Final draft ETSI EN 302 550-1-1 V1.1.0 (2009-12)

European Standard (Telecommunications series)

Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 1: Outer Physical Layer

Reference
DEN/SES-00312-1-1

Keywords
digital, layer 1, radio, 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, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

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 European Standard (Telecommunications series) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES), and is now submitted for the Vote phase of the ETSI standards Two-step Approval Procedure.

The present document is part 1, sub-part 1 of a multi-part deliverable covering Satellite Digital Radio (SDR), as identified below:

Part 1: "Physical Layer of the Radio Interface";

- **Sub-part 1: "Outer Physical Layer";**
- Sub-part 2: "Inner Physical Layer Single Carrier Modulation";
- Sub-part 3: "Inner Physical Layer Multi Carrier Modulation".

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

Introduction

TC SES is producing standards and other deliverables for Satellite Digital Radio (SDR) systems. An SDR system enables broadcast to fixed and mobile receivers through satellites and complementary terrestrial transmitters. Functionalities, architecture and technologies of such systems are described in TR 102 525 [i.1].

Several existing and planned ETSI standards specify parts of the SDR system, with the aim of interoperable implementations. The physical layer of the radio interface (air interface) is divided up into the outer physical layer, the inner physical layer with a single carrier modulation, and the inner physical layer with multi carrier modulation. These parts can be used all together in SDR compliant equipment, or in conjunction with other existing and future specifications.

The present document specifies the outer physical layer. The inner physical layer with single carrier modulation is specified in EN 302 550-1-2 [i.2], and with multi carrier modulation in EN 302 550-1-3 [i.3]. Guidelines for using the physical layer standard can be found in TR 102 604 [i.4].

The physical layer specifications have previously been published as "Technical Specification (TS)" type ETSI deliverables. The present document supersedes TS 102 550 [i.5] and is recommended for new implementations.

1 Scope

The present document concerns the radio interface of SDR broadcast receivers. It specifies the functionality of the outer physical layer. It allows implementing this part of the system in an interoperable way.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ISO/IEC 13818-1: "Information technology - Generic coding of moving pictures and associated audio information: Systems".

[2] ISO/IEC 11172-1: "Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 1: Systems".

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TR 102 525: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) service; Functionalities, architecture and technologies".

[i.2] ETSI EN 302 550-1-2: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 2: Inner Physical Layer Single Carrier Modulation".

[i.3] ETSI EN 302 550-1-3: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 3: Inner Physical Layer Multi Carrier Modulation".

[i.4] ETSI TR 102 604: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Guidelines for the Use of the Physical Layer Standards".

[i.5] ETSI TS 102 550 (V1.3.1): "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Outer Physical Layer of the Radio Interface".

3 Symbols and abbreviations

3.1 Symbols

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

<R>	Code rate

3.2 Abbreviations

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

AWGN	Additive White Gaussian Noise
BCH	Bose, Ray-Chaudhuri, Hocquenghem code
CRC	Cyclic Redundancy Checksum
C-TS	Channel-Transport Stream
CU	Capacity Unit
FEC	Forward Error Correction
ID	IDentifier
IP	Internet Protocol
IPL	Inner Physical Layer
IU	Interleaving Unit
LSB	Least Significant Bit
MPEG-TS	MPEG Transport Stream
MSB	Most Significant Bit
MTU	Maximum Transfer Unit
OPL	Outer Physical Layer
PF	Physical layer FEC
PFIW	Physical layer FEC Info Word
PL	Physical Layer
QoS	Quality of Service
RFU	Reserved for Future Use
SL	Service Layer
SOF	Start Of Frame
S-TS	Service-Transport Stream
VBR	Variable Bit Rate
WER	Word Error Rate

4 Outer physical layer

Refer to annex A for number format definitions.

4.1 Overview

Figure 1 displays the position and the interfaces of the Outer Physical Layer (in the following denoted by OPL) inside a complete broadcast transmission chain. The OPL connects to the Service Layer, where the interface is Service Transport Streams (S-TS) on the one side, and on the other side to the Inner Physical Layer (IPL - described in EN 302 550-1-2 [i.2] and EN 302 550-1-3 [i.3]), where the interfaces are Channel Transport Streams (C-TS).

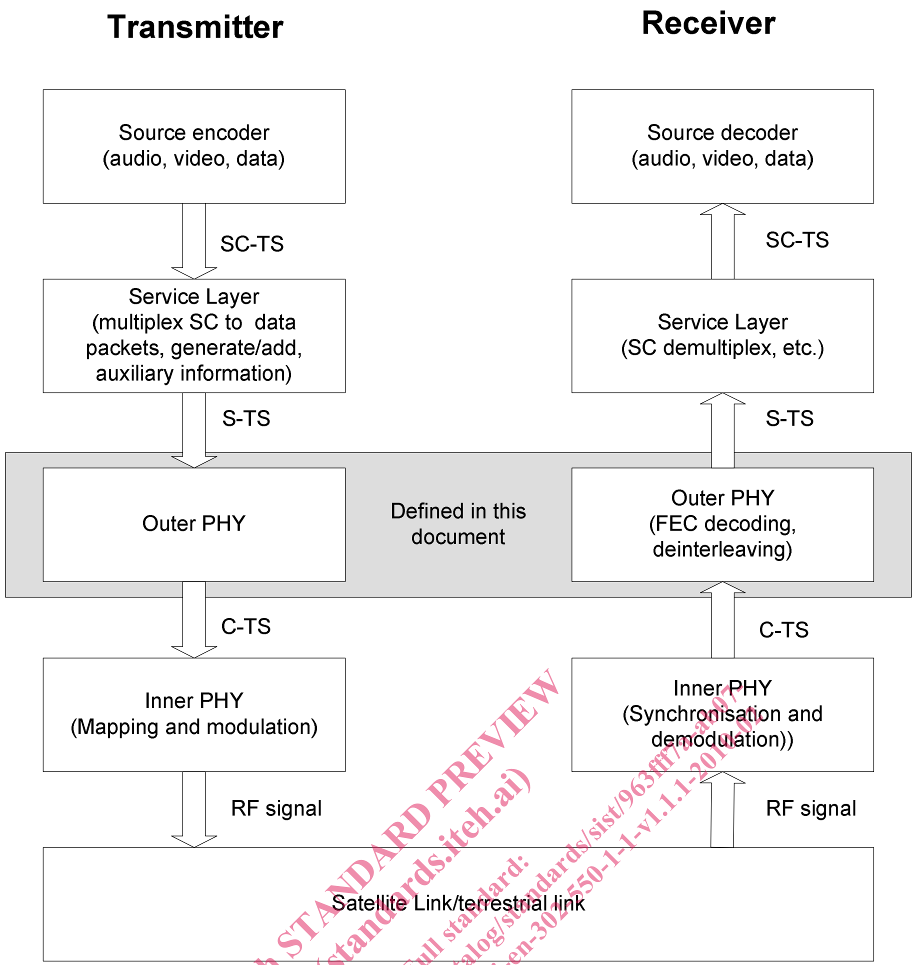

Figure 1: Position and interfaces of the OPL inside the transmission chain

The following table gives an overview about the terminology used for the data streaming through the system.

Description		Comments
SC	Service component	E.g. source encoded audio or video or other data
SC-TS	Service component transport stream	
ES	Elementary Stream	ES: Elementary Stream, a generic term for one of the coded video, coded audio or other coded data bitstreams, cf. MPEG-1 standard ISO/IEC 11172-1 [2].
Program	A program is a collection of program elements. Program elements may be elementary streams (ES, SC-TS).	In line with the definition used for MPEG standard ISO/IEC 13818-1 [1].
Service	Set of programs and related auxiliary information	
S-TS	Service transport stream	Generalized term for transport stream. MPEG-TS is one example for a service transport stream.
MPEG-TS	Transport stream compliant to MPEG standard ISO/IEC 13818-1 [1]	
C-TS	Channel transport stream	Data stream (bit stream) representing the input to the modulator = data stream including all redundancy added by the FEC encoder - possibly with time-interleaving - and carrying configuration signalling information for the receiver. The content of the C-TS is referred to as a C-TS multiplex (a multiplex of encoded and interleaved S-TS plus signalling information). A bouquet of programs is carried by one or more C-TS multiplexes.

Description		Comments
Channel	RF resource	The meaning "RF resource" is aligned with the terminology used for DVB.

The functionality of the Outer Physical Layer is to provide Forward Error Correction and time interleaving for resistance against a variety of transmission channel conditions. Different transport channels are used in the OPL to offer the requested performance for different types of services. These transport channels are called pipes in the scope of the present document. The OPL is configurable in terms of error protection, outage mitigation in case of signal losses, end-to-end delay, zapping time, payload throughput and receiver complexity.

Multiple pipes can be used as described above. Each of them contains FEC, Mixer and Disperser. One special pipe exists whose functionality is to transmit all relevant parameters to decode the other pipes. The so-called signalling pipe is always transmitted at the lowest coderate which is 1/5. The modulation of the signalling pipe is equal to the modulation of the data pipes.

The general block diagram of the OPL functionality is given in figure 2.

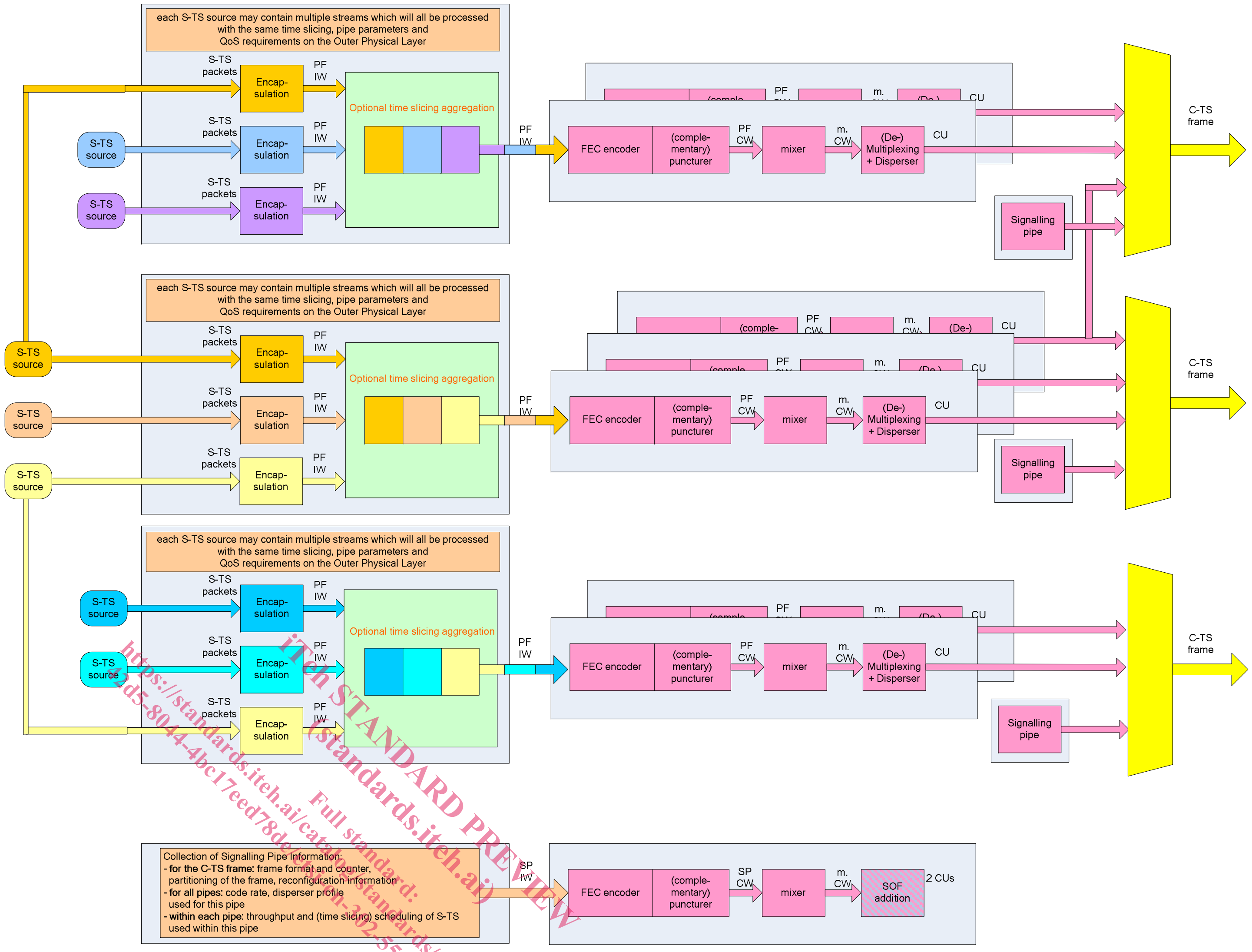

Figure 2: General overview of the OPL functionality

The processing, multiplexing and demultiplexing of the data in the OPL is displayed in figure 3. An S-TS scheduler multiplexes together all S-TS contained in the pipe. The scheduler is controlled by an S-TS schedule, which determines the number of words taken from one S-TS before the multiplexer selects the next S-TS of the pipe. After an encapsulation, FEC encoding and mixing, the codewords (segmented into interleaver units) are demultiplexed codeword-wise to the slots of the considered pipe, each of the slots possessing its individual disperser. After demultiplexing a codeword to a slot, i.e. to the input of its disperser, the slot demultiplexer selects the next slot/disperser. At the outputs of the dispersers, the dispersed codewords are multiplexed together again by the collector to form one pipe. The slot demultiplexer and the collector always select synchronously the same slot/disperser.

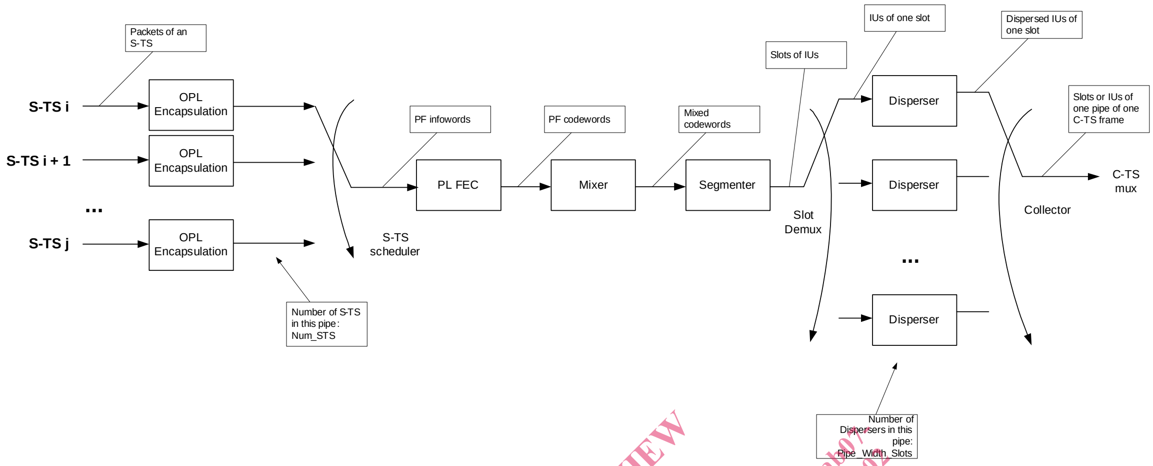

Figure 3: Definition of the different blocks involved in the OPL processing

4.2 Interfacing to Service Layer (SL)

The interface to the service layer is the so-called Service-Transport Stream (S-TS). For the OPL, each S-TS source is the smallest granularity which can be processed independently.

The interface may work synchronously or asynchronously. In the case of asynchronous interface, the PL must be able to accept at least the average data rate that is provided by the SL. Any data buffering shall be done inside the SL, such that no data from the S-TS is lost at this interface. When the PL requests new data for transmission, the SL can either provide the requested data to the PL or it can signal that no data is currently available. If no data is available for transmission, the PL instead transmits dummy data that is discarded in the receiver.

Inside an S-TS, multiplexing and de-multiplexing of information shall be carried out by the service layer.

Each pipe provides a different set of transmission parameters (e.g. FEC code rate and disperser profile), and achieves a different QoS in terms of protection against transmission errors and end-to-end delay. One pipe of the OPL may carry several S-TS, all with the same QoS parameters.

If PL time slicing is used, each time slice is associated with one S-TS. The scheduling of the S-TS, i.e. their start instants and lengths, inside a pipe can be adapted frequently (once per schedule/time slicing period). This opens the possibility of handling Variable Bit Rate (VBR) transmission.

The maximum allowed payload throughput per S-TS is 3,2 Mbit/s (this corresponds to approximately 8 to 10 video services inside one S-TS). This is the throughput that the processing chain inside the receiver (e.g. the turbo decoder) must be able to handle at least.

4.3 S-TS to OPL adaptation layer: S-TS encapsulation

The OPL is prepared to transport different types of S-TS, and a mixture of different S-TS types may be transported simultaneously over one C-TS multiplex.

The following parameters have to be determined for each S-TS (for parameters, refer to signalling pipe in clause 4.10.1):

- S-TS ID: identifier for the transported S-TS, that is unique for each network operator (i.e. for each Operator_ID); observe that one S-TS may be transported over multiple instances of the PL and still have a single unique S-TS ID; this helps, for example, for diversity combining of one S-TS transmitted over satellite and simultaneously over terrestrial repeaters. Several rules apply for the S-TS:
  - S-TS ID 0 plays a special role: this is the Service Layer configuration S-TS (the SL can signal its own configuration via this S-TS).
  - An S-TS may be fed to several C-TS multiplexes. The S-TS IDs in all of these C-TS multiplexes are identical.
  - An S-TS may not be fed to several pipes inside the same C-TS multiplex, and an S-TS may not be fed several times to the same pipe inside one C-TS multiplex either.
  - S-TS IDs must be unique over the complete network of one operator except for S-TS ID `0` which is allowed on every C-TS multiplex.
  - S-TS with an identical `Operator_ID` and S-TS ID can always be diversity combined (except for S-TS ID 0).
  - The length of an S-TS can be configured in a granularity of one PL infoword per C-TS frame.
- Pipe number that this S-TS is transported over.

Moreover, for the ensemble of S-TS contained inside a complete C-TS multiplex, the following parameters have to be fixed (for parameters, refer also to signalling pipe in clause 4.10.1):

- Operator_ ID: unique identifier for the network operator.
- Partitioning of the C-TS multiplex into pipes and scheduling of the S-TS inside the pipes, i.e. what is the data rate of one S-TS and when are the bursts of one S-TS transported.

Each S-TS is partitioned into packets to match the length of the PL FEC information word (PF infoword). The packet size is individual for each type of S-TS. The OPL encapsulation inside the S-TS to OPL adaptation layer adapts the length of the S-TS packets to the PF infoword length by appending a suffix to the S-TS packet. Table 1 defines the S-TS packet length and the suffix length for different S-TS types.

Table 1: Defined S-TS type IDs

S-TS Type	S-TS Type ID	S-TS payload packet Size in bytes	Suffix length in bits	Comment
Dummy packet	0	0	26	used for asynchronous sl/pl interface. is discarded in receiver.
Transparent	1	1 532	26	sl has to decide what to do with this data.
MPEG-TS	2	1 504	250	payload packet is 8 mpeg packets of 188 bytes each; additionally, a bch code of 196 bits is applied.
IP stream	3	1 504	250	mtu of ip = 4 095 bytes with 2 bytes additional header per packet.
RFU	4 to 7			reserved for future s-ts types.

The detailed format for the different types of S-TS is given in the following clauses. The Cyclic Redundancy Check (CRC) polynomial, which appears in the following clauses, is $x^8 + x^5 + x^3 + x^2 + x + 1$ for all S-TS stream types. The calculation of the CRC is described in annex B.