ETSI TS 102 188-2 V1.1.1 (2004-03)

Technical Specification

Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 2: Frame structure

Reference

DTS/SES-00RSM-A-PHY-P2

Keywords

air interface, broadband, IP, multimedia, satellite

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 2 of a multi-part deliverable covering the BSM Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specifications, as identified below:

Part 1: "General description";

Part 2: "Frame structure";

Part 3: "Channel coding";

Part 4: "Modulation";

Part 5: "Radio transmission and reception";

Part 6: "Radio link control";

Part 7: "Synchronization".

1 Scope

The present document defines the frame structure used within the SES BSM Regenerative Satellite Mesh - A (RSM-A) air interface family. It includes frame, time slot, and burst structure definition.

2 References

Void.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Network Operations Control Centre (NOCC): centre that controls the access of the satellite terminal to an IP network and also provides element management functions and control of the address resolution and resource management functionality

satellite payload: part of the satellite that provides air interface functions

NOTE: The satellite payload operates as a packet switch that provides direct unicast and multicast communication between STs at the link layer.

Satellite Terminal (ST): terminal installed in the user premises

terrestrial host: entity on which application level programs are running

NOTE: It may be connected directly to the Satellite Terminal or through one or more networks.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BPSK	Binary Phase Shift Keying
I	In Phase
IP	Internet Protocol
kbps	kilo bits per second (thousands of bits per second)
LHCP	Left Hand Circular Polarization
LS	Long Slot
LSB	Least Significant Bit
Mbps	Mega bits per second (millions of bits per second)
MSB	Most Significant Bit
Msps	Mega symbols per second (millions of symbols per second)
NOCC	Network Operations Control Centre
OQPSK	Offset Quaternary Phase Shift Keying
PHY	PHYsical
PTP	Point-to-Point
Q	Quadrature
QPSK	Quaternary Phase Shift Keying
RHCP	Right Hand Circular Polarization
RS	Reed-Solomon
RSM	Regenerative Satellite Mesh
SLC	Satellite Link Control
SS	Standard Slot

ST	Satellite Terminal
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TIP	Transmission Information Packet
UW	Unique Word

4 General

The functions of the physical layer are different for the uplink and downlink. The major functions are illustrated in figure 4.

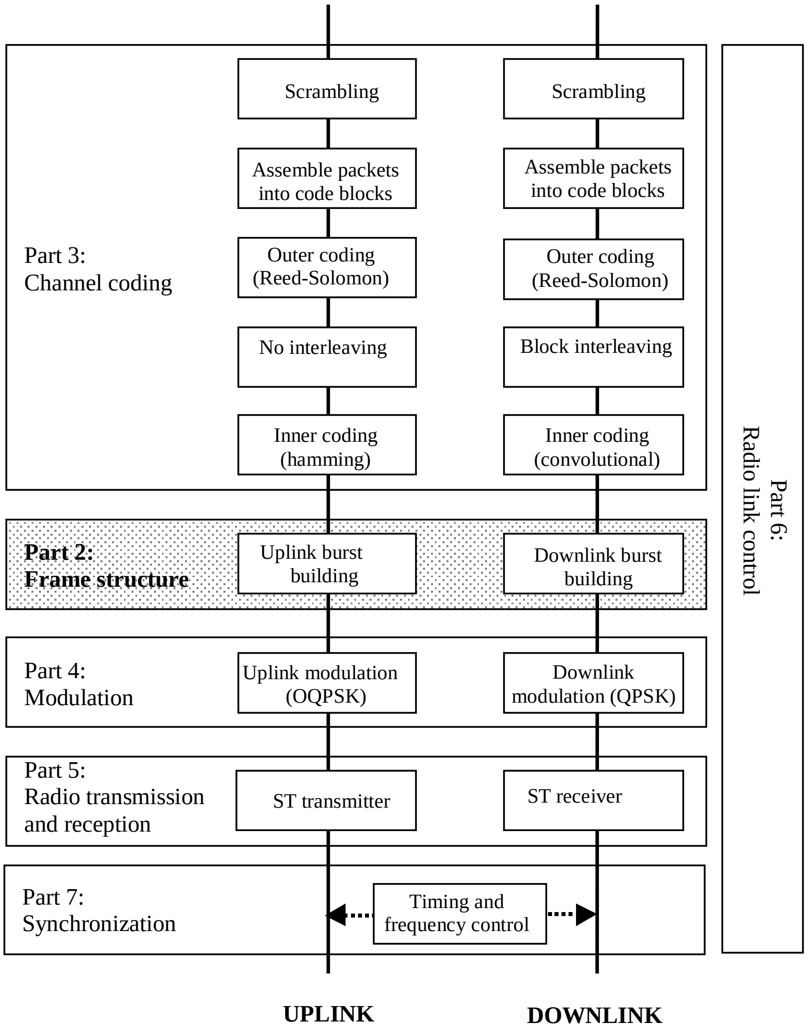

Figure 4: Physical layer functions

The present document describes the frame structure - this group of functions is highlighted in figure 4.

The uplink frame structure requirements are described in clause 5, and the downlink frame structure requirements are described in clause 6.

5 Uplink

5.1 Frame structure

The uplink frame is 96ms in duration, and is composed of a dead time period followed by a fixed number of time slots for code block transmission as shown in figure 5.1. The number of time slots is a function of the carrier mode.

NOTE: The uplink carrier modes in operation at any given time is defined by system information broadcast messages as defined in the RSM-A SMAC/SLC layer specification.

The two general types of TDMA slot formats are the Standard Slot (SS) and the Long Slot (LS). The beginning of the uplink frame is the start of the dead time period as shown in figure 5.1.

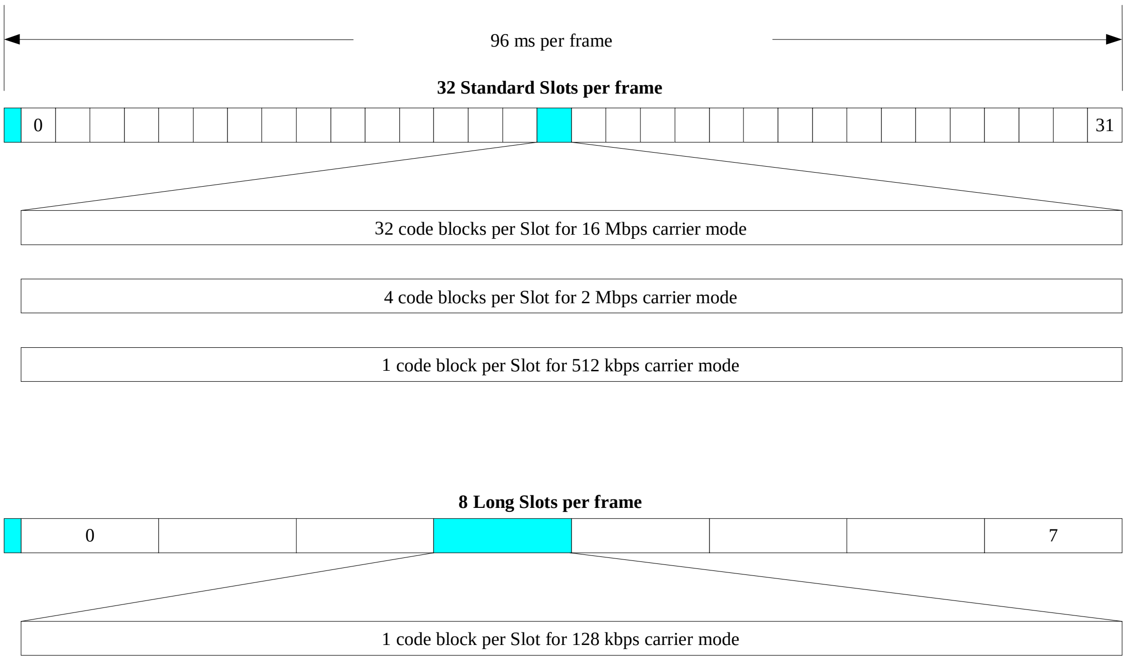

Figure 5.1: Uplink frame structure

5.1.1 Dead time period

The time duration and corresponding length in modulated symbols of the dead time period are defined in table 5.1.1. The ST shall not transmit during the dead time period.

Table 5.1.1: Uplink frame dead time period durations

Carrier mode	Time duration (μs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	153,6	$520\ 5/6 \times 10^3$	80
512 kbps	153,6	$520\ 5/6 \times 10^3$	80
2 Mbps	153,6	$2\ 1/12 \times 10^6$	320
16 Mbps	153,6	$16\ 2/3 \times 10^6$	2 560

5.1.2 TDMA Slots

The uplink frame shall consist of 32 standard slots for the 16 Mbps, 2 Mbps and 512 kbps carrier modes, and 8 long slots for the 128 kbps carrier mode. The time slot numbering scheme is shown in figure 5.1.2.

Standard and long slots are not mixed within an uplink frame on a given carrier. All time slots within an uplink frame belong to the same carrier mode (i.e. 512 kbps slots cannot be intermixed with 2 Mbps slots within a frame).

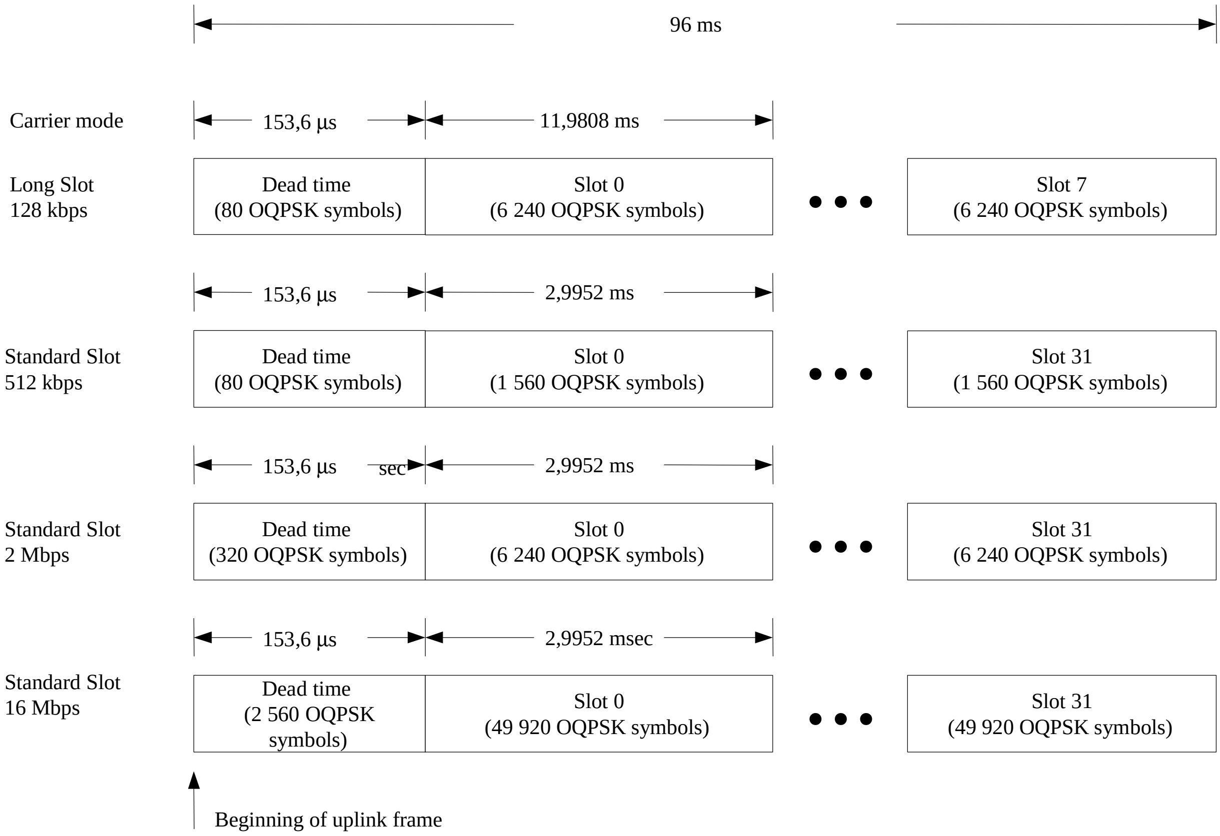

Figure 5.1.2: Uplink TDMA slot definition

The time duration and corresponding length in modulated symbols of each uplink time slot are defined in table 5.1.2.

Table 5.1.2: Uplink frame TDMA slot durations

Carrier mode	Slots per frame	Time duration (ms)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	8	11,9808	$520\ 5/6 \times 10^3$	6 240
512 kbps	32	2,9952	$520\ 5/6 \times 10^3$	1 560
2 Mbps	32	2,9952	$2\ 1/12 \times 10^6$	6 240
16 Mbps	32	2,9952	$16\ 2/3 \times 10^6$	49 920

The start of any time slot relative to the start of an uplink frame is according to the following relation:

$$\text{Slot}(N_{slot})\text{start} = t_{\text{dead time}} + t_{\text{slot}} \times N_{slot}$$

where $t_{\text{dead time}}$ is the time duration for the dead time period shown in table 5.1.1, t_{slot} is the time duration for each slot period as shown in table 5.1.2, and N_{slot} is the slot designator number. The slot designator number starts at 0 and ends at 31 and 7 for the short slot and long slot respectively.

5.2 Slot structure

An uplink TDMA time slot is composed of a start guard time period, a ramp-up time period, a TDMA burst, a ramp-down time period, an end guard time period, and a slot alignment time period, as shown in figure 5.2.

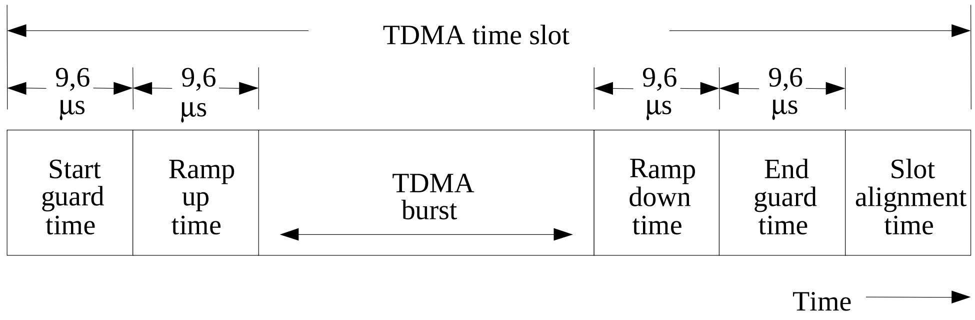

Figure 5.2: Uplink slot structure

5.2.1 Start guard time period

The time designated as guard time is used to prevent interference in time between adjacent time slots due to arrival uncertainty. Uplink TDMA bursts are transmitted between the start guard time and the end guard time periods of the designated time slots.

The time duration and corresponding length in modulated symbols of the start guard time period are defined in table 5.2.1.

Table 5.2.1: Uplink slot start guard time period durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	9,6	520 5/6 $\times 10^3$	5
512 kbps	9,6	520 5/6 $\times 10^3$	5
2 Mbps	9,6	2 1/12 $\times 10^6$	20
16 Mbps	9,6	16 2/3 $\times 10^6$	160

5.2.2 Ramp-up time period

The ST uses the ramp-up time period to control the turn-on of the radio, thereby controlling emissions. The time duration and corresponding length in modulated symbols of the ramp-up time period are defined in table 5.2.2.1.

Table 5.2.2.1: Uplink slot ramp-up time period durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	9,6	520 5/6 $\times 10^3$	5
512 kbps	9,6	520 5/6 $\times 10^3$	5
2 Mbps	9,6	2 1/12 $\times 10^6$	20
16 Mbps	9,6	16 2/3 $\times 10^6$	160

The ramp-up and ramp-down patterns for I-channel and Q-channel are defined in table 5.2.2.2.

Table 5.2.2.2: Uplink slot ramp-up patterns

Carrier mode	Number of symbols	Ramp-up pattern
128 kbps	5	11000
512 kbps	5	11000
2 Mbps	20	11000011110000111100
16 Mbps	160	110000111100001111000011 111000011110000111100000 111100001111000011111000 011111000011110000111100 001111100001111000011110 000111110000111100001111 0000111110000111100011

5.2.3 Ramp-down time period

The ST uses the ramp-down time period to control the turn-off of the radio, thereby controlling emissions. The time duration and corresponding length in modulated symbols of the ramp-down time period are defined in table 5.2.3.1.

Table 5.2.3.1: Uplink slot ramp-down time period durations

Carrier mode	Time duration (μs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	9,6	$520\ 5/6 \times 10^3$	5
512 kbps	9,6	$520\ 5/6 \times 10^3$	5
2 Mbps	9,6	$2\ 1/12 \times 10^6$	20
16 Mbps	9,6	$16\ 2/3 \times 10^6$	160

The ramp-down patterns for I-channel and Q-channel are defined in table 5.2.3.2.

Table 5.2.3.2: Uplink slot ramp-down patterns

Carrier mode	Number of symbols	Ramp-down pattern
128 kbps	5	01111
512 kbps	5	01111
2 Mbps	20	00111100001111000
16 Mbps	160	110000111100001111000011 111000011110000111100000 111100001111000011111000 011111000011110000111100 001111100001111000011110 000111110000111100001111 0000111110000111100011

5.2.4 End guard time period

The time designated as guard time is used to prevent interference in time between adjacent time slots due to arrival uncertainty. Uplink TDMA bursts are transmitted between the start guard time and the end guard time periods of the designated time slots.

The time duration and corresponding length in modulated symbols of the end guard time period are defined in table 5.2.4.

Table 5.2.4: Uplink slot end guard time period durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	9,6	$520\ 5/6 \times 10^3$	5
512 kbps	9,6	$520\ 5/6 \times 10^3$	5
2 Mbps	9,6	$2\ 1/12 \times 10^6$	20
16 Mbps	9,6	$16\ 2/3 \times 10^6$	160

5.2.5 Slot alignment time period

The slot alignment time is added to force the time slots for 512 kbps, 2 Mbps and 16 Mbps to be of equal length and for the 128 kbps long slot to be four times longer than the other time slots. No data is transmitted during the slot alignment time.

The time duration and corresponding length in modulated symbols of the slot alignment time period are defined in table 5.2.5.

Table 5.2.5: Uplink slot alignment time period durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	115,20	$520\ 5/6 \times 10^3$	60
512 kbps	0	$520\ 5/6 \times 10^3$	0
2 Mbps	109,44	$2\ 1/12 \times 10^6$	228
16 Mbps	141,36	$16\ 2/3 \times 10^6$	2356

5.3 Burst Structure

The ST transmission access within an uplink time slot is a TDMA burst. Each TDMA burst is composed of a Unique Word (UW) followed by code blocks. The quantity of code blocks is carrier mode dependent. The TDMA burst structure and code block numbering for the four carrier modes are depicted in figure 5.3.

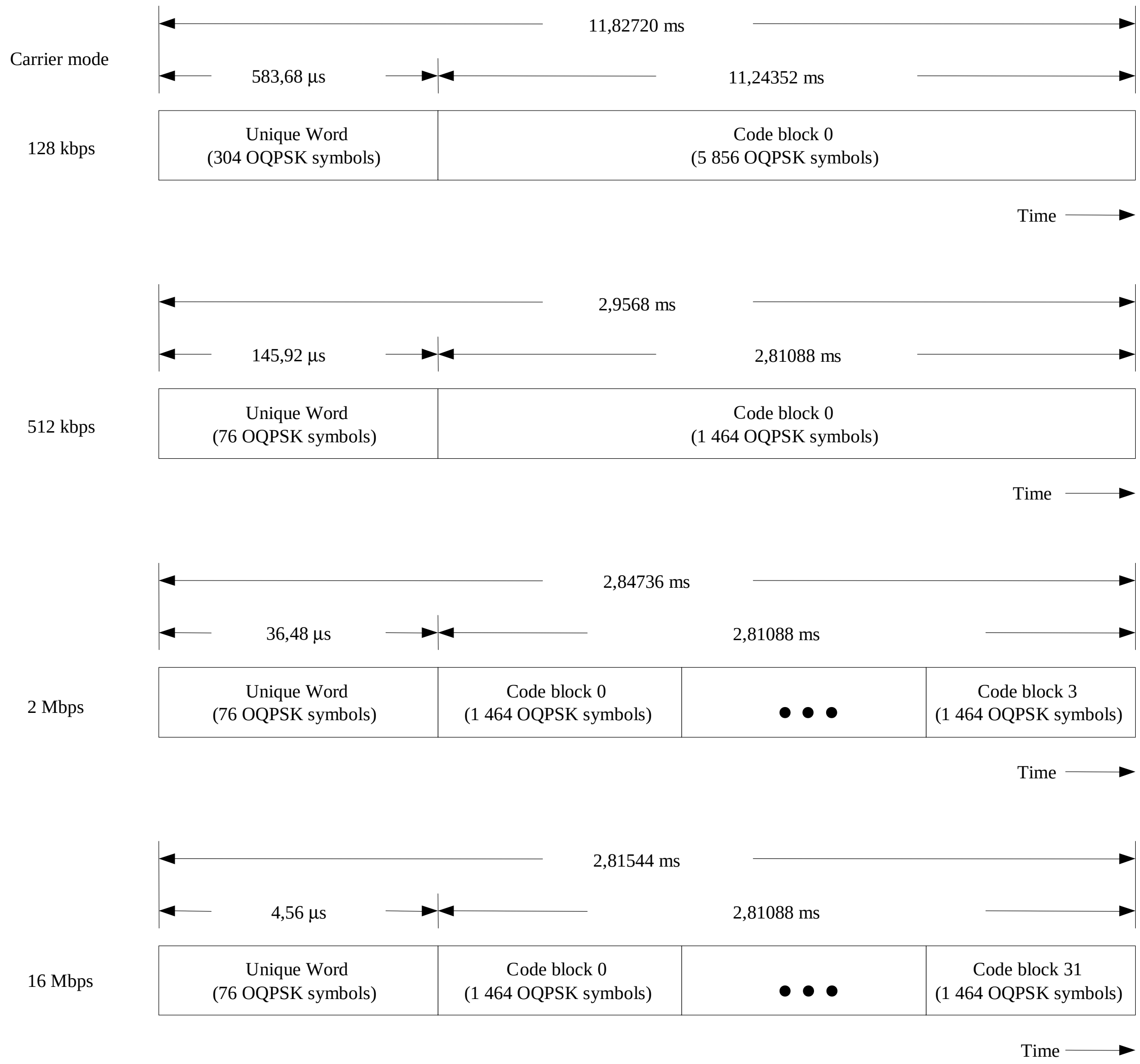

Figure 5.3: Uplink burst structure

The time duration and corresponding length in modulated symbols of the TDMA burst period are defined in table 5.3.

Table 5.3: Uplink TDMA burst durations

Carrier mode	Time duration (ms)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	11,8272	520 5/6 $\times 10^3$	6 160
512 kbps	2,95680	520 5/6 $\times 10^3$	1 540
2 Mbps	2,84736	2 1/12 $\times 10^6$	5 932
16 Mbps	2,81544	16 2/3 $\times 10^6$	46 924

5.3.1 Unique Word field

The STs transmit the unique word associated with its uplink cell at the beginning of the TDMA burst time. The ST shall be capable of managing and utilizing up to 30 distinct UW patterns.

The time duration and corresponding length in modulated symbols of the unique word field are defined in table 5.3.1.1.

Table 5.3.1.1: Uplink burst Unique Word field durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
128 kbps	583,68	$520\ 5/6 \times 10^3$	304
512 kbps	145,92	$520\ 5/6 \times 10^3$	76
2 Mbps	36,48	$2\ 1/12 \times 10^6$	76
16 Mbps	4,560	$16\ 2/3 \times 10^6$	76

To minimize impairments caused by interference, the uplink uses multiple unique words selected from a fixed set of 7 UWs for each ST transmission using a 7-cell reuse pattern.

The bit pattern of the seven UWs is given in table 5.3.1.2.

The first bit of the first hexadecimal of the UW pattern (76 or 304 symbols) is the MSB. The last bit of the last hexadecimal of the UW pattern is the LSB. The MSB is the first bit that is presented and the LSB is the last bit that is presented. The real I UW is presented a half symbol ahead of the imaginary Q UW.

Table 5.3.1.2: Uplink burst Unique Word patterns

UW index	Carrier mode	UW length (symbols)	Real I UW pattern (hexadecimal)	Imaginary Q UW pattern (hexadecimal)
1	128 kbps	304	CAE209AF32A92 D6 3DDF (repeated 4 times)	C2F4DB4146E9F B66A1A (repeated 4 times)
2	128 kbps	304	B9E67AA6AE3ED 5E3556 (repeated 4 times)	4EF1E452A791A 88CFD2 (repeated 4 times)
3	128 kbps	304	A9129B6631A39 4186DF (repeated 4 times)	FBDA4926EEA6A ABB13F (repeated 4 times)
4	128 kbps	304	2A65975E14BA3 150AB8 (repeated 4 times)	6BBFA4BD76079 16551E (repeated 4 times)
5	128 kbps	304	87929E3A55FDF 58176A (repeated 4 times)	B7A775154A8D9 635D69 (repeated 4 times)
6	128 kbps	304	18FF4B1B6611C 8895A1 (repeated 4 times)	47A2C657B5771 4C88BB (repeated 4 times)
7	128 kbps	304	A072CA5E0DBAB 702298 (repeated 4 times)	001F5AADB7568 A78A0D (repeated 4 times)
1	512 kbps, 2 Mbps, or 16 Mbps	76	CAE209AF32A92 D63DDF	C2F4DB4146E9F B66A1A
2	512 kbps, 2 Mbps, or 16 Mbps	76	B9E67AA6AE3ED5E3556	4EF1E452A791A 88CFD2
3	512 kbps, 2 Mbps, or 16 Mbps	76	A9129B6631A39 4186DF	FBDA4926EEA6A ABB13F
4	512 kbps, 2 Mbps, or 16 Mbps	76	2A65975E14BA3 150AB8	6BBFA4BD76079 16551E
5	512 kbps, 2 Mbps, or 16 Mbps	76	87929E3A55FDF58176A	B7A775154A8D9 635D69
6	512 kbps, 2 Mbps, or 16 Mbps	76	18FF4B1B6611C8895A1	47A2C657B5771 4C88BB
7	512 kbps, 2 Mbps, or 16 Mbps	76	A072CA5E0DBA B702298	001F5AADB7568 A78A0D

5.3.2 Data field

The data field immediately follows the UW within each burst. The traffic field is composed of one, one, four, or thirty-two code blocks for the 128 kbps, 512 kbps, 2 Mbps and 16 Mbps carrier modes, respectively. The order of code blocks with respect to time is given in figure 5.3. The time duration and corresponding length in modulated symbols of the data field are defined in table 5.3.2.

Table 5.3.2: Uplink burst data field durations

Carrier mode	Time duration (ms)	Symbol rate (symbols/s)	Time duration (modulated symbols)	Code block duration (modulated symbols)
128 kbps	11,24352	$520\ 5/6 \times 10^3$	5 856	5 856
512 kbps	2,81088	$520\ 5/6 \times 10^3$	1 464	1 464
2 Mbps	2,81088	$2\ 1/12 \times 10^6$	5 856	1 464
16 Mbps	2,81088	$16\ 2/3 \times 10^6$	46 848	1 464

6 Downlink

6.1 Frame structure

The downlink frame is 3ms in duration, and is composed of a beacon slot, shaped-broadcast slots, an idle slot, and Point-to-Point (PTP) slots, as shown in figure 6.1. There are either N/3 or N/4 shaped-broadcast slots in the downlink frame depending on modulation mode.

NOTE: The downlink frame structure in operation at any given time is defined by system information broadcast messages as defined in the RSM-A SMAC/SLC layer specification.

The beginning of the downlink frame is the start of the beacon slot. Once every frame, a beacon slot is used to transmit a portion of a 0,768 s PN sequence to synchronize the ST with the downlink timing reference. The ST uses the received PN sequence to synchronize uplink and downlink frame counters.

Shaped-broadcast slots are performed in increments of three or four PTP slots and are scheduled before the PTP transmission. The shaped-broadcast slots are used for transmitting packets over shaped beams that cover all or a portion of a geographical location.

Idle slots occur once every frame to perform system functions, and are identified with the slot number immediately following the last shaped-broadcast slot.

Finally, the PTP transmission is performed contiguously in each remaining slot until the 137^{th} slot is reached. The cycle repeats starting from the transmission of the beacon signals. PTP slots are used for transmitting packets to one microcell or seven microcells for cellcast.

The LHCP and RHCP downlinks are commanded to follow the same frame and time slot structure within a frame. Both downlink polarizations simultaneously transmit beacon, shaped-broadcast, idle, and PTP signals.

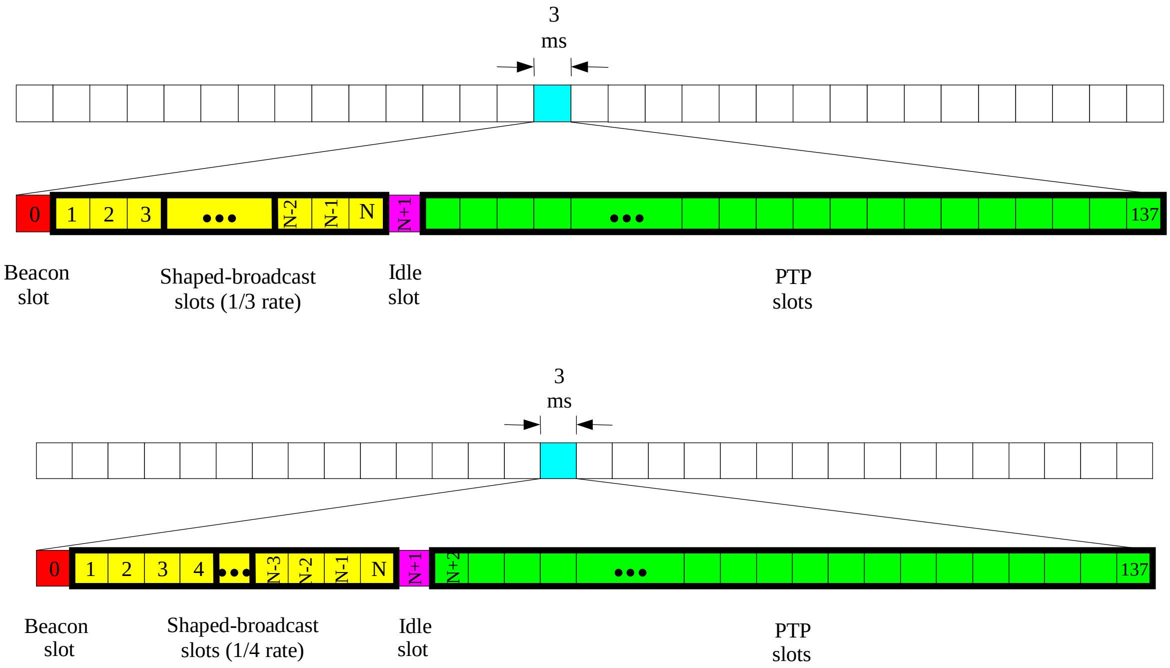

Figure 6.1: Downlink frame structure

6.1.1 Slot transmission rates

The transmission rate during the beacon slot and idle slot is at the 1/3-rate, or 133 1/3 Msps. The transmission rate during shaped-broadcast slots is at either the 1/3-rate (133 Msps) or 1/4-rate (100 Msps). The transmission rate during PTP time slots is at the full rate, or 400 Msps. The transmission modes are shown in figure 6.1.1.

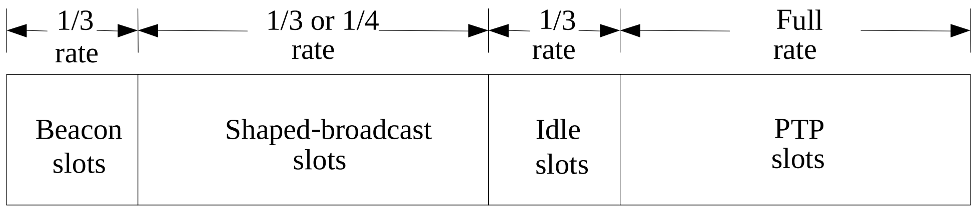

Figure 6.1.1: Downlink Frame Slot Transmission Rates

6.1.2 Slot combinations

The possible combinations of downlink slot transition boundaries (end of the idle slot) from shaped-broadcast 1/3-rate slots to PTP slots are as listed in table 6.1.2.1. The transition boundary is defined as the beginning of the PTP slots. The first PTP slot starting time is derived from the following equation:

$$\text{Start time of first PTP slot}\,(\boldsymbol{S}_{1/3}) = 24{,}36\,\text{ms} + (21{,}72\,\text{ms} \times 3) \times \boldsymbol{C}_{1/3} + 21{,}72\,\mu\text{s}$$

where $C_{1/3} \in \{0,1,\cdots 45\}$ is the number of shaped-broadcast slots and $S_{1/3} = C_{1/3} \times 3 + 2$ is the first PTP slot number.

Table 6.1.2.1: Downlink frame slot configuration for shaped-broadcast (1/3 rate)

1st PTP slot number, S	Number of shaped-broadcast slots, C	Number of PTP slots	Start of PTP slot, µs
2	0	136	46,08
5	1	133	111,24
8	2	130	176,40
11	3	127	241,56
14	4	124	306,72
17	5	121	371,88
20	6	118	437,04
23	7	115	502,20
26	8	112	567,36
29	9	109	632,52
32	10	106	697,68
35	11	103	762,84
38	12	100	828,00
41	13	97	893,16
44	14	94	958,32
47	15	91	1 023,48
50	16	88	1 088,64
53	17	85	1 153,80
56	18	82	1 218,96
59	19	79	1 284,12
62	20	76	1 349,28
65	21	73	1 414,44
68	22	70	1 479,60
71	23	67	1 544,76
74	24	64	1 609,92
77	25	61	1 675,08
80	26	58	1 740,24
83	27	55	1 805,40
86	28	52	1 870,56
89	29	49	1 935,72
92	30	46	2 000,88
95	31	43	2 066,04
98	32	40	2 131,20
101	33	37	2 196,36
104	34	34	2 261,52
107	35	31	2 326,68
110	36	28	2 391,84
113	37	25	2 457,00
116	38	22	2 522,16
119	39	19	2 587,32
122	40	16	2 652,48
125	41	13	2 717,64
128	42	10	2 782,80
131	43	7	2 847,96
134	44	4	2 913,12
137	45	1	2 978,28

Similarly, the possible combinations of downlink slot transition boundaries (end of the idle slot) from shaped-broadcast 1/4-rate slots to PTP slots are as listed in table 6.1.2.2. The first PTP slot starting time is derived from the following equation:

$$\text{Start time of first PTP slot } (\boldsymbol{S}_{1/4}) = 24{,}36\,\text{ms} + (21{,}72\,\text{ms} \times 4) \times \boldsymbol{C}_{1/4} + 21{,}72\,\mu\text{s}$$

where $C_{1/4} \in \{0,1,\cdots 34\}$ is the number of shaped-broadcast slots and $S_{1/4} = C_{1/4} \times 4 + 2$ is the first PTP slot number.

Table 6.1.2.2: Downlink frame slot configuration for shaped-broadcast (1/4 rate)

1st PTP slot number, S	Number of shaped-broadcast slots, C	Number of PTP slots	Start of PTP slot, μs
2	0	136	46,08
6	1	132	132,96
10	2	128	219,84
14	3	124	306,72
18	4	120	393,6
22	5	116	480,48
26	6	112	567,36
30	7	108	654,24
34	8	104	741,12
38	9	100	828
42	10	96	914,88
46	11	92	1 001,76
50	12	88	1 088,64
54	13	84	1 175,52
58	14	80	1 262,4
62	15	76	1 349,28
66	16	72	1 436,16
70	17	68	1 523,04
74	18	64	1 609,92
78	19	60	1 696,8
82	20	56	1 783,68
86	21	52	1 870,56
90	22	48	1 957,44
94	23	44	2 044,32
98	24	40	2 131,2
102	25	36	2 218,08
106	26	32	2 304,96
110	27	28	2 391,84
114	28	24	2 478,72
118	29	20	2 565,6
122	30	16	2 652,48
126	31	12	2 739,36
130	32	8	2 826,24
134	33	4	2 913,12
0	34	0	N/A

The number of downlink time slots transmitted as shaped-broadcast and PTP slots is reconfigurable. The first PTP slot number is communicated to the ST in the Transmission Information Packet (TIP). The minimum and maximum number of slots per slot type is shown in table 6.1.2.3.

Table 6.1.2.3: Downlink frame minimum and maximum number of slots

Slot types	Minimum slots per downlink frame	Maximum slots per downlink frame
Beacon	1	1
Shaped-broadcast 1/3-rate	0	45
Shaped-broadcast 1/4-rate	0	34
Idle	1	1
PTP when shaped-broadcast is 1/3-rate	1	136
PTP when shaped-broadcast is 1/4-rate	0	136

6.2 Slot structure

6.2.1 Beacon slot

The downlink beacon slot structure is discussed in TS 102 188-7.

6.2.2 Shaped-broadcast, idle, and PTP slots

The shaped-broadcast, idle, and PTP slot structures are described in figure 6.2.2. Each shaped-broadcast slot is three or four times longer than the PTP slot depending on the transmission rate, 1/3-rate or 1/4-rate, respectively. The slot for either mode starts with a beam-settling time period.

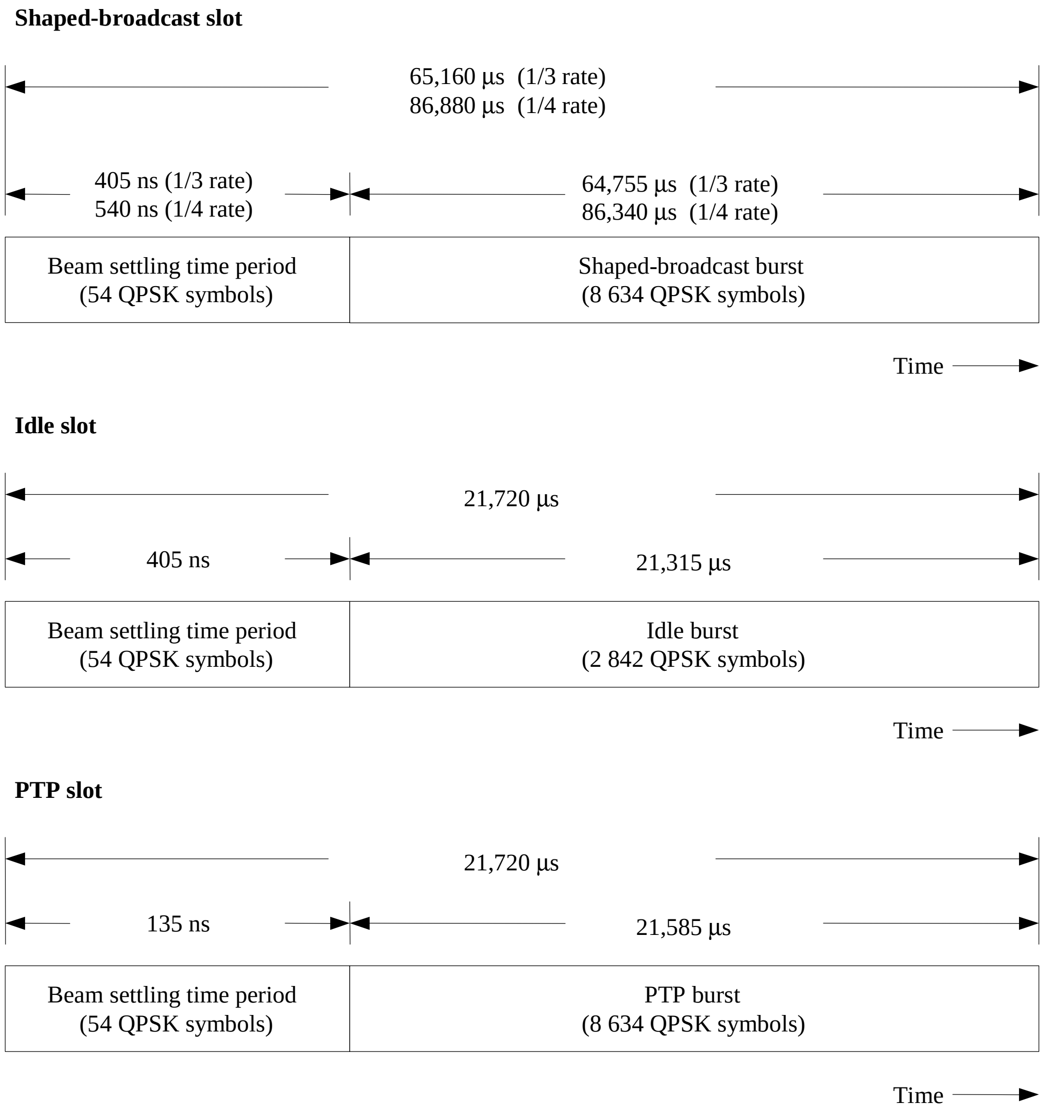

Figure 6.2.2: Downlink slot structure

The time duration and corresponding length in modulated symbols of the downlink TDM slots are defined in table 6.2.2.

Table 6.2.2: Downlink TDM slot durations

Carrier mode	Time duration (μs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
Shaped-broadcast 1/3-rate	65,160	$133\ 1/3 \times 10^6$	8 688
Shaped-broadcast 1/4-rate	86,880	100×10^6	8 688
Idle	21,720	$133\ 1/3 \times 10^6$	2 896
PTP	21,720	400×10^6	8 688

6.2.2.1 Beam settling time period

The time duration and corresponding length in modulated symbols of the beam settling time period are defined in table 6.2.2.1.1.

Table 6.2.2.1.1: Downlink slot beam settling time period durations

Carrier mode	Time duration (ns)	Symbol rate (symbols/s)	Time duration (modulated symbols)
Shaped-broadcast 1/3-rate	405	$133\ 1/3 \times 10^6$	54
Shaped-broadcast 1/4-rate	540	100×10^6	54
Idle	405	$133\ 1/3 \times 10^6$	54
PTP	135	400×10^6	54

The bit pattern sent during the beam settling time periods is described in table 6.2.2.1.2.

Table 6.2.2.1.2: Downlink slot beam settling time pattern

Index No. (note 1)	Slot type (note 2)	Number of symbols in beam settling time period (note 3)	Transmitted bit pattern (bit representation) (notes 4 and 5)
0	Shaped-Broadcast and Idle : S1, (LHCP)	54 QPSK 1/3-rate or 1/4-rate symbols	011001010111100110101101000 001101110001001001100011101
1	Shaped-Broadcast and Idle : S1, (RHCP)	54 QPSK 1/3-rate or 1/4-rate symbols	011001010111100110101101000 001101110001001001100011101
2	Shaped-Broadcast and Idle: S2, (LHCP)	54 QPSK 1/3-rate or 1/4-rate symbols	011001010111100110101101000 001101110001001001100011101
3	Shaped-Broadcast and Idle: S2, (RHCP)	54 QPSK 1/3-rate or 1/4 -rate symbols	011001010111100110101101000 001101110001001001100011101
4	PTP (LHCP)	54 QPSK full-rate symbols	000100100000011001011010111 101000001111001101010001110
5	PTP (LHCP)	54 QPSK full-rate symbols	000110100110111010000000111 011010101111011100111100101
6	PTP (LHCP)	54 QPSK full-rate symbols	000110001101100100000111111 011011111010111000101011010
7	PTP (LHCP)	54 QPSK full-rate symbols	101111000010011011101110011 101001011101010000110100000
8	PTP (LHCP)	54 QPSK full-rate symbols	101011000100010100100101101 110000111000001000100111111
9	PTP (LHCP)	54 QPSK full-rate symbols	011000111111001111011110101 100000101110100110101001001
10	PTP (LHCP)	54 QPSK full-rate symbols	010001010101111111101111000 110100111011000100111100100
11	PTP (RHCP)	54 QPSK full-rate symbols	010001110101001100001111101 100010100101100111111011011
12	PTP (RHCP)	54 QPSK full-rate symbols	010110000110001000010101001 100111111101000100110100111
13	PTP (RHCP)	54 QPSK full-rate symbols	001001101100011000101001010 111000101100001001000000111
14	PTP (RHCP)	54 QPSK full-rate symbols	000010110000101011101001011 100111011101100100001111011
15	PTP (RHCP)	54 QPSK full-rate symbols	111100011110011001011011010 111011100101011111100100010
16	PTP (RHCP)	54 QPSK full-rate symbols	110010010101100101110100000 110101111011110011111100011
17	PTP (RHCP)	54 QPSK full-rate symbols	000010000000110101011101001 001111001000110111001011000

NOTE 1: The downlink beam settling time transmission bit pattern matches one-for-one with the downlink PTP and Shaped-Broadcast Unique Words (UW) listed in table 6.3.2.1.2. That is, the first PTP unique word is used with the first PTP beam-settling pattern, etc.
NOTE 2: S1 refers to satellite 1, and S2 refers to satellite 2.
NOTE 3: Both I and Q send out the same bit pattern.
NOTE 4: Patterns are transmitted from left to right. The first bit of the bit pattern is the MSB. The last bit of the bit pattern is the LSB. The MSB is the first bit that is presented, and the LSB is the last bit that is presented.
NOTE 5: The same beam-settling pattern is shared by all the shaped-broadcast UWs.

6.3 Burst structure

6.3.1 Beacon burst

The downlink beacon burst structure is discussed inTS 102 188-7.

6.3.2 Shaped-broadcast, idle, and PTP bursts

The unit of transmission access on a downlink slot is a shaped-broadcast, idle, or PTP burst.

Each downlink data burst is composed of a downlink UW bit pattern followed by the data field, as shown in figure 6.3.2.

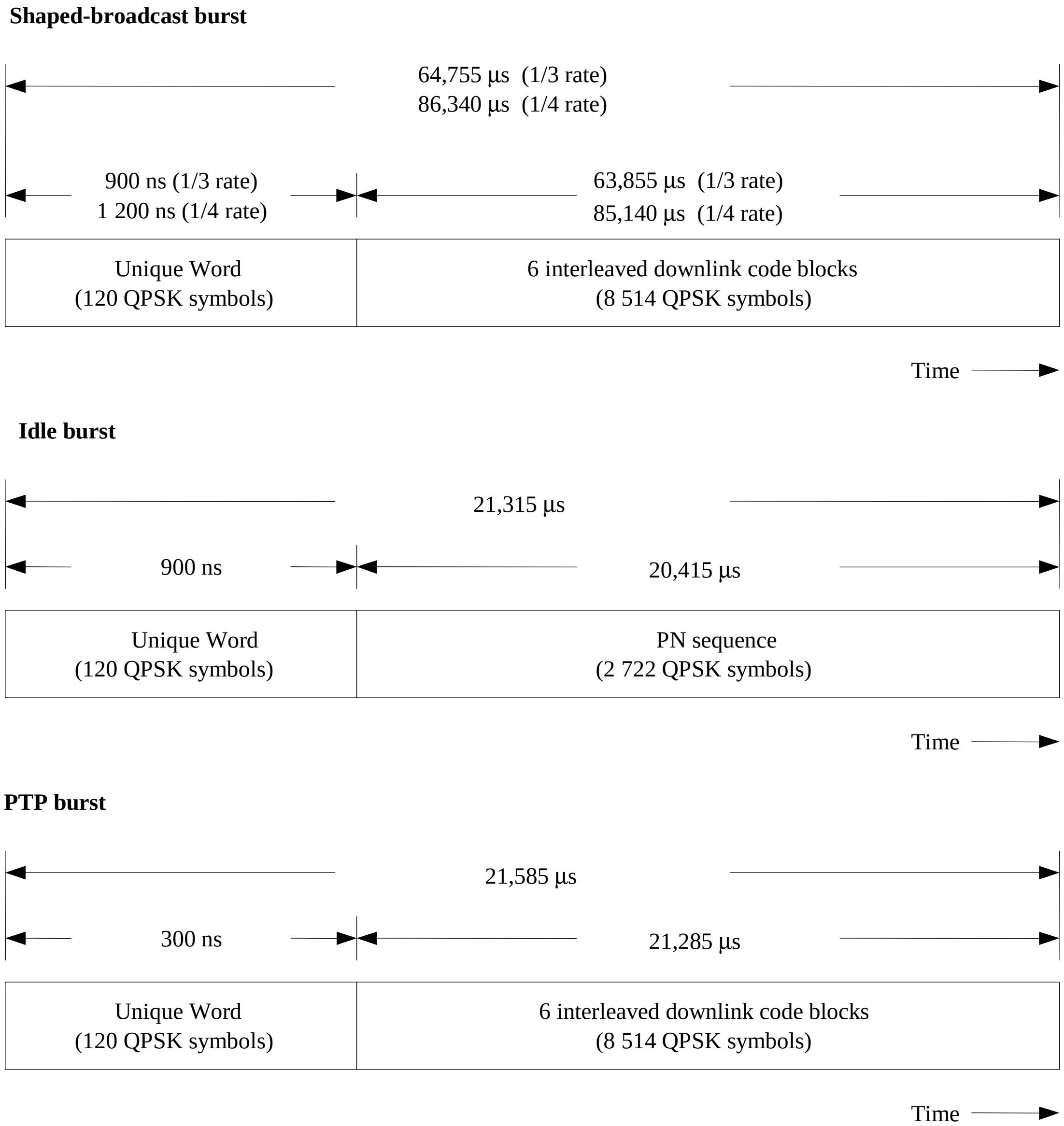

Figure 6.3.2: Downlink burst structure

The time duration and corresponding length in modulated symbols of the TDM burst period are defined in table 6.3.2.

Table 6.3.2: Downlink TDM burst durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Tine duration (modulated symbols)
Shaped-broadcast 1/3-rate	64,755	$133\ 1/3 \times 10^6$	8 634
Shaped-broadcast 1/4-rate	86,340	100×10^6	8 634
Idle	21,315	$133\ 1/3 \times 10^6$	2 842
PTP	21,585	400×10^6	8 634

6.3.2.1 Unique Word field

To minimize impairments caused by cross polarization interference, the downlink uses multiple unique words. A unique word is selected from a fixed set of 22 UWs to accommodate two satellite operations:

1. 2 for the beacon slot (1 UW per polarization).
2. 2 for shaped-broadcast and idle slots (1 UW per polarization).
3. 14 UWs for PTP slots (7 UWs per polarization; i.e. a 7 cell reuse pattern for each polarization).
4. The other 4 UWs are for use by the shaped-broadcast/idle and beacon slots for the second satellite.

The time duration and corresponding length in modulated symbols of the unique word period are defined in table 6.3.2.1.1.

Table 6.3.2.1.1: Downlink burst Unique Word field durations

Carrier mode	Time duration (ns)	Symbol rate (symbols/s)	Time duration (modulated symbols)
Shaped-broadcast 1/3-rate	900	$133\ 1/3 \times 10^6$	120
Shaped-broadcast 1/4-rate	1 200	100×10^6	120
Idle	900	$133\ 1/3 \times 10^6$	120
PTP	300	400×10^6	120

For each slot type, the 18-set distinct downlink UW patterns are listed in table 6.3.2.1.2. The remaining 4 UWs for the Beacon transmission are given in TS 102 188-7.

The unique word patterns that are listed in table 6.3.2.1.2 match the order for the beam-settling pattern, as presented in table 6.2.2.1.2, from top to bottom. That is, the first PTP unique word is for the first PTP beam-settling pattern, etc.

Every ST receiving on the same polarization in an uplink cell is assigned the same downlink unique word as shown in table 6.3.2.1. A group of seven uplink cells form a 7-cell downlink unique word reuse pattern. The reuse pattern is repeated to cover the coverage area. A different downlink unique word 7-cell reuse pattern is used for the opposite polarization for a total of 14 downlink unique words for this mode. The appropriate downlink unique word is based on the satellite routing information.

The downlink PTP UWs shown in table 6.3.2.1.2 are identical for all satellites.

Table 6.3.2.1.2: Downlink burst Unique Word patterns

UW index (note 1)	Burst type (note 2)	UW length (note 3)	UW pattern (binary) (note 4)
0	Shaped-broadcast and Idle : S1, (LHCP)	120 QPSK 1/3-rate or 1/4-rate symbols	101010001101000001010011000000111101100110110111010111000110 011101001010110011111010111100100000011010111110011000110010
1	Shaped-broadcast and Idle : S1, (RHCP)	120 QPSK 1/3-rate or 1/4-rate symbols	111011001100001111110010101101001100111010001001011011011001 111110101111110101010000010101100111000111100010011000110010
2	Shaped-broadcast and Idle: S2, (LHCP)	120 QPSK 1/3-rate or 1/4-rate symbols	000001100001001100111010011010111011100000000110110110000010 110000001111010100111101001110001101010101101110011000110010
3	Shaped-broadcast and Idle: S2, (RHCP)	120 QPSK 1/3-rate or 1/4-rate symbols	000010011000111010100010110011001111011111101101100111010100 100101101011101101010000111111000100000111100011011000110010
4	PTP (LHCP)	120 QPSK full-rate symbols	111011011111100110100101000110111110000110010101110001000100 100000011001011010111101000001111001101010001110111011011111
5	PTP (LHCP)	120 QPSK full-rate symbols	111001011001000101111111001100101010000100011000011010000110 100110111010000000111011010101111011100111100101111001011001
6	PTP (LHCP)	120 QPSK full-rate symbols	111001110010011011111000000100100001101000111010100101000110 001101100100000111111011011111010111000101011010111001110010
7	PTP (LHCP)	120 QPSK full-rate symbols	010000111101100100110001100010110100010101111001011111101111 000010011011101110011101001011101010000110100000010000111101
8	PTP (LHCP)	120 QPSK full-rate symbols	010100111011101011011010011001111000111110111011000000101011 000100010100100101101110000111000001000100111111010100111011
9	PTP (LHCP)	120 QPSK full-rate symbols	100111000000110000100001010111111010001011001010110110011000 111111001111011110101100000101110100110101001001100111000000
10	PTP (LHCP)	120 QPSK full-rate symbols	101110101011000000001000011100101100010011101100001101101000 1 010101111111101111000110100111011000100111100100101110101011
11	PTP (RHCP)	120 QPSK full-rate symbols	101110001010110011110000010111101011010011000000100100010001 110101001100001111101100010100101100111111011011101110001010
12	PTP (RHCP)	120 QPSK full-rate symbols	101001111001110111101010110111000000010111011001011000010110 000110001000010101001100111111101000100110100111101001111001
13	PTP (RHCP)	120 QPSK full-rate symbols	110110010011100111010110101000111010111110110111111000001001 101100011000101001010111000101100001001000000111110110010011
14	PTP (RHCP)	120 QPSK full-rate symbols	111101001111010100010110100011000110010011011110000100000010 110000101011101001011100111011101100100001111011111101001111
15	PTP (RHCP)	120 QPSK full-rate symbols	000011100001110110100100101000100011010100000011011101111100 011110011001011011010111011100101011111100100010000011100001
16	PTP (RHCP)	120 QPSK full-rate symbols	001101101010011010001011111101010000100001100000011100110010 010101100101110100000110101111011110011111100011001101101010
17	PTP (RHCP)	120 QPSK full-rate symbols	111101111111101010100010110110000110111001000110100111000010 000000110101011101001001111001000110111001011000111101111111
NOTE 1: The downlink PTP and Shaped-Broadcast UW matches one-for-one with the downlink beam settling time transmission bit patterns defined in table 6.2.2.1.2. That is, the first PTP unique word is used with the first PTP beam-settling pattern, etc. NOTE 2: S1 refers to satellite 1 and S2 refers to satellite 2. NOTE 3: Both I and Q send out the same bit patterns. NOTE 4: Patterns are transmitted from left to right. The first bit of the bit pattern is the MSB. The last bit of the bit pattern is the LSB. The MSB is the first bit that is presented, and the LSB is the last bit that is presented.			

6.3.2.2 Data field

The data field immediately follows the UW within each burst. The data field is composed of six interleaved code blocks, for the shaped-broadcast and PTP bursts cases, or a PN data sequence, for the idle burst case.

6.3.2.2.1 Shaped-broadcast and PTP code blocks

The Shaped-Broadcast and PTP slots carry six interleaved downlink code blocks containing 12 packets each. The time duration and corresponding length in modulated symbols of the data field are defined in table 6.3.2.2.1.

Table 6.3.2.2.1: Downlink burst shaped-broadcast and PTP slot data field durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
Shaped-broadcast 1/3-rate	63,855	133 1/3 $\times 10^6$	8 514
Shaped-broadcast 1/4-rate	85,140	100 $\times 10^6$	8 514
PTP	21,285	400 $\times 10^6$	8 514

6.3.2.2.2 Idle slot PN sequence

The idle slot is used for system calibration/nulling and to provide time for downlink polarization switching. . The time duration and corresponding length in modulated symbols of the idle slot data field are defined in table 6.3.2.2.2.1.

Table 6.3.2.2.2.1: Downlink burst Idle slot data field durations

Carrier mode	Time duration (µs)	Symbol rate (symbols/s)	Time duration (modulated symbols)
Idle	20,415	133 1/3 $\times 10^6$	2 722

The PN sequence that immediately follows the UW is defined in table 6.3.2.2.2.2.

Table 6.3.2.2.2.2: Idle slot PN sequence characteristics

Interval	Generator polynomial	Initial state (seed) $X_0, X_1, \ldots, X_{10}$
Calibration	$1 + x^2 + x^{11}$	11111111111
Null	$1 + x^2 + x^{11}$	10101000000
NOTE 1: Identical sequences on (I, Q) (Effectively generating BPSK symbols from QPSK modulators). NOTE 2: The MSB is the first bit that is presented, and the LSB is the last bit that is presented.		

The PN generator is shown in figure 6.3.2.2.2, where the adder performs modulo-2 arithmetic.

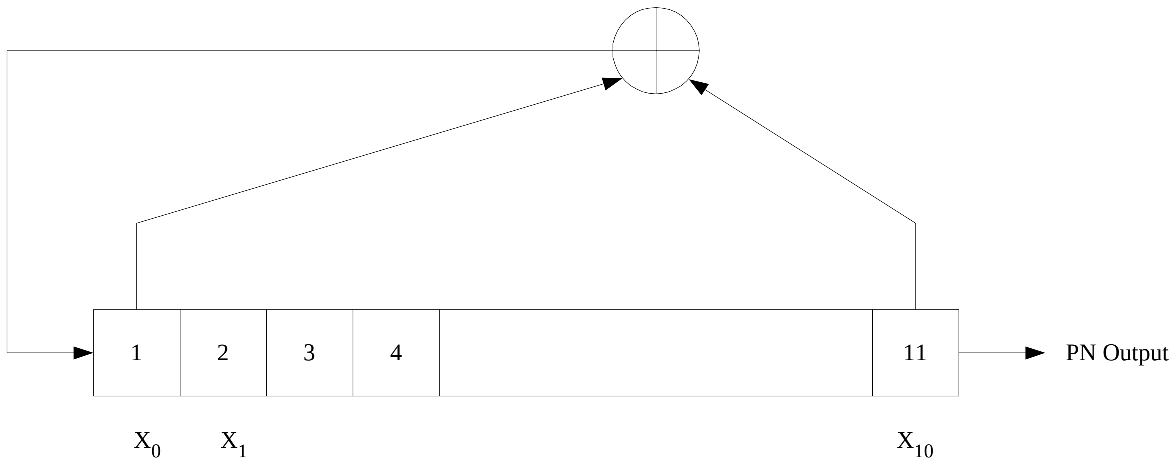

Figure 6.3.2.2.2: Downlink burst idle slot PN sequence generator

Annex A (informative): Bibliography

ETSI TR 101 984: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Services and Architectures".

ETSI TS 102 188-1: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 1: General description".

ETSI TS 102 188-3: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 3: Channel coding".

ETSI TS 102 188-4: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 4: Modulation".

ETSI TS 102 188-5: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 5: Radio transmission and reception".

ETSI TS 102 188-6: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 6: Radio link control".

ETSI TS 102 188-7: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface Physical Layer specification; Part 7: Synchronization".

ETSI TS 102 189-2: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; MAC/SLC layer specification; Part 2: MAC layer".

History

Document history		
V1.1.1	March 2004	Publication