ETSI TS 102 188-1 V1.1.2 (2004-07)

Technical Specification

Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 1: General description

Reference

RTS/SES-00203-1

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

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, send your comment to:
editor@etsi.org

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

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

The present document is part 1 of a multi-part deliverable covering the BSM Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification, 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 is an introduction to the physical layer specification for the SES BSM Regenerative Satellite Mesh - A (RSM-A) air interface family. It consists of a general description of the organization of the physical layer with reference to the parts of this multi-part deliverable where each function is specified in more detail.

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
BSM	Broadband Satellite Multimedia
DLPC	DownLink Power Control
DNS	Directory Name Server
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
HTTP	HyperText Transfer Protocol
IP	Internet Protocol
kbps	kilo bits per second (thousands of bits per second)
MAC	Medium Access Control
Mbps	Mega bits per second (millions of bits per second)
NOCC	Network Operations Control Centre
OQPSK	Offset Quaternary Phase Shift Keying
PEP	Performance Enhancing Proxy
PHY	PHYsical
PN	Pseudo Noise
PTP	Point-To-Point
QPSK	Quaternary Phase Shift Keying
RS	Reed-Solomon
RSM	Regenerative Satellite Mesh

SLC	Satellite Link Control
ST	Satellite Terminal
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
ULPC	UpLink Power Control
USB	Universal Serial Bus
UW	Unique Word

4 Air interface overview

4.1 Network architecture

4.1.1 Network elements

Figure 4.1.1 illustrates the network architecture from the satellite terminal viewpoint and also shows the different interfaces as seen by the satellite terminal.

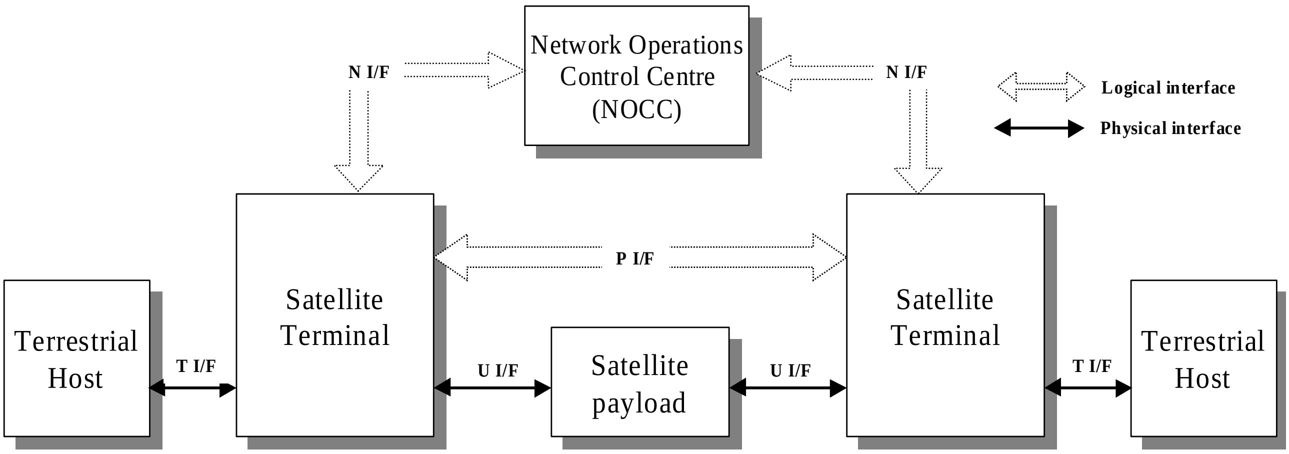

Figure 4.1.1: Network architecture

The network elements are described below.

Network Operations Control Centre (NOCC): the NOCC 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: the satellite payload is the part of the satellite that provides air interface functions. The satellite payload operates as a packet switch that provides direct unicast and multicast communication between STs at the link layer.

Satellite Terminal (ST): the ST is the terminal that is installed in the user premises. It offers an IP data transportation service over the satellite network.

Terrestrial host: this is the entity on which application level programs are running. It may be connected directly to the Satellite Terminal or through one or more networks. It maintains an IP route to one or more STs and uses their services to transmit IP data over the satellite network to destination IP hosts.

4.1.2 Network interfaces

The network interfaces are briefly described below.

U interface: this is the physical interface (the air interface) between a ST and the Satellite payload. All data transactions to and from the terminal including all user data to the destination ST, all management data to the NOCC and all signalling go over this interface. The same physical interface is used for both the BSM I.5 and I.6 interfaces.

T interface: this is the physical interface between the ST and the hosts. Multiple hosts can be connected to a single ST. The same physical interface is used for both the BSM I.2 and I.10 interfaces.

N interface: this is a logical interface between the ST and NOCC for transaction of management and signalling data between a ST and the NOCC.

P interface: this is a logical interface between two STs for transaction of peer layer signalling traffic and user data traffic.

4.2 Air interface overview

All satellite terminals employ the same air-interface using FDMA-TDMA transmissions in the uplink to the satellite and TDM in the downlink from the satellite. Different sizes of the transmission platform support user-data burst rates from the low kbps to multiple Mbps.

The uplink uses spot beams that provide coverage for cells geographically distributed over the satellite coverage area. The downlink also uses spot beams for point-to-point services but in addition to these spot beams, there are separate downlink broadcast beams that cover a major portion of the coverage area.

The satellite and NOCC manage the assignment of uplink bandwidth in each beam to individual users as required. All packets received at the satellite from all beams are recovered and switched to their destination downlink beams per address-fields in the packet-header. Packets destined for same destination beam are grouped and transmitted in the downlink direction via very high-rate TDM carrier bursts. Both end-user and gateway terminal types dynamically soft-share the total available bandwidth as needed to support the traffic flow in each direction.

4.3 Air interface protocol architecture

The air interface is logically divided into the P-interface and the U-interface:

- The P-interface is a peer-to-peer interface between the two STs.
- The U-interface is the interface between each ST and the satellite payload.

Figure 4.3 illustrates the User plane (U-plane) architecture from the ST viewpoint. This architecture is derived from the general protocol architecture as defined in the BSM services and architectures report.

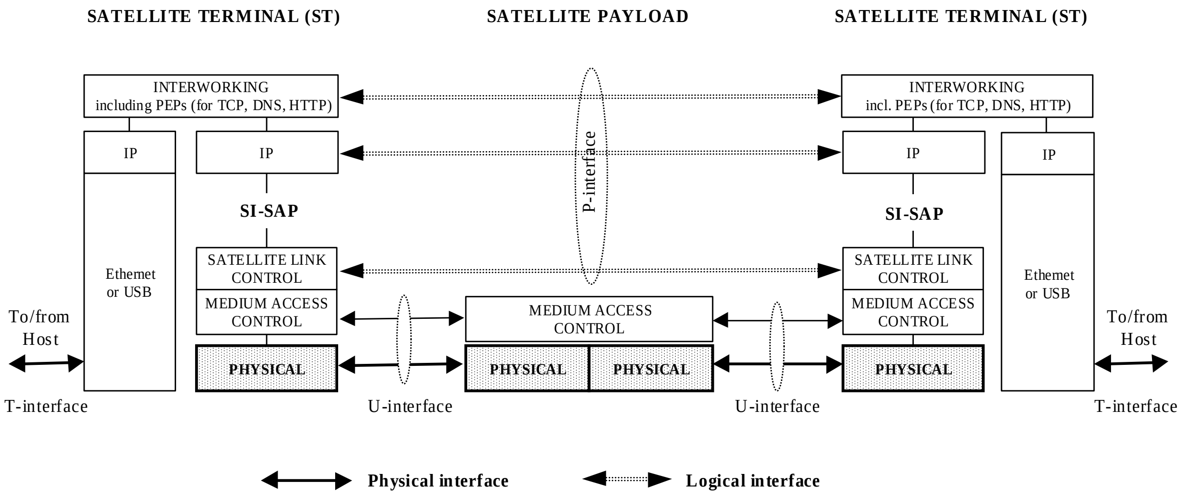

Figure 4.3: Air interface architecture

The ST provides air interface functions at all layers, and provides interworking between the air interface protocols and the user port protocols such as Ethernet or USB.

The multi-part deliverable TS 102 188 defines the functions of the air interface physical layer - shown shaded in figure 4.3.

5 Physical layer (PHY) overview

5.1 General

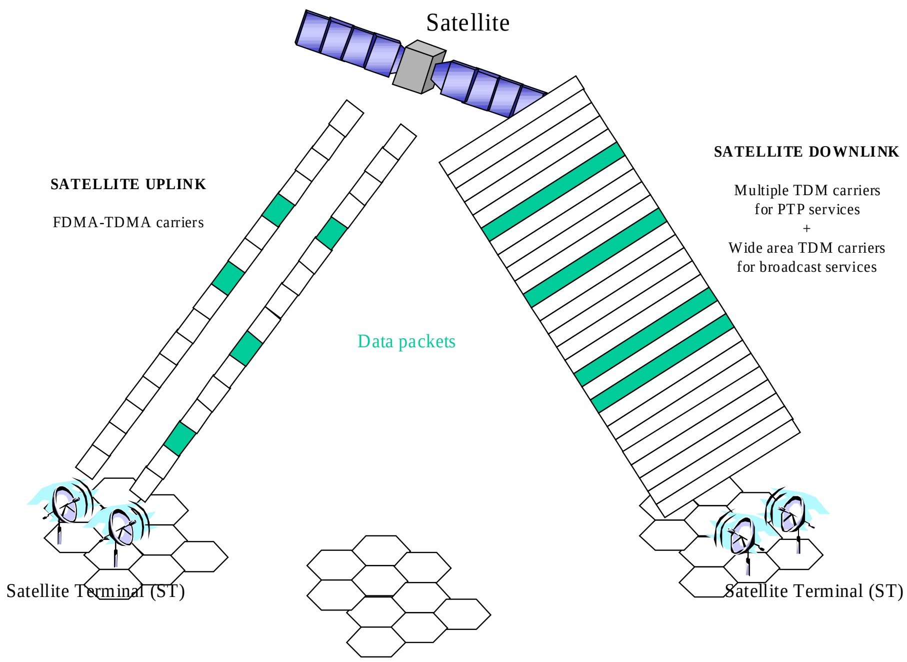

Figure 5.1: Physical layer overview

The uplink and downlink use different transmission formats as illustrated in figure 5.1:

- **Satellite uplink:** the satellite uplink consists of a set of Frequency and Time Division Multiple Access (FDMA-TDMA) carriers. Each uplink cell operates with a number of separate carriers. There are several alternative FDMA-TDMA carrier modes supporting user-data burst rates from the low kbps to multiple Mbps.

- **Satellite downlink:** the satellite downlink consists of a set of simultaneous Time Division Multiplex (TDM) carriers. Each TDM carrier contains the user traffic for a given geographic area and the set of TDM carriers can be redirected in every downlink time slot to service different downlink cells. The downlink capacity of each satellite can be allocated between point-to-point and broadcast services on an as-needed and/or time-of-day basis.

5.2 Services provided by the physical layer

The physical layer provides the following services and functions:

- The physical layer executes the initial acquisition and synchronization procedure with the network.

- The physical layer accepts outgoing packets from the MAC layer and transmits them on particular slots and channels as instructed by MAC.

- The physical layer receives incoming packets and passes them to the MAC for filtering.

- The physical layer detects a dead link and informs the Radio Resource management layer accordingly.

- The physical layer adjusts transmission power based on the commands of the Radio Resource Management layer.

5.3 Functional description of the physical layer

5.3.1 General

The physical layer is the lowest layer of the U-interface, as illustrated in figure 4.3. The functions of the physical layer are different for the uplink and downlink. The major functions are illustrated in figure 5.3.1.

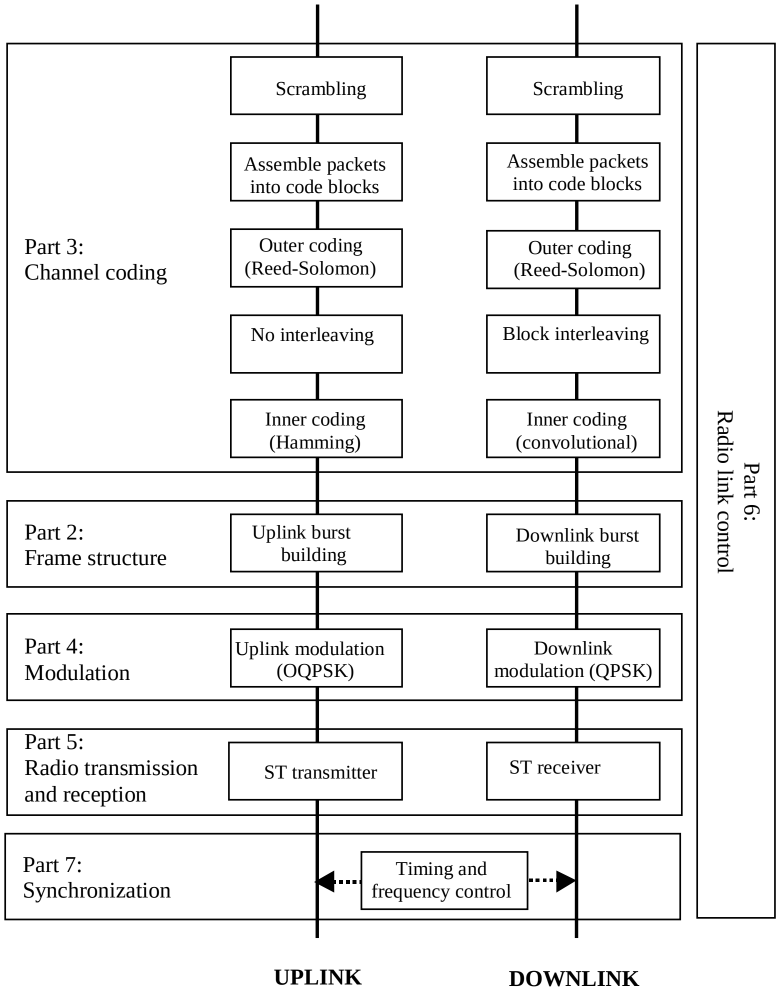

Figure 5.3.1: Physical layer functions

A brief description of these physical layer functions is given in clauses 5.3.2, 5.3.3 and 5.3.4. The detailed specifications for these functions are given in the other parts of this multi-part deliverable, as referenced below.

5.3.2 Uplink

5.3.2.1 Overview of uplink data structures

An overview of the uplink data structures is given in figure 5.3.2.1.

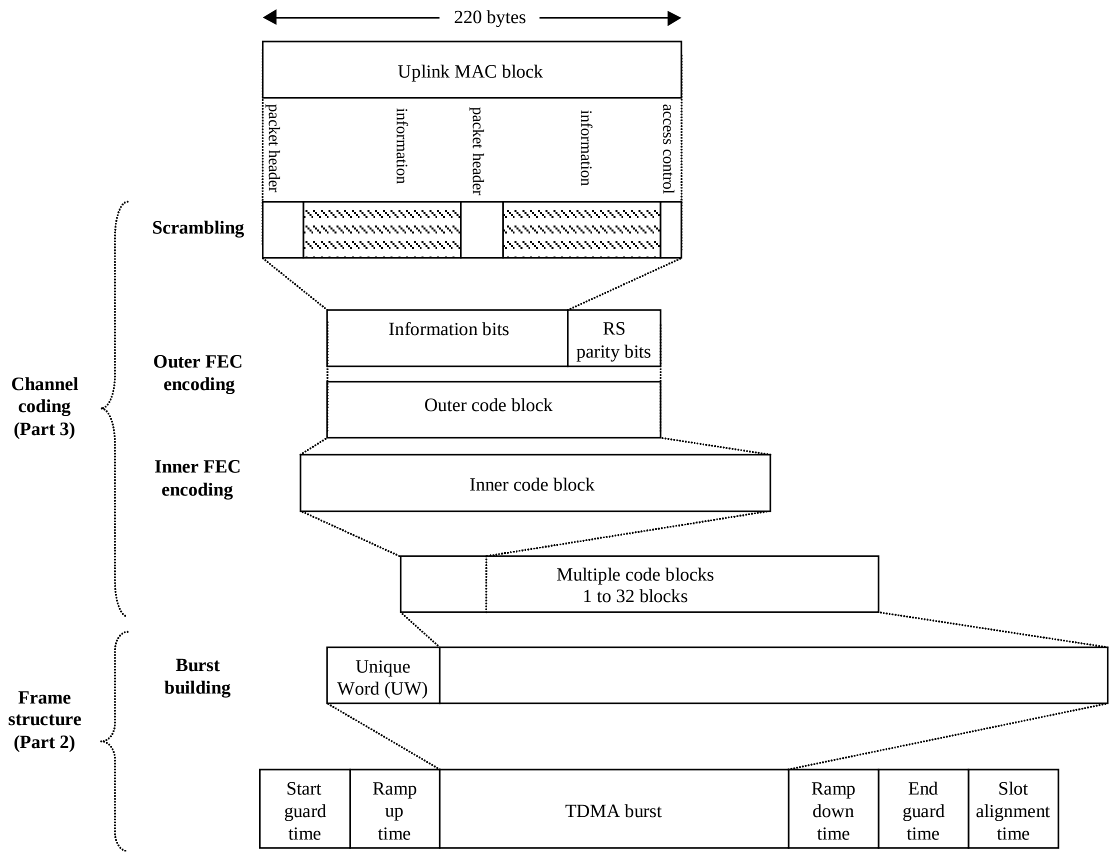

Figure 5.3.2.1: Uplink data structures

Data is exchanged with the MAC layer as an uplink MAC block which contains two RSM-A packets plus an access control field. This MAC block is selectively scrambled and assembled at the top of the physical layer. This is followed by two stages of FEC encoding (outer coding followed by inner coding). Multiple code blocks are then assembled into a single TDMA burst, where the number of code blocks in the burst depends on the uplink carrier mode.

More details of these data structures and the associated functions are given in the following clauses.

5.3.2.2 Scrambling and packet assembly

A RSM-A packet comprises a total of 108 bytes; an 8 byte header plus a 100 byte information field. The information portion of the packet is scrambled prior to transmission, except for packets that are destined for the satellite on-board processor. The packet header portion is not scrambled. The scrambling is performed on a packet-by-packet basis.

Two packets are combined into a single block and a 4 byte access control header is appended to the complete uncoded uplink MAC block as illustrated in figure 5.3.2.2.

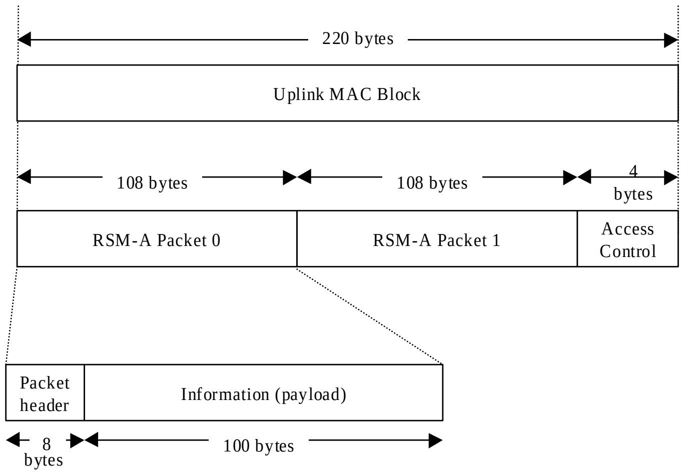

Figure 5.3.2.2: Uplink MAC block assembly

The uplink scrambling and uplink MAC block assembly functions are defined in TS 102 188-3.

5.3.2.3 Coding

The uncoded uplink MAC block is then coded in two stages:

- An outer Reed-Solomon code using a RS (244,220) code.
- An inner Hamming code with a (12,8) block code.

This results in a coded code block of 366 bytes.

The uplink coding functions are defined in TS 102 188-3.

5.3.2.4 Frame structure

There are four possible FDMA carrier modes: 128 kbps, 512 kbps, 2 Mbps and 16 Mbps modes.

Each uplink carrier operates with one of the two alternative uplink TDMA frame structures shown in figure 5.3.2.4.

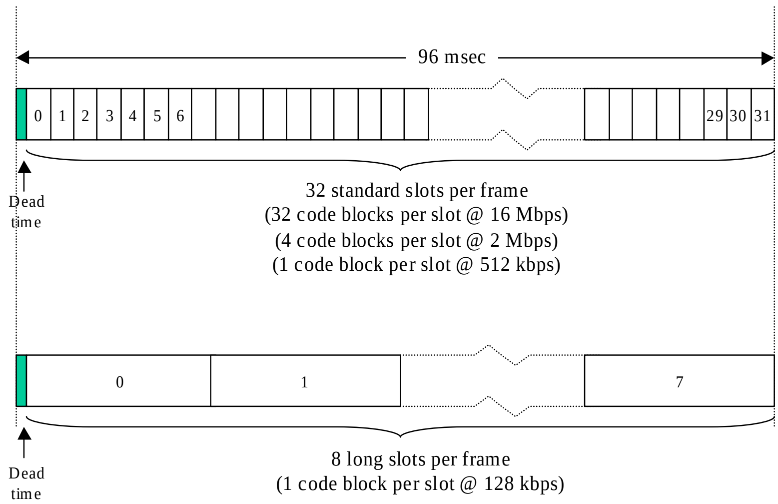

Figure 5.3.2.4: Uplink frame structure

Each carrier is partitioned into a dead time period followed by a fixed number of time slots for code block transmission as shown. The number of time slots is a function of the TDMA slot format as follows:

- The uplink frame consists of 32 standard slots for the 16 Mbps, 2 Mbps and 512 kbps carrier modes.
- The uplink frame consists of 8 long slots for the 128 kbps carrier mode.

The uplink frame structures are defined in TS 102 188-2.

5.3.2.5 Burst building

The FDMA-TDMA carrier modes can be flexibly configured for each cell to provide user data rates from 128 kbps to over 16 Mbps. Within each FDMA carrier, the TDMA timeslots are dynamically allocated: each slot can be allocated for either multiple access (i.e. contention) or for reservation access (i.e. to one specific ST).

A single TDMA burst is positioned within each timeslot. Each burst is preceded and followed by a guard time and power ramping time as illustrated in figure 5.3.2.4. The guard time is used to prevent interference between adjacent time slots and the power ramping times are used to key-on and key-off the uplink carrier.

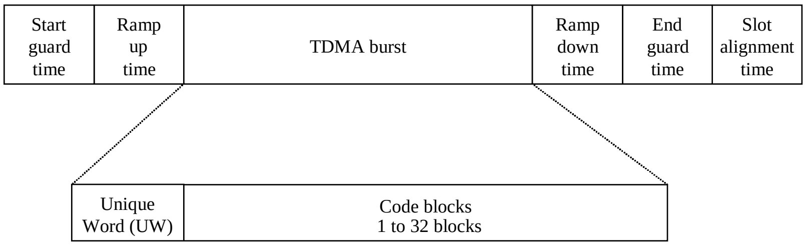

Figure 5.3.2.5: Uplink slot and burst structure (not to scale)

The TDMA burst comprises a Unique Word (UW) which is used for synchronization, followed by a traffic field composed of between 1 and 32 code blocks. The number of code blocks depends on the carrier mode.

The uplink burst structures are defined in TS 102 188-2.

5.3.2.6 Modulation

The uplink uses Offset Quaternary Phase Shift Keying (OQPSK) modulation. The modulation rate is determined by the carrier mode.

The uplink modulation functions are defined in TS 102 188-4.

5.3.2.7 Uplink carrier modes

The uplink frequency band of 500 MHz is divided into 16 sub-bands of 62,5 MHz; 8 sub-bands for each of 2 polarizations.

Each uplink sub-band can be independently configured for a combination of 128 kbps, 512 kbps, 2 Mbps or 16 Mbps carrier modes. An illustration of the possible configuration of one sub-band is illustrated in figure 5.3.2.7.

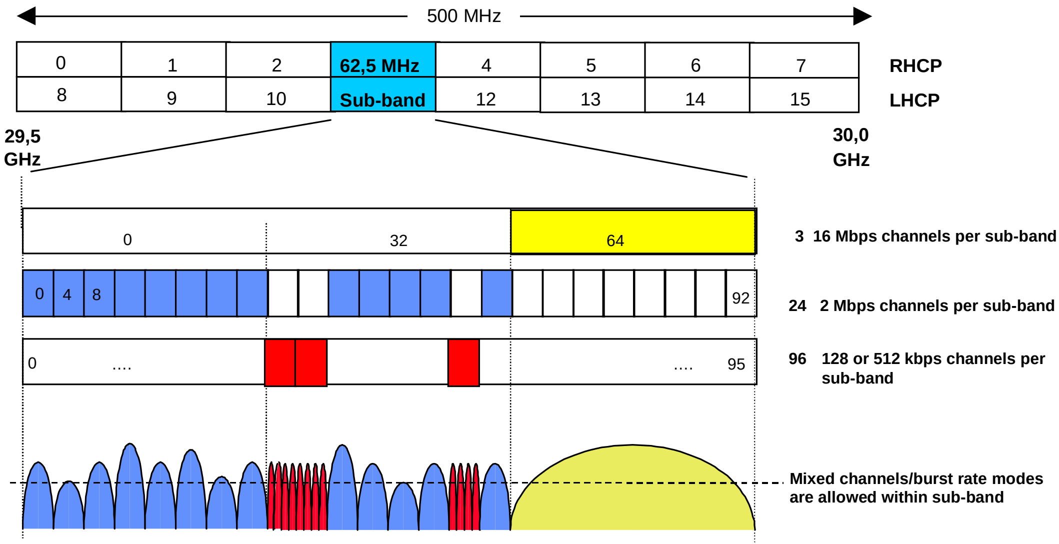

Figure 5.3.2.7: Possible arrangement of uplink carriers within a sub-band

The carrier bandwidth for a 128 kbps fallback carrier mode and a 512 kbps carrier mode is 651 041$^{2}/_{3}$ Hz. This value is obtained by dividing a 62,5 MHz uplink sub-band into 96 equally spaced uplink carriers. The 128 kbps or 512 kbps carriers are labelled 0, 1, 2 to 95, corresponding to increasing operating frequency.

The carrier bandwidth for a 2 Mbps carrier mode is 2 604 166$^{2}/_{3}$ Hz. This value is obtained by dividing a 62,5 MHz uplink sub-band into 24 equally spaced uplink carriers. The 2 Mbps carriers are labelled 0, 4, 8 to 92, corresponding to increasing operating frequency.

The carrier bandwidth for a 16 Mbps carrier mode is 20 833 333⅓ Hz. This value is obtained by dividing a 62,5 MHz uplink sub-band into 3 equally spaced uplink carriers. The 16 Mbps carriers are labelled 0, 32 and 64 corresponding to increasing operating frequency.

5.3.2.8 Uplink Power Control

UpLink Power Control (ULPC) function is used to control ST transmit power to attain the following objectives:

1) Minimize interference, in particular during clear sky conditions.

2) Assure adequate margins against interference and atmospheric effects to meet the uplink packet loss rate and power control error objectives.

3) Compensate for the ST RF imperfections such as power versus frequency variation.

The ULPC function is distributed between the satellite and STs and uses a dual control loop: each ST adjusts its uplink transmit power per carrier frequency based on local downlink beacon power measurements together with feedback in the form of response packets from the satellite.

The uplink power control functions are defined in TS 102 188-6.

5.3.3 Downlink

5.3.3.1 Overview of downlink data structures

An overview of the downlink data structures is given in figure 5.3.3.1.

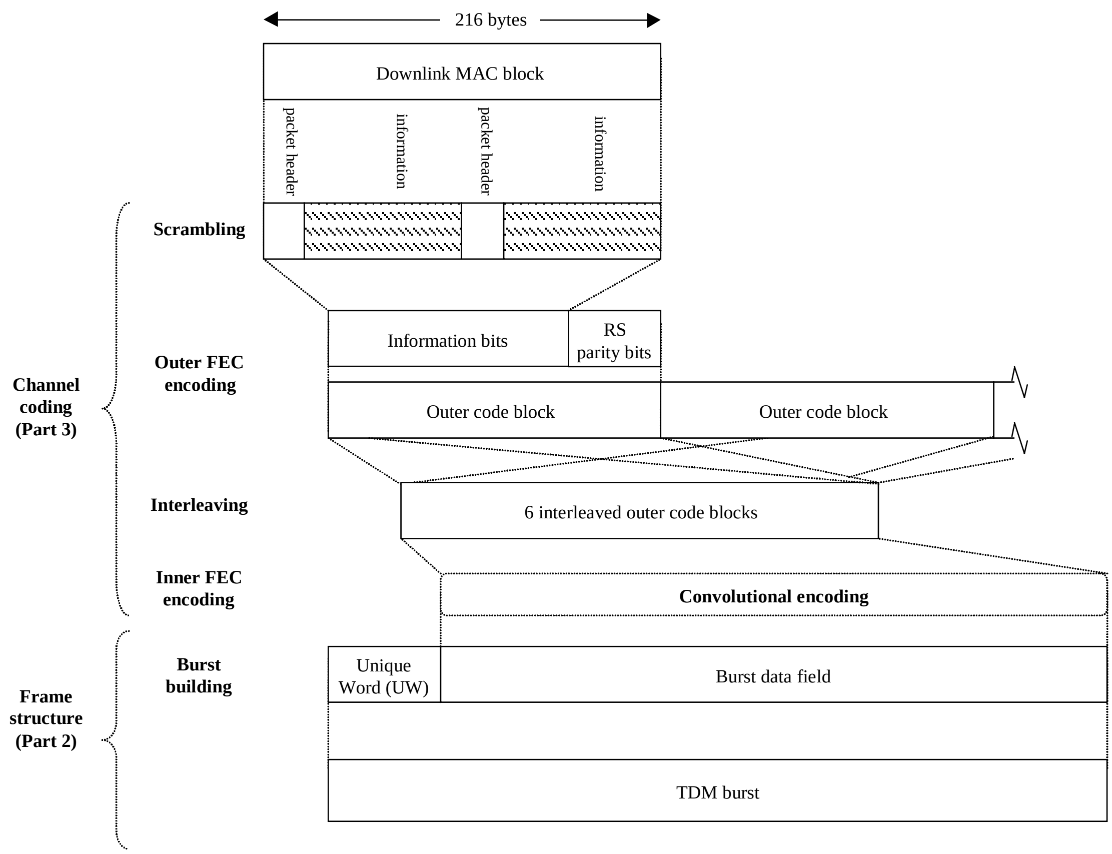

Figure 5.3.3.1: Downlink data structures

Downlink data is transmitted in large TDM bursts, where each burst contains 6 interleaved code block. FEC decoding followed by de-interleaving results.

Data is exchanged with the MAC layer as a downlink MAC block which contains two RSM-A. This MAC block is selectively scrambled and assembled at the top of the physical layer. This is followed by two stages of FEC encoding (outer coding and inner coding) separated by an interleaving stage. The interleaved code blocks are assembled into a single TDM burst.

More details of these data structures and the associated functions are given in the following clauses.

5.3.3.2 Scrambling and packet assembly

A RSM-A packet comprises a total of 108 bytes; an 8 byte header plus a 100 byte information field. The information payload portion of all packets either originated from STs or generated on board the satellite, are scrambled. The packet header portion is not scrambled. The scrambling is performed on a packet-by-packet basis.

Two packets are combined into a single downlink MAC block as illustrated in figure 5.3.3.2.

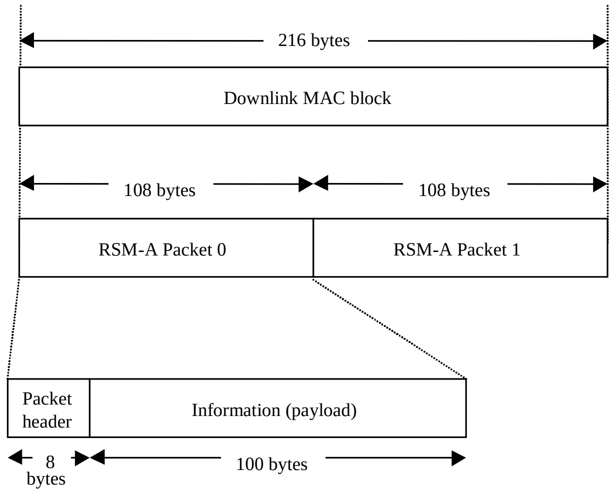

Figure 5.3.3.2: Downlink MAC block assembly

The downlink scrambling and downlink MAC block assembly functions are defined in TS 102 188-3.

5.3.3.3 Coding

A total of 6 downlink MAC blocks are combined into each downlink burst, in three stages:

- Each uncoded downlink MAC block is separately coded with an outer Reed-Solomon code using a RS (236,216) code.
- The resulting 6 encoded code blocks are then block interleaved.
- The interleaved code blocks are then coded with an inner convolution code of rate $^2/_3$.

The outputs of the interleaver are divided into four independent streams. Each output stream consists of a total of 2 838 bits (354-byte input plus 6 flush bits) at the input to the inner encoder and a total of 4 257 bits at the output of the encoder.

The downlink coding functions are defined in TS 102 188-3.

5.3.3.4 Frame structure

The downlink frame is composed of a beacon slot, broadcast slots, idle slot, and Point-To-Point (PTP) slots as illustrated in figure 5.3.3.4.

The beacon slot is used to transmit a portion of a 0,768 s PN sequence to synchronize the ST with the satellite timing. It is also used to synchronize uplink and downlink frame counters.

The broadcast slots are scheduled before the PTP transmission. A broadcast slot is three or four times longer than the PTP slot depending on the broadcast mode transmission rate (i.e. ⅓-rate or ¼-rate, respectively).

Idle slots occur once every frame to perform system functions.

Finally, the PTP transmissions are allocated into the remaining slots until the 137th slot is reached.

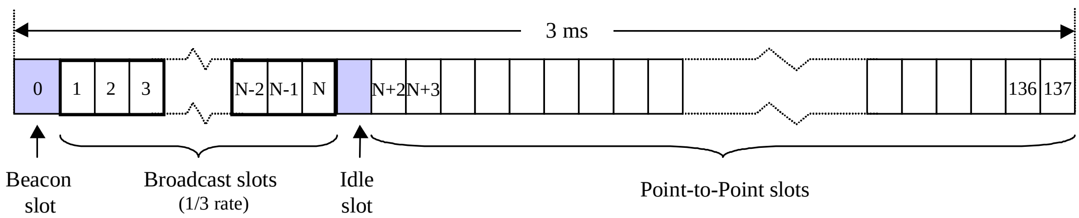

Figure 5.3.3.4: Downlink frame structure

The transmission rate is at the full rate during PTP time slots. The transmission rate during the beacon slot and idle slot is at the ⅓-rate and the transmission rate during the broadcast slots is at either ⅓-rate or ¼-rate. The frame structure permits a variable number of broadcast slots (allocated in increments of three or four PTP slots, depending on the rate) with the remaining slots being allocated to PTP. The following range of configurations is supported.

Broadcast mode	Number of broadcast slots	Number of PTP slots
Broadcast slots at ⅓ rate	0 to 45	1 to 136
Broadcast slots at ¼ rate	0 to 34	0 to 136

The downlink frame structures are defined in TS 102 188-2.

The ST determines the number of broadcast slots and the broadcast mode via system information broadcasts as defined in the RSM-A SMAC/SLC specification.

5.3.3.5 Burst building

The downlink carriers use a TDM frame. Two downlink slot types are defined: a broadcast slot and a PTP slot. Each slot starts with a guard time followed by a single data burst.

The data burst comprises a downlink Unique Word (UW) followed by the data field as illustrated in figure 5.3.3.5.

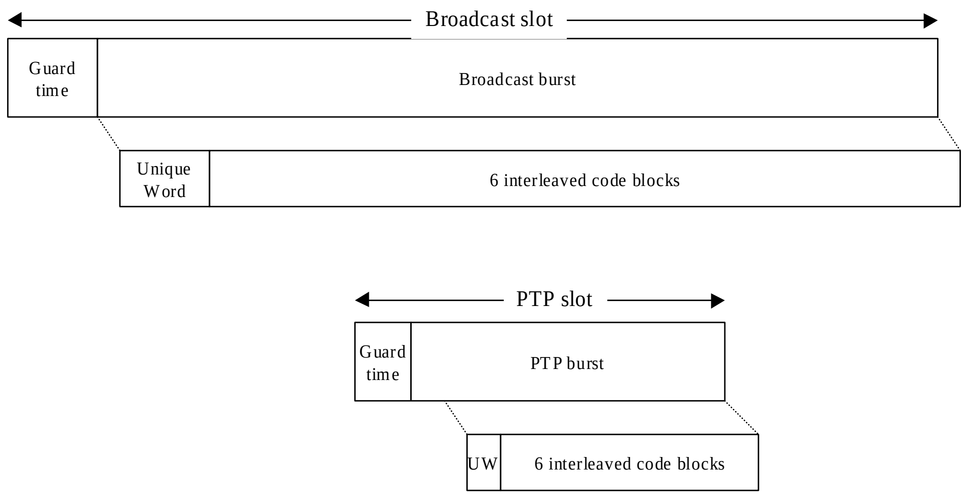

Figure 5.3.3.5: Downlink slot and burst structures (not to scale)

The downlink burst structures are defined in TS 102 188-2.

5.3.3.6 Modulation

The downlink uses QPSK modulation.

The downlink modulation functions are defined in TS 102 188-4.

5.3.3.7 Downlink carrier modes

The downlink operates with a single carrier in one of two polarizations. The system achieves frequency reuse by using polarization independently on each downlink beam. The downlink polarization of beacon, broadcast, idle and PTP is independent of the uplink polarization.

Additionally, the downlink carrier can operate in one of three possible operating modes. These modes are referred as full-rate, ⅓-rate, and ¼-rate corresponding to the burst modulation rate of the carrier:

- ⅓-rate - The downlink transmits at a rate of 133⅓ $\times 10^6$ QPSK symbols/second (i.e. each of the I and Q arms of the modulator operates at a symbol rate of 133⅓ $\times 10^6$ BPSK symbols/second);
- ¼-rate - The downlink transmits at a rate of 100×10^6 QPSK symbols/second (i.e. each of the I and Q arms of the modulator operates at a symbol rate of 100×10^6 BPSK symbols/second);
- full-rate - The downlink transmits at a rate of 400×10^6 QPSK symbols/second (i.e. each of the I and Q arms of the modulator operates at a symbol rate of 400×10^6 BPSK symbols per second).

5.3.3.8 Downlink power control

The DownLink Power Control (DLPC) function is used to maintain link availability by providing additional power to downlink spot beams that are affected by rain.

5.3.4 Other physical layer functions

The physical layer transmission involves other functions. These include:

a) The radio transmissions from the ST and the receiver of the ST are required to meet certain minimum levels of performance. In addition, the radio frequency emissions from the ST are required to conform to the relevant standards. These requirements are defined in TS 102 188-5.

b) The measurements and sub-procedures used for initial acquisition by the ST, and for uplink mode selection and uplink power control during normal operation. These functions are defined in TS 102 188-6.

c) The synchronization of the ST receiver with regard to frequency and time (time acquisition and time frame alignment). These functions are defined in TS 102 188-7.

Annex A (informative): Bibliography

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

ETSI TS 102 188-2: "Satellite Earth Stations and Systems (SES); RSM-A Air Interface; Physical Layer specification; Part 2: Frame structure".

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 102 189-1: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; MAC/SLC layer specification; Part 1: General description".

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".

ETSI EN 301 459 (V1.2.1): "Satellite Earth Stations and Systems (SES); Harmonized EN for Satellite Interactive Terminals (SIT) and Satellite User Terminals (SUT) transmitting towards satellites in geostationary orbit in the 29,5 to 30,0 GHz frequency bands covering essential requirements under article 3.2 of the R&TTE Directive".

History

Document history		
V1.1.1	March 2004	Publication
V1.1.2	July 2004	Publication