LS} + A_{0\text{-}n} + A_{1\text{-}n}(t_{QZSST} - t_{ot} + 604800(WN - WN_{ot})) + A_{2\text{-}n}(t_{QZSST} - t_{ot} + 604800(WN - WN_{ot}))^2$

(2) When the user's current time is less than 6 hours before or after the leap second update timing indicated by WN_{LSF} and DN

The relationship between UTC [s] and QZSS time [s] is shown in the following equation:

$W = (t_{QZSST} - \Delta t_{UTC} - 43200)$ [mod 86400] $+ 43200$[s]
$t_{UTC} = W$ [mod $(86400 + \Delta t_{LSF} - \Delta t_{LS}$][s]

Here, Δt_{UTC} is calculated by the algorithm shown in Table 5.12.2-1

(3) When the user's current time is 6 hours or more after the leap second update timing indicated by WN_{LSF} and DN

The relationship between UTC [s] and QZSS time [s] is shown in the following equation:

$t_{UTC} = (t_{QZSST} - \Delta t_{UTC})$ [mod 86400][s]

Here, Δt_{UTC} is calculated by the algorithm shown in Table 5.12.2-1 using Δt_{LSF} in place ofΔt_{LS} .

5.13. Earth Orientation Parameters (EOP)

5.13.1. Parameter Definition

Table 5.13.1-1 shows the earth orientation parameters (EOP) for CNAV2(L1C) and CNAV(L2C,L5).

Users can transform coordinates between ECEF and ECI by using EOP.

Table 5.13.1-1 EOP Parameters

Parameter	Description	Units
t_{EOP}	Epoch of earth orientation parameter (EOP data reference time)	sec
PM_X	X-axis polar motion value at reference time+	arc-sec
$PM\_\dot{X}$	X-axis polar motion drift at reference time	arc-sec/day
PM_Y	Y-axis polar motion value at reference time++	arc-sec
$PM\_\dot{Y}$	Y-axis polar motion drift at reference time	arc-sec/day
$\Delta UT1$	UT1-UTC Difference at Reference Time+++	sec
$\Delta U\dot{T}1$	Rate of UT1-UTC Difference at Reference Time	sec/day

5.13.2. Algorithm

In the algorithm to transform coordinate between ECEF and ECI, calculations shall be conducted in accordance with Chapter 5 of Applicable Document (2) IERS Technical Note 36 (IERS Conventions 2010). In the calculation process, the relationship between UT1 and UTC at time t indicated by Table 5.13.2-1 and the X-axis and Y-axis polar motions shall be used when both criteria are met. If both criteria are not met, the week number for t_{EOP} is not equal to the WN_{ot} value, so the calculation in Table 5.13.2-1 should not be used.

Note that the relationship between UT1 and UTC and the X-axis and Y-axis polar motions include zonal, diurnal, and semi-diurnal components that are described in Chapter 8 of IERS Technical Note 36 (IERS Conventions 2010), and thus the user does not need to additionally apply these effects.

Table 5.13.2-1 EOP Calculation Algorithm

$t_{diff} = t - t_{EOP} + 604800(WN - WN_{ot})$	difference time between time t and EOP reference time [sec]
$UT1 = UTC + \Delta UT1 + \Delta U\dot{T}1 * t_{diff}/86400$	UT [sec] at time t
$x_P = PM\_X + PM\_\dot{X} * t_{diff}/86400$	X-axis polar motion [arc-sec]
$y_P = PM\_Y + PM\_\dot{Y} * t_{diff}/86400$	Y-axis polar motion [arc-sec]
Criteria for CNAV2 ・t_{EOP} in subframe 3 page 2 is equal to the t_{ot} in subframe 3 page 1 ・Subframe 3 page 1 and subframe 3 page 2 were transmitted within a continuous 4-hour period	
Criteria for CNAV ・t_{EOP} in Message Type 32 is equal to the t_{ot} in Message Type 33 ・t_{op} in Message Type 32 is equal to the t_{op} in Message Type 33	

6. LDPC Matrix of CNAV2(L1C)

The definitions of LDPC submatrices A, B, C, D, E and T of CNAV2(L1C) subframe 2 are shown in Table 6.2-2 to Table 6.2-7 of Reference Document (3), and those of CNAV2(L1C) subframe 3 are shown in Table 6.2-8 to Table 6.2-17 of Reference Document (3).