GLOBAL NAVIGATION SATELLITE SYSTEM

GLONASS

INTERFACE
CONTROL
DOCUMENT

Code Division Multiple Access
Open Service Navigation Signal
in L1 frequency band

Edition 1.0

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Definitions and acronyms

CE – Convolution Encoder

CDMA – Code Division Multiple Access

CRC – Cyclic Redundancy Check

d – symbol in signal name, indicating attribution to a data component

DC – Digital Circuit

f_b – Base frequency (1.023 MHz)

FDMA – Frequency Division Multiple Access

GLONASS – Global Navigation Satellite System

ICD – Interface Control Document

IS – Initial State

L1OC – CDMA Open Service Navigation Signal in L1 frequency band

L1OCd time – time scale determined by phase of L1OCd signal at the phase center of an SV antenna

L1OCp time – time scale determined by phase of L1OCp signal at the phase center of an SV antenna

L1SC – CDMA Secured Service Navigation Signal in L1 frequency band

L2OCp – CDMA Open Service Navigation Signal in L2 frequency band (pilot signal)

L2OCp time – time scale determined by phase of L2OCp signal at the phase center of an SV antenna

MS – Meander Sequence

MSD – Mean Solar day

MT – Moscow Time

OC – Overlay Code

p – symbol in signal name, indicating attribution to a pilot component

PRN – Pseudorandom Noise sequence (ranging code)

S – Sequence

SC – Synchronous Counter

SV – Space Vehicle

TAI – Temps Atomique International – International Atomic Time

TDM – chip by chip Time-Division Multiplexing

TS – Time Stamp

UT1– Universal Time is mean solar time at 0° longitude accounted for the effect of polar motion on position of meridians

UTC – Coordinated Universal Time

UTC(SU) – Coordinated Universal Time of Russia

1 Scope

1.1 This Interface Control Document (ICD) defines the parameters between the space segment, represented by Glonass-K2 space vehicles (SV), and the navigation user equipment (UE) of GLONASS for L1 Code Division Multiple Access (CDMA) navigation.

Information common to all GLONASS CDMA signals is given in the document “GLONASS. Interface Control Document. General Description of Code Division Multiple Access Signal System” (hereinafter General Description ICD) which consists of the following sections:

- purpose, composition and concept of GLONASS-based positioning;
- time scales used in GLONASS;
- GLONASS geodetic reference;
- general characteristics of GLONASS signals;
- monitoring GLONASS signal-in-space;
- recommendations and algorithms for processing of data transmitted in GLONASS signals.

1.2 Russian Rocket and Space Engineering and Information Systems Corporation, Joint Stock Company (Russian Space Systems, JSC) – the designer of the GLONASS mission payload – is assigned as the developer of ICD and is responsible for its drafting, coordination, revision and maintenance.

The current Document comes into force provided that it is signed by the following persons/entities:

- GLONASS Chief Designer;
- Russian Rocket and Space Engineering and Information Systems Corporation, Joint Stock Company (Russian Space Systems, JSC) of ROSCOSMOS State Space Corporation which is the leading organization on the GLONASS payload, service radiofrequency and telemetry systems, ground control and command facilities, and a set of user equipment for different user groups;
- Academician M.F. Reshetnev Information Satellite Systems (ISS, JSC) of ROSCOSMOS State Space Corporation – prime for development and integration of GLONASS satellites, including system integration of space, launch, and ground control complexes, on-board mission software used to generate navigation message and SV control data;

- Research and Development Center (Korolev) of the Central Research Institute of the Russian Federation Space Forces – leading research and development organization of the Russian Ministry of Defense on the GLONASS system;
- Russian Institute of Radionavigation and Time (RIRT, OJSC) of Ministry of Industry and Trade of Russian Federation responsible for developing timing facilities of special and dual use, facilities for generating space segment system time; synchronization of GLONASS timing facilities and developing user equipment for different user groups;
- Central Research Institute of Machine Building, Federal State Unitary Enterprise (TSNIIMASH, FSUE) – the head research institute of the ROSCOSMOS State Space Corporation.

ICD is approved by authorized representatives of ROSCOMOS State Space Corporation and Space Forces. ICD comes into force on approval by the Commanding General of the Space Forces and the Director General of the ROSCOSMOS State Space Corporation.

In the course of GLONASS system evolution, its individual parameters may change. The developer of ICD bears responsibility for coordination of the suggested modifications with all responsible parties and, if necessary, for drafting new edition of the Document containing such modifications.

Modifications and new editions of ICD come into force on approval by the Commanding General of the Space Forces and the Director General of the ROSCOSMOS State Space Corporation.

The Russian Space Systems, JSC is responsible for official distribution of GLONASS ICD.

2 L1OC signal structure

2.1 L1OC generation

2.1.1 General scheme of L1OC signal generation

L1OC signal is transmitted on carrier frequency (nominal value)

$$f_{L1} = 1565 \cdot f_b = 313 \cdot 5.115 \, MHz = 1600.995 \, MHz$$

and consists of two components of the same power: L1OCd (data component) and L1OCp (pilot component). These components are obtained by chip by chip time-division multiplexing (TDM) of two pseudorandom noise sequences (PRNs).

L1OC signal is in phase quadrature with L1SC signal, which is delayed by 90º (Figure 2.1).

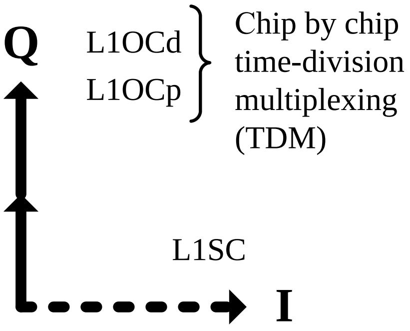


Figure 2.1 – L1OC signal structure

Figure 2.2 shows L1OC signal generation scheme.

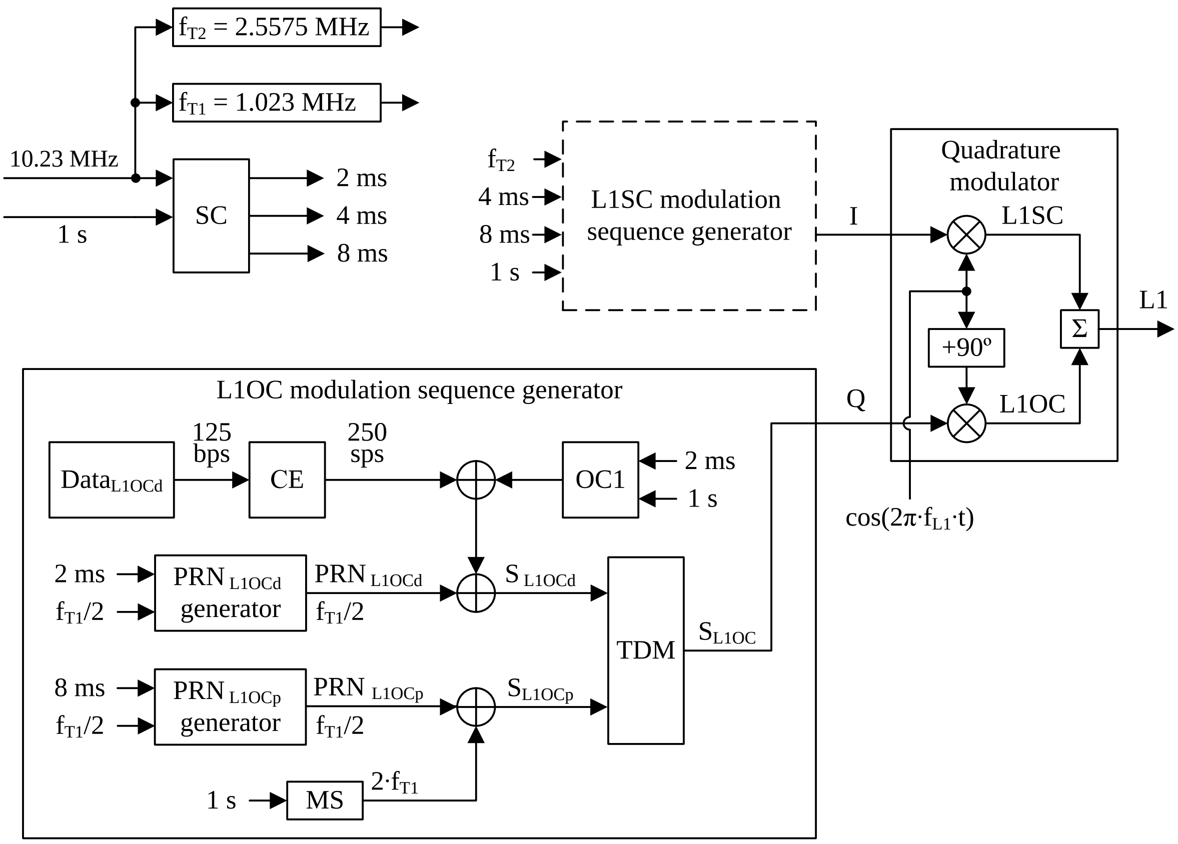


Figure 2.2 – L1OC signal generation scheme

2.1.2 L1OCd signal generation

Modulation sequence of symbols of L1OCd signal (S_{L1OCd}) is the modulo-2 sum of PRN_{L1OCd} chip stream clocked at $f_{T1}/2$ = 0.5115 MHz (see 2.2.1), overlay code (OC1) symbol stream clocked at 500 sps, and convolution encoder (CE) symbol stream clocked at 250 sps (see 2.3) as shown in Figure 2.2.

OC1 is a periodic 2-symbol code 01 synchronized with CE symbols (T_{CE} = 8 ms) and transmitted with the most significant bits first (the first symbol of OC1 for a CE symbol duration is 0).

2.1.3 L1OCp signal generation

Modulation sequence of symbols for L1OCp signal (S_{L1OCp}) is the modulo-2 sum of PRN_{L1OCp} chip stream clocked at $f_{T1}/2$ = 0.5115 MHz (see 2.2.2) and meander sequence (MS) clocked at $2\cdot f_{T1}$ = 2.046 MHz as shown in Figure 2.2.

MS is a 0101 periodic sequence, synchronized with PRN_{L1OCp} chips and transmitted with most significant bits ahead (the first symbol of MS for a PRN_{L1OCp} chip duration is 0). MS is intended to form BOC(1,1) spectrum for L1OCp component.

2.1.4 L1OCd and L1OCp multiplexing

The modulation sequence of symbols for L1OC signal (S_{L1OC}) is formed at the TDM output. Figure 2.3 shows the TDM principle of operation. It also shows the second mark position corresponding to PRN chips end/start. The second mark also corresponds to PRN periods' end/start.

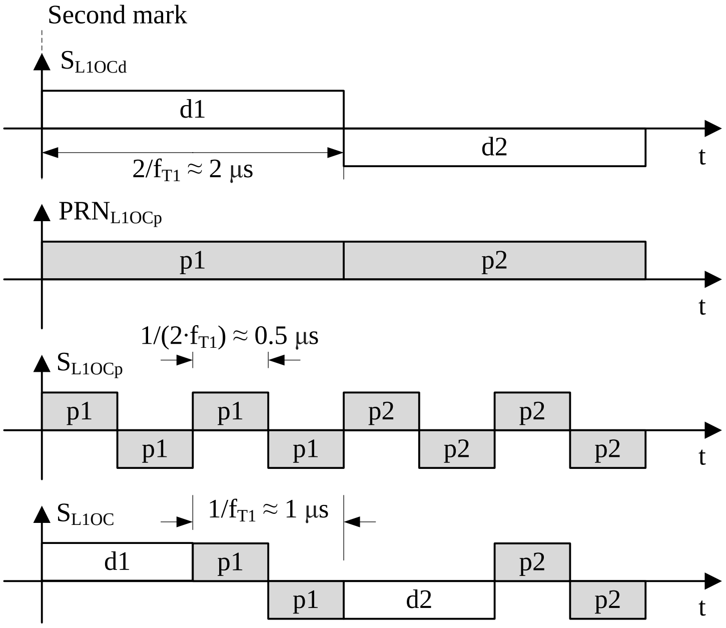


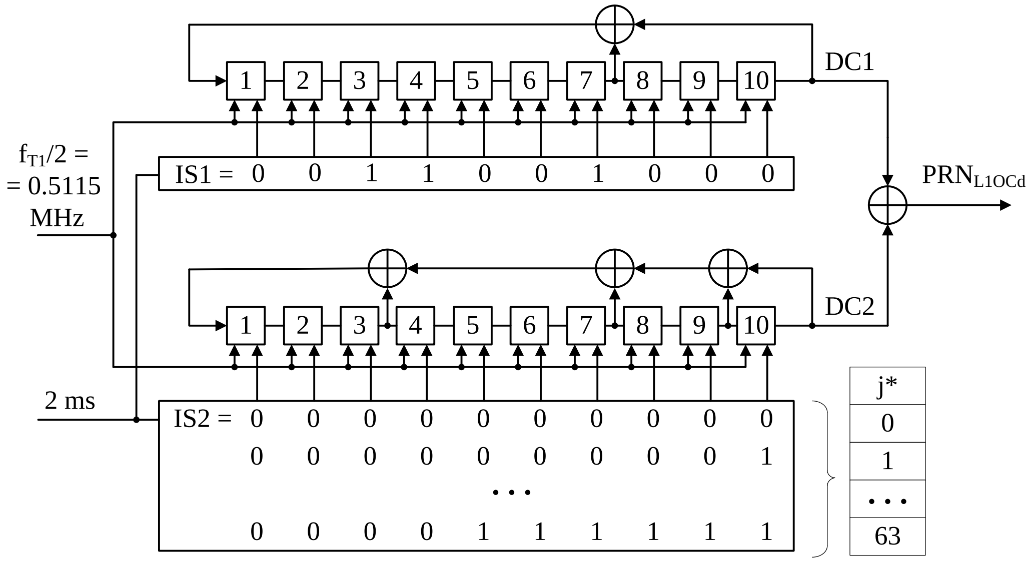
Figure 2.3 – Timing relationship between components of L1OC modulation sequence

Sequence S_{L1OC} is used to phase-shift key Q-component of carrier frequency in L1 by 180°.

2.2 Structure of L1OC PRN generator

2.2.1 L1OCd PRN generator

Figure 2.4 shows the structure of L1OCd PRN generator.



* j = 0...63 – SV ID number
IS2 = j

Figure 2.4 – L1OCd PRN generator structure

Zero SV ID number is the reserved one, which can only be enabled upon termination of GLONASS CDMA and FDMA signals combined use.

L1OCd PRNs are Gold sequences of length N = 1023 and period T = 2 ms. These sequences are generated by the modulo-2 addition of binary digits (1 and 0) incoming at clock rate $f_{T1}/2 = 0.5115\,\text{MHz}$ from digital circuits DC1 and DC2 shown in Figure 2.4.

The shift register of DC1 has 10 triggers and feedback from triggers number 7 and 10. The shift register of DC2 has 10 triggers and feedback from triggers number 3, 7, 9, and 10. The shift direction in all registers is from lower to higher trigger number.

The following initial state (IS) codes are set into DC registers at 2 ms intervals:

- IS1 = 0011001000 into DC1;
- IS2 = j = 0000000000, 0000000001…0000111111 into DC2, where j is an SV ID number.

IS1 and IS2 (binary numbers) are registered into DC1 and DC2 in such a way that the least significant bit enters the last trigger of register.

Short pulses at 2 ms intervals, marking moments of IS codes registering to DCs, are formed in synchronous counter (SC) shown on Figure 2.2 based on 10.23 MHz signal and 1 s pulses.

Table 2.1 shows first and last 32 chips of L1OCd PRNs in HEX. For example, 13228DB8 means 00010011001000101000110110111000. The record of sequences means that the left-most chip is generated first.

Table 2.1 – First and last 32 chips of L1OCd PRNs

j	IS2 (Figure 2.4)	$\text{PRN}_{\text{L1OCd}}$		j	IS2 (Figure 2.4)	$\text{PRN}_{\text{L1OCd}}$	
		First 32 chips	Last 32 chips			First 32 chips	Last 32 chips
0	0000000000	13228DB8	D51F792C	32	0000100000	1728D5B3	C89D8272
1	0000000001	9306460E	0E8093A7	33	0000100001	970C1E05	130268F9
2	0000000010	531423D5	634F66E2	34	0000100010	571E7BDE	7ECD9DBC
3	0000000011	D330E863	B8D08C69	35	0000100011	D73AB068	A5527737
4	0000000100	3339DA8E	8E3776CB	36	0000100100	37338285	93B58D95
5	0000000101	B31D1138	55A89C40	37	0000100101	B7174933	482A671E
6	0000000110	730F74E3	38676905	38	0000100110	77052CE8	25E5925B
7	0000000111	F32BBF55	E3F8838E	39	0000100111	F721E75E	FE7A78D0
8	0000001000	030BED95	A3149454	40	0000101000	0701B59E	BE966F0A
9	0000001001	832F2623	788B7EDF	41	0000101001	87257E28	65098581
10	0000001010	433D43F8	15448B9A	42	0000101010	47371BF3	08C670C4
11	0000001011	C319884E	CEDB6111	43	0000101011	C713D045	D3599A4F
12	0000001100	2310BAA3	F83C9BB3	44	0000101100	271AE2A8	E5BE60ED
13	0000001101	A3347115	23A37138	45	0000101101	A73E291E	3E218A66
14	0000001110	632614CE	4E6C847D	46	0000101110	672C4CC5	53EE7F23
15	0000001111	E302DF78	95F36EF6	47	0000101111	E7088773	887195A8
16	0000010000	1B363DAE	EE1A8F90	48	0000110000	1F3C65A5	F39874CE
17	0000010001	9B12F618	3585651B	49	0000110001	9F18AE13	28079E45
18	0000010010	5B0093C3	584A905E	50	0000110010	5F0ACBC8	45C86B00
19	0000010011	DB245875	83D57AD5	51	0000110011	DF2E007E	9E57818B
20	0000010100	3B2D6A98	B5328077	52	0000110100	3F273293	A8B07B29
21	0000010101	BB09A12E	6EAD6AFC	53	0000110101	BF03F925	732F91A2
22	0000010110	7B1BC4F5	03629FB9	54	0000110110	7F119CFE	1EE064E7
23	0000010111	FB3F0F43	D8FD7532	55	0000110111	FF355748	C57F8E6C
24	0000011000	0B1F5D83	981162E8	56	0000111000	0F150588	859399B6
25	0000011001	8B3B9635	438E8863	57	0000111001	8F31CE3E	5E0C733D
26	0000011010	4B29F3EE	2E417D26	58	0000111010	4F23ABE5	33C38678
27	0000011011	CB0D3858	F5DE97AD	59	0000111011	CF076053	E85C6CF3
28	0000011100	2B040AB5	C3396D0F	60	0000111100	2F0E52BE	DEBB9651
29	0000011101	AB20C103	18A68784	61	0000111101	AF2A9908	05247CDA
30	0000011110	6B32A4D8	756972C1	62	0000111110	6F38FCD3	68EB899F
31	0000011111	EB166F6E	AEF6984A	63	0000111111	EF1C3765	B3746314

2.2.2 L1OCp PRN generator

Figure 2.5 shows the structure of L1OCp PRN generator.

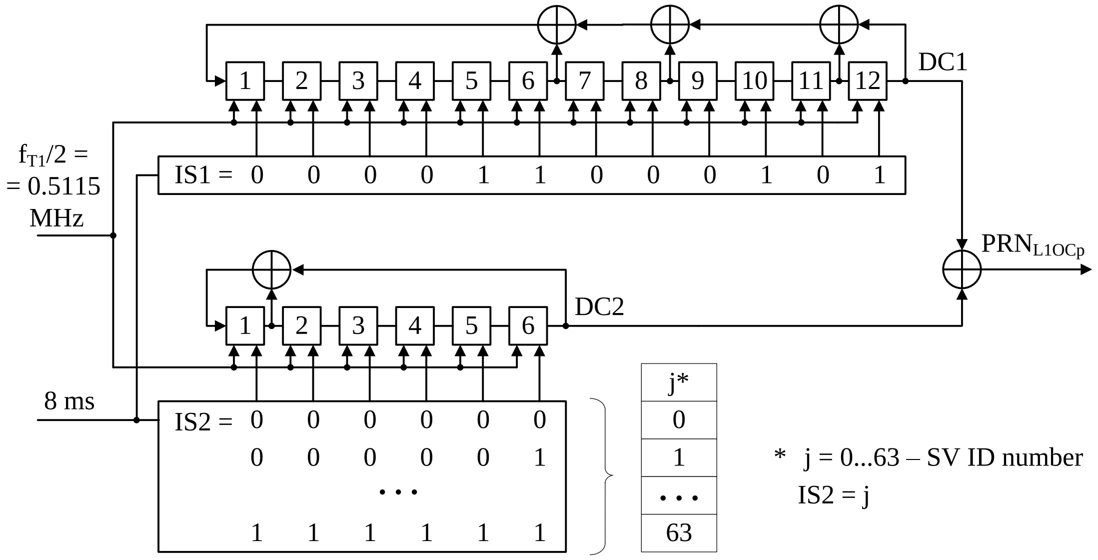


Figure 2.5 – L1OCp PRN generator structure

Zero SV ID number is the reserved one, which can only be enabled upon termination of GLONASS CDMA and FDMA signals combined use.

L1OCp PRNs are truncated Kasami sequences. Their length is N = 4092 and the period is T = 8 ms. These sequences are generated by the modulo-2 addition of binary symbols (1 and 0) incoming at clock rate $f_{T1}/2 = 0.5115\,\text{MHz}$ from DC1 and DC2 in accordance with Figure 2.5.

Shift register in DC1 has 12 triggers and feedback from triggers number 6, 8, 11 and 12. Shift register in DC2 has 6 triggers and feedback from triggers number 1 and 6. The shift direction in all registers is from lower to higher trigger number.

The following initial state codes are set into DC registers at 8 ms intervals:

- IS1 = 000011000101 into DC1;
- IS2 = j = 000000, 000001…111111 into DC2, where j is an SV ID number.

IS1 and IS2 (binary numbers) are recorded into in DC1 and DC2 in such a way that the least significant bit enters the last trigger of register.

Short pulses at 8 ms intervals marking moments of IS codes registering to DCs are formed in synchronous counter (SC) shown in Figure 2.2 based on 10.23 MHz signal and 1 s pulses.

Table 2.2 shows first and last 32 chips of L1OCp PRNs in HEX. For example, A301543B means 10100011000000010101010000111011. The record of sequences means that the left-most chip is generated first.

Table 2.2 – First and last 32 chips of L1OCp PRNs

j	IS2 (Fig. 2.5)	PRN_{L1OCp}		j	IS2 (Fig. 2.5)	PRN_{L1OCp}	
		First 32 chips	Last 32 chips			First 32 chips	Last 32 chips
0	000000	A301543B	DA55EDB8	32	100000	A4EB99E1	7EB71F34
1	000001	20F432D6	082494FE	33	100001	271EFF0C	ACC66672
2	000010	E2FBE74D	B36D511B	34	100010	E5112A97	178FA397
3	000011	610E81A0	611C285D	35	100011	66E44C7A	C5FEDAD1
4	000100	83FC0D80	6EC9B3E9	36	100100	8416C05A	CA2B4165
5	000101	00096B6D	BCB8CAAF	37	100101	07E3A6B7	185A3823
6	000110	C206BEF6	07F10F4A	38	100110	C5EC732C	A313FDC6
7	000111	41F3D81B	D580760C	39	100111	461915C1	71628480
8	001000	B37FF8E6	001BC290	40	101000	B495353C	A4F9301C
9	001001	308A9E0B	D26ABBD6	41	101001	376053D1	7688495A
10	001010	F2854B90	69237E33	42	101010	F56F864A	CDC18CBF
11	001011	71702D7D	BB520775	43	101011	769AE0A7	1FB0F5F9
12	001100	9382A15D	B4879CC1	44	101100	94686C87	10656E4D
13	001101	1077C7B0	66F6E587	45	101101	179D0A6A	C214170B
14	001110	D278122B	DDBF2062	46	101110	D592DFF1	795DD2EE
15	001111	518D74C6	0FCE5924	47	101111	5667B91C	AB2CABA8
16	010000	AB3E0255	3772FA2C	48	110000	ACD4CF8F	939008A0
17	010001	28CB64B8	E503836A	49	110001	2F21A962	41E171E6
18	010010	EAC4B123	5E4A468F	50	110010	ED2E7CF9	FAA8B403
19	010011	6931D7CE	8C3B3FC9	51	110011	6EDB1A14	28D9CD45
20	010100	8BC35BEE	83EEA47D	52	110100	8C299634	270C56F1
21	010101	08363D03	519FDD3B	53	110101	0FDCF0D9	F57D2FB7
22	010110	CA39E898	EAD618DE	54	110110	CDD32542	4E34EA52
23	010111	49CC8E75	38A76198	55	110111	4E2643AF	9C459314
24	011000	BB40AE88	ED3CD504	56	111000	BCAA6352	49DE2788
25	011001	38B5C865	3F4DAC42	57	111001	3F5F05BF	9BAF5ECE
26	011010	FABA1DFE	840469A7	58	111010	FD50D024	20E69B2B
27	011011	794F7B13	567510E1	59	111011	7EA5B6C9	F297E26D
28	011100	9BBDF733	59A08B55	60	111100	9C573AE9	FD4279D9
29	011101	184891DE	8BD1F213	61	111101	1FA25C04	2F33009F
30	011110	DA474445	309837F6	62	111110	DDAD899F	947AC57A
31	011111	59B222A8	E2E94EB0	63	111111	5E58EF72	460BBC3C

2.3 Convolution encoder structure

The 125 bps data stream of L1OCd signal is encoded by a rate 1/2 convolution encoder (133,171) shown in Figure 2.6. The switch of the encoder is set to position 1 (lower position) for the first half of a 8-millisecond data bit period.

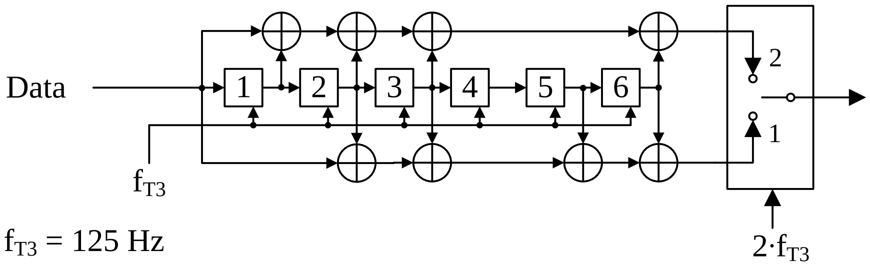


Figure 2.6 – Convolution encoder structure

3 General overview of L1OCd navigation message structure

The following definitions are used to describe data structure of navigation messages:

bit – binary symbol of data;

string – sequence of binary symbol bits of specific length;

string field – aggregate of string bits containing a specific parameter or zeros;

service fields of a string – fields that contain service data. The semantic scope of these fields is the same for all strings of this signal;

data fields of a string – fields that contain data which semantic scope is different for different strings of this signal;

reserved fields of a string – fields which semantic scope and value are not described in ICD. UE shall ignore these fields.

Navigation message of L1OCd signal is transmitted as a continuous sequence of strings of non-fixed and non-predetermined structure.

Navigation message of L1OCd signal is transmitted at 125 bps. Navigation message consists of 250-bit strings of 2-second duration, as well as of 125- and 275-bit anomalous strings of 1- and 3-second duration, respectively.

4 Service field structure of L1OCd data

4.1 General structure of L1OCd string

4.1.1 Bit sequence in a string

Figure 4.1 shows general structure of a string of L1OCd signal. The string is 250 bits long and of 2 seconds duration. The string consists of fields – separate bits or groups of bits containing specific parameters.

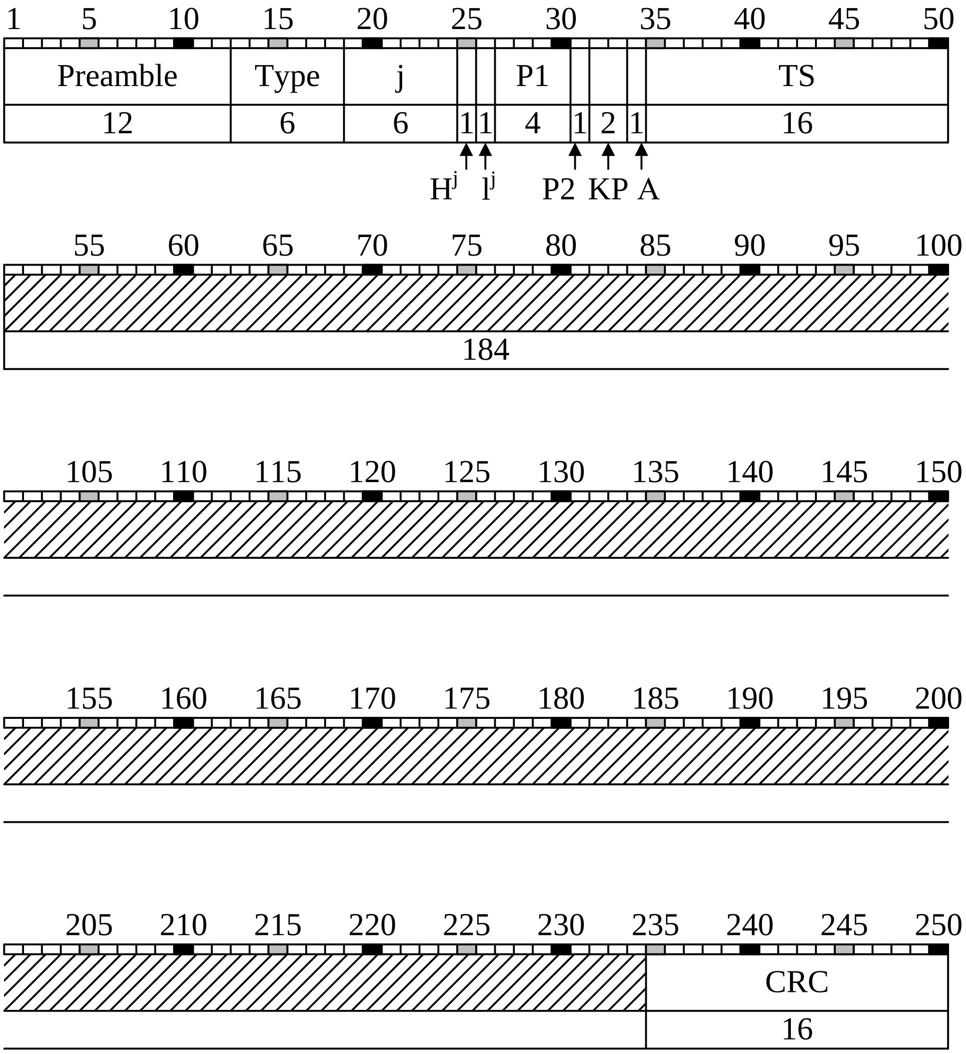


Figure 4.1 – General structure of L1OCd data string

Figure 4.1 shows string bit numeration, field designation and the number of bits in each field. According to this bit numeration, transmission of a string starts with bit 1 (the first bit of Preamble field) and ends with bit 250 (last bit of a cyclic redundancy check (CRC) field).

4.1.2 Types of fields

Each string contains two types of fields: service and data. These fields are defined in accordance with Section 3.

Figure 4.1 shows service fields, locations of data fields are shaded.

Shaded fields in figures depicting strings of specific type (Figure 5.1, for example) are reserved fields, which shall be ignored by UE.

4.1.3 Rule for recording digits in fields

In the words which numerical values may be positive or negative, the most significant bit is the sign bit. Symbol "0" corresponds to "+" and symbol "1" corresponds to "-". The most significant bit is registered in the bit field which is transmitted first. For example, if j = 000001 (SV ID number, see 4.2.2.3), then bit number 24 of a string (Figure 4.1) is registered as "1" and bits number 19 to 23 are registered as "0".

4.2 Service fields of L1OCd string

4.2.1 List of L1OCd service fields

Each L1OCd string contains service fields of permanent set and position, namely repeated in each string. Table 4.1 shows the list and parameters of service fields (also see Figure 4.1).

Table 4.1 – Parameters of L1OCd service fields

Field	Number of bits	Least significant bit	Value range	Unit
Preamble	12	1	010111110001	-
Type	6	1	0 – 63	-
j	6	1	0 – 63	-
H^j	1	1	0, 1	-
l^j	1	1	0, 1	-
P1	4	see 4.2.2.6		
P2	1	see 4.2.2.7		
KP	2	1	00, 01, 10, 11	-
A	1	1	0, 1	-
TS	16	1	0 – 43199	2 s
CRC	16	1	see 4.2.2.11	-

4.2.2 Semantic scope of L1OCd service fields

4.2.2.1 Field Preamble contains the constant value: Preamble = 010111110001. When passing through convolution encoder (133,171) described in Figure 2.3 the first six bits of the sequence ensure its specific initial state. This initial state when combined with the last six bit generates the constant 12-symbol synchronizing sequence 000111011010 at the output of convolution encoder (133,171).

4.2.2.2 Field Type is a type of a current string. It determines the data (set and position of string data fields) transmitted in the string that contains this field. For example, if current string is of Type 1, then Type = 000001.

4.2.2.3 Field j is the ID number of the SV that transmits this navigation message. Semantic scope of j field is constant for strings of any type except for those containing almanac. In strings containing almanac, field j is denoted j_A and means the ID number of the SV, to which almanac data belongs.

Zero SV ID number is the reserved one, which can only be enabled upon termination of of GLONASS CDMA and FDMA signals combined use.

4.2.2.4 Field H^j is the attribute of healthy ("0") or non-healthy ("1") navigation signal of the SV ID number j.

4.2.2.5 Field l^j is the attribute of validity ("0") or non-validity ("1") of data in the current string of the SV ID number j.

4.2.2.6 Field P1 denotes SV call to ground control. This field is not used by a user.

4.2.2.7 Field P2 denotes regime of SV orientation:

P2 = 0 – for the duration of a current string in L1OCd time, SV is Sun-pointing;

P2 = 1 – for the duration of a current string in L1OCd time, SV either performs noon/midnight turn maneuver or transits from Sun-pointing to noon/midnight turn maneuver or vice versa.

4.2.2.8 Field KP is the indication of the expected UTC(SU) correction by plus or minus 1 s at the end of current quarter in GMT (at 3:00 in MT). UTC(SU) corrections shall result in the corresponding corrections of L1OCd time:

KP = 00 – no correction planned;

KP = 01 – day length is increased by 1 s in L1OCd time;

KP = 10 – correction decision is pending;

KP = 11 – day length is reduced by 1 s in L1OCd time.

4.2.2.9 Field A is the indication of correction L1OCd time by plus or minus 1 s at the end of the next string:

A = 0 – no correction is planned;

A = 1 – correction is planned.

Combination of A = 1 and KP = 11 in the current string denotes that the next string will be an anomalous string Type 1 which is 1 s shorter and of 1 s duration. If the current string shows the combination of A = 1 and KP = 01, then the next string will be anomalous string Type 2 which is 1 s longer and of 3 s duration (also see Appendix E in General Description ICD).

4.2.2.10 Field TS is time stamp, i.e. L1OCd time at the start of a current string. TS is expressed in 2-second intervals within a current day (in L1OCd time). TS = 0 for the first 2-second interval within a day.

4.2.2.11 Field CRC is cyclic redundancy check bits. CRC field is formed as described in 4.4.

4.3 Anomalous strings of L1OCd signal

4.3.1 L1OCd anomalous strings are longer or shorter than 2 s. Strings of Types 1 and 2 are anomalous.

4.3.2 Figure 4.2 shows L1OCd string of Type 1. This string is used for leap second corrections of L1OCd time when a day length is reduced by 1 s. The string has non-standard duration of 1 s and contains 125 bits.

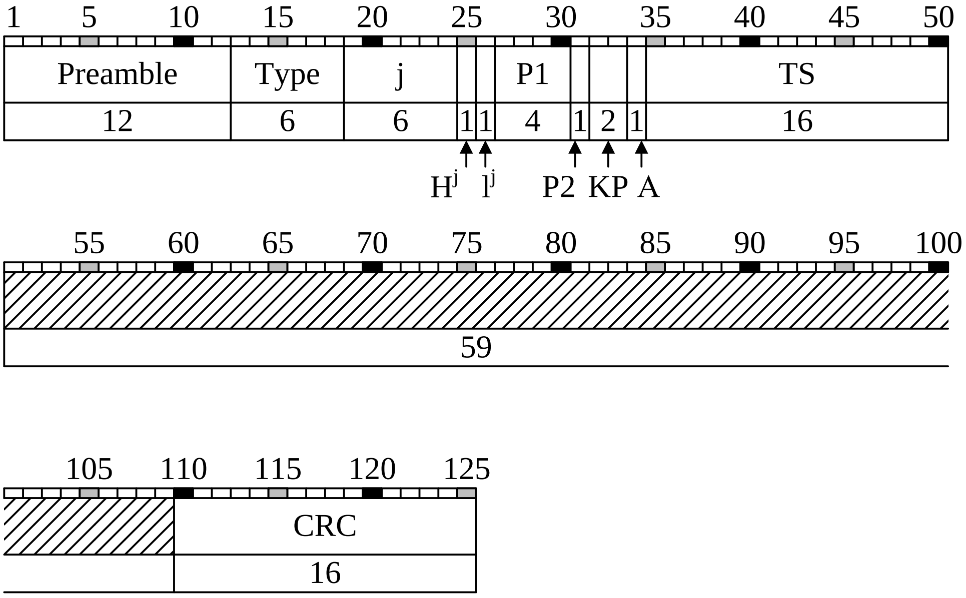


Figure 4.2 – Anomalous L1OCd data string Type 1

Service fields are transmitted in the string (see 4.2), the only difference is that CRC field is generated using CRC encoding scheme, as described in 4.5 (also see also Appendix E of the General Description ICD).

4.3.3 Figure 4.3 shows L1OCd string of Type 2. This string is used to denote leap second corrections of L3OC time when a day length is increased by 1 s. The string has a nonstandard duration of 3 s and contains 375 bits.

Service fields are also transmitted in the string (see 4.2), the only difference is that CRC field contains 24 bits and is generated using CRC encoding scheme described in 4.6 (also see Appendix E in the General Description ICD).

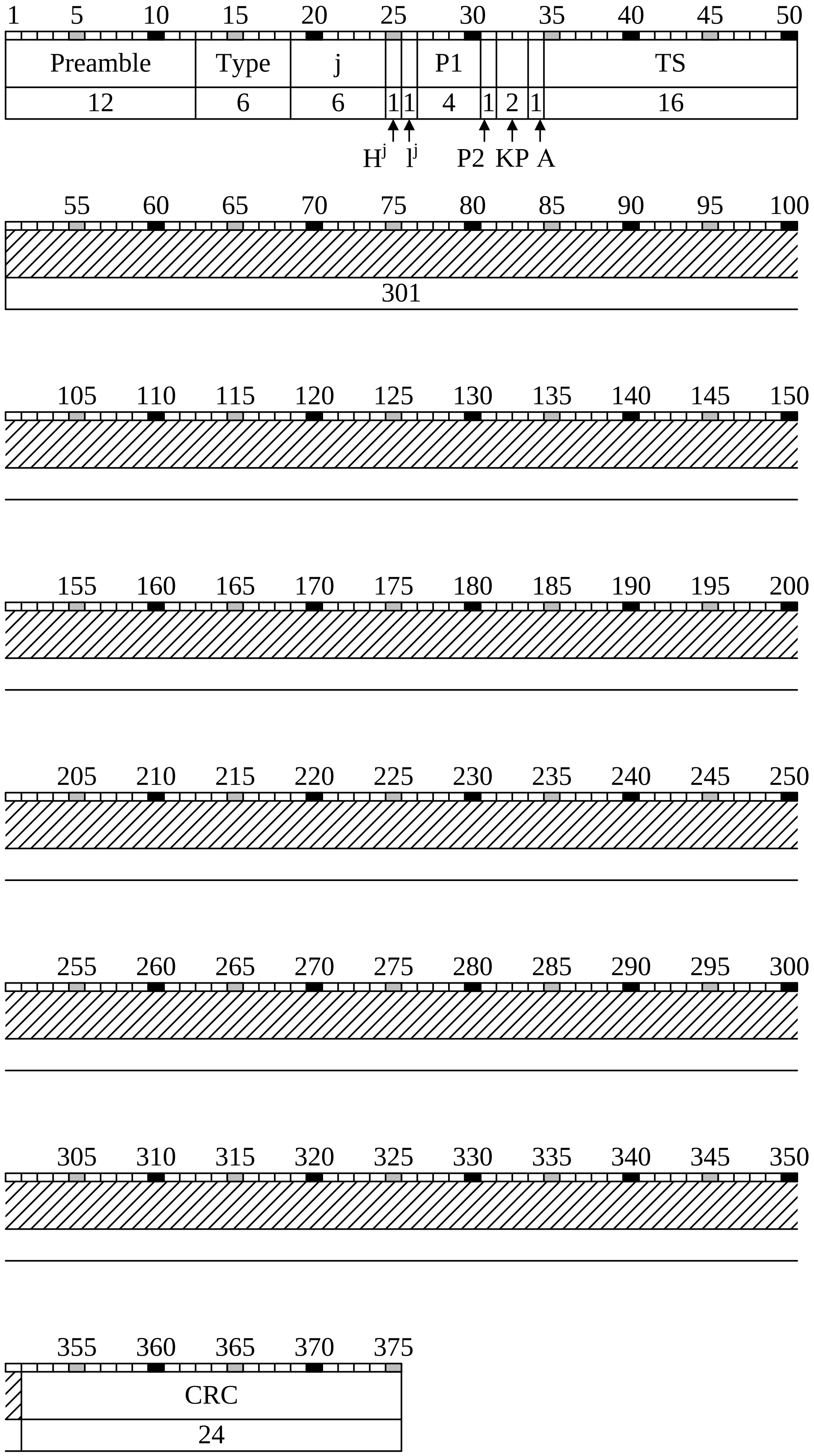


Figure 4.3 – Anomalous L1OCd data string Type 2

4.4 CRC (250,234)

CRC (250,234) is used in L1OCd signal for filling CRC field in 2-second strings of navigation message.

The location of the CRC field in a string is given in Table 4.2. The string contains 250 bits, where 16 bits are allocated for check bits of CRC code, 12 bits for Preamble, and 22 bits for data. String transmission starts from Preamble field.

Table 4.2 – CRC (250,234) in a 2-second string structure of L1OCd signal

Preamble	Data	CRC
12	222	16
Data bits		Check bits

CRC (250,234) generator polynomial is as follows:

$$g(X) = 1 + X + X^5 + X^6 + X^8 + X^9 + X^{10} + X^{11} + X^{13} + X^{14} + X^{16}.$$

CRC field is filled by using CRC encoding scheme shown on Figure 4.4. 234-bit data block is delivered to the input of encoder (starting from 1st bit of Preamble and ending with 222nd bit of data). 250-bit code block is generated at the output of encoder by adding 16 check bits.

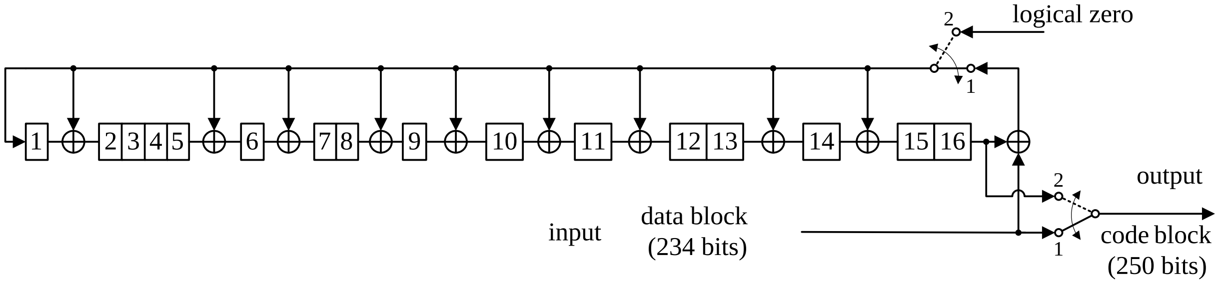


Figure 4.4 – CRC (250,234) encoding scheme

The following steps describe the encoding procedure using the device shown in Figure 4.4:

1) Initial state of the 16-bit shift register is zeros.

2) During first 234 shifts both keys are set to position 1, data block is directly transmitted to the output of the encoder, the register feedback is closed, and the register state is being updated.
3) After transmitting the last 234th data bit, both keys are set to position 2, the register feedback is opened, and during next 16 shifts the register state is being replaced by zeros, check bits are being transmitted to the output of the encoder.

Error detection in a string is performed by analyzing the syndrome, which is calculated for each string of data by using the scheme shown in Figure 4.5.

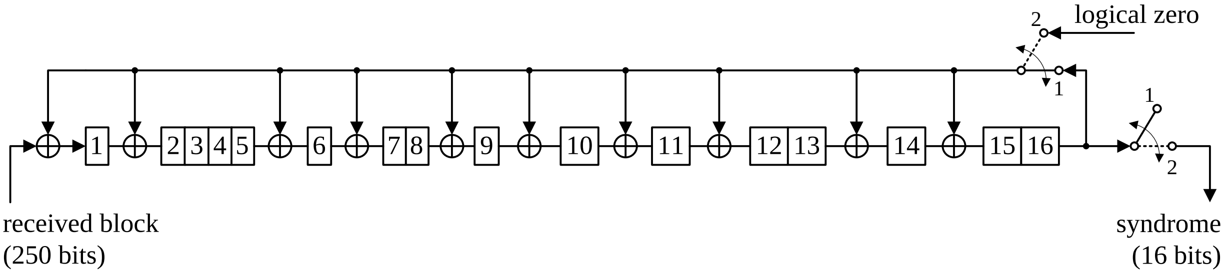


Figure 4.5 – CRC (250,234) syndrome calculation scheme

The following steps describe the procedure of error detection in a received block (a string, starting from the 1st bit of Preamble and ending with the 16th bit of CRC field) using the device shown on Figure 4.5:

1) Initial state of the 16-bit shift register is some bits (ones and zeros).
2) During first 16 shifts both keys are set to position 2, the received block (first 16 bits) is being downloaded to the register.
3) After downloading the 16th bit of the received block, keys are set to position 1, the received block (the remaining 234 bits) keeps being downloaded to the register. Syndrome is the name of the state of the register at the instant when the last 250th bit of the received block is downloaded to trigger 1.
4) After downloading the 250th bit of the received block to the register, both keys are set to position 2 for the next 16 shifts in order to enable extraction of the syndrome from the register (and simultaneous downloading of first 16 bits of the next string to the register). Zeros in all 16 bits of the syndrome indicate absence of errors. Otherwise it shall be decided that the received block (string) contains errors.

4.5 CRC (125,109) of string Type 1

CRC (125,109) is used in L1OCd signal to fill in CRC field in strings Type 1. It is generated similarly to code (250,234) through the scheme shown in Figure 4.4 except for the number of bits delivered to the input (109 instead of 234).

Error detection is realized through the scheme shown in Figure 4.5 except for the number of bits transmitted to the input (250 instead of 125).

4.6 CRC (375,351) of string Type 2

CRC (375,351) is used in L1OCd signal to fill in CRC field in strings Type 2. Table 4.3 shows the CRC field location. The string contains 375 bits, where 24 bits are allocated for check bits of CRC code; 12 bits for Preamble, and 339 bits for data. String transfer starts from Preamble field.

Table 4.3 – CRC (375,351) in the structure of L1OCd string Type 2

Preamble	Data	CRC
12	339	24
Data bits		Check bits

CRC (375,351) generator polynomial has the following form:

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

CRC field is filled by using CRC encoding scheme shown on Figure 4.6. 351-bit data block is delivered to the input of encoder (starting from 1st bit of Preamble and ending with 339th bit of data). 375-bit code block is generated at the output of encoder by adding 16 check bits.

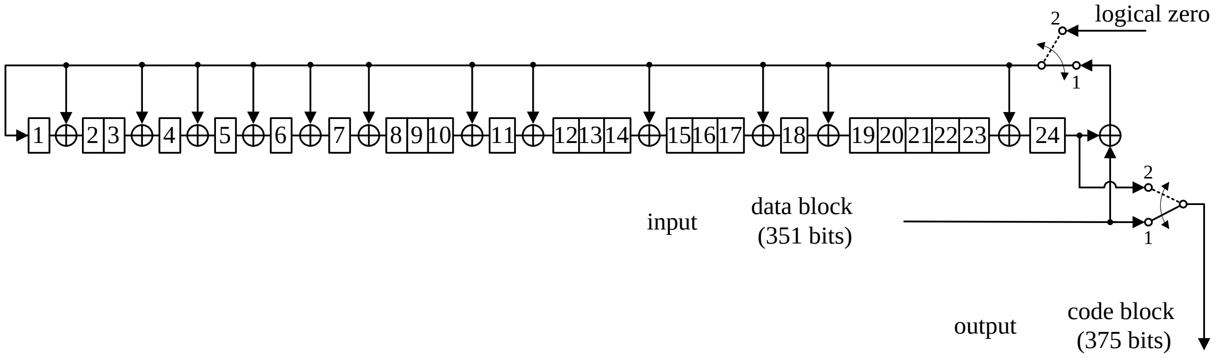


Figure 4.6 – CRC (375,351) encoding scheme

The following steps describe the encoding procedure using the device shown in Figure 4.6:

1) Initial state of the 24-bit shift register is zeros.
2) During first 351 shifts both keys are set to position 1, data block is being directly transmitted to the output of encoder, the register feedback is closed, and the register state is being updated.
3) After transmitting the last 251st data bit, both keys are set to position 2, the register feedback is opened, and during next 24 shifts the register state is being replaced by zeros, check bits are being transmitted to the output of the encoder.

Error detection in a string is performed by analyzing the syndrome, which is calculated for each string of data by using the scheme shown in Figure 4.7.

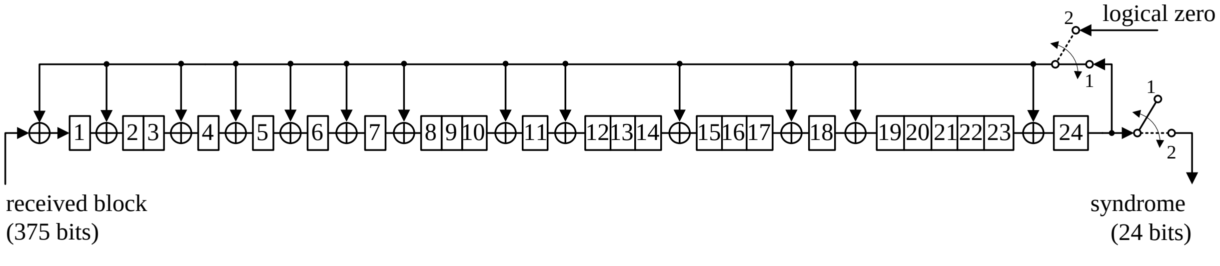


Figure 4.7 – CRC (375,351) syndrome calculation scheme

The following steps describe the procedure of error detection in the received block (a string, starting from the 1st bit of Preamble and ending with the 24th bit of CRC field) using the device shown in Figure 4.7:

1) Initial state of the 24-bit shift register is some bits (ones and zeros).

2) During first 24 shifts both keys are set to position 2, the received block (first 24 bits) is being downloaded to the register.
3) After downloading the 24th bit of the received block, keys are set to position 1, the received block (the remaining 351 bits) keeps being downloaded to the register. Syndrome is the name of the state of the register at the instant when the last 275th bit of the received block is downloaded to trigger 1.
4) After downloading the 375th bit of the received block to the register, both keys are set to position 2 for the next 24 shifts in order to enable extraction of the syndrome from the register (and simultaneous downloading of first 24 bits of the next string to the register). Zeros in all 24 bits of the syndrome indicate absence of errors. Otherwise it shall be decided that the received block (string) contains errors.

5 Data field structure of L1OCd

5.1 Data fields and types of L1OCd strings

Content of data fields depends on a string type indicated in service field Type (see 4.2.2.2).

Data fields are occupied by bits numbered:

- 51-234 in all strings except Type 1 and 2 (see Figure 4.1);
- 51-109 in strings Type 1 (see Figure 4.2);
- 51-351 in strings Type 2 (see Figure 4.3).

Table 5.1 enlists string Types used in L1OCd signal. Subsequently in case of navigation message update necessity, new types of strings with updated data or new types of data will be introduced.

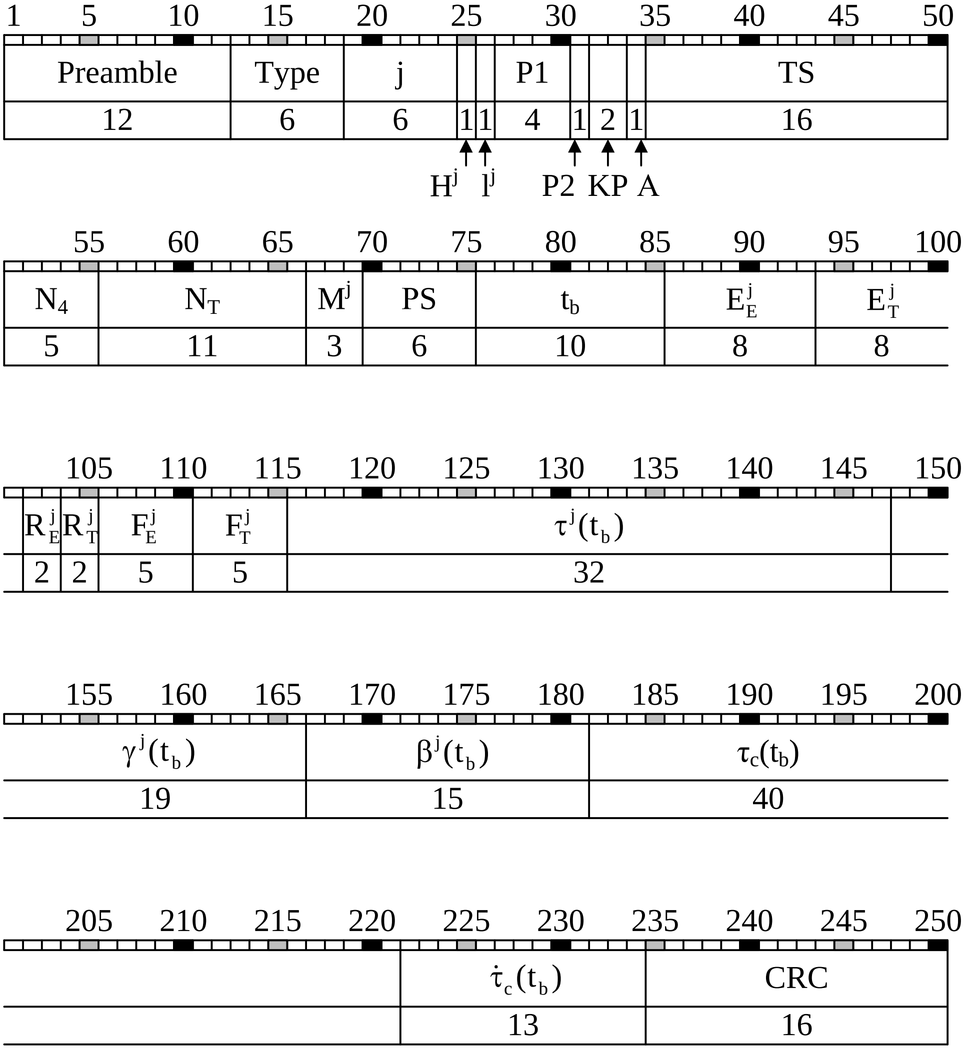
Table 5.1 – Types of string and their content for L1OCd

String type	Content
10, 11, 12	Immediate data
20	Almanac
25	Earth rotation parameters, ionospheric model parameters, UTC(SU) and International atomic time (TAI) offset model parameters.
16	SV attitude parameters during noon/midnight turn maneuver
31, 32	Long-term dynamic model parameters (LDMP)
50	Cospas-Sarsat notices of receipt
60	Text messages
0	For technological tasks. Ignored by a user
1	Anomalous string which is used for leap second correction purpose in case a day length is reduced by 1 s
2	Anomalous string which is used for leap second correction purpose in case a day is increased by 1 s
Note: Strings Type 10, 11 and 12 compose a data package, so string Type 11 always follows string Type 10, and string Type 12 follows string Type 11.	

5.2 L1OCd strings Type 10, 11 and 12

5.2.1 Structure of strings Type 10, 11 and 12

Figures 5.1–5.3 show the structure of strings Type 10, 11 and 12. String Type 11 always follows string Type 10, and string Type 12 always follows string Type 11. These strings transmit immediate data.



Preamble	Type	j			P1				TS
12	6	6	1	1	4	1	2	1	16

N_4	N_T	M^j	PS	t_b	E_E^j	E_T^j
5	11	3	6	10	8	8

	R_E^j	R_T^j	F_E^j	F_T^j	$\tau^j(t_b)$	
	2	2	5	5	32	

$\gamma^j(t_b)$	$\beta^j(t_b)$	$\tau_c(t_b)$
19	15	40

	$\dot{\tau}_c(t_b)$	CRC
	13	16

Figure 5.1 – String Type 10 of L1OCd data

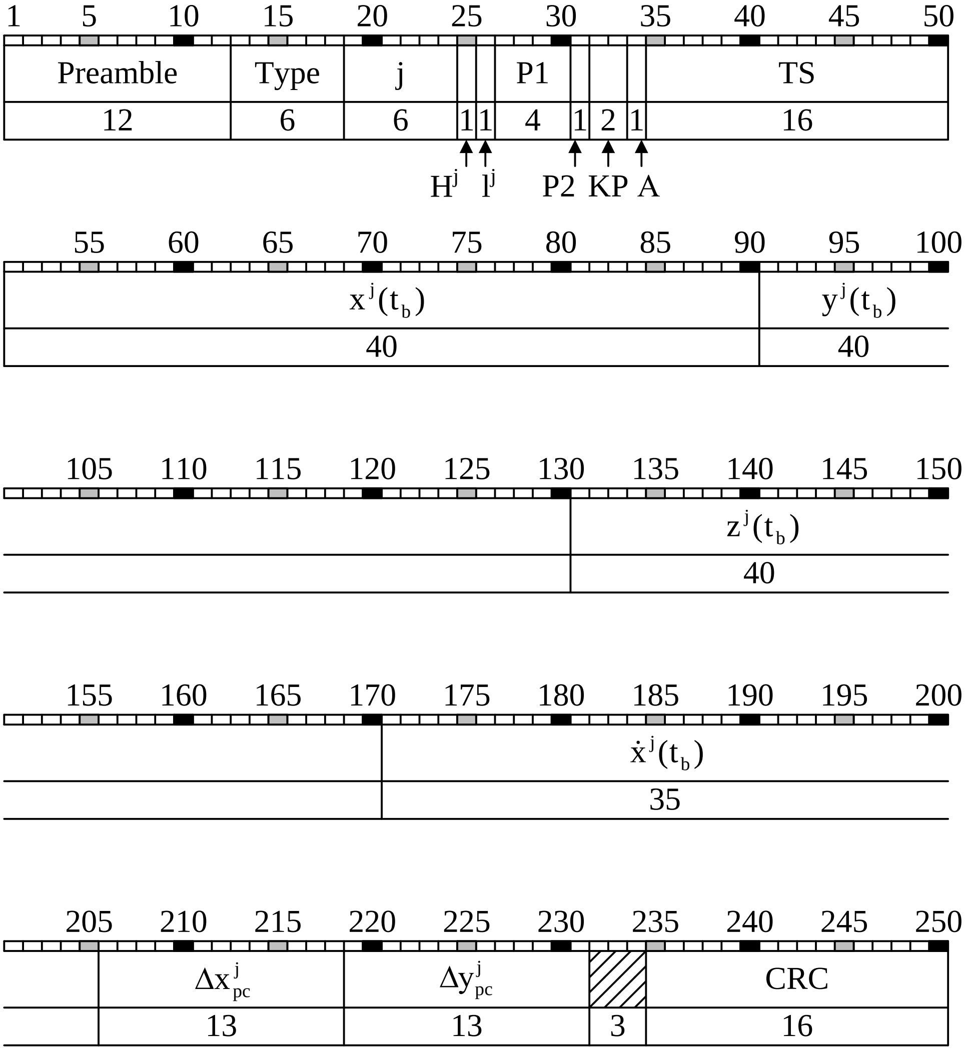


Figure 5.2 – String Type 11 of L1OCd data

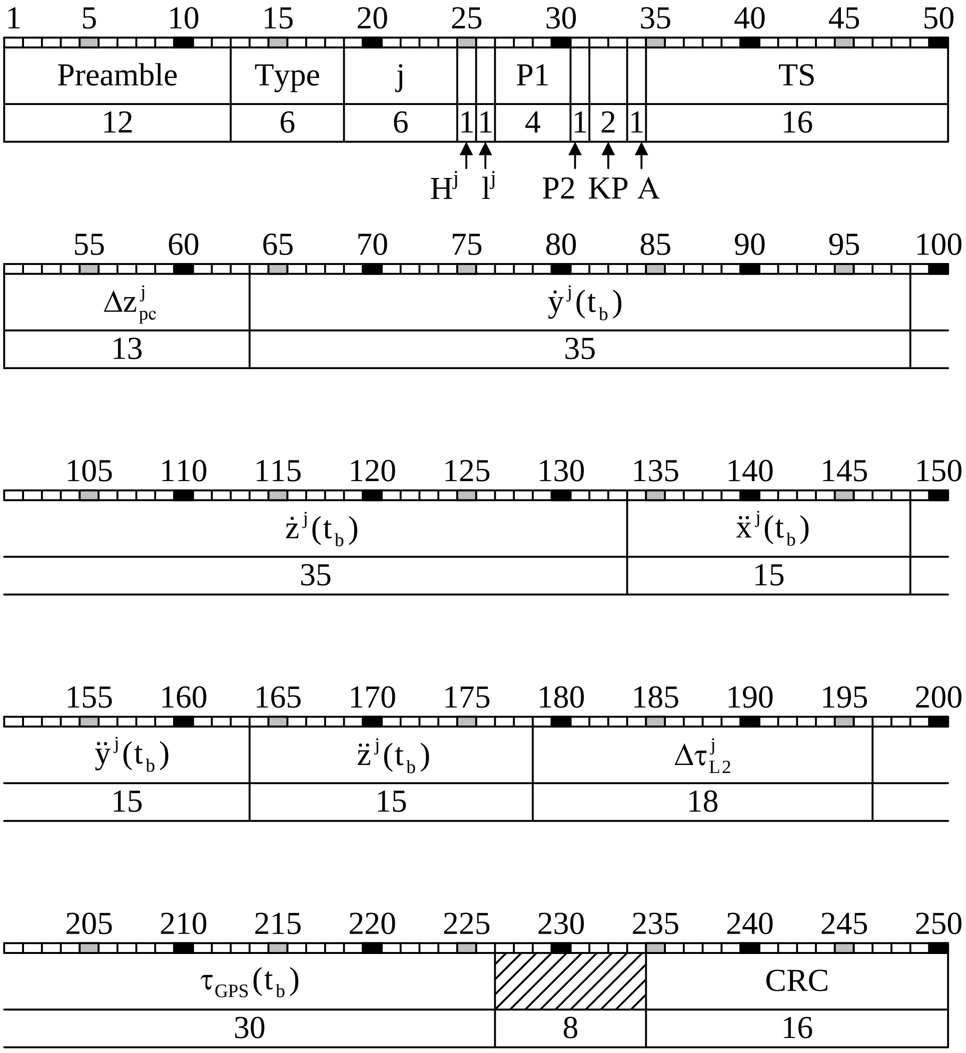


Figure 5.3 – String Type 12 of L1OCd data

Parameter of data fields of strings Type 10, 11 and 12 are given in Table 5.2. Horizontal double lines divide the fields that refer to different strings.

Table 5.2 – Parameters of data fields for strings Type 10, 11 and 12

Field	Number of bits	Least significant bit	Value range	Unit
N_4	5	1	1 – 31	4- year interval
N_T	11	1	1 – 1461	24 hours
M^j	3	1	see 5.2.2.4	–
PS	6	1	0 – 63	–
t_b	10	90	0 – 86310	s
E_E^j, E_T^j	8	1	1 – 255	6 hours
R_E^j, R_T^j	2	1	see 5.2.2.8	–
$F_E^j,\ F_T^j$	5	1	see 5.2.2.9	–
$\tau^j(t_b)$	32	2^{-38}	$\pm 7.8 \cdot 10^{-3}$	s
$\gamma^j(t_b)$	19	2^{-48}	$\pm 0{,}9 \cdot 10^{-9}$	–
$\beta^j(t_b)$	15	2^{-57}	$\pm 1.1 \cdot 10^{-13}$	s^{-1}
$\tau_c(t_b)$	40	2^{-31}	± 256	s
$\dot{\tau}_c(t_b)$	13	2^{-49}	$\pm 0.7 \cdot 10^{-11}$	–
$x^j(t_b),\ y^j(t_b),\ z^j(t_b)$	40	2^{-20}	$\pm 5.2 \cdot 10^5$	km
$\dot{x}^j(t_b)$	35	2^{-30}	± 16	km/s
$\Delta x_{pc}^j,\ \Delta y_{pc}^j$	13	2^{-10}	±4	m
Reserved	3	–	–	–
Δz_{pc}^j	13	2^{-10}	±4	m
$\dot{y}^j(t_b),\ \dot{z}^j(t_b)$	35	2^{-30}	± 16	km/s
$\ddot{x}^j(t_b),\ \ddot{y}^j(t_b),\ \ddot{z}^j(t_b)$	15	2^{-39}	$\pm 2.9 \cdot 10^{-8}$	km/s^2
$\Delta\tau_{L2}^j$	18	2^{-38}	$\pm 4.8 \cdot 10^{-7}$	s
$\tau_{GPS}(t_b)$	30	2^{-38}	$\pm 2 \cdot 10^{-3}$	s
Reserved	8	–	–	–

Note: Field $\tau_c(t_b)$ has ± 256 range in case of future cancellation of GLONASS time correction by 1 s.

5.2.2 Semantic scope of fields for strings Type 10, 11 and 12

5.2.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.2.2.2 Field N_4 is the number of the four-year interval in Moscow time (MT) that includes MT day containing the instant t_b (hereinafter ephemeris N_4). At the boundary of a four-year interval the value of ephemeris N_4 may differ from the number N_4^{cur} of a current four-year interval in MT (see Appendix F of General Description ICD). The first year of the first current four-year interval corresponds to 1996, namely N_4^{cur} = 1 on 1996-1999 interval (MT).

5.2.2.3 Field N_T is the number of the day in MT within ephemeris N_4 that contains the instant t_b (hereinafter ephemeris N_T). At the day's boundaries the value of ephemeris N_T may differ from number N_T^{cur} of a current day in MT (see Appendix G of General Description ICD). January 1 in MT of each leap year corresponds to N_T^{cur} = 1. January 1, 2100 that according to Gregorian calendar is not a leap year also corresponds to N_T^{cur} = 1.

Appendix K of General Description ICD describes the algorithm for transformation of N_4^{cur} and N_T^{cur} values to Gregorian calendar date and Greenwich Mean Sidereal Time (GMST).

5.2.2.4 Field M^j denotes a modification of an SV ID number j (which transmits the current navigation message):

M^j = 000 – Glonass-M with L3 navigation payload transmit L3 CDMA signals;

M^j = 001 – Glonass-K1 transmitting L3 CMDA signals;

M^j = 011 – Glonass-K1 transmitting L2 and L3 CDMA signals;

M^j = 010 – Glonass-K2 transmitting L1, L2, and L3 CDMA signals.

In the course of GLONASS modernization SV with new modifications from 100 to 111 may be introduced in the orbital constellation. Introduction of such SVs in the constellation shall not result in disruption of UE manufactured earlier.

5.2.2.5 Field PS is pseudoframe size. This field is defined as a number of strings to be transmitted starting from the current string Type 10 to the next string Type 10. For example, PS=5 means that the current string Type 10 will be first followed by four strings of different types and then by a string Type 10.

PS = 0 means that no data on pseudoframe size is transmitted.

5.2.2.6 Field t_b is the instant in MT to which immediate data (ephemeris and clock data) relates. t_b is expressed by 90-second intervals during current day N_T in MT. In this document that instant is referred to as the instant t_b (timescale MT is implied).

Any change of immediate data is accompanied by a compulsory change of t_b field. In case data is updated every 30 minutes, the first and the last instant t_b are 15 minutes apart from the boundary of a day. The data can be updated every 90 seconds upon necessity. In this case t_b becomes multiple of 90 s.

5.2.2.7 Fields E_E^j, E_T^j denote an age of ephemeris and clock data, respectively, of an SV ID number j (which transmits this navigation message) expressed in the number of six-hour intervals elapsed either between ephemeris and clock data receipt and the instant t_b for the relay regime or between initial data receipt and the instant t_b for the ephemeris prediction (propagation) regime.

5.2.2.8 Fields R_E^j, R_T^j denote regime for generation of ephemeris and clock data, respectively:

$R_{E,T}^j$ = 01 – relay;

$R_{E,T}^j$ = 10 – prediction (propagation);

$R_{E,T}^j$ = 11 – use of intersatellite measurements.

This data is used by GLONASS Telemetry, Command and Control facilities.

5.2.2.9 Fields F_E^j, F_T^j denote accuracy factors dependent on ephemeris and clock errors, respectively. These fields contain equivalent pseudorange errors (σ) to SV ID number j at the instant t_b. Table 5.3 shows values of F_E^j and F_T^j (in decimals) and their corresponding errors σ.

Table 5.3 – Ephemeris and time accuracy factors

F_E^j, F_T^j	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4
σ, m	0.01	0.02	0.03	0.04	0.06	0.08	0.1	0.15	0.2	0.3	0.4	0.6
F_E^j, F_T^j	-3	-2	-1	0	1	2	3	4	5	6	7	8
σ, m	0.7	0.8	0.9	1	2	2.5	4	5	7	10	12	14
F_E^j, F_T^j	9	10	11	12	13	14	15					
σ, m	16	32	64	128	256	512	not defined					

Appendix P of General Description ICD provides recommendations on F_E^j, F_T^j accuracy factors.

5.2.2.10 Field $\tau^j(t_b)$ denotes a correction to L1OCd time of the SV ID number j (transmitting current navigation message) for transformation to GLONASS time at the instant t_b. The relations of field $\tau^j(t_b)$ to L1OCd time (T_{L1OCd}) and GLONASS time (T_{GL}) at the instant t_b are as follows:

$$T_{GL}(t_b) = T_{L1OCd}(t_b) + \tau^j(t_b).$$

5.2.2.11 Field $\gamma^j(t_b)$ denotes relative deviation of carrier frequency $f^j(t_b)$ of SV ID number j from the nominal carrier frequency f_c at the instant t_b:

$$\gamma^j(t_b) = \frac{f^j(t_b) - f_C}{f_C}.$$

5.2.2.12 Field $\beta^j(t_b)$ is a half rate of relative deviation ($\gamma^j(t_b)$) of carrier frequency $f^j(t_b)$ of nominal carrier frequency f_C of SV ID number j at the instant t_b. The value in field $\beta^j(t_b)$ shall be defined as follows:

$$\beta^j(t_b) = \frac{1}{2} \cdot \left. \frac{d\gamma^j(t)}{dt} \right|_{\text{instant } t_b}.$$

Appendix D of General Description ICD describes the transformation from time of incoming signal to GLONASS time.

5.2.2.13 Field $\tau_c(t_b)$ denotes a correction for transformation from GLONASS time to MT at the instant t_b. Field $\tau_c(t_b)$ relates to GLONASS time (T_{GL}) and MT at the instant t_b as follows:

$$T_{MT}(t_b) = T_{GL}(t_b) + \tau_c(t_b).$$

5.2.2.14 Field $\dot{\tau}_c(t_b)$ denotes rate of correction $\tau_c(t_b)$ at the instant t_b. The value in field $\dot{\tau}_c(t_b)$ is defined as follows:

$$\dot{\tau}_c(t_b) = \left.\frac{d\tau_s(t)}{dt}\right|_{\text{instant } t_b}.$$

Appendix D of General Description ICD describes transformation from GLONASS time to MT.

5.2.2.15 Fields $x^j(t_b), y^j(t_b), z^j(t_b)$ denote the coordinates of the center of mass of the SV ID number j at the instant t_b in the orthogonal geocentric Greenwich coordinate system employed in GLONASS. Fields $x^j(t_b)$, $y^j(t_b)$, $z^j(t_b)$ contain precise ephemerides (coordinates) calculated based on precise dynamic model.

5.2.2.16 Field $\dot{x}^j(t_b)$, $\dot{y}^j(t_b)$, $\dot{z}^j(t_b)$ denote velocity vectors of the SV ID number j center of mass at the instant t_b in the orthogonal geocentric Greenwich coordinate system employed in GLONASS. Fields $\dot{x}^j(t_b)$, $\dot{y}^j(t_b)$, $\dot{z}^j(t_b)$ contain the coordinated ephemerides (velocities) which are calculated based on precise ephemerides in the manner which allows minimizing methodological errors of ephemeris prediction using the simplified dynamic model inherent to many receivers.

5.2.2.17 Field $\ddot{x}^j(t_b)$, $\ddot{y}^j(t_b)$, $\ddot{z}^j(t_b)$ denote vector components of perturbing bodies induced accelerations of the SV ID number j center of mass at the instant t_b in the orthogonal geocentric Greenwich coordinate system accepted for GLONASS. Fields $\ddot{x}^j(t_b)$, $\ddot{y}^j(t_b)$, $\ddot{z}^j(t_b)$ contain the coordinated ephemerides (accelerations) which were calculated based on precise ephemerides in the manner which allows minimizing methodological errors of ephemeris prediction using the simplified dynamic model inherent to many receivers.

Algorithms for calculation of coordinates and velocity vector components for the SV’s center of mass based on ephemeris data is described in Appendix J of General Description ICD.

5.2.2.18 Fields Δx^j_{pc}, Δy^j_{pc}, Δz^j_{pc} denote coordinates of the antenna phase center transmitting L1OC signal in the coordinate system which axes are parallel to an SV-fixed reference system and its origin is referenced to the SV’s center of mass. Description of the SV-fixed reference system is provided in Appendix R of General Description ICD. This Appendix also contains algorithm for transformation SV’s center of mass coordinates to coordinates (in PZ-90) of its antenna phase center.

5.2.2.19 Field $\Delta\tau_{L2}^{j}$ denotes offset of L2OCp time (T_{L2OCp}) relative to L1OCd time (T_{L1OCd}):

$$\Delta\tau_{L2}^{j} = T_{L2OCp} - T_{L1OCd}.$$

Parameter $\Delta\tau_{L2}^{j}$ is necessary for transformation from L2OCp time to L1OCd time and then to GLONASS time.

5.2.2.20 Field $\tau_{GPS}(t_b)$ is a fractional part of a second in the offset of the GPS time (N_A) relative to GLONASS time (T_{GL}) at the instant t_b:

$$\tau_{GPS}(t_b) = T_{GPS} - T_{GL} + 10800 - \Delta T,$$

where ΔT is an integer offset expressed in integer seconds and calculated by a user based on the received GPS navigation messages.

Transformation from GLONASS time to GPS time is described in Appendix C of General Description ICD.

5.3 L1OCd string Type 20

5.3.1 Structure of string Type 20

Figure 5.4 shows the structure of string Type 20. Strings of this type are used for transmission of almanac data for one SV j_A transmitting one or several CDMA signals.

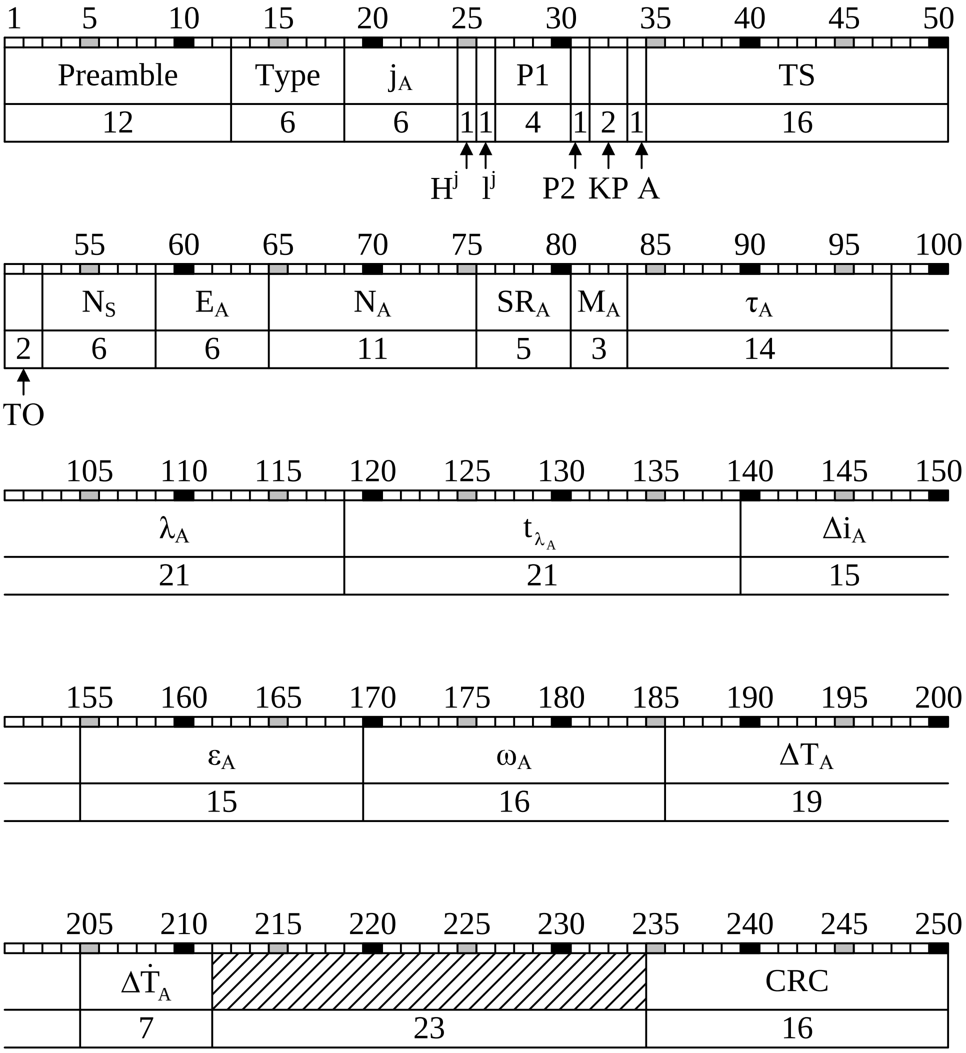


Figure 5.4 – String Type 20 of L1OCd data

Table 5.4 provides parameters of data fields for string Type 20.

Table 5.4 – Parameters of data fields for string Type 20

Field	Number of bits	Least significant bit	Value range	Unit
j_A	6	1	0 – 63	–
TO	2	1	see 5.3.2.3	–
N_S	6	1	0 – 63	–
E_A	6	1	0 – 63	24 hours
N_A	11	1	1 – 1461	24 hours
SR_A	5	1	see 5.3.2.7	–
M_A	3	1	see 5.3.2.8	–
τ_A	14	2^{-20}	$\pm 7.8 \cdot 10^{-3}$	s
λ_A	21	2^{-20}	± 1	half-cycle
t_{λ_A}	21	2^{-5}	0 – 44100	s
Δi_A	15	2^{-20}	± 0.0156	half-cycle
ε_A	15	2^{-20}	0 – 0.03	–
ω_A	16	2^{-15}	± 1	half-cycle
ΔT_A	19	2^{-9}	± 512	s
$\Delta \dot{T}_A$	7	2^{-14}	$\pm 3.9 \cdot 10^{-3}$	s/orbit
Reserved	23	–	–	–

5.3.2 Semantic scope of fields for String Type 20

5.3.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.3.2.2 Field j_A is a number of the SV for which almanac data in the current string is transmitted

5.3.2.3 TO field – orbit type. Content and structure of data fields for string Type 20 depend on the value in the Field TO. TO = 00 corresponds to the circular orbit of 19.100 km (current GLONASS orbit). This document summarizes data fields for string Type 20 only for TO = 00.

5.3.2.4 Field N_S denotes the number of SVs in the orbital constellation transmitting one or several CDMA signals for which almanac is broadcast.

5.3.2.5 Field E_A denotes age of SV's almanac from the time almanac parameters (ephemeris and clock data) were uploaded to an SV till the date numbered N_A (see 5.3.2.6).

5.3.2.6 Field N_A is a calendar number of days in MT within a four-year interval to which almanac relates. January 1 of a leap year corresponds to N_A = 1. January 1, 2100 which is not a leap year in the Gregorian calendar also corresponds to N_A = 1.

5.3.2.7 Field SR_A denotes status register of L1, L2 and L3 signals. This field contains 5 bits. The first (most significant) bit represents L1 status, the second one represents that of L2, the third one – that of L3. Bit “1” denotes transmission of the corresponding signal; “0” means absence of the signal. Health of the given navigation signal and its data validity is determined by attributes H^j and x_p (see 4.2.2.4 и 4.2.2.5). 4th and 5th bits of SR_A field are reserved ones.

5.3.2.8 Field M_A denotes a modification of the SV j_A:

M_A = 000 – Glonass-M carrying L3 navigation payload transmitting L3 CDMA;

M_A = 001 – Glonass-K1 transmitting L3 CDMA signals;

M_A = 011 – Glonass-K1 transmitting L2 and L3 CDMA signals;

M_A = 010 – Glonass-K2 transmitting L1, L2, and L3 CDMA signals.

In the course of GLONASS modernization SV with new modifications (from 100 to 111) may be introduced in the orbital constellation. Introduction of such SVs in the constellation shall not result in disruption of UE manufactured earlier.

5.3.2.9 Field τ_A denotes rough correction for transformation from L3OCd time of SV j_A to GLONASS time at the beginning of day (N_A+1) in MT.

$$\tau_A = T_{GL,N_A+1} - T_{L1OCd,N_A+1} - \left\langle \frac{T_{GL,N_A+1} - T_{L1OCd,N_A+1}}{86400} \right\rangle \cdot 86400,$$

where T_{GL,N_A+1} is GLONASS time corresponding to the beginning of day (N_A+1) in MT;

T_{L1OCd,N_A+1} is L1OCd time of SV j_A corresponding to the beginning of day (N_A+1) in MT;

Operator $\langle\cdot\rangle$ denotes the nearest integer.

Note: value τ_A in almanac data of each SV is the same and its accuracy is about 1 ms for all signals of this SV.

5.3.2.10 Field λ_A denotes geodetic longitude of the first ascending node of SV j_A orbit within day N_A, in geocentric coordinate system used in GLONASS.

5.3.2.11 Field t_{λ_A} denotes the instant in MT when SV j_A passes the first ascending node within day N_A.

5.3.2.12 Field Δi_A is correction to nominal value (64.8º) of orbit inclination of SV j_A at the instant t_{λ_A} (MT).

5.3.2.13 Field ε_A is eccentricity of SV j_A orbit at the instant t_{λ_A} (MT).

5.3.2.14 Field ω_A is argument of perigee for SV j_A orbit at the instant t_{λ_A} (MT).

5.3.2.15 Field ΔT_A denotes correction to nominal value (40544 s) of mean draconic orbital period of SV j_A at the instant t_{λ_A} (MT).

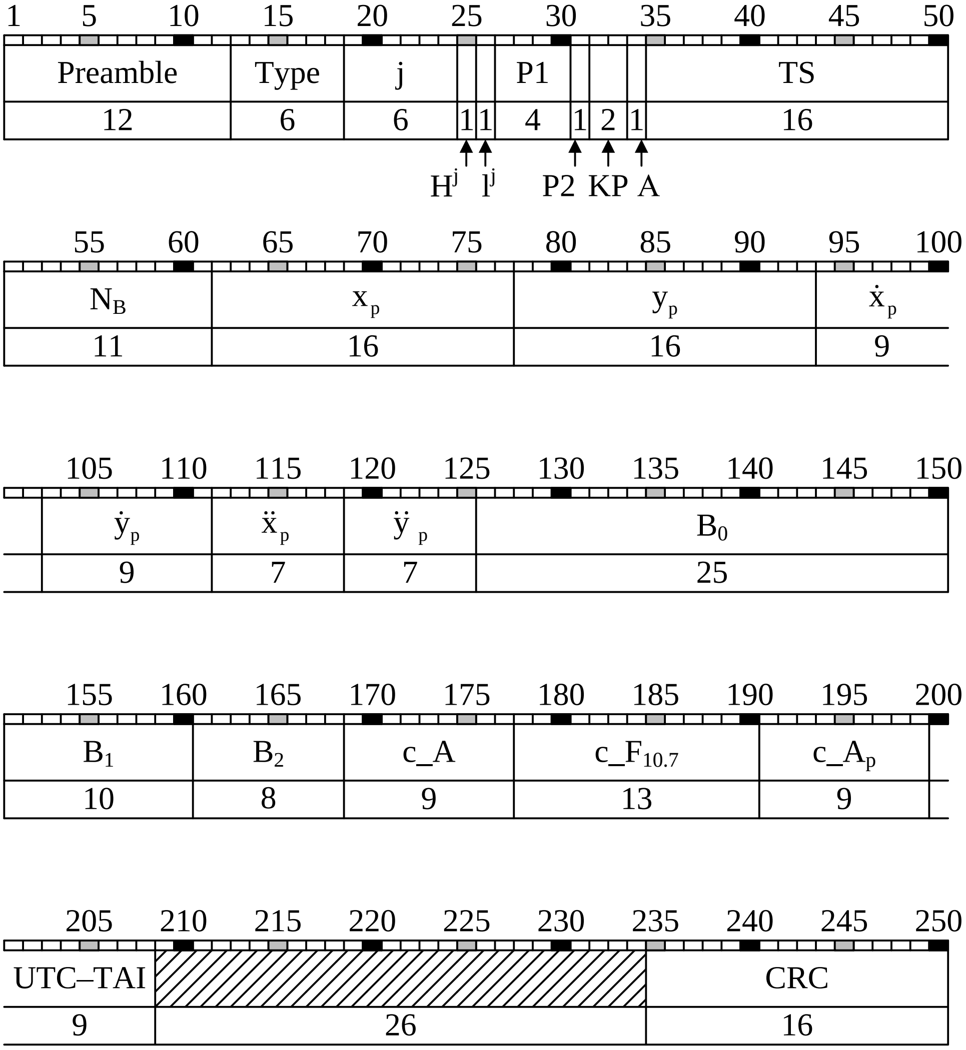
5.3.2.16 Field $\Delta\dot{T}_A$ is the rate of draconic orbital period of SV j_A at the instant t_{λ_A} (MT).

Appendix M of General Description ICD provides the algorithm for calculating coordinates and velocity vector components for the SV’s center of mass based on almanac.

5.4 L1OCd string Type 25

5.4.1 Structure of string Type 25

Figure 5.5 shows the structure of string Type 25. This type of string is used for transmission of Earth rotation parameters (see Appendix L of General Description ICD), ionosphere model parameters (see Appendix Q of General Description ICD), UTC(SU) and TAI offset model parameters (see Appendix H of General Description ICD) and other parameters.



Preamble	Type	j			P1				TS
12	6	6	1	1	4	1	2	1	16
			H^j	l^j		P2	KP	A	

N_B	x_p	y_p	$\dot{x}_p$
11	16	16	9

	$\dot{y}_p$	$\ddot{x}_p$	$\ddot{y}_p$	B_0
	9	7	7	25

B_1	B_2	c_A	c_$F_{10.7}$	c_A_p	
10	8	9	13	9	

UTC–TAI		CRC
9	26	16

Figure 5.5 – String Type 25 of L1OCd data

Table 5.5 provides parameters of data fields for string Type 25.

Table 5.5 – Parameters of data fields for string Type 25

Field	Number of bits	Least significant bit	Value range	Unit
N_B	11	1	1 – 1461	24 hours
x_p, y_p	16	2^{-14}	± 1	arc second
$\dot{x}_p$, $\dot{y}_p$	9	2^{-14}	$\pm 8 \cdot 10^{-3}$	arc second/day
$\ddot{x}_p$, $\ddot{y}_p$	7	2^{-14}	$\pm 2 \cdot 10^{-3}$	arc second/day^2
B_0	25	2^{-16}	± 256	s
B_1	10	2^{-16}	$\pm 7.8 \cdot 10^{-3}$	s/msd
B_2	8	2^{-16}	$\pm 1.9 \cdot 10^{-3}$	s/msd^2
c_A	9	2^{-7}	0 – 4	–
$c\_F_{10.7}$	13	2^{-4}	0 – 500	SFU
c_A_p	9	2^{0}	0 – 500	nT
$UTC - TAI$	9	1	± 255	s
Reserved	26	–	–	–

Notes:

1 For field B_0 ± 256 range is selected to allow for possible future cancellation of UTC(SU) correction.

2 SFU – solar flux unit, 1 SFU = $1 \cdot 10^{-22}$ $W/(m^2 \cdot Hz)$.

5.4.2 Semantic scope of fields for string Type 25

5.4.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.4.2.2 Field N_B is the calendar number of a day (MT) within a four-year interval to which parameters transmitted in the current string relate. January 1 of a leap year corresponds to N_B = 1. January 1, 2100 that according to Gregorian calendar is not a leap year also corresponds to N_B = 1.

5.4.2.3 Fields x_p, y_p, $\dot{x}_p$, $\dot{y}_p$, $\ddot{x}_p$, $\ddot{y}_p$ are parameters of quadratic polynomial used to determine the position of the instantaneous Earth's pole. These parameters are specified as for the beginning of day N_B in MT (T_{MT}).

5.4.2.4 Fields B_0, B_1, B_2 are parameters of quadratic polynomial which are used to determine difference

$$\tau_{UT1} = T_{UT1} - T_{UTC},$$

where T_{UT1} is mean solar time at 0° longitude accounted for the effect of polar motion on position of meridians;

T_{UTC} is Coordinated Universal Time of Russia UTC(SU) which determined by atomic clock whose readings are periodically corrected for minus or plus 1 s to keep difference τ_{UT1} within 0,9 s.

Parameters B_0, B_1, B_2 are set at the beginning of day N_B in MT:

B_0 is T_{UT1} difference;

B_1 denotes daily change of difference during a mean solar day;

B_2 denotes rate of difference change.

The algorithm for calculating time in UT1 scale is provided in Appendix B of General Description ICD.

5.4.2.5 Fields c_A, $c\_F_{10.7}$, c_A_p are current parameters of the Earth ionosphere model:

c_A is a numerical factor of peak TEC (total electron content) of ionospheric F2-layer;

$c\_F_{10.7}$ is solar activity index value;

c_A_p is geomagnetic activity index value.

5.4.2.6 Field $UTC-TAI$ denotes UTC(SU) to TAI offset at the beginning of a day N_B in MT.

$UTC-TAI = T_{UTC} - T_{TAI}$.

Appendix H of General Description ICD describes transformation from UTC(SU) to TAI.

5.5 L1OCd string Type 16

5.5.1 Structure of string Type 16

Figure 5.6 shows the structure of string Type 16. This string type is used for transmission of parameters enabling recalculation of coordinates of the SV’s center of mass into those of its antenna phase center during the noon/midnight turn maneuver.

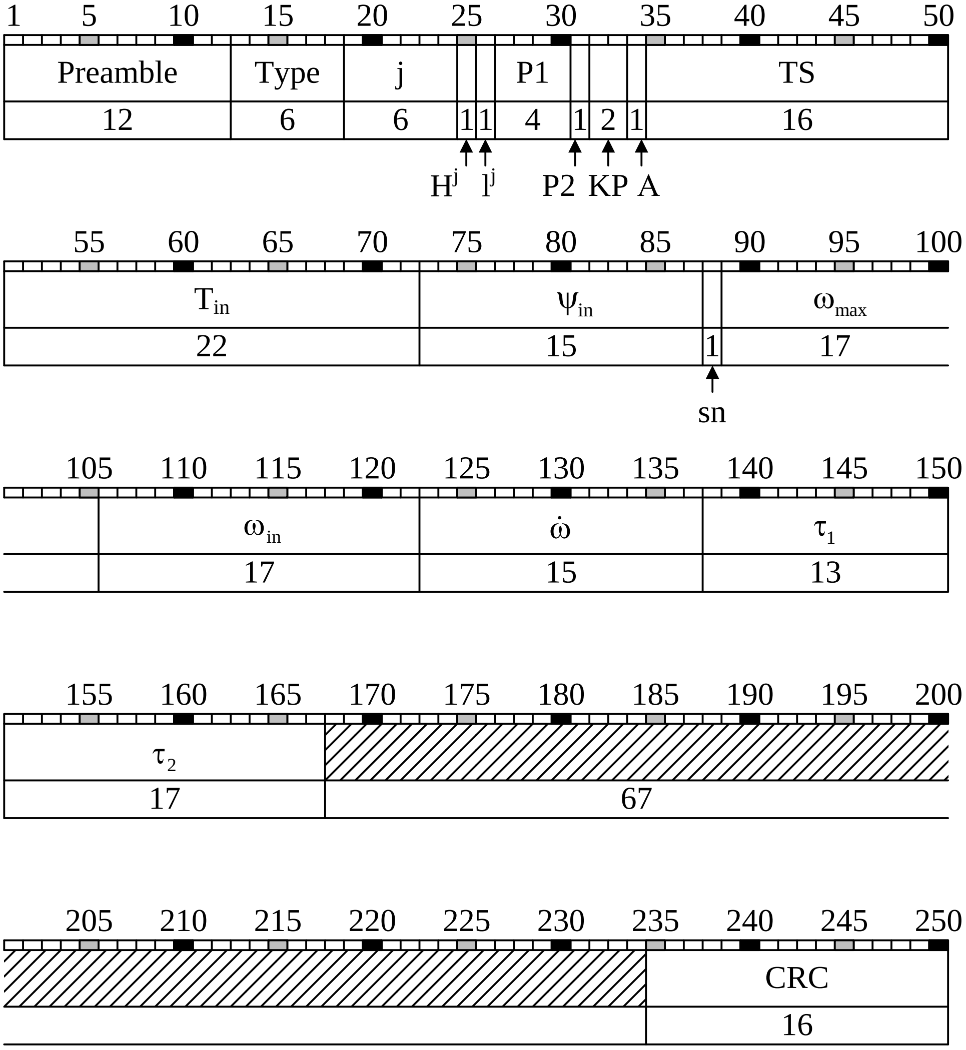


Figure 5.6 – String Type 16 of L1OCd data

Table 5.6 provides data field parameters of strings Type 16.

Table 5.6 – Parameters of data fields for string Type 16

Field	Number of bits	Least significant bit	Value range	Unit
T_{in}	22	2^{-5}	0 – 86399	s
ψ_{in}	15	2^{-14}	0 – 2	half cycle
sn	1	1	0, 1	–
ω_{max}	17	2^{-26}	$0 - 16 \cdot 10^{-4}$	half cycle/s
ω_{in}	17	2^{-26}	$0 - 16 \cdot 10^{-4}$	half cycle/s
$\dot{\omega}$	15	2^{-30}	$0 - 2.96 \cdot 10^{-5}$	half cycle/ s^2
τ_1	13	2^{-5}	0 – 200	s
τ_2	17	2^{-5}	0 – 3480	s
Reserved	67	–	–	–

Overview of data fields of string Type 16 is provided below. Appendix R of General Description ICD contains the detailed description of an SV’s attitude parameters and the algorithm for their use.

5.5.2 Semantic scope of fields for string Type 16

5.5.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.5.2.2 Field T_{in} denotes the instant in signal time of noon/midnight turn maneuver start.

5.5.2.3 Field ψ_{in} is the yaw angle at the instant T_{in}.

5.5.2.4 Field sn is a sign of noon/midnight turn maneuver (see Appendix R of General Description ICD).

5.5.2.5 Field ω_{max} is the maximum angular rate of the SV performing the maneuver.

5.5.2.6 Field ω_{in} is the angular rate of the SV at the instant T_{in}.

5.5.2.7 Field $\dot{\omega}$ is the constant angular acceleration (or deceleration) of the SV.

5.5.2.8 Field τ_1 denotes either the interval between T_{in} and the termination moment of angular rate increment with the constant angular acceleration $\dot{\omega}$, or the duration of angular rate decrement with the constant deceleration $\dot{\omega}$ up to the value $\omega_{out} = \omega_{in}$ at the instant the SV exits the noon/midnight turn maneuver.

5.5.2.9 Field τ_2 denotes the time it takes to perform the turn maneuver with a given maximum angular rate ω_{max} .

5.6 L1OCd strings Type 31 and 32

5.6.1 Structure of strings Type 31 and 32

Figures 5.7 and 5.8 show the structure of strings Type 31 and 32. These strings are used for transmission of long-term dynamic model parameters (LDMP). LDMP enable the usage of an SV’s movement prediction parameters for a 30-minute or less interval of the SV’s orbit to predict its movement for a 4-hour interval.

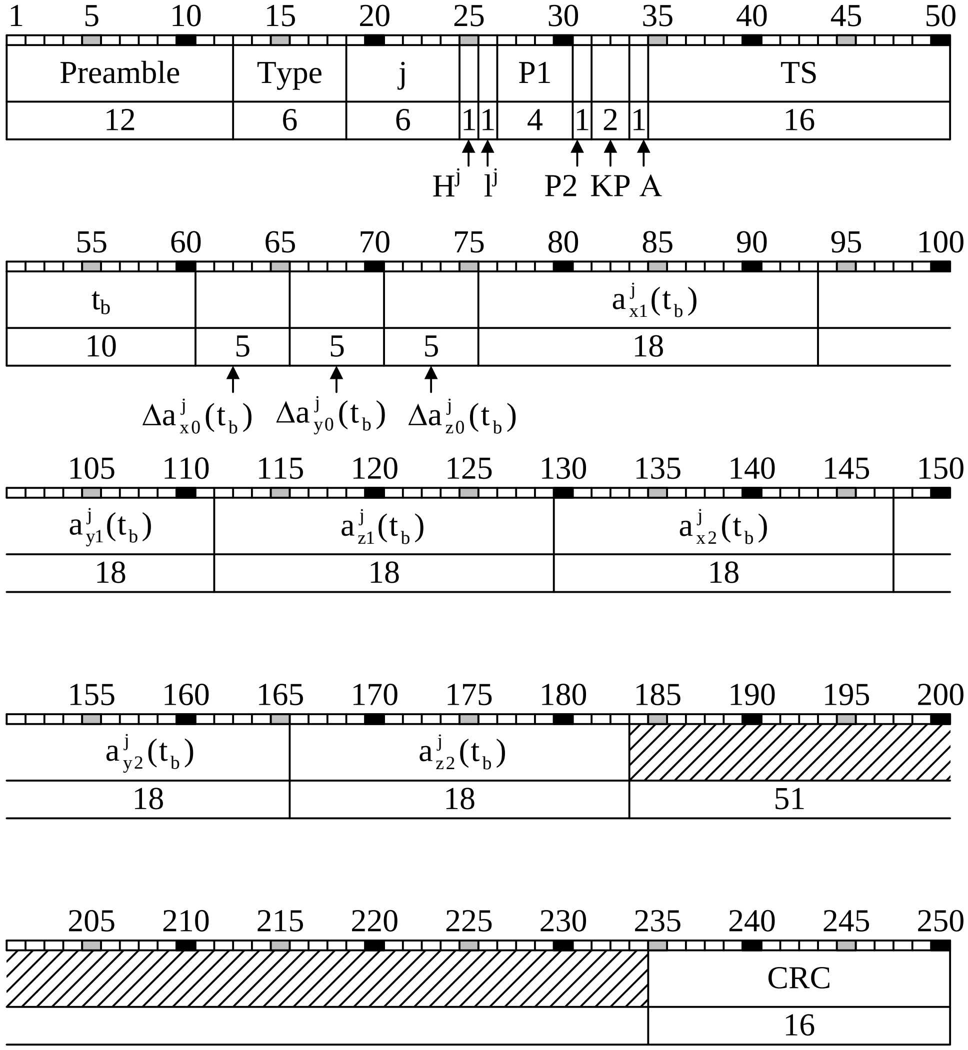


Figure 5.7 – String Type 31 of L1OCd data

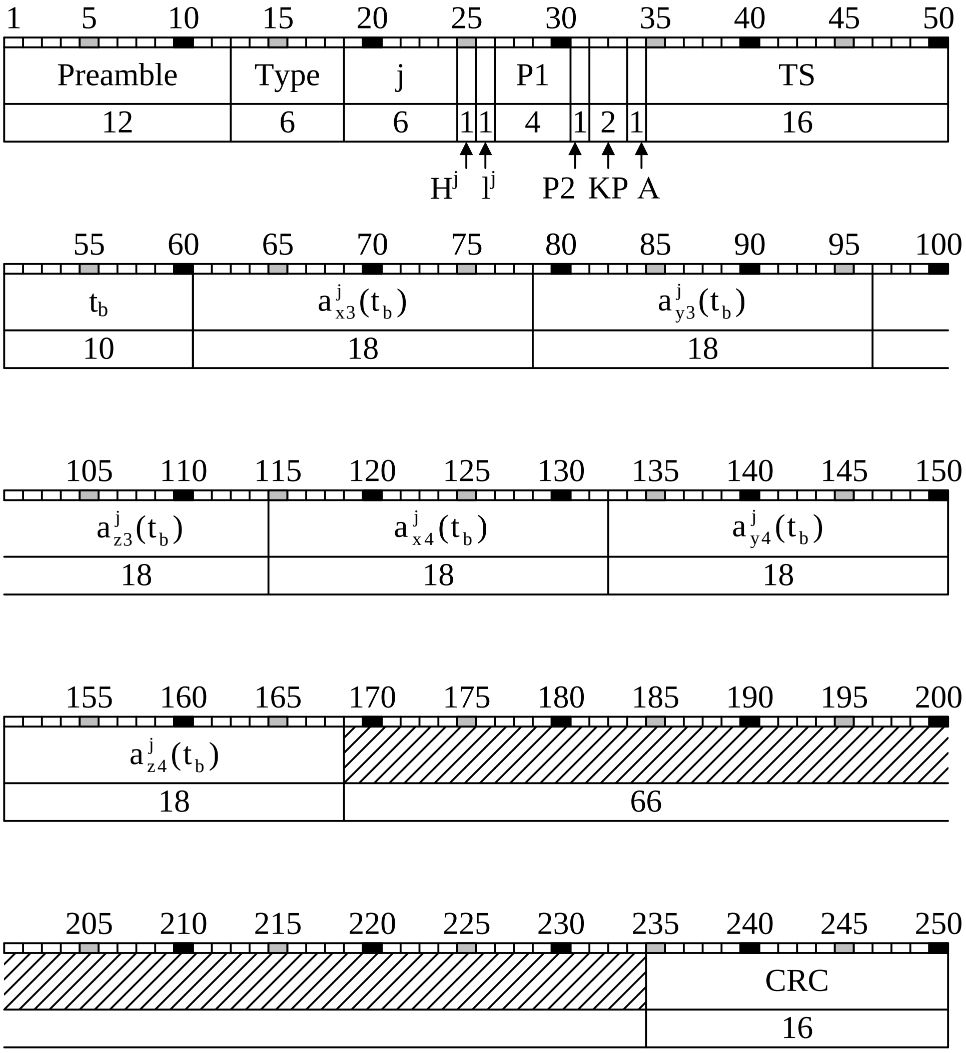


Figure 5.8 – String Type 32 of L1OCd data

Table 5.7 describes the parameters of strings Type 31 and 32. The double horizontal line separates fields belonging to different strings.

Table 5.7 – Parameters of data fields for strings Type 31 and 32

Field	Number of bits	Least significant bit	Value range	Unit
t_b	10	90	0 – 86310	s
$\Delta a^j_{x0}(t_b)$, $\Delta a^j_{y0}(t_b)$, $\Delta a^j_{z0}(t_b)$	5	2^{-42}	$\pm 3.41 \cdot 10^{-12}$	km/s^2
$a^j_{x1}(t_b)$, $a^j_{y1}(t_b)$, $a^j_{z1}(t_b)$	18	2^{-54}	$\pm 7.276 \cdot 10^{-12}$	km/s^3
$a^j_{x2}(t_b)$, $a^j_{y2}(t_b)$, $a^j_{z2}(t_b)$	18	2^{-67}	$\pm 2^{-50}$	km/s^4
Reserved	51	–	–	–
t_b	10	90	0 – 86310	s
$a^j_{x3}(t_b)$, $a^j_{y3}(t_b)$, $a^j_{z3}(t_b)$	18	2^{-80}	$\pm 2^{-63}$	km/s^5
$a^j_{x4}(t_b)$, $a^j_{y4}(t_b)$, $a^j_{z4}(t_b)$	18	2^{-95}	$\pm 2^{-78}$	km/s^6
Reserved	66	–	–	–

5.6.2 Semantic scope of fields for Strings Type 31 and 32

5.6.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.6.2.2 Field t_b is described in 5.2.2.6. Field t_b is the same for strings Type 31 and 32. It denotes the instant of MT to which parameters $\Delta a^j(t_b)$, $a^j(t_b)$ (see 5.6.2.3) are referenced. These parameters are intended for combined use with parameters of ephemeris data in strings Type 10, 11, referenced to the same instant t_b.

5.6.2.3 Fields $\Delta a^j(t_b)$, $a^j(t_b)$ contain coefficients of four-degree polynomials which allow calculating additional accelerations $a_x(t, t_b)$, $a_y(t, t_b)$, $a_z(t, t_b)$ of an SV. When summing these accelerations together with accelerations $\ddot{x}^j(t_b)$, $\ddot{y}^j(t_b)$, $\ddot{z}^j(t_b)$ (see 5.2.2.16) one can predict the SV movement with a very high accuracy for 0 to 4 hours interval relative to the instant t_b.

5.7 L1OCd string Type 50

Figure 5.9 shows the structure of string Type 50 that is used for transmission of Cospas-Sarsat notices of receipt. The string contains 2 notices of receipt, 92 bits each.

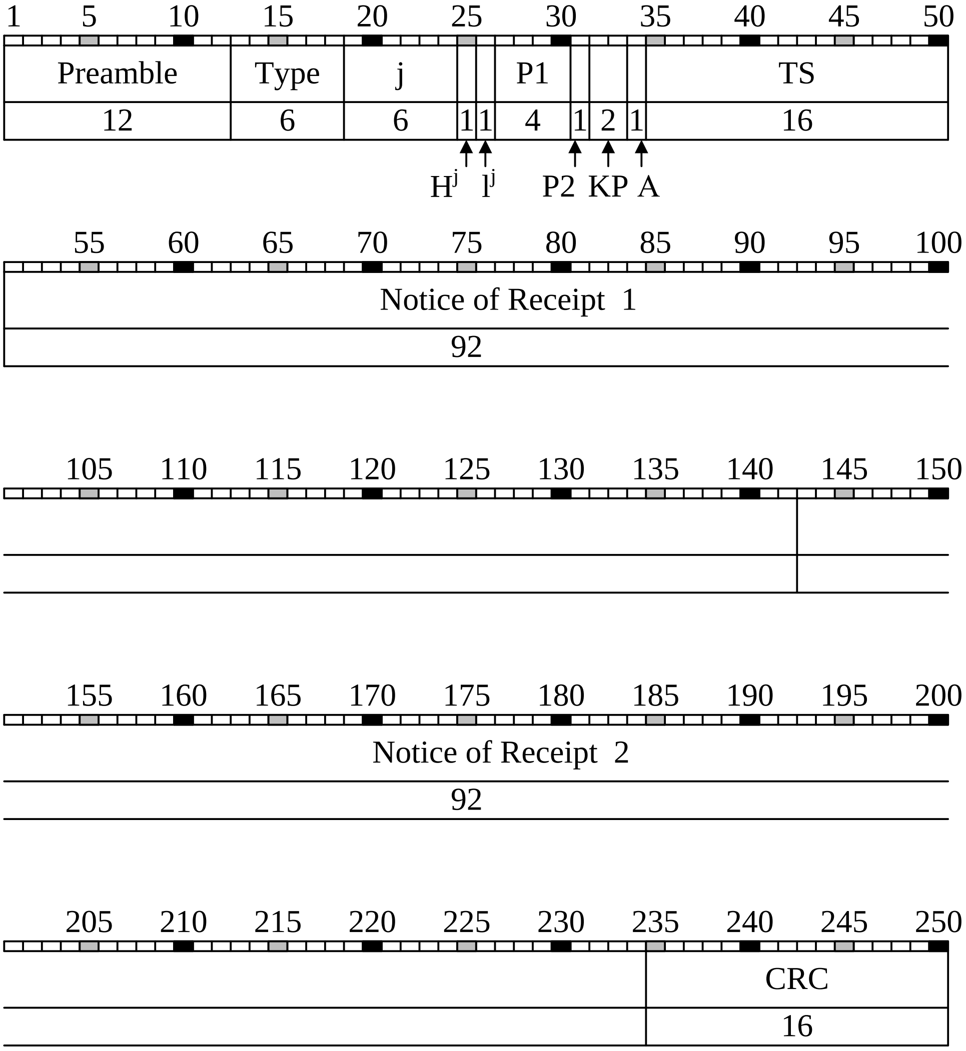


Figure 5.9 – String Type 50 of L1OCd data

Table 5.8 shows the structure of Cospas-Sarsat notice of receipt. The description of its individual fields is shown below.

Table 5.8 – The structure of Cospas-Sarsat notice of receipt

Field	Beacon ID	CS	Data from SAR Services	Reserved
Number of bits	60	4	16	12

Beacon ID is ID number of emergency beacon (Beacon-406).

CS is checking sum.

Data from SAR services is data from search and rescue services to emergency beacon (currently at approval stage).

Reserve is the reserved field for transmission of generalized telemetry on notices of receipt in an SV’s on-board radio control system.

5.8 L1OCd string Type 60

5.8.1 Structure of string Type 60

Figure 5.10 shows the structure of string Type 60 used to broadcast text messages. For this purpose the string Type 60 contains 184 bits.

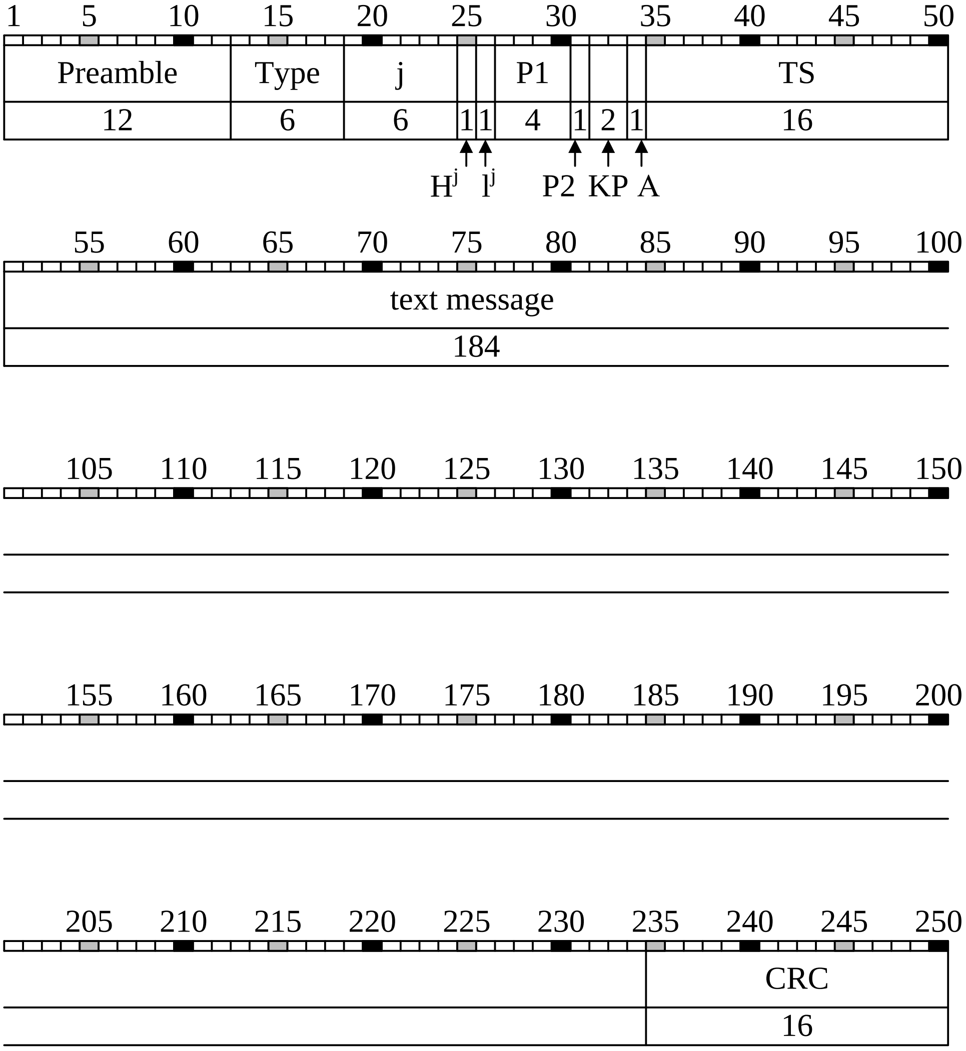


Figure 5.10 – String Type 60 of L1OCd data

Table 5.9 provides the parameters of data fields for strings Type 60.

Table 5.9 – Parameters of data fields for string Type 60

Field	Number of bits	Least significant bit	Value range	Unit
text message	184	–	–	–

5.8.2 Semantic scope of fields for string Type 60

5.8.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.8.2.2 Text message field contains text data. Its structure is described in a separate document.

5.9 L1OCd string Type 0

5.9.1 Structure of string Type 0

Figure 5.11 shows the structure of string Type 0. This string type is used for engineering purposes associated with SV commissioning. UE equipment shall ignore strings Type 0.

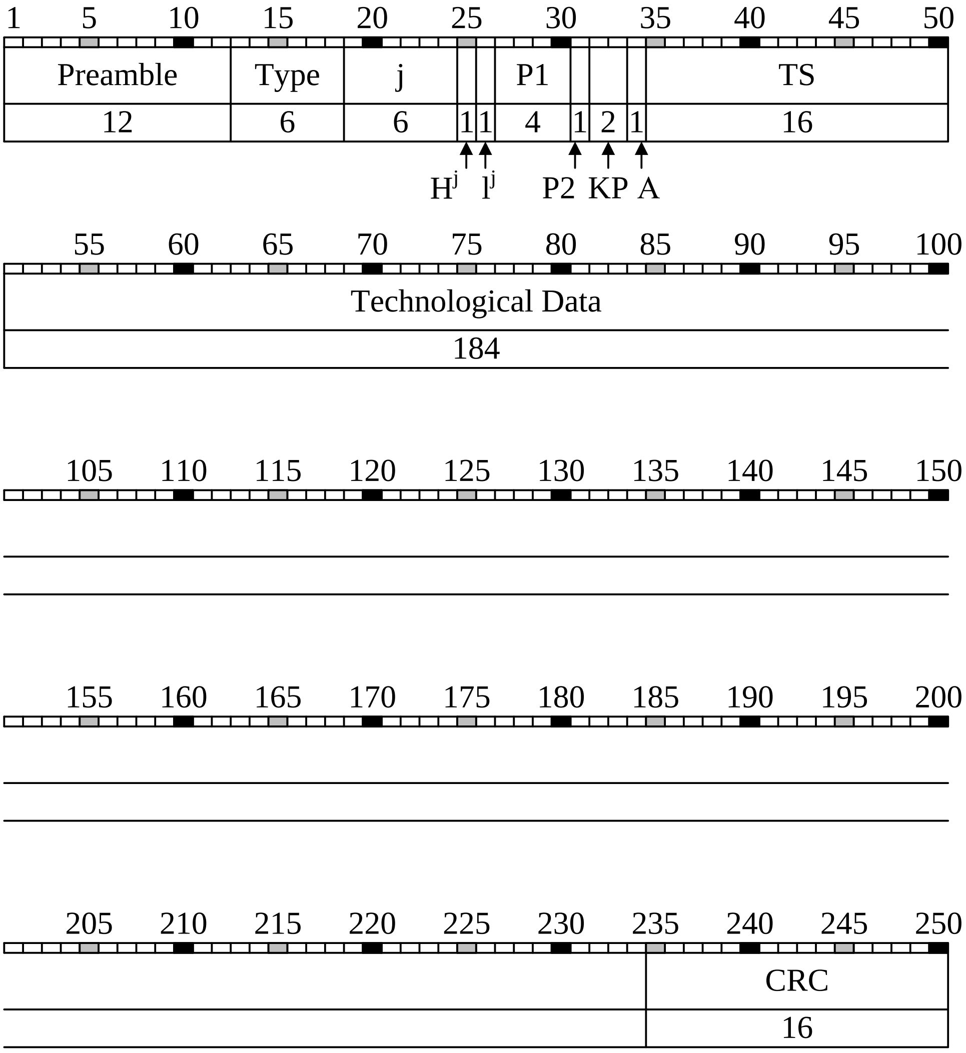


Figure 5.11 – String Type 0 of L1OCd data

Table 5.10 describes parameters of data fields for string Type 0.

Table 5.10 – Parameters of data fields for string Type 0

Field	Number of bits	Least significant bit	Value range	Unit
Technological data	184	–	–	–

5.9.2 Semantic scope of fields for string Type 0

5.9.2.1 Preamble, Type, j, H^j, l^j, P1, P2, KP, A, TS, CRC are service fields (see 4.2).

5.9.2.2 Technological data field contains technological data.

5.10 Anomalous strings Type 1 and 2

String Type 1 is described in 4.3.2.

String Type 2 is described in 4.3.3.

Number of bits allocated for data fields are given in 5.1. These bits constitute reserved fields.

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