GLOBAL NAVIGATION SATELLITE SYSTEM

GLONASS

INTERFACE CONTROL DOCUMENT

Code Division Multiple Access Open Service Navigation Signal in L3 frequency band

Edition 1.0

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Definitions and acronyms

BC – Baker code

BPSK – Binary Phase-Shift Keying

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 (shift register)

EI – Ephemeris Information

f_b – Base frequency (1.023 MHz)

FDMA – Frequency Division Multiple Access

GLONASS – Global Navigation Satellite System

ICD – Interface Control Document

IS – Initial State

L3OC – CDMA Open Service Navigation Signal in L3 frequency band

L3OCd time – time scale determined by phase of L3OCd signal at the phase center of an SV antenna

L3OCp time – time scale determined by phase of L3OCp signal at the phase center of an SV antenna

LDMP – Long-term Dynamic Model Parameters

MS – Meander Sequence

MSD – Mean Solar Day

MT – Moscow Time

NF – Newman-Huffman code

OC – Overlay Code

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

PRN – Pseudorandom Noise sequence (ranging code)

RMS error (σ) – Root mean square error

S – Sequence

SC – Synchronous Counter

SV – Space Vehicle

TAI – International Atomic Time

TS – Time Stamp

UE – User Equipment

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 L3 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 time scale; 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 L3OC signal structure

2.1 General scheme of L3OC signal generation

L3OC signal is transmitted on carrier frequency (nominal value)

$$f_{L3} = 1175 \cdot f_b = 235 \cdot 5.115 \text{ MHz} = 1202.025 \text{ MHz}$$

and consists of two BPSK(10) components of the same power: L3OCd (data component) and L3OCp (pilot component). These components are in phase quadrature with each other and L3OCd is delayed by 90° (Figure 2.1).

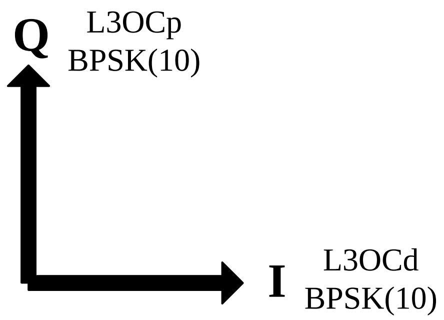

Figure 2.1 – L3OC signal structure

Figure 2.2 shows L3OC signal generation scheme.

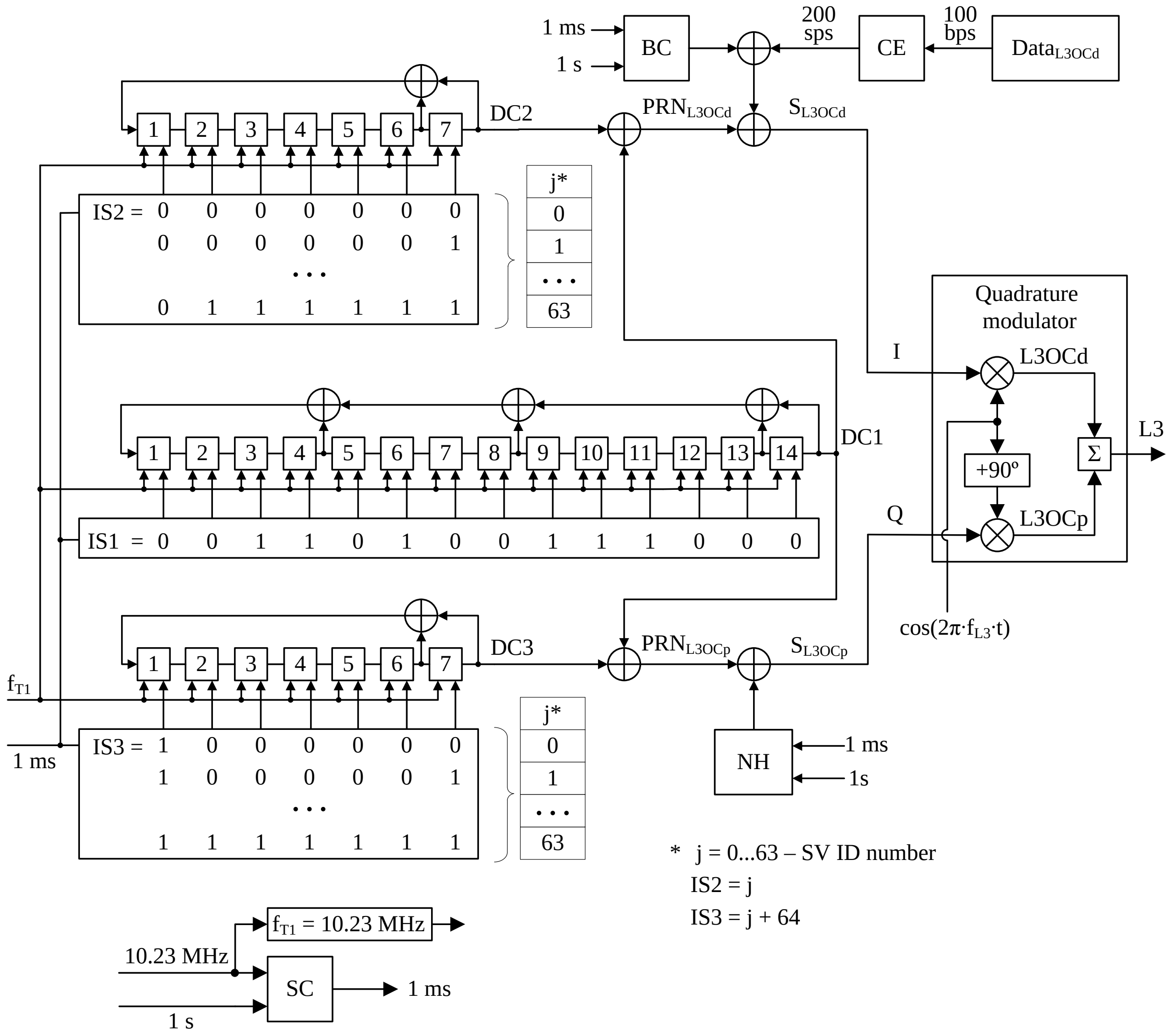

Figure 2.2 – L3OC signal generation scheme

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

Modulation sequence of symbols of L3OCd signal (S_{L3OCd}) is the modulo-2 sum of PRN_{L3OCd} chip stream clocked at f_{T1} = 10.23 MHz (see 2.2), Barker code (BC) symbol stream clocked at 1000 sps (see 2.4), and convolution encoder (CE) symbol stream clocked at 200 sps (see 2.3). Sequence S_{L3OCd} is used to phase-shift key I-component of carrier frequency in L3 by 180°.

Modulation sequence of symbols of L3OCp signal (S_{L3OCp}) is the modulo-2 sum of PRN_{L3OCp} chip stream clocked at f_{T1} = 10.23 MHz (see 2.2) and Newman-Huffman code (NH) symbol stream clocked at 1000 sps (see 2.4). Sequence S_{L3OCp} is used to phase-shift key Q-component of carrier frequency in L3 by 180°.

2.2 Structure of L3OC PRN generator

PRN_{L3OCd} and PRN_{L3OCp} generation scheme is shown in Figure 2.2. PRN_{L3OCd} and PRN_{L3OCp} are truncated Kasami sequences of length N = 10230 and period T = 1 ms. These sequences generated by the modulo-2 addition of binary digits (1 and 0) incoming at clock rate $f_{T1} = 10.23\,\text{MHz}$ from digital circuits DC1, DC2, DC3 shown in Figure 2.2:

- DC1 and DC2 for PRN_{L3OCd} generation;
- DC1 and DC3 for PRN_{L3OCp} generation.

The shift register of DC1 has 14 triggers and feedback from triggers number 4, 8, 13, 14. The shift register of DC2 and DC3 has 7 triggers and feedback from triggers number 6 and 7. 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 1 ms intervals:

- IS1 = 00110100111000 into DC1;
- IS2 = j = 0000000, 0000001…0111111 into DC2, where j is SV ID number;
- IS3 = j + 64 = 1000000, 1000001…1111111 into DC3, where j is the SV ID number.

IS1, IS2 and IS3 (binary numbers) are recorded in DC1, DC2 and DC3 in such a way that the least significant bit enters the last trigger of register.

Short pulses at 1 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.

Tables 2.1 and 2.2 shows first and last 32 chips of L3OCd and L3OCp PRNs in HEX. For example, 1CB31510 denotes 00011100101100110001010100010000. The record of sequences means that the left-most chip is generated first.

Table 2.1 – First and last 32 chips of L3OCd PRNs

j	IS2 (Figure 2.2)	PRN_{L3OCd}		j	IS2 (Figure 2.2)	PRN_{L3OCd}	
		First 32 chips	Last 32 chips			First 32 chips	Last 32 chips
0	0000000	1CB31510	213B0657	32	0100000	18AB44F4	54058145
1	0000001	9DB50169	BC74A793	33	0100001	99AD508D	C94A2081
2	0000010	5D360B55	72D37771	34	0100010	592E5AB1	07EDF063
3	0000011	DC301F2C	EF9CD6B5	35	0100011	D8284EC8	9AA251A7
4	0000100	3C719A32	88CF3EC4	36	0100100	3869CBD6	FDF1B9D6
5	0000101	BD778E4B	15809F00	37	0100101	B96FDFAF	60BE1812
6	0000110	7DF48477	DB274FE2	38	0100110	79ECD593	AE19C8F0
7	0000111	FCF2900E	4668EE26	39	0100111	F8EAC1EA	33566934
8	0001000	0CD25281	F5C11A1E	40	0101000	08CA0365	80FF9D0C
9	0001001	8DD446F8	688EBBDA	41	0101001	89CC171C	1DB03CC8
10	0001010	4D574CC4	A6296B38	42	0101010	494F1D20	D317EC2A
11	0001011	CC5158BD	3B66CAFC	43	0101011	C8490959	4E584DEE
12	0001100	2C10DDA3	5C35228D	44	0101100	28088C47	290BA59F
13	0001101	AD16C9DA	C17A8349	45	0101101	A90E983E	B444045B
14	0001110	6D95C3E6	0FDD53AB	46	0101110	698D9202	7AE3D4B9
15	0001111	EC93D79F	9292F26F	47	0101111	E88B867B	E7AC757D
16	0010000	1483B6D8	CB460873	48	0110000	109BE73C	BE788F61
17	0010001	9585A2A1	5609A9B7	49	0110001	919DF345	23372EA5
18	0010010	5506A89D	98AE7955	50	0110010	511EF979	ED90FE47
19	0010011	D400BCE4	05E1D891	51	0110011	D018ED00	70DF5F83
20	0010100	344139FA	62B230E0	52	0110100	3059681E	178CB7F2
21	0010101	B5472D83	FFFD9124	53	0110101	B15F7C67	8AC31636
22	0010110	75C427BF	315A41C6	54	0110110	71DC765B	4464C6D4
23	0010111	F4C233C6	AC15E002	55	0110111	F0DA6222	D92B6710
24	0011000	04E2F149	1FBC143A	56	0111000	00FAA0AD	6A829328
25	0011001	85E4E530	82F3B5FE	57	0111001	81FCB4D4	F7CD32EC
26	0011010	4567EF0C	4C54651C	58	0111010	417FBEE8	396AE20E
27	0011011	C461FB75	D11BC4D8	59	0111011	C079AA91	A42543CA
28	0011100	24207E6B	B6482CA9	60	0111100	20382F8F	C376ABBB
29	0011101	A5266A12	2B078D6D	61	0111101	A13E3BF6	5E390A7F
30	0011110	65A5602E	E5A05D8F	62	0111110	61BD31CA	909EDA9D
31	0011111	E4A37457	78EFFC4B	63	0111111	E0BB25B3	0DD17B59

Table 2.2 – First and last 32 chips of L3OCp PRNs

j	IS3 (Figure 2.2)	PRN_{L3OCp} First 32 chips	PRN_{L3OCp} Last 32 chips	j	IS3 (Figure 2.2)	PRN_{L3OCp} First 32 chips	PRN_{L3OCp} Last 32 chips
0	1000000	1EBF3DE2	1BA445DE	32	1100000	1AA76C06	6E9AC2CC
1	1000001	9FB9299B	86EBE41A	33	1100001	9BA1787F	F3D56308
2	1000010	5F3A23A7	484C34F8	34	1100010	5B227243	3D72B3EA
3	1000011	DE3C37DE	D503953C	35	1100011	DA24663A	A03D122E
4	1000100	3E7DB2C0	B2507D4D	36	1100100	3A65E324	C76EFA5F
5	1000101	BF7BA6B9	2F1FDC89	37	1100101	BB63F75D	5A215B9B
6	1000110	7FF8AC85	E1B80C6B	38	1100110	7BE0FD61	94868B79
7	1000111	FEFEB8FC	7CF7ADAF	39	1100111	FAE6E918	09C92ABD
8	1001000	0EDE7A73	CF5E5997	40	1101000	0AC62B97	BA60DE85
9	1001001	8FD86E0A	5211F853	41	1101001	8BC03FEE	272F7F41
10	1001010	4F5B6436	9CB628B1	42	1101010	4B4335D2	E988AFA3
11	1001011	CE5D704F	01F98975	43	1101011	CA4521AB	74C70E67
12	1001100	2E1CF551	66AA6104	44	1101100	2A04A4B5	1394E616
13	1001101	AF1AE128	FBE5C0C0	45	1101101	AB02B0CC	8EDB47D2
14	1001110	6F99EB14	35421022	46	1101110	6B81BAF0	407C9730
15	1001111	EE9FFF6D	A80DB1E6	47	1101111	EA87AE89	DD3336F4
16	1010000	168F9E2A	F1D94BFA	48	1110000	1297CFCE	84E7CCE8
17	1010001	97898A53	6C96EA3E	49	1110001	9391DBB7	19A86D2C
18	1010010	570A806F	A2313ADC	50	1110010	5312D18B	D70FBDCE
19	1010011	D60C9416	3F7E9B18	51	1110011	D214C5F2	4A401C0A
20	1010100	364D1108	582D7369	52	1110100	325540EC	2D13F47B
21	1010101	B74B0571	C562D2AD	53	1110101	B3535495	B05C55BF
22	1010110	77C80F4D	0BC5024F	54	1110110	73D05EA9	7EFB855D
23	1010111	F6CE1B34	968AA38B	55	1110111	F2D64AD0	E3B42499
24	1011000	06EED9BB	252357B3	56	1111000	02F6885F	501DD0A1
25	1011001	87E8CDC2	B86CF677	57	1111001	83F09C26	CD527165
26	1011010	476BC7FE	76CB2695	58	1111010	4373961A	03F5A187
27	1011011	C66DD387	EB848751	59	1111011	C2758263	9EBA0043
28	1011100	262C5699	8CD76F20	60	1111100	2234077D	F9E9E832
29	1011101	A72A42E0	1198CEE4	61	1111101	A3321304	64A649F6
30	1011110	67A948DC	DF3F1E06	62	1111110	63B11938	AA019914
31	1011111	E6AF5CA5	4270BFC2	63	1111111	E2B70D41	374E38D0

2.3 Convolution encoder structure

The 100 bps data stream of L3OCd signal is encoded by a rate 1/2 convolution encoder (133,171) shown in Figure 2.3. The switch of the encoder is set to position 1 (lower position) for the first half of a 10-millisecond data bit period.

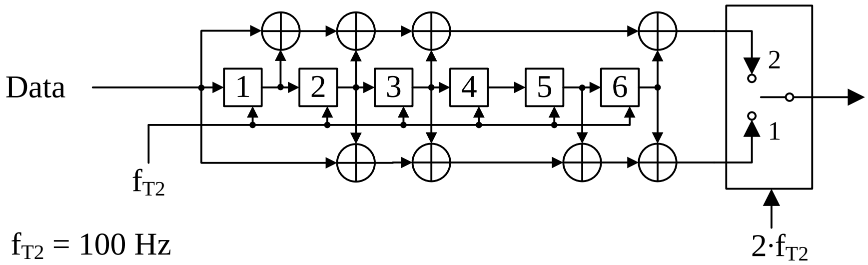

Figure 2.3 – Convolution encoder structure

2.4 BC and NH overlay codes

BC (Baker code) is a periodic 5-symbol code 00010 synchronized with CE symbols (T_{CE} = 5 ms) and transmitted with the most significant bits first (the fourth symbol of BC for a CE symbol duration is 1).

NH (Newman-Huffman code) is a periodic 10-symbol code 0000110101 synchronized with data bits (T_{data} = 10 ms) and transmitted with the most significant bits first (the first symbol of NH for a data bit duration is 0).

3 General overview of L3OCd navigation message structure

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

bit – binary symbol of data;

string – sequence of binary symbols 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 L3OCd signal is transmitted as a continuous sequence of strings of non-fixed and non-predetermined structure.

Navigation message of L3OCd signal is transmitted at 100 bps. Navigation message consists of 300-bit strings of 3-second duration, as well as of 200- and 400-bit anomalous strings of 2- and 4-second duration, respectively.

4 Service field structure of L3OCd data

4.1 General structure of L3OCd string

4.1.1 Bit sequence in a string

Figure 4.1 shows general structure of a string of L3OCd signal. The string is 300 bits long and of 3 seconds duration. The string consists of fields – separate bits or groups of bits containing specific parameters.

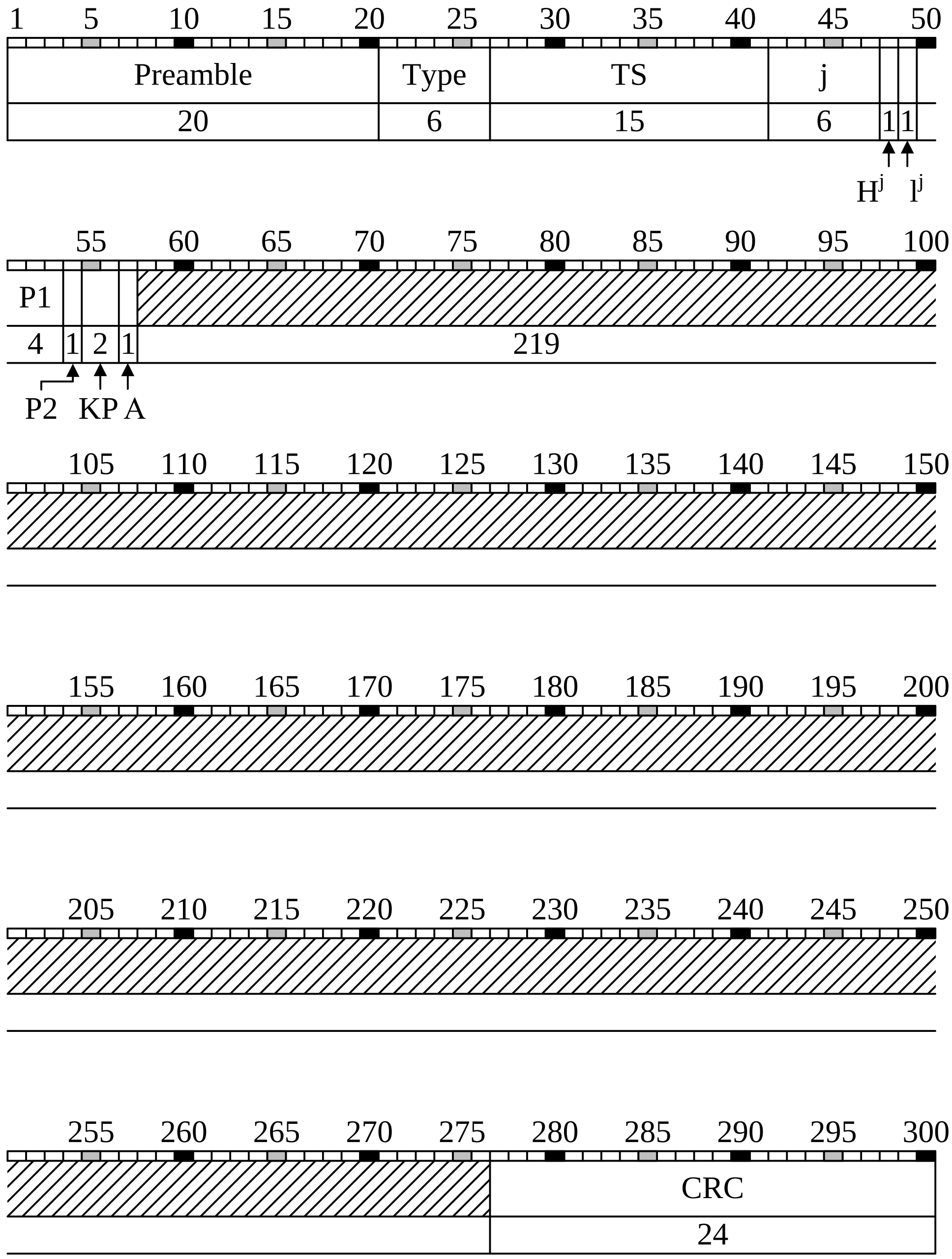

Figure 4.1 – General structure of L3OCd data string

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 300 (the last bit of a cyclic redundancy check (CRC) field).

4.1.2 Types of fields

Each string has 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 (for example, Figure 5.1) 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 field bit which is transmitted first. For example, if j = 1 = 000001 (SV ID number, see 4.2.2.4), then bit number 47 of a string (Figure 4.1) is registered as “1” and bits number 42 to 46 are registered as “0”.

4.2 Service fields of L3OCd string

4.2.1 List of L3OCd service fields

Each L3OCd 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 L3OCd service fields

Field	Number of bits	Least significant bit	Value range	Unit
Preamble	20	1	00000100100101001110	-
Type	6	1	0 – 63	-
TS	15	1	0 – 28799	3 s
j	6	1	0 – 63	-
H^j	1	1	0, 1	-
l^j	1	1	0, 1	-
P1	4	see 4.2.2.7		
P2	1	see 4.2.2.8		
KP	2	1	00, 01, 10, 11	-
A	1	1	0, 1	-
CRC	24	1	see 4.2.2.11	-

4.2.2 Semantic scope of service fields

4.2.2.1 Field Preamble contains the constant value:

Preamble = 00000100100101001110.

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 the current string is of Type 1, then Type = 000001.

4.2.2.3 Field TS is time stamp, i.e. L3OCd time at the start of a current string. TS is expressed in 3-second intervals within a current day (in L3OCd time). TS = 0 for the first 3-second interval within a day.

4.2.2.4 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 GLONASS CDMA and FDMA signals combined use.

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

4.2.2.6 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.

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

4.2.2.8 Field P2 denotes regime of SV orientation:

P2 = 0 – for the duration of current string in L3OCd time, SV is Sun-pointing;

P2 = 1 – for the duration of current string in L3COd time, SV either performs noon/midnight turn maneuver or transits from Sun-pointing to noon/midnight turn maneuver or vice versa.

4.2.2.9 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 L3OCd time:

KP = 00 – no correction planned;

KP = 01 – day length is increased by 1 s in L3OCd time;

KP = 10 – correction decision is pending;

KP = 11 – day length is decreased by 1 s in L3OCd time.

4.2.2.10 Field A is the indication of correction L3OCd 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 the anomalous string Type 1 which is 1 s shorter and of 2 s duration. If the current string shows the combination of A = 1 and KP = 01, then the next string will be the string Type 2 which is 1 s longer and of 4 s duration (also see Appendix E in General Description ICD).

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 L3OCd signal

4.3.1 L3OC anomalous strings are those which are longer or shorter than 3 s. Strings of Types 1 and 2 are anomalous.

4.3.2 Figure 4.2 shows L3OC string of Type 1. This string is used for leap second corrections of L3OC time when a day length is reduced by 1 s. The string has non-standard duration of 2 s and contains 200 bits.

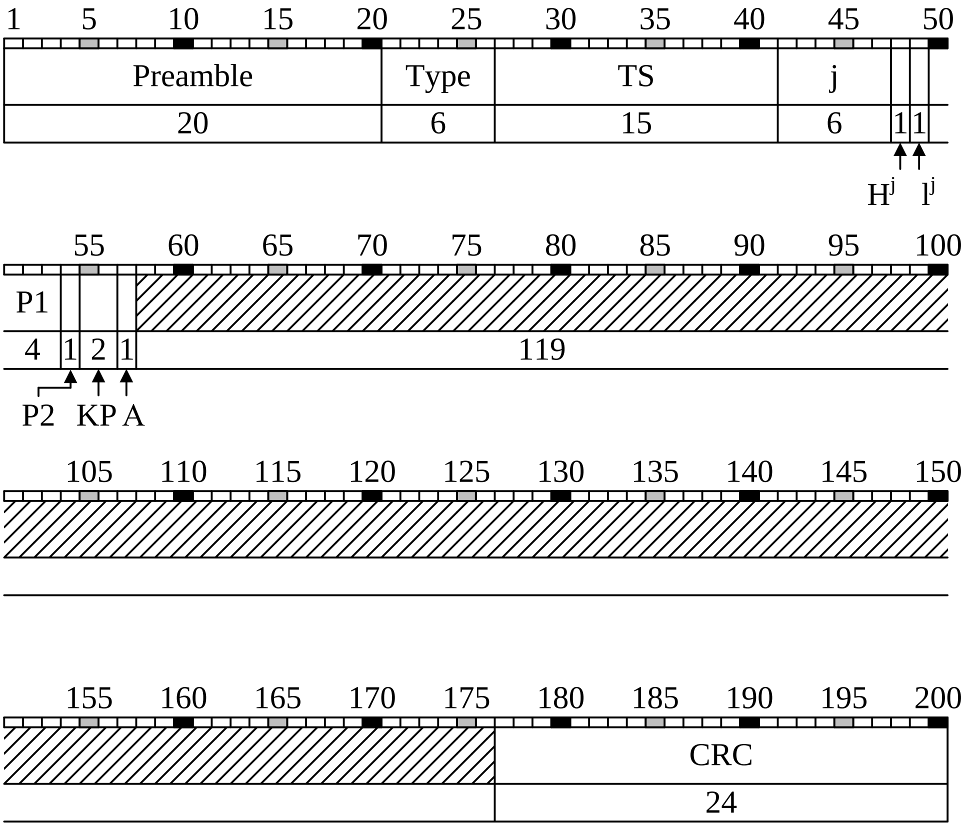

Figure 4.2 – Anomalous L3OCd data string Type 1

The string transmits service fields (see 4.2), the only difference is that CRC field is generated using cycle encoding scheme described in 4.5 (also see Appendix E in General Description ICD).

4.3.3 Figure 4.3 shows L3OC string of Type 2. This string is used for leap second corrections of L3OC time when a day length is increased by 1 s. The string has a non-standard duration of 4 s and contains 400 bits.

The string transmits service fields (see 4.2), the only difference is that CRC field is generated using cycle encoding scheme described in 4.6 (also see Appendix E in General Description ICD).

Bits number 301 to 320 are filled by Preamble (see 4.2.2.1).

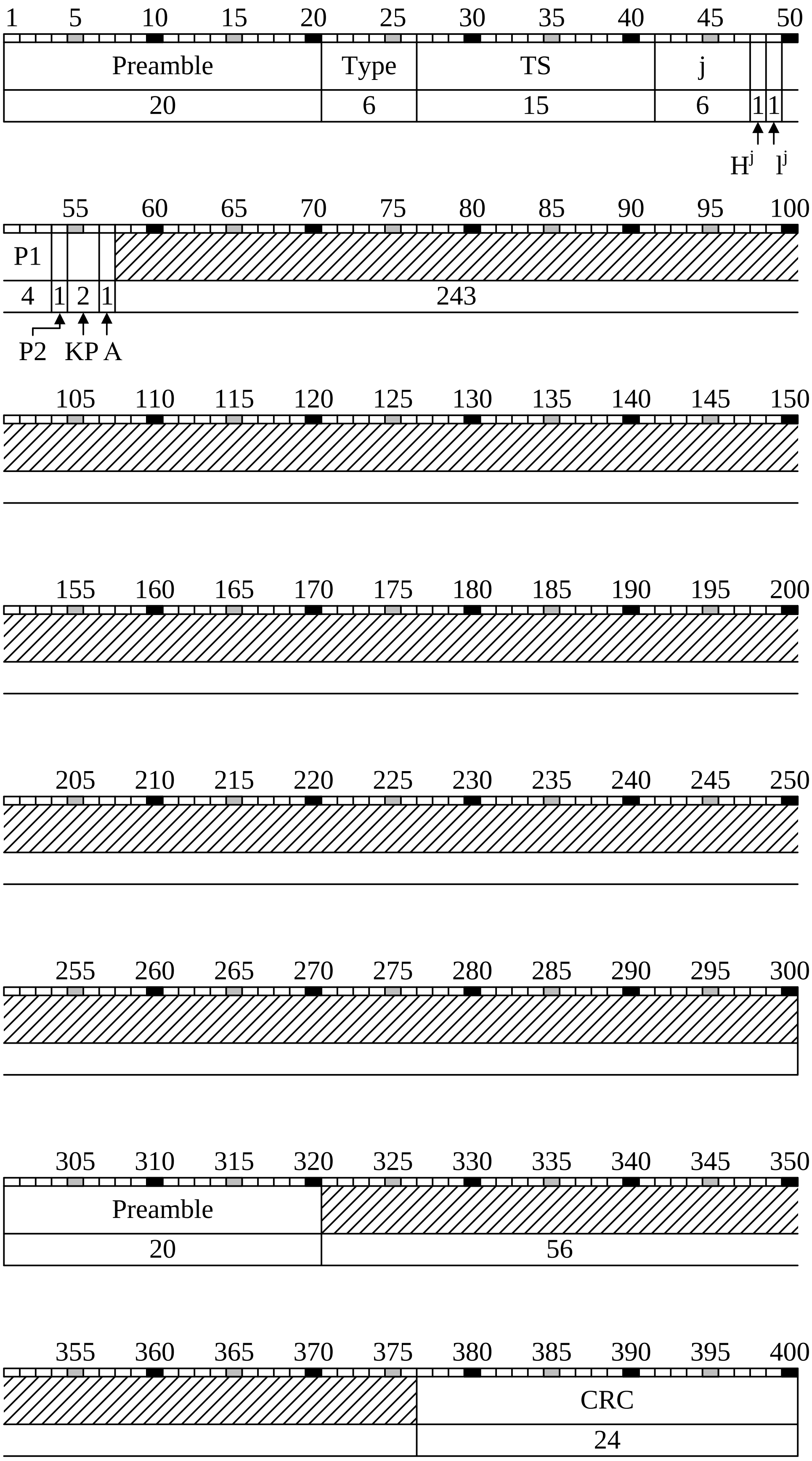

Figure 4.3 – Anomalous L3OCd data string Type 2

4.4 CRC (300,276)

CRC (300,276) is used in L3OCd signal for filling CRC field in 3 second strings of navigation message.

The location of the CRC field in a string is given in Table 4.2. The string contains 300 bits, where 24 bits are allocated for check bits of CRC code, 20 bits for Preamble, and 256 bits for data. String transmission starts from Preamble field.

Table 4.2 – CRC (300,276) in a 3-second string structure of L3OCd signal

Preamble	Data	CRC
20	256	24
Data bits		Check bits

CRC (300,276) generator polynomial is as follows:

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

CRC field is filled by using CRC encoding scheme shown in Figure 4.4. 276-bit data block is delivered to the input of encoder (starting from 1st bit of Preamble and ending with 256th bit of data). 300-bit code block is generated at the output of encoder by adding 24 check bits.

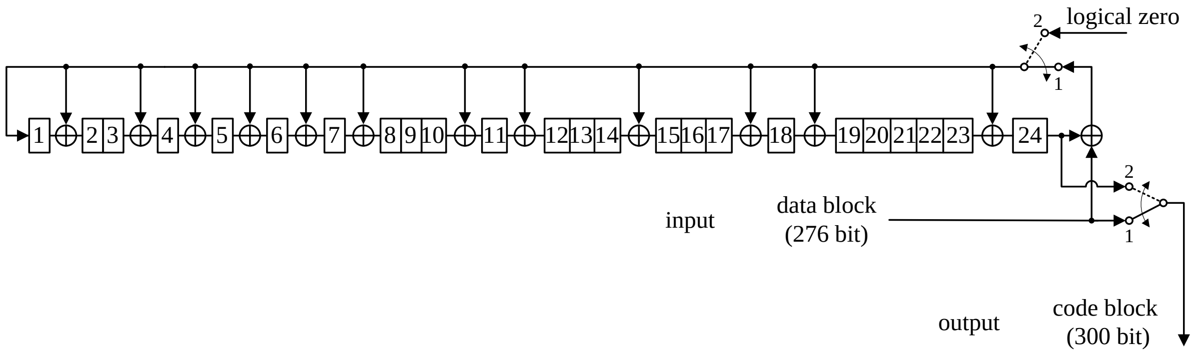

Figure 4.4 – CRC (300,276) encoding scheme

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

1) Initial state of the 24-bit shift register is zeros.

2) During first 276 shifts both keys are set to position 1, data block is being 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 276th 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 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.

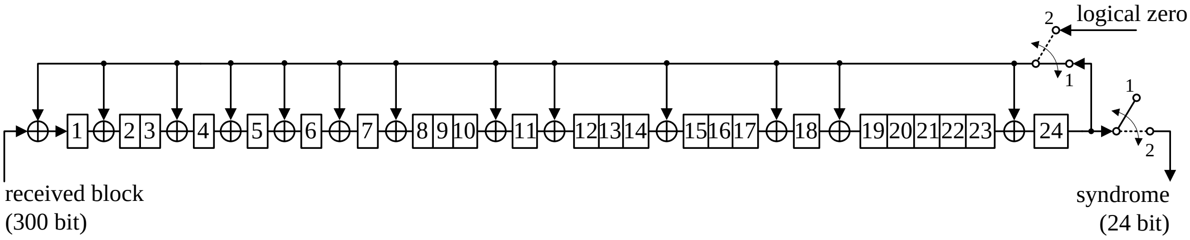

Figure 4.5 – CRC (300,276) syndrome calculation scheme

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 24th bit of CRC field) using the device shown in Figure 4.5:

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 276 bits) keeps being downloaded to the register. Syndrome is the name of the state of the register at the instant when the last 300th bit of the received block is downloaded to trigger 1.
4) After downloading the 300th 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.

4.5 CRC (200,176) of string Type 1

CRC (200,176) is used in L3OCd signal to fill in CRC field in strings Type 1. It is generated similarly to code (300,276) through the scheme shown in Figure 4.4 except for the number of bits delivered to the input (176 instead of 276).

Error detection is realized through the scheme shown in Figure 4.5 except for the number of bits transmitted to the input (200 instead of 300).

4.6 CRC (400,176) of string Type 2

CRC (400,176) is used in L3OCd signal to fill in CRC field in strings Type 2. It is generated similarly to code (300,276) through the scheme shown in Figure 4.4 except for the number of bits delivered to the input (376 instead of 276).

Error detection is realized through the scheme shown in Figure 4.5 except for the number of bits transmitted to the input (400 instead of 300).

5 Data field structure of L3OCd

5.1 Data fields of L3OCd strings and types of L3OCd strings

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

Data fields in a string are occupied by bits numbered:

- 58-276 in all strings except Type 1 and 2 (see Figure 4.1);
- 58-176 in strings of Type 1 (see Figure 4.2);
- 58-300 and 321-376 in strings Type 2 (see Figure 4.3).

Table 5.1 enlists string Types used in L3OCd 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 L3OCd

String type	Content
10, 11, 12	Immediate data
20	Almanac data
25	Parameters of Earth’s rotation, ionosphere model parameters, parameters of models for relating time scales UTC(SU) and TAI
16	SV attitude parameters during noon/midnight turn maneuver
31, 32	Long-term dynamic model parameters (LDMP)
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 Type 10, and string Type 12 follows string Type 11.	

5.2 L3OCd 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 Type 10, and string Type 12 always follows string Type 11. These strings transmit of immediate data.

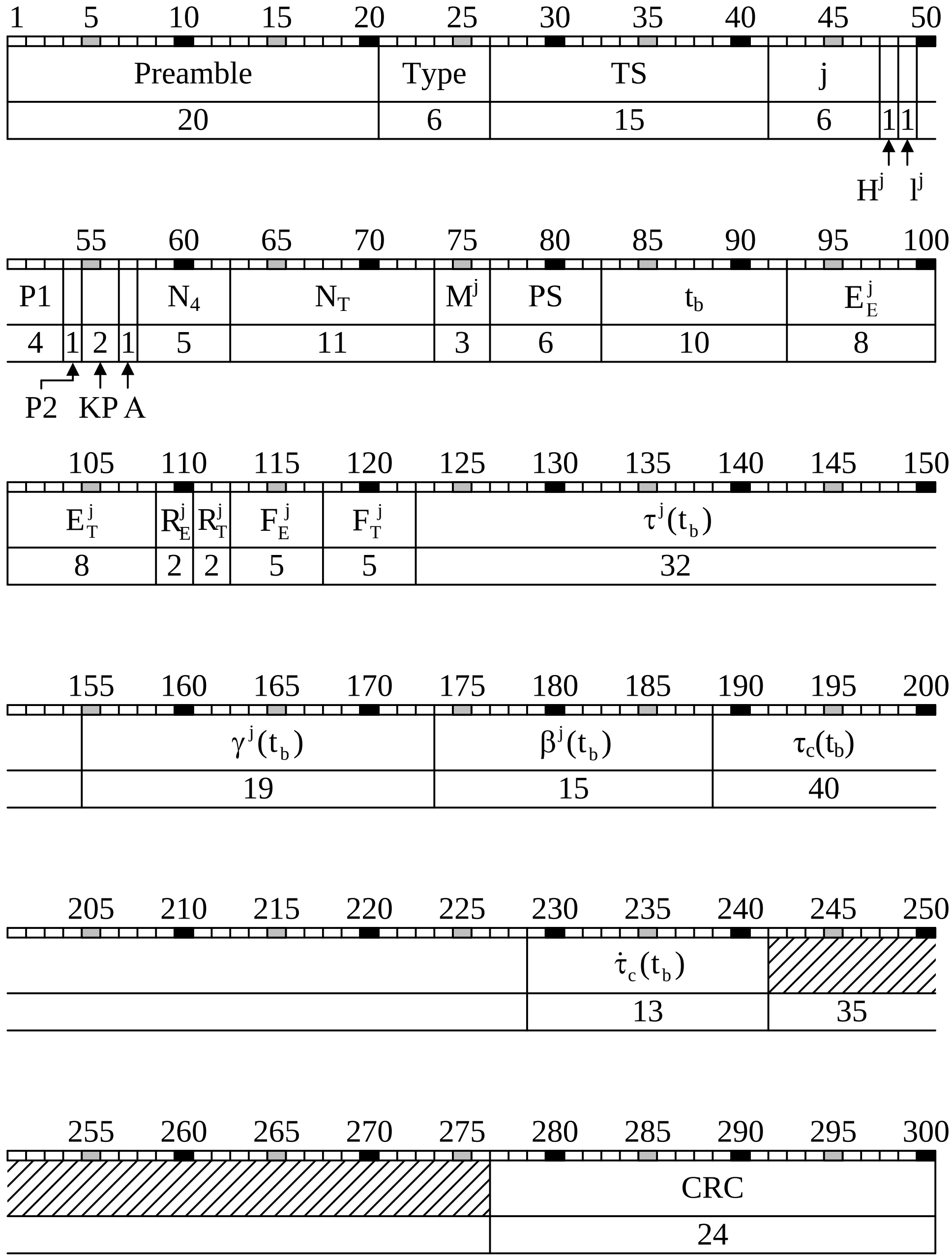

Figure 5.1 – String Type 10 of L3OCd data

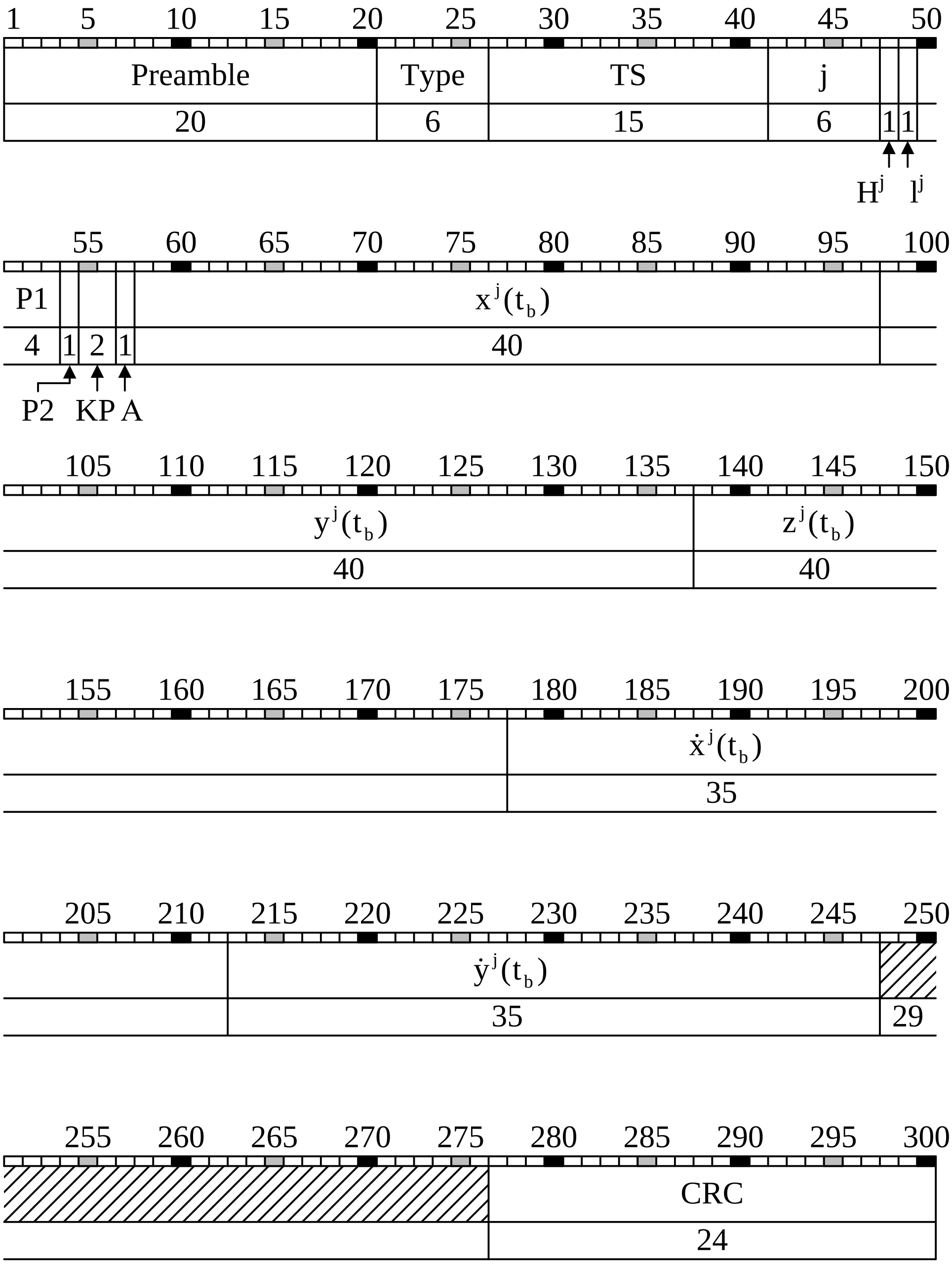

Figure 5.2 – String Type 11 of L3OCd data

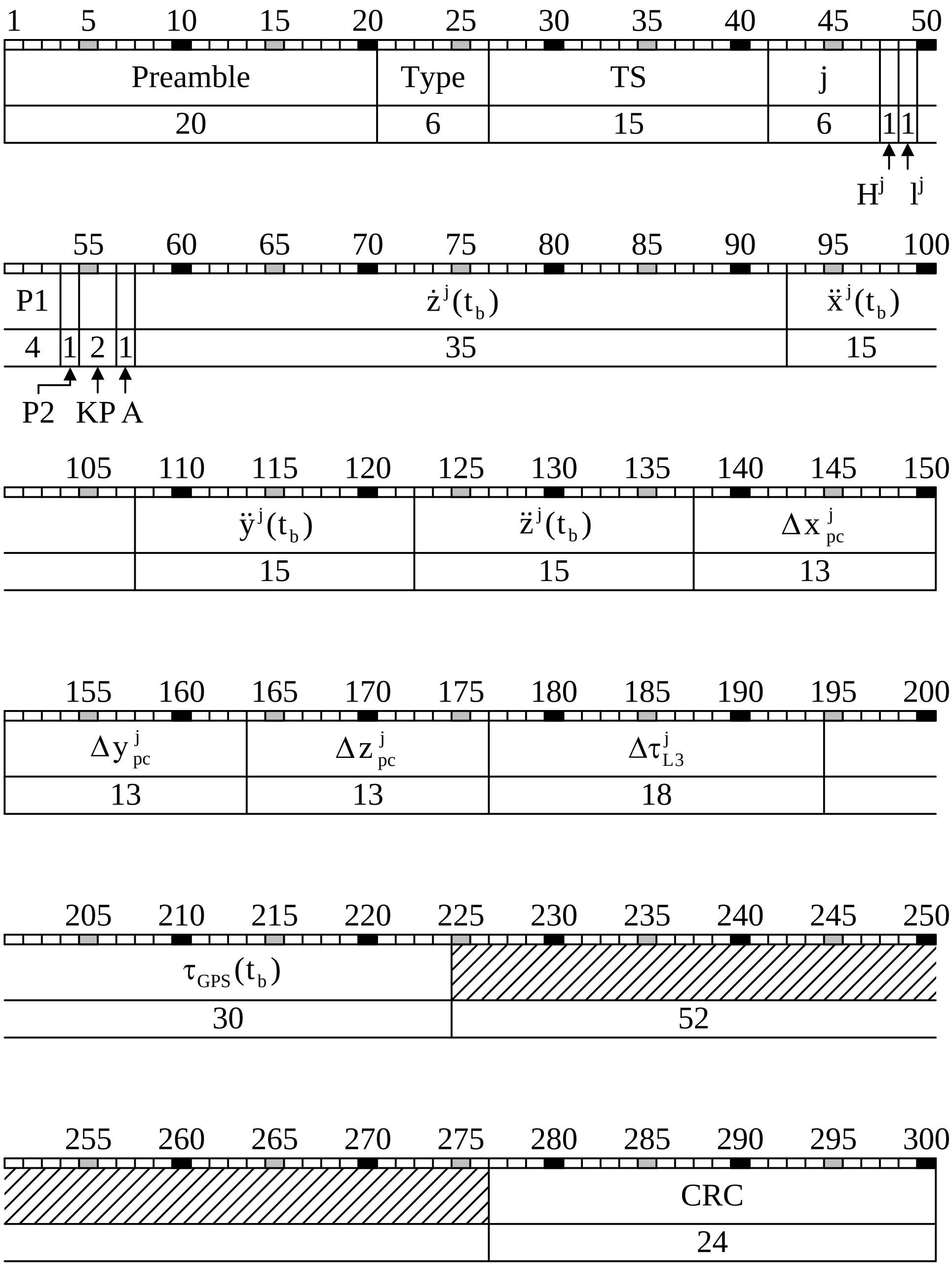

Figure 5.3 – String Type 12 of L3OCd data

Parameters 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 of 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	day
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}	N_4	s^{-1}
$\tau_c(t_b)$	40	2^{-31}	± 256	s
$\dot{\tau}_c(t_b)$	13	2^{-49}	$\pm 0.7 \cdot 10^{-11}$	–
Reserved	35	–	–	–
$x^j(t_b)$, t_b, $z^j(t_b)$	40	2^{-20}	$\pm 5.2 \cdot 10^5$	km
$\dot{x}^j(t_b)$, $\dot{y}^j(t_b)$	35	2^{-30}	± 16	km/s
Reserved	29	–	–	–
$\dot{z}^j(t_b)$	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
Δx_{pc}^j, Δy_{pc}^j, Δz_{pc}^j	13	2^{-10}	±4	m
$\Delta\tau_{L3}^j$	18	2^{-38}	$\pm 4.8 \cdot 10^{-7}$	s
$\tau_{GPS}(t_b)$	30	2^{-38}	$\pm 2 \cdot 10^{-3}$	s
Reserved	52	–	–	–

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 of strings Type 10, 11 and 12

5.2.2.1 Preamble, Type, TS, j, H^j, l^j, P1, P2, KP, A, 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 can 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 for 1996-1999 (in 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 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 which by the 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 transmits L3 CDMA signals;

M^j = 001 – GLONASS-K1 transmits L3 CDMA signals;

M^j = 011 – GLONASS-K1 transmits L2 and L3 CDMA signals;

M^j = 010 – GLONASS-K2 transmits 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 a 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.

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					

Recommendations on use of F_E^j and F_T^j accuracy factors are provided in Appendix P of General Description ICD.

5.2.2.10 Field $\tau^j(t_b)$ denotes a correction to L3OCd 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 L3OCd time (T_{L3OCd}) and GLONASS time (T_{GL}) at the instant t_b are as follows:

$$T_{GL}(t_b) = T_{L3OCd}(t_b) + \tau^j(t_b).$$

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 $f^j(t_b)$ from 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:

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

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 Fields $\dot{x}^j(t_b)$, $\dot{y}^j(t_b)$, $\dot{z}^j(t_b)$ 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 Fields $\ddot{x}^j(t_b)$, $\ddot{y}^j(t_b)$, $\ddot{z}^j(t_b)$ 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 L3OC 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 $\Delta\tau^{j}_{L3}$ denotes offset of L3OCp time (T_{L3OCp}) relative to L3OCd time (T_{L3OCd}):

$$\Delta\tau^{j}_{L3} = T_{L3OCp} - T_{L3OCd}.$$

Parameter $\Delta\tau^{j}_{L3}$ is necessary for transformation from L3OCp time to L3OCd 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 (T_{GPS}) 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 a 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 L3OCd string Type 20

5.3.1 Structure of string Type 20

Figure 5.4 shows a 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.

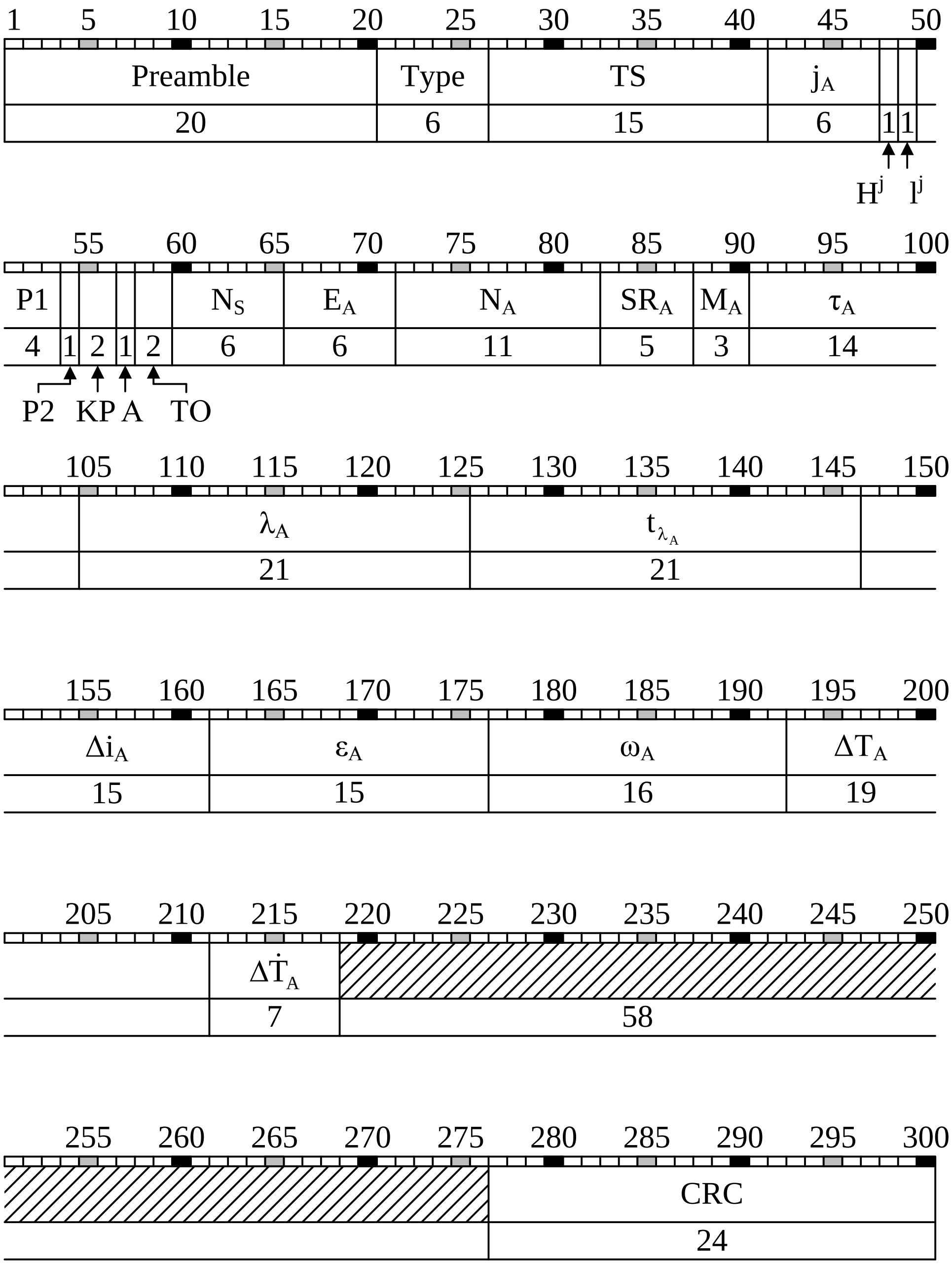

Figure 5.4 – String Type 20 of L3OCd data

Parameters of data fields for string Type 20 are given in Table 5.4.

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	day
N_A	11	1	1 – 1461	day
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 a cycle
t_{λ_A}	21	2^{-5}	0 – 44100	s
Δi_A	15	2^{-20}	± 0.0156	half a cycle
ε_A	15	2^{-20}	0 – 0.03	–
ω_A	16	2^{-15}	± 1	half a cycle
ΔT_A	19	2^{-9}	± 512	s
$\Delta \dot{T}_A$	7	2^{-14}	$\pm 3.9 \cdot 10^{-3}$	s/orbit
Reserved	58	–	–	–

5.3.2 Semantic scope of fields of string Type 20

5.3.2.1 Preamble, Type, TS, j, H^j, l^j, P1, P2, KP, A, 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 Field TO – 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 l^j (see 4.2.2.5 и 4.2.2.6). 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-К1 transmitting L3 CDMA signals;

M_A = 011 – Glonass-К1 transmitting L2 and L3 CDMA signals;

M_A = 010 – Glonass-К2 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.

$$\tau_A = T_{GL,N_A+1} - T_{L3OCd,N_A+1} - \left\langle \frac{T_{GL,N_A+1} - T_{L3OCd,N_A+1}}{86400} \right\rangle \cdot 86400,$$

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

T_{L3OCd,N_A+1} is L3OCd 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 employed 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 denotes correction to the nominal value of orbit inclination (64.8º) of SV j_A at the instant t_{λ_A} (MT).

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

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

5.3.2.15 Filed ΔT_A denotes correction to a nominal value (40,544 s) of mean draconic orbital period of SV j_A at the instant t_{λ_A} (MT).

5.3.2.16 Field $\Delta\dot{T}_A$ denotes draconic orbital period rate for 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 L3OCd string Type 25

5.4.1 Structure of string Type 25

Figure 5.5 shows the structure of a string Type 25. This type of a string is used for transmission of the 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.

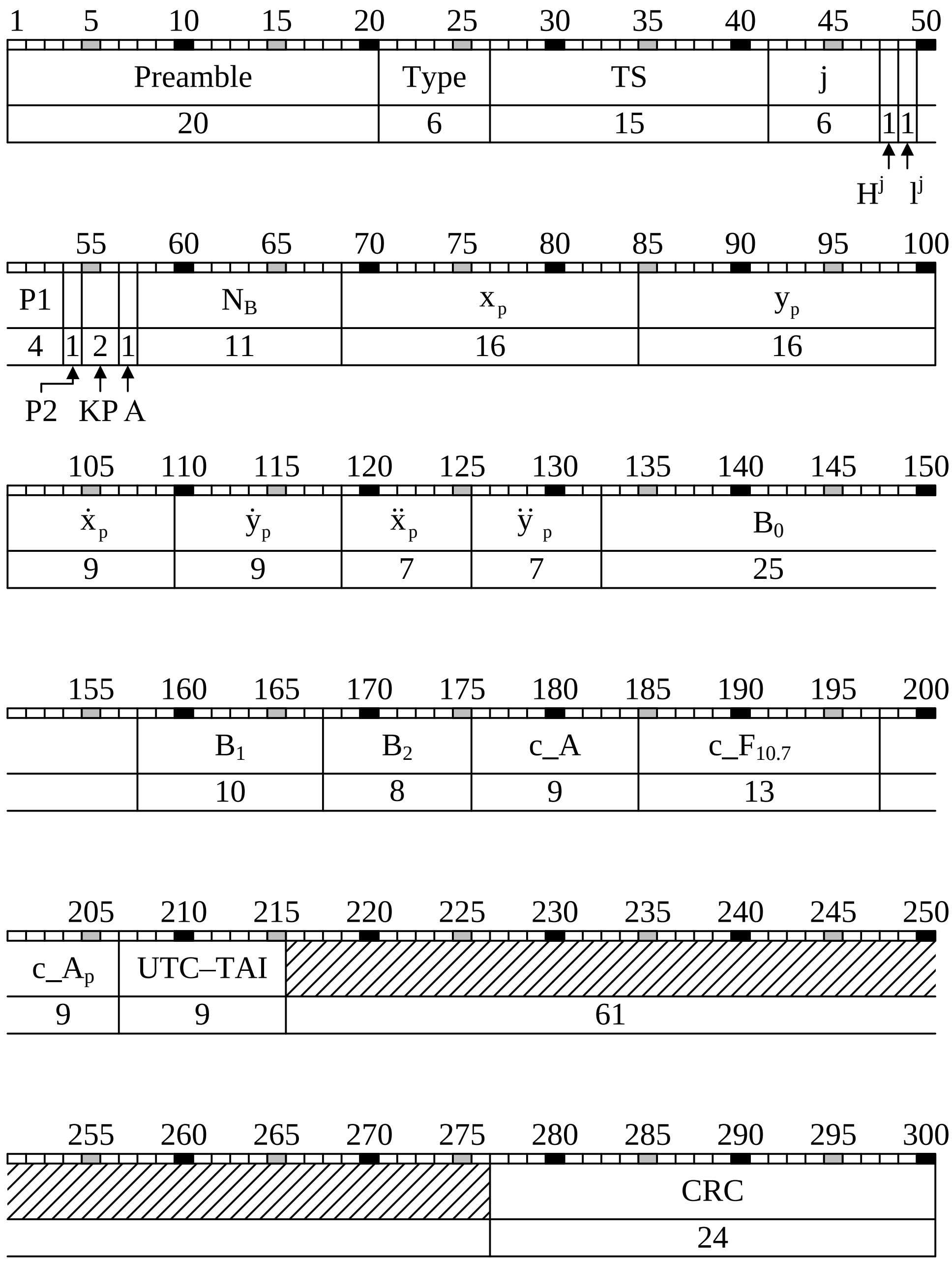

Figure 5.5 – String Type 25 of L3OCd data

Parameters of data fields for string Type 25 are provided in Table 5.5.

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	day
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	61	–	–	–

Notes:
1 For Field B_0 ± 256 range is selected to allow for possible future cancelation 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, TS, j, H^j, l^j, P1, P2, KP, A, CRC are service fields (see 4.2).

5.4.2.2 Field N_B denotes 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 which is not a leap year according to Gregorian calendar 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 the 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 of 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 L3OCd 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.

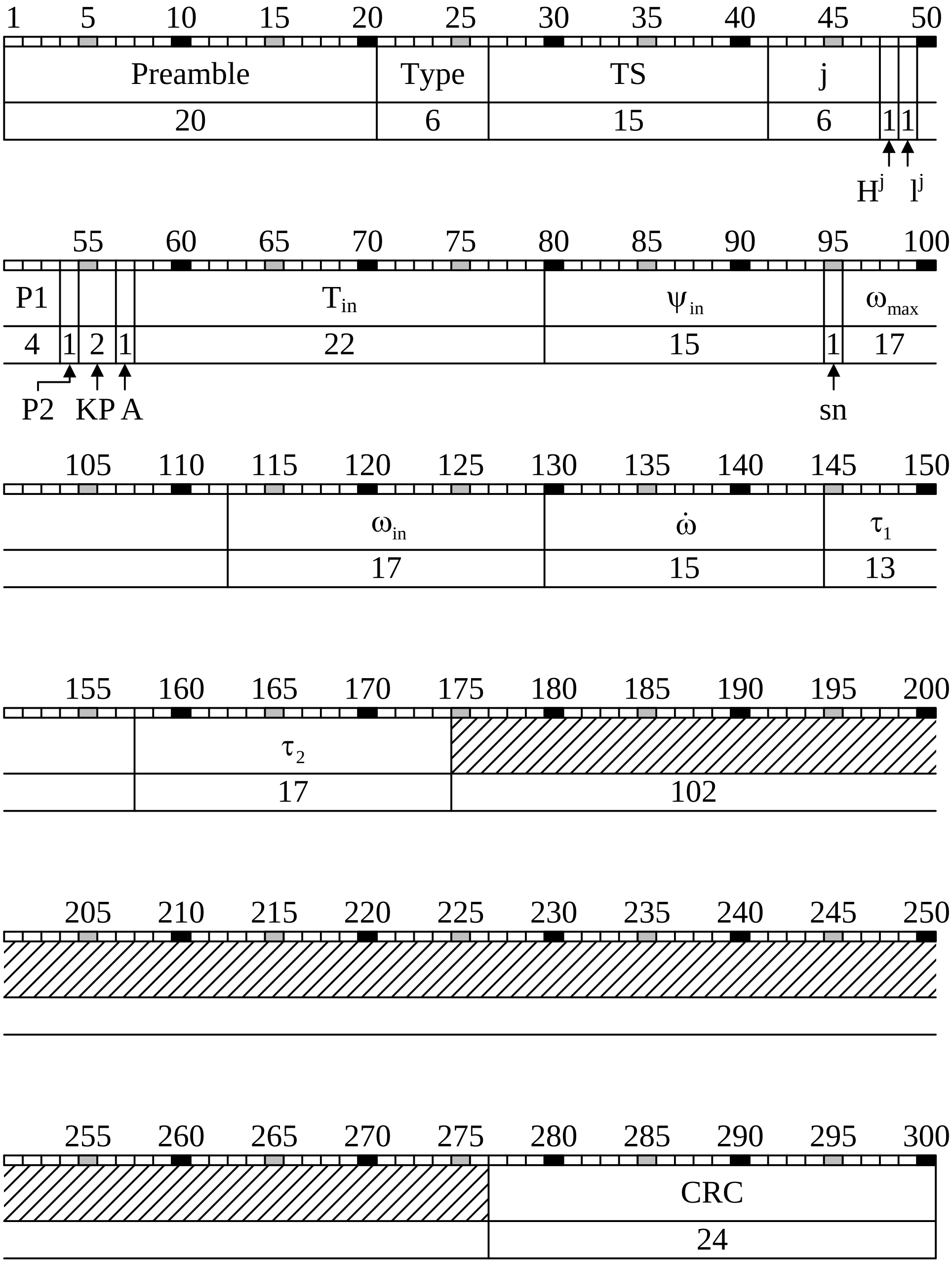

Figure 5.6 – String Type 16 of L3OCd data

Parameters of data fields of string Type 16 are provided in Table 5.6.

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	102	–	–	–

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, TS, j, H^j, l^j, P1, P2, KP, A, 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 the 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 Filed 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 (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 L3OCd 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.

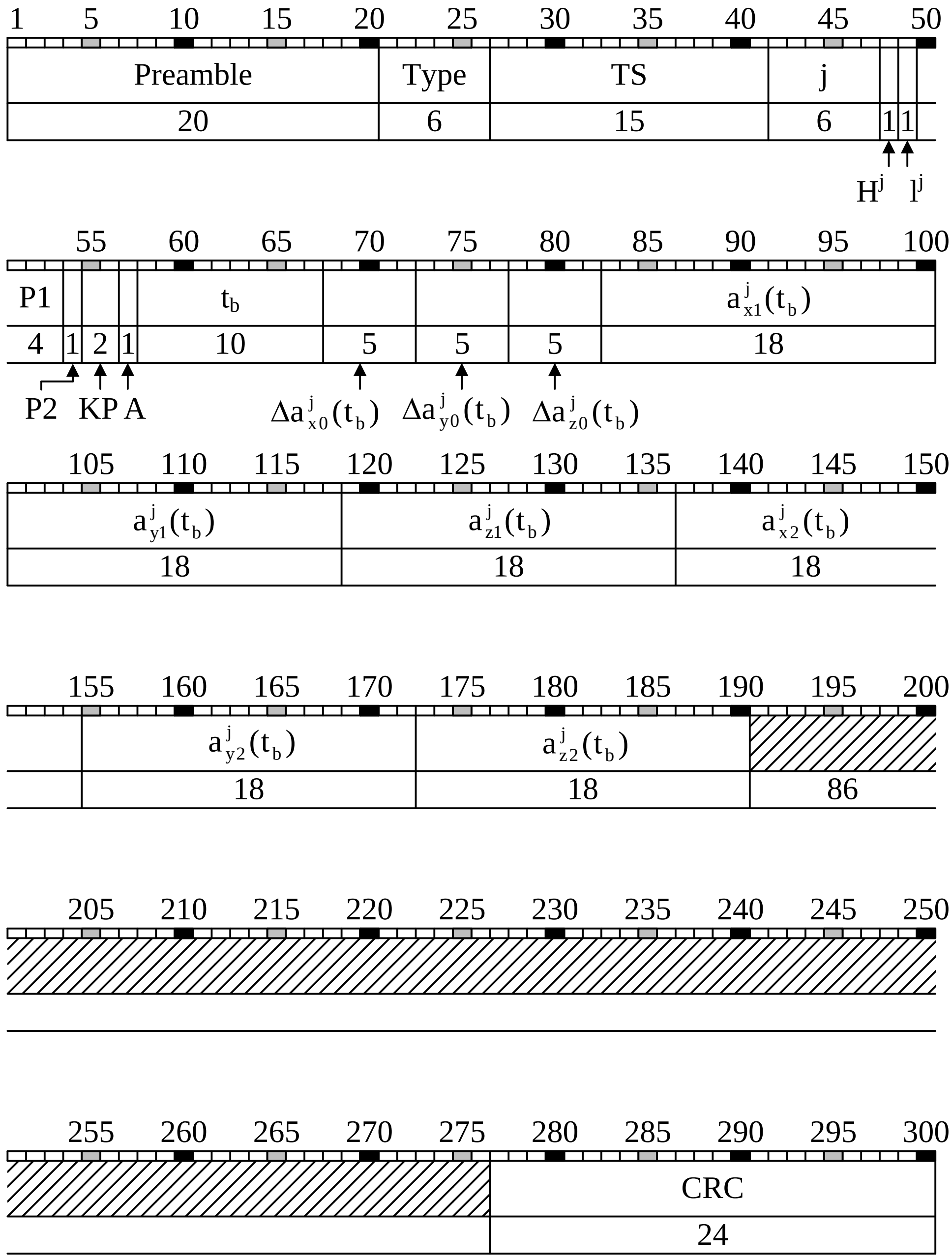

Figure 5.7 – String Type 31 of L3OCd data

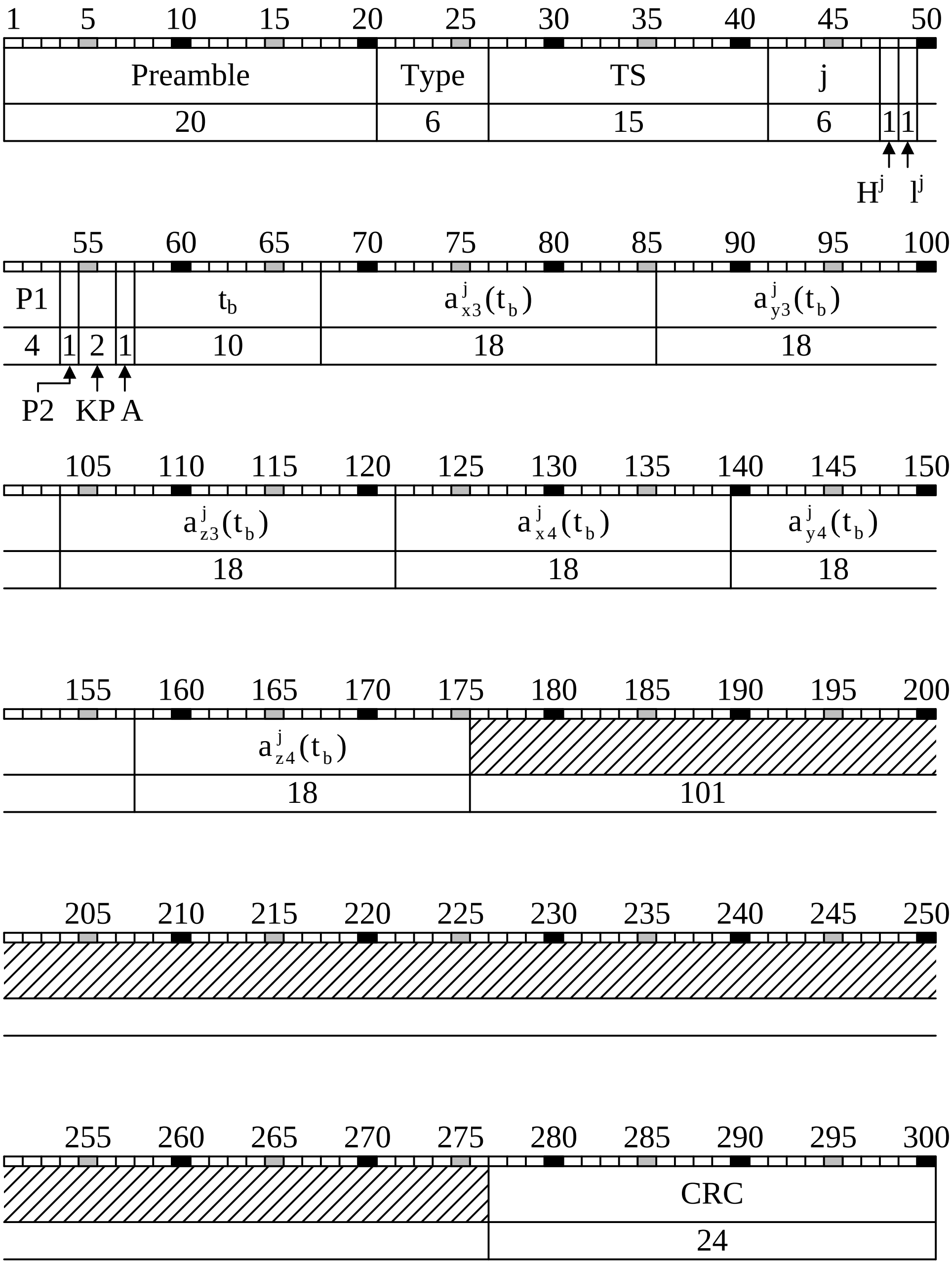

Figure 5.8 – String Type 32 of L3OCd data

Parameters of fields for strings Type 31 and 32 are provided in Table 5.7. 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	86	–	–	–
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	101	–	–	–

5.6.2 Semantic scope of fields for strings Type 31 and 32

5.6.2.1 Preamble, Type, TS, j, H^j, l^j, P1, P2, KP, A, 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 5.2.2.17) 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 L3OCd string Type 60

5.7.1 Structure of string Type 60

Figure 5.9 shows the structure of string Type 60 used to broadcast text messages. For this purpose the string Type 60 contains 219 bits.

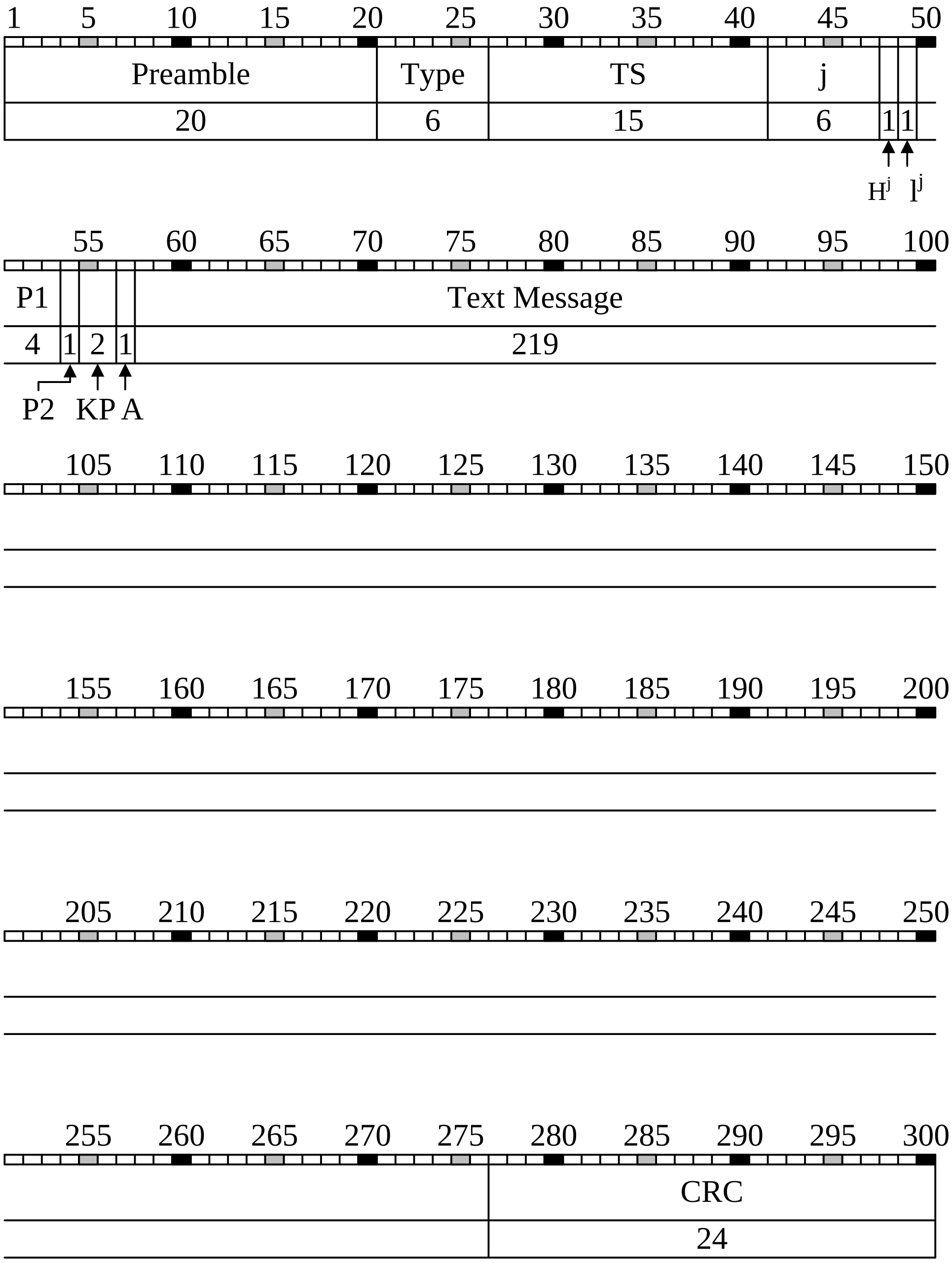

Figure 5.9 – String Type 60 of L3OCd data

Parameters of data fields for string Type 60 are provided in Table 5.8.

Table 5.8 – Parameters of data fields for string Type 60

Field	Number of bits	Least significant bit	Value range	Unit
text message	219	–	–	–

5.7.2 Semantic scope of fields of string Type 60

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

5.7.2.2 Field of text message contains text data. Its structure is described in a separate document.

5.8 L3OCd string Type 0

5.8.1 Structure of string Type 0

Figure 5.10 depicts 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.

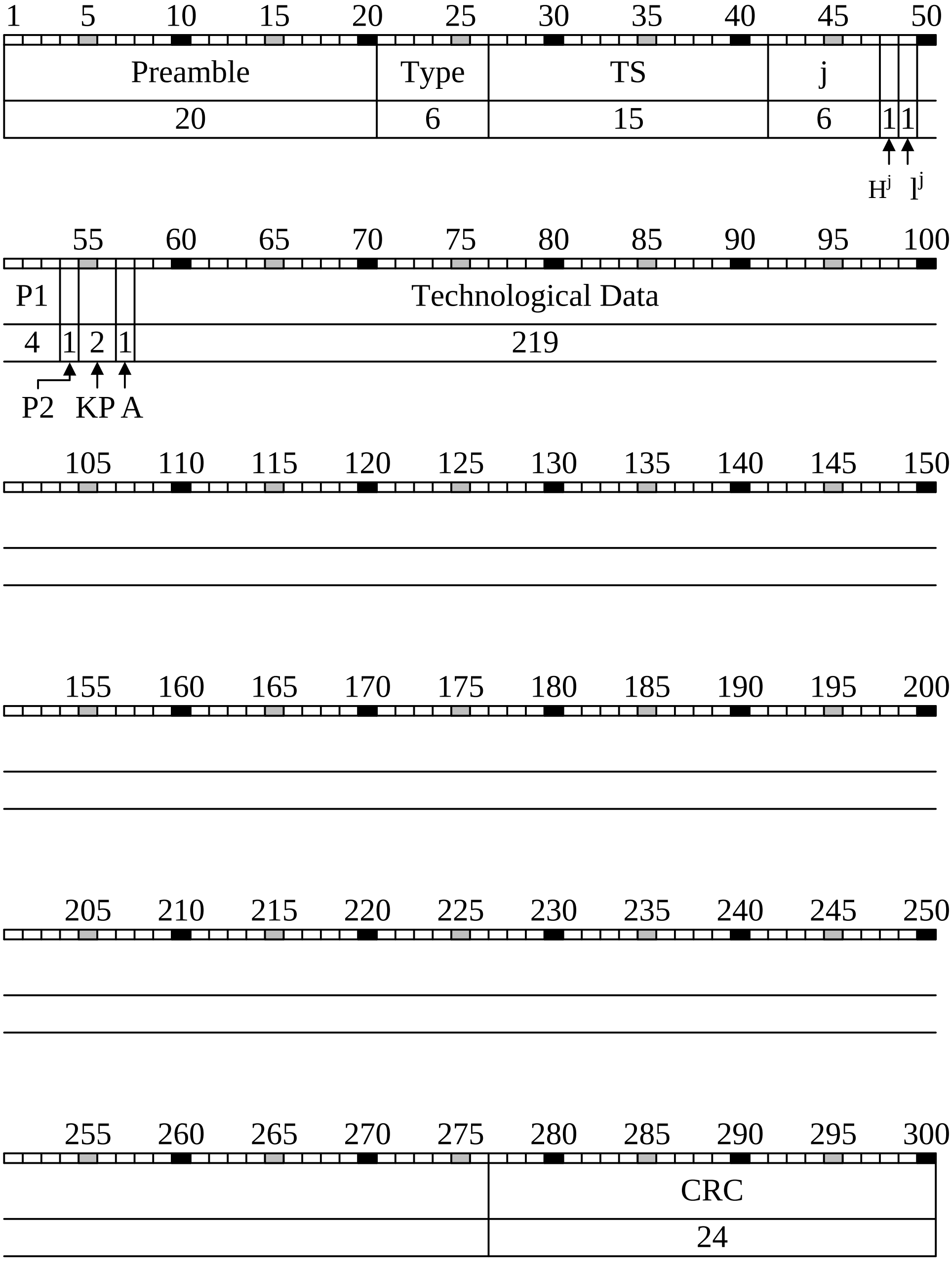

Figure 5.10 – String Type 0 of L3OCd data

Parameters of data fields for string Type 0 are provided in Table 5.9.

Table 5.9 – Parameters of data fields for string Type 0

Field	Number of bits	Least significant bit	Value range	Unit
Technological data	219	–	–	–

5.8.2 Semantic scope of fields for string Type 0

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

5.8.2.2 Field of technological data contains technological data.

5.9 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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