Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast

ARIB STANDARD

ARIB STD-B47 Version 1.1

Version 1.0 November 5, 2010
Version 1.1 July 3, 2012

Association of Radio Industries and Businesses

Forward

1. Introduction

With participation of radio equipment manufacturers, telecommunications operators, broadcasting equipment manufacturers, broadcasters and general users, Association of Radio Industries and Businesses (ARIB) defines basic technical requirements for standard specifications of radio equipment, etc. as an "ARIB STANDARD" in the field of various radio systems.

In conjunction with national technical standards which are intended for effective spectrum utilization and avoidance of interference with other spectrum users, an ARIB STANDARD is intended as a standard for use by a private sector compiling various voluntary standards regarding the adequate quality of radio and broadcasting service, compatibility issues, etc., and aims to enhance conveniences for radio equipment manufacturers, telecommunications operators, broadcasting equipment manufacturers, broadcasters and general users.

An ARIB STANDARD herein is published as "Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast." In order to ensure fairness and transparency in the defining stage, the standard was set by consensus of the standard council with participation of interested parties including radio equipment manufacturers, telecommunications operators, broadcasting equipment manufacturers, broadcasters, general users, etc. with impartiality.

It is our sincere hope that the standard would be widely used by radio equipment manufacturers, telecommunications operators, broadcasting equipment manufacturers, broadcasters, general users, etc.

2. Scope

This standard applies to the multimedia broadcasting defined in Section 2 of Chapter 4, Ordinance No.87 of the Ministry of Internal Affairs and Communications, 2011.

3. Standard References for Forward Link Only

The following list identifies the current version of the standards in the FLO family of standards.

Standard#	Title
STD-B47	Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast
STD-B48	Forward Link Only Transport Specification
STD-B49	Forward Link Only Media Adaptation Layer Specification
STD-B50	Forward Link Only Open Conditional Access (OpenCA) Specification
STD-B51	Forward Link Only System Information Specification
STD-B52	Forward Link Only Messaging Transport Specification
STD-B32	Video Coding, Audio Coding and Multiplexing Specifications for Digital Broadcasting*

*NOTE: The original document of this standard is Japanese version. Part 3 of this standard is not applicable to Forward Link Only system.

4. Industrial Property Rights

This standard does not describe industrial property rights mandatory to this standard. However, the right proprietor of the industrial property rights has expressed that "Industrial property rights related to this standard, listed in the annexed table below, are possessed by the applicator shown in the list. However, execution of the right listed in the annexed table below is permitted indiscriminately, without exclusion, under appropriate condition, to the user of this standard. In the case when the user of this standard possesses the mandatory industrial property rights for all or part of the contents specified in this standard, and when he asserts his rights, it is not applied."

Annexed Table (Selection of Option 2)

Patent Applicant/Holder	Name of Patent	Registration No./ Application No.	Remarks
QUALCOMM Incorporated (*1)	A comprehensive confirmation form has been submitted with regard to ARIB STD-B47 Ver.1.0.		
JVC KENWOOD Holdings, Inc. (*1)	A comprehensive confirmation form has been submitted with regard to ARIB STD-B47 Ver.1.0.		
QUALCOMM Incorporated (*2)	Methods and apparatus for determining the location of a mobile device in an OFDM wireless network	JP2009-522947	US7,706,328; US20090117917; AR; BR; CN; EP; IN; KR; RU; SG; TW
	Method for transmission of FLO and FLO-EV packets in the same RF channel	WO2011031859	US20110085499, TW
	MFN support for FLO rev A and FLO rev B operation in a FLO network	WO2011031869	US20110069657, TW
	Method for signaling overhead information in a broadcast network	WO2011031878	US12/876,958, TW

(*1) These patents are applied to the part defined by ARIB STD-B47 Ver. 1.0. (Received on October 28, 2010)

(*2) These patents are applied to the part defined by ARIB STD-B47 Ver. 1.0. (Received on May 10, 2011)

Reference (Not applied in Japan)

Patent Applicant/Holder	Name of Patent	Registration No./ Application No.	Remarks
QUALCOMM Incorporated (*3)	FLO air interface specification 3.0 enhancements to support FLO-EV physical layer and control layer messages in addition to the existing FLO physical layer and control layer messages	US61/240,965	

(*3) This patent is applied to the part defined by ARIB STD-B47 Ver. 1.0. (Received on May 10, 2011)

Table of Contents

(This foreword is not part of this Standard)

This specification provides a set of procedures that the Forward Link Only device and the Forward Link Only network can use to receive multicast services.

Equipment built to this standard can be used in a Forward Link Only RF channel subject to the allocation of that RF channel and to the rules and regulations of the country to which the allocated Forward Link Only RF channel has been assigned.

REFERENCES

NORMATIVE REFERENCES

The following standards and documents contain provisions, which, through reference in this text, constitute provisions of this specification. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[1] FCC 01-364, Reallocation and service rules for the 698-746 MHz spectrum, CN Docket Number 01-74, Release January 18, 2002.

[2] TIA-1103-A, Minimum Performance Specification for Terrestrial Mobile Multimedia Multicast Forward Link Only Transmitters, March 2009.

[3] MIL-STD-2401, "DoD Standard Practice, World Geodetic System (WGS 84)", January 1994.

[4] ARIB-STD B48, Forward Link Only Messaging Transport Specification.

[5] TIA-1099-A, Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast, April 2009.

[6] TIA-1099-B Errata, Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast Errata.

[7] Regulation No.18 of the Radio Regulatory Council, 1950.

[8] Ordinance No.87 of the Ministry of Internal Affairs and Communications, 2011.

[9] Notification No.299 of the Ministry of Internal Affairs and Communications, 2011.

INFORMATIVE REFERENCES

[10] ETSI TS 123 032 V7.0.0, Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Universal Geographical Area Description (GAD), June 2007.

[11] TIA-801-A, Position Determination Service for cdma2000 Spread Spectrum Systems, April 2004.

1 OVERVIEW

The Forward Link Only system multicasts several services.

A service is an aggregation of one or more independent data components. Each independent data component of a service is called a flow. For example, a flow can be the video component, audio component, text or signaling component of a service.

Services are classified into two types based on their coverage: Wide-area services and Local-area services. A Local-area service is multicast for reception within a metropolitan area. By contrast, Wide-area services are multicast in one or more metropolitan areas.

Forward Link Only services are carried over one or more logical channels. These logical channels are called Multicast Logical Channels or MLCs.

An MLC may be divided into a maximum of three logical sub-channels. These logical sub-channels are called streams. Each flow is carried in a single stream.

1.1 Scope of This Document

These technical requirements form a compatibility standard for Forward Link Only multimedia multicast systems. These requirements ensure that a compliant Forward Link Only device can obtain service through any Forward Link Only network conforming to this standard.

Revision A [5][6] of this specification provides support for extending the operation of Forward Link Only systems to a frequency range wider than the UHF band. In addition, the Positioning Pilot Channel is specified to allow for the identification of individual transmitters operating on the same or different carrier center frequencies. A new control protocol message is also added to support the extended frequency range and to enhance operation in networks with multiple carrier center frequencies.

Specifically, Revision A includes the following:

- A new Extended Neighbor List Description Message that replaces the Neighbor List Description and RF Channel Description Messages.
- FFT sizes of 1024, 2048 and 8192 in addition to the value of 4096.
- Flat guard interval fractions of 1/16, 3/16 and 1/4 in addition to the value of 1/8.
- Addition of a new pilot pattern and slot to interlace mapping.
- A new Signaling Parameter Channel to convey the FFT size, flat guard interval fraction and slot to interlace mapping.
- An updated specification for the Positioning Pilot Channel.

Revision B of this specification provides an additional option for the Physical layer of the Data Channel referred to as PHY Type 2. The Physical layer option supported by the Revision A of this document is referred to as PHY Type 1. The Signaling Parameter Channel payload definition is updated to include the Physical layer option used by the Data Channel and the status of the Positioning Pilot Channel. The SystemParameters message in the OIS channel has been updated with a new type of MLC records to provide support for MLCs that require higher throughput in a superframe and for MLCs using PHY Type 2 Physical layer option. A new control protocol message is also added to support the higher rate MLCs as well as MLCs that use PHY Type 2.

Revision B adds support for the following:

- A new Physical layer option (PHY Type 2) for the Data Channel.
- A new type of MLC record in the OIS channel to signal high rate MLCs and MLCs that employ PHY Type 2 option.
- A new control protocol message for high rate MLCs and MLCs that employ PHY Type 2 option.
- An updated payload for the Signaling Parameters Channel to allow the option for conveying the Physical layer option used by the Data Channel and the presence of Positioning Pilot Channel.

1.2 Requirements Language

“Shall” and “shall not” identify requirements to be followed strictly in conformance with the standard and from which no deviation is permitted. “Should” and “should not” indicate that one of several possibilities is recommended as particularly suitable, without mentioning or excluding others, that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is discouraged but not prohibited. “May” and “need not” indicate a course of action permissible within the limits of the standard. “Can” and “cannot” are used for statements of possibility and capability, whether material, physical, or causal.

1.3 Architectural Reference Model

The architectural reference model is presented in Figure 1.3-1.

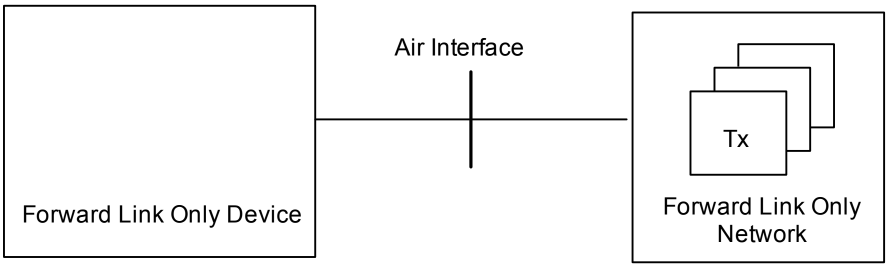

Figure 1.3-1 Architecture Reference Model

The reference model consists of the following functional units: The Forward Link Only device, and the Forward Link Only network.

The reference model includes the air interface between the Forward Link Only device and the Forward Link Only network. From the perspective of this reference model the Forward Link Only Network consists of multiple transmitters. In the Forward Link Only system, the term Local-area refers to a market, typically a metropolitan area, covered by a designated set of Local-area services. Transmitters within a Local-area may transmit on the same or different carrier center frequencies. Transmitters within a Local-area operating on the same carrier center frequency deliver the same set of services.

In the Forward Link Only system, the term Wide-area refers to a set of markets, typically one or more metropolitan areas, covered by a designated set of Wide-area services. A Wide-area consists of one or more Local-areas, with the group of transmitters in the different Local-areas multicasting the same set of Wide-area services and typically different Local-area services.

The Forward Link Only system also supports the transmission of waveforms in multiple RF channel bandwidths and at carrier center frequencies selectable from a wide RF frequency range. In this regard, a wide-area could consist of multiple local-areas with transmitters in the different local-areas using the same RF channel bandwidth but transmitting at different center frequencies. In this scenario, the Forward Link Only Air Interface specification is designed so that a Forward Link Only device could receive a wide-area service without interruption as it transitions between local-areas.

The protocols used over this air interface are specified in this document.

1.4 Protocol Architecture

The air interface has been layered, with the interface defined for each layer.

1.4.1 Layers

Figure 1.4.1-1 describes the layering architecture for the Forward Link Only System.

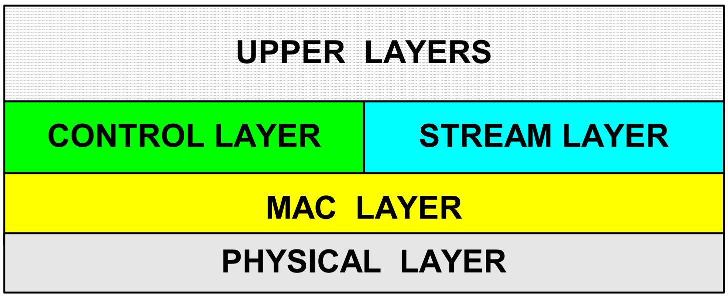

Figure 1.4.1-1 Forward Link Only Layering Architecture

The protocols and layers specified in Figure 1.4.1-1 are:

1. Upper Layers: The “upper” protocol layers provide multiple functions including compression of multimedia content, controlling access to the multimedia content and formatting of Control information. This specification does not cover these Upper layers.
2. Control Layer: This layer is used by the network to disseminate information to facilitate the device operation in the Forward Link Only system. The device uses the Control layer to maintain synchronization of its Control information with that in the network. This layer is defined in section 2.
3. Stream Layer: The Stream layer provides for binding of upper layer flows to streams on an MLC-by-MLC basis. The Stream layer is at the same level as the Control layer in the air interface layering architecture. This layer is defined in section 3.
4. MAC Layer: This layer does multiplexing of packets belonging to different media streams associated with MLCs. The MAC (Medium Access Control) layer defines the procedures used to receive and transmit over the Physical layer. The MAC layer is defined in section 4.
5. Physical Layer: The Physical layer provides the channel structure, frequency, power output, modulation and encoding specification for the Forward Link. The Physical layer is defined in section 5 .

1.5 Physical Layer Channels

The Physical layer defines the Forward Link Only Physical layer channels and hierarchies shown in Figure 1.5-1.

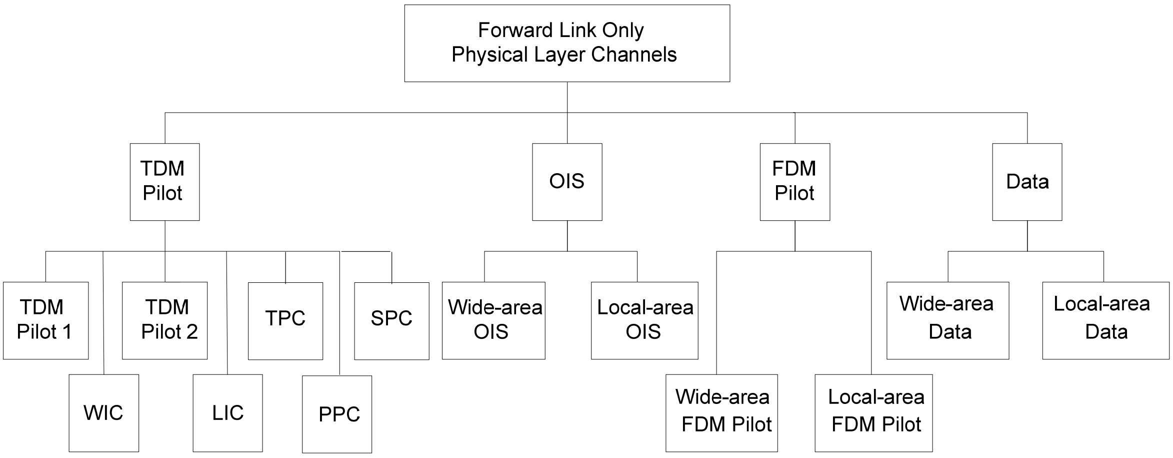

Figure 1.5-1 Forward Link Only Physical Layer Channel Structure

The transmitted signal in the Forward Link Only system is organized into superframes. Each superframe has a duration of 1 second.

For reference Figure 1.5-2 shows the general relationship (not to scale) between the various Physical layer channels in a superframe. Four of the seven TDM Pilot channels namely TDM Pilot 1, Wide-area Identification Channel (WIC), Local-area Identification Channel (LIC) and TDM Pilot 2 occur consecutively at the start of the superframe. The FDM Pilot channel is frequency division multiplexed with the Overhead Information Symbols (OIS) Channels and Data Channels. The Transition Pilot Channel (TPC) is time division multiplexed with the OIS and the Data Channels over a superframe. The Positioning Pilot Channel (PPC)[1] and the Signaling Parameter Channel (SPC) appear at the end of the superframe. In order to support the transmission of Wide-area and Local-area services:

- The OIS Channel is divided into the Wide-area OIS Channel and the Local-area OIS Channel, which are time-division multiplexed within the OIS Channel.
- The FDM Pilot Channel is divided into the Wide-area FDM Pilot Channel and the Local-area FDM Pilot Channel, which are time-division multiplexed within the FDM Pilot Channel.
- The Data Channel is divided into the Wide-area Data Channel and the Local-area Data Channel, which are time-division multiplexed within the Data Channel.

Wide-area services that are multicast in a specific Wide-area are transmitted in the Wide-area Data Channel, while the Local-area services that are multicast in a specific Local-area are transmitted in the Local-area Data Channel. Transmitters that deliver the same set of Wide-area services transmit identical waveforms during the Wide-area Data Channel. Transmitters that deliver the same set of Local-area services transmit identical waveforms during the Local-area Data Channel.

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[1] Transmission of the PPC is optional and the presence/absence of the PPC is signaled over the OIS channel.

This Physical layer structure is discussed in detail in section 5.

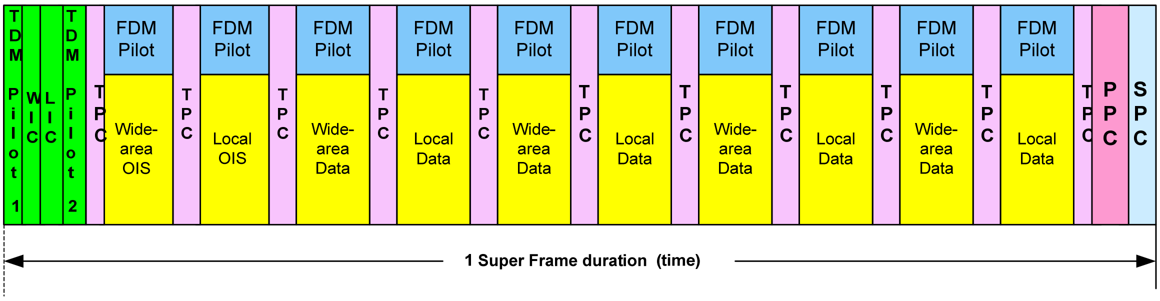


Figure 1.5-2 Forward Link Only Physical Layer Superframe Structure

1.6 Protocols

1.6.1 Interfaces

This standard defines a set of interfaces for communicating between protocols in the same entity and between protocols executing in the other entity.

Throughout the following, the generic term “entity” is used to refer to either the Forward Link Only device or the Forward Link Only network.

Protocols in this standard have four types of interfaces:

- Headers and Messages are used for communication between a protocol executing in one entity and the same protocol executing in another entity.
- Commands are used by a protocol to obtain a service from another protocol within the same Forward Link Only network or device.
- Indications are used by a lower layer protocol to convey information regarding the occurrence of an event. Any higher layer protocol can register to receive these indications. A same layer protocol can also register to receive an indication but only in one direction.
- Public Data is used to share information in a controlled way between protocols. Public data is shared between protocols in the same layer, as well as between protocols in different layers.

Indications are written in the form of *Protocol.Indication.* Indications are always written in the past tense since they announce events that have happened.

Headers and messages are binding on all implementations. Indications and public data are used as a device for a clear and precise specification. Forward Link Only devices and Forward Link Only networks can be compliant with this specification while choosing a different implementation that exhibits identical behavior.

Unless noted otherwise, the protocol procedures listed in the Forward Link Only Network Requirements and Forward Link Only Device Requirements of Chapters 2, 3 and 4 shall be executed in the same order in which they are listed in this specification.

1.6.2 Protocol Overview

Figure 1.6.2-1 presents protocols defined for each of the layers shown in Figure 1.4.1-1. A complete description is provided in the introduction section for each layer.

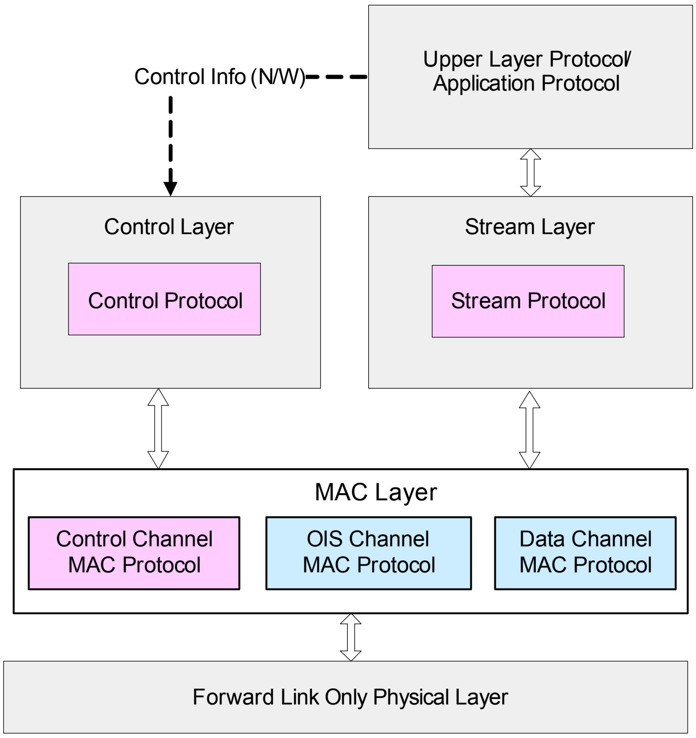


Figure 1.6.2-1 Forward Link Only Protocol Suite

1.7 Forward Link Only System Time

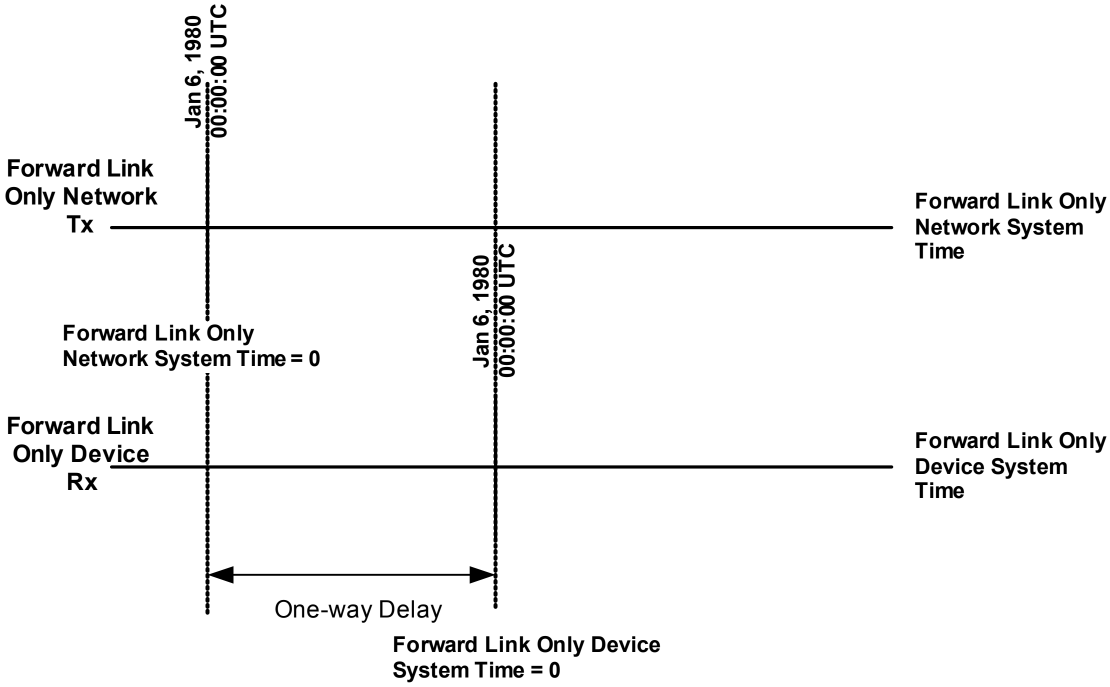
All Forward Link Only network transmissions are referenced to a common system wide timing that uses the Global Positioning System (GPS) time, which is traceable to and synchronous with Universal Coordinated Time (UTC). The GPS time and the UTC differ by an integer number of seconds, specifically the number of leap second corrections added to the UTC since January 6, 1980. The start of Forward Link Only System Time is January 6, 1980 00:00:00 UTC, which coincides with the start of GPS time.

Forward Link Only System Time keeps track of leap second corrections to the UTC but does not use these corrections for physical adjustments to the Forward Link Only System Time clocks.

The Forward Link Only System Time is expressed in units of seconds since the start of the Forward Link Only System Time.

Forward Link Only transmissions are divided into superframes. Each superframe has one second duration. Every superframe transmission begins on one second tick of the Forward Link Only System Time.

Figure 1.7-1 shows the relation of Forward Link Only System Time at various points in the system. The Forward Link Only System Time at various points in the transmission and the reception processes is the absolute time referenced at the Forward Link Only network antenna offset by the one-way trip delay of the transmission. Time measurements are referenced to the transmit antenna of the Forward Link Only network and the RF connector of the Forward Link Only device.



Note: (1) Time measurements are made at the antennas of Forward Link Only transmitters and the RF connectors of the Forward Link Only device .

Figure 1.7-1 Forward Link Only System Time Line

1.8 Revision Number

Forward Link Only devices and Forward Link Only networks complying with the requirements of this specification shall set their revision number to 0x02.

1.9 Signaling Message Requirements

The following requirements are common to all protocols that use signaling messages and that provide for message extensibility. The Forward Link Only device and the Forward Link Only network shall abide by the following rules when generating and processing any signaling messages:

- Messages are always an integer number of octets in length; and, if necessary, include a Reserved field at the end of the message to make them so. The receiver shall ignore the value of the Reserved fields.
- Message identifiers shall be unambiguous for each protocol defined by the MinimumRevision and above.
- For future revisions, the transmitter shall add new fields only at the end of a message (excluding any trailing Reserved field). The transmitter shall not add fields if their addition makes the parsing of previous fields ambiguous for receivers whose protocol revision is equal to or greater than MinimumRevision.
- The receiver shall discard all unrecognized messages.
- The receiver shall discard all unrecognized fields.

- The receiver shall discard a message if any of the fields in the message is set to a value outside of the defined field range, unless the receiver is specifically directed to ignore this field. A field value is outside of the allowed range if a range was specified with the field and the value is not in this range, or the field is set to a value that is defined as invalid.
- The receiver shall ignore any “Reserved” fields present in a message.

1.10 Message Bit Order

Figure 1.10-1 shows a generic message with n fields with total size equal to k octets[2]. The bits in this generic message shall be ordered according to the following procedure:

1. The fields in the message shall be concatenated from right to left with the first field in the message appearing at rightmost position as illustrated in Figure 1.10-2.
2. The bits shall be ordered from right to left with the least significant bit of Field_1 denoted as b_0 appearing first and most significant bit of Field_n denoted b_j appearing last as shown in Figure 1.10-2.

The bit order shown in Figure 1.10-2 is applicable to the Control, Stream and MAC layers. The bit order at the Physical layer is described in 5.1.3.

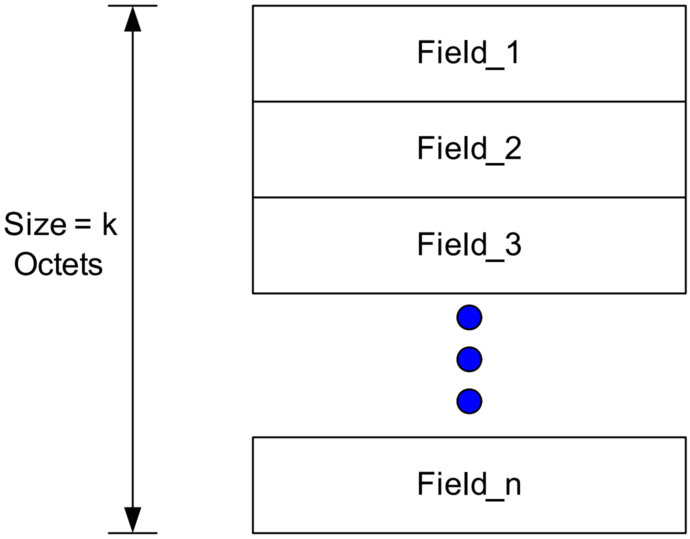


Figure 1.10-1 A Generic Message with n Fields

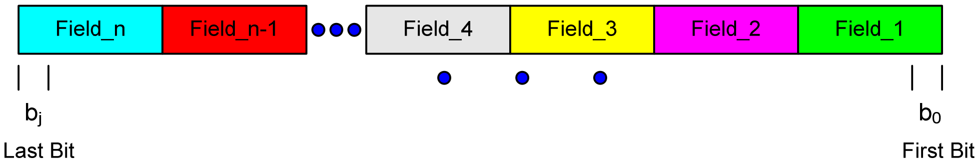


Figure 1.10-2 Concatenation of Fields in the Generic Message

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[2] Each of the n fields has its own bit length.

1.11 Terms

Active Sub-carriers. These are the sub-carriers that are modulated with modulation symbols.

Control Information. The information transmitted by the Control layer to assist the Forward Link Only device to select, receive and decode particular services in the Forward Link Only network.

Control Layer. Control layer disseminates relevant information to facilitate the device operation in the Forward Link Only system.

Chip. A unit of time corresponding to 1/(0.925 x W), where W is the RF channel bandwidth and can be 5, 6, 7 or 8 MHz.

CRC. Cyclic Redundancy Check.

FCS. Frame Check Sequence.

FDM. Frequency Division Multiplexing.

FFT Size. The total number of sub-carriers in the OFDM waveform. The Forward Link Only System uses 1024, 2048, 4096 or 8192 sub-carriers. The active sub-carriers are a subset of the total sub-carriers.

Flow. A flow is an independent data component in a Forward Link Only service. A flow may consist of two components: a base component and an enhancement component.

Forward Link Only Network (FN). The collection of infrastructure equipment that multicasts the overhead information and content associated with the services offered on the Forward Link Only system.

Forward Link Only Device (FD). A device that can be activated to receive multicast transmissions from the Forward Link Only Network.

Forward Link Only RF Channel. A Forward Link Only RF Channel denotes a specific combination of RF channel bandwidth and carrier center frequency that is used to transmit a waveform compliant with the Forward Link Only Air Interface specification.

Forward Link Only Service: A collection of multicast content offered under the same label. Examples of possible Forward Link Only Services include CNN, ESPN, NPR and stock ticker.

Frame. A sub-unit of a superframe. Each superframe includes 4 frames and the duration of each frame is approximately 250 ms. The slots allocated to an MLC are the same across the frames in a superframe.

Global Positioning System (GPS). A US government satellite system that provides location and time information to users. See Navstar GPS Space Segment/Navigation User Interfaces ICD-GPS-200 for specification.

Guard Sub-carriers. These are the sub-carriers that are unused. No energy is transmitted on the Guard Sub-carriers.

Hz. Hertz.

IFT. Inverse Fourier Transform.

Interlace. A group of sub-carriers that is uniformly spaced among the active sub-carriers. The size of the group depends on the FFT size and can be 125, 250, 500 or 1000.

kHz. Kilohertz.

Layered Modulation. A type of modulation in which each modulation symbol has bits corresponding to both the base and enhancement components of a flow.

Local-area. Local-area refers to a market, typically a metropolitan area, covered by a designated set of Local-area services.

Local-area Data Channel. Local-area Data Channel carries data corresponding only to Local-area services within a specific Local-area.

Local-area Differentiator (LID). This is a 4-bit field used to identify the group of transmitters within a Local-area Operations Infrastructure (LOI) that carry the same set of local area services. This field is used for scrambling purposes in the Local-area OIS Channel, the Local-area FDM Pilot Channel, and the Local-area Data Channel.

Local-area Identification Channel (LIC). This is an overhead channel that is used for conveying the Local-area Differentiator to Forward Link Only receivers.

Local-area Operations Infrastructure (LOI). LOI is a group of transmitters that provide coverage to a Local-area.

LOI_ID. Identifier assigned to the LOI and carried as InfrastructureID field of the SystemParameters message in the Local-area OIS Channel.

Local-area Service. Local-area service is a service that is multicast only within a metropolitan area.

MAC Layer. The MAC layer defines the procedures used by the network to transmit and the device to receive over the Physical layer. The MAC layer is defined in 4.

Multicast Logical Channel (MLC). Smallest addressable element in the Forward Link Only Network transmission.

MAC Time Unit. The MAC Time Unit denotes the lowest level of time granularity over which Physical layer resources are allocated to the MAC layer payload.

MHz. Megahertz.

ms. Millisecond.

ns. Nanosecond.

OFDM. Orthogonal Frequency Division Multiplexing.

OFDM Symbol Interval. A duration of time that consists of a windowed guard interval, a flat guard interval, a useful duration and a post-fix interval. (See Figure 5.2.2.3-1].

OIS. Overhead Information Symbols.

Physical Layer. The Physical layer provides the channel structure, frequency, power output, modulation and encoding specification for the Forward Link Only link. The Physical layer is defined in 5.

PHY Type 1. PHY Type 1 corresponds to Physical layer options supported in Revision A and Revision B of this document.

PHY Type 2. PHY Type 2 corresponds to additional Physical layer options introduced in Revision B of this document.

PPC. Positioning Pilot Channel.

QAM. Quadrature Amplitude Modulation.

QPSK. Quadrature Phase Shift Keying

Residual Errors. The transmission errors that are not corrected by outer Reed-Solomon decoder.

RS Code. Reed-Solomon Code.

s. Second

Slot. The unit of bandwidth allocated over a MAC Time Unit that corresponds to a group of 500 constellation symbols.

SPC. Signaling Parameter Channel.

Stream. An MLC may consist of up to three logical sub-channels. Each logical sub-channel is called a stream. Each flow is carried in a single stream.

Stream Layer. The Stream layer provides for multiplexing of up to three distinct flows to an MLC.

Sub-carrier. A sub-component of the OFDM waveform that may be modulated with a modulation symbol.

Superframe. A duration of 1 second. A superframe is the smallest unit of time over which the slots allocated to an MLC can be changed.

Transmit Mode. The combination of modulation type, inner code rate, and PHY Type is called the Transmit Mode.

Transmitter ID (Tx ID). A unique 18 bit identifier assigned to each transmitter in the Forward Link Only Network.

TDM. Time Division Multiplexing.

TPC. Transition Pilot Channel.

Universal Coordinated Time(UTC). An internationally agreed-upon time scale maintained by the Bureau International de l'Heure (BIH) used as the time reference by nearly all commonly available time and frequency distributions systems.

UTC. Universal Temps Coordine. See Universal Coordinated Time.

μs. Micro-second.

WGS 84. World Geodetic System 1984.

WGS 84 reference ellipsoid. Worldwide datum reference system defining the surface of the Earth, i.e., the standard physical model of the Earth used for GPS applications [3].

Wide-area. Wide-area refers to a set of markets, typically one or more metropolitan areas, covered by a designated set of Wide-area services.

Wide-area Data Channel. Wide-area Data Channel carries data corresponding only to Wide-area services within a specific Wide-area.

Wide-area Differentiator (WID). This is a 4-bit field used to identify the group of transmitters within a Wide-area Operations Infrastructure (WOI) that carry the same set of wide area services. This field is used for scrambling purposes in the Wide-area OIS Channel, the Wide-area FDM Pilot Channel, and the Wide-area Data Channel.

Wide-area Identification Channel (WIC). This is an overhead channel that conveys the Wide-area Differentiator to Forward Link Only receivers.

Wide-area Operations Infrastructure (WOI). WOI is a group of transmitters that provide coverage to a Wide-area.

WOI_ID. Identifier assigned to the WOI and carried as InfrastructureID field of the SystemParameters message in the Wide-area OIS Channel.

Wide-area Service. Wide-area service is a service that is multicast in one or more metropolitan areas.

2 CONTROL LAYER

2.1 Introduction

The service offered by the Forward Link Only network consists of multicasting data flows (referred to simply as *flows*) provided by the upper layers. The role of the Control layer is to provide the device with the information needed to receive particular flow(s). Each flow is addressed by a unique, 20-bit identifier called a FlowID. The FlowID consists of two parts; FlowID_bits_4_thru_19 and FlowID_bits_0_thru_3. The structure of the FlowID is shown in Figure 2.1-1.

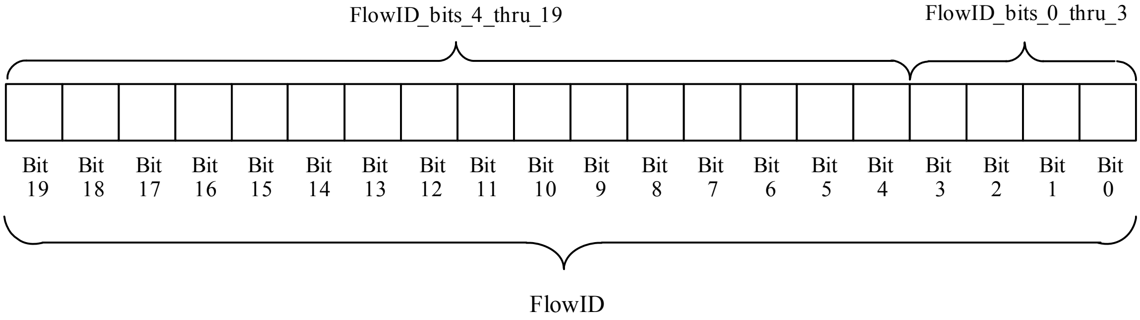

Figure 2.1-1 Flow ID Structure

The flows are carried over logical channels. These logical channels are called Multicast Logical Channels or MLCs.

The Control layer of the network disseminates information (referred to as control information) needed by the device to operate in the Forward Link Only system. The Control layer of the device receives this information and maintains synchronization of its control information with that in the network. The Control layer provides the latest information to other protocol entities.

The Control layer maintains three categories of information:

- Flow Description Information: This includes the mapping of flows to MLCs and flow configuration parameters.
- Radio Frequency Channel Information: This includes the Radio Frequency Channels in use in the Forward Link Only network.
- Neighbor List Information: This includes the list of neighboring Wide-areas and Local- areas.

The Control layer maintains and disseminates the information in each of the above categories as two logically separate classes, namely, Bin 0 and Bin 1. This separation allows the network to localize updates to the control information to a particular bin. This allows the Forward Link Only devices to process and utilize the information in one bin independent of the other.

The Control layer functions are implemented by the Control protocol.

2.2 Control Protocol

2.2.1 Overview

The Control protocol provides the procedures and messages required for the network to transmit and for the device to receive the Control information on a dedicated MLC called the Control Channel MLC.

The Control protocol operates in one of the following two states:

- Inactive State: In this state the protocol waits for an *Activate* command. This state applies only to the device.
- Active state: In this state network transmits information on Control Channel MLC and the device receives them.

The protocol states and the allowed transitions between the states are shown in Figure 2.2.1-1

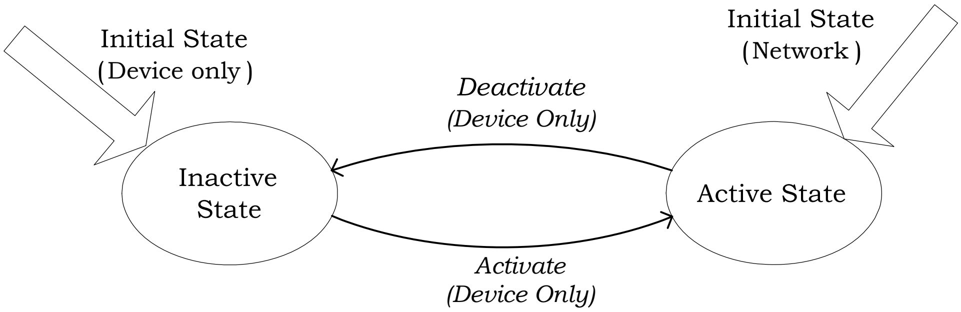

Figure 2.2.1-1 Control Protocol State Diagram

2.2.2 Primitives and Public Data

2.2.2.1 Commands

This protocol defines the following commands:

- *Activate (device only)*
- *Deactivate (device only)*
- *UpdateControlInfo (network only)*
- *SendControlChannelMACPayload (network only)*

2.2.2.1.1 Activate (device only)

It is used to cause the protocol to transition to the Active state.

2.2.2.1.2 Deactivate (device only)

It is used to cause the protocol to transition to the Inactive state.

2.2.2.1.3 UpdateControlInfo (network only)

It is used to cause the protocol to update Control information from the Upper layer.

2.2.2.1.4 SendControlChannelMACPayload (network only)

It is used to cause the protocol to deliver the Control protocol capsule (see 2.2.5.1) to the Control Channel MAC protocol for transmission in the next super frame.

2.2.2.2 Return Indications

This protocol returns the following indications:

- *UpdateComplete (network only)*
- *ControlInfoUpdated (device only)*

- *ControlChannelMACPayloadAvailable (network only)*
- *ControlSequenceNumberUpdated (device Only)*

2.2.2.2.1 UpdateComplete (network only)

This indication is sent in response to the *UpdateControlInfo* command upon successfully receiving the Control information from the Upper layer.

2.2.2.2.2 ControlInfoUpdated (device only)

This indication is sent when all Control protocol capsules representing Control protocol information in their entirety have been correctly received.

2.2.2.2.3 ControlChannelMACPayloadAvailable (network only)

This indication is sent to signal the availability of Control protocol capsule for the next superframe.

2.2.2.2.4 ControlSequenceNumberUpdated (device only)

This indication is sent to signal that the ControlSequenceNumber(s) associated with one or more Control protocol capsules has changed.

2.2.2.3 Public Data

This protocol shall make the following data public:

- ControlCapsuleID for all the Control protocol capsule(s).
- For each Control protocol capsule being transmitted on the Control Channel MLC,
    - Bin0_ControlSequenceNumber (see 2.2.5.1).
    - Bin1_ControlSequenceNumber (see 2.2.5.1).
- For messages belonging to bin 1, the following information shall be maintained:
    - UpdateInProgress flag (device only) – This flag indicates that the Control information belonging to bin 1 is currently being updated.
    - Content of the Flow Description message (device only) – see 2.2.5.2.2.1.
    - Content of the Extended Flow Description message (device only) – see 2.2.5.2.2.1.
    - Content of the Extended Neighbor List Description message (device only) – described in 2.2.5.2.2.2.
    - Content of the Forward Link Only Messaging Transport Fragment message (device only) – described in 2.2.5.2.2.3.
- For messages belonging to bin 0, the following information shall be maintained:
    - UpdateInProgress flag (device only) – This flag indicates that the Control information belonging to bin 0 is currently being updated.
    - Content of the Flow Description message (device only) – see 2.2.5.2.2.1.
    - Content of the Extended Flow Description messages (device only) – see 2.2.5.2.2.1.
    - Content of the Extended Neighbor List Description message (device only) – see 2.2.5.2.2.2.
    - Content of the Forward Link Only Messaging Transport Fragment message (device only) – described in 2.2.5.2.2.3.

2.2.3 Protocol Data Unit

The transmission unit of the Control protocol is a Control protocol packet (CPP). Each CPP contains a single but complete Control protocol message.

2.2.4 Protocol Initialization

The device shall start this protocol in the inactive state.

- Upon first time power up, the device shall
  - Set the Bin0_ControlSequenceNumber and Bin1_ControlSequenceNumber to an uninitialized value for all ControlCapsuleIDs.
  - Set UpdateInProgress flag to 1 for all the FlowIDs.

The network shall start this protocol in the active state.

2.2.5 Procedures and Messages

2.2.5.1 Procedures

2.2.5.1.1 Data Encapsulation

The Control protocol packet carries a Control protocol message as follows:

- A single Control protocol message occupies a CPP. The size of the Control protocol message is less than or equal to the CPP payload.
- Control protocol header specified in 2.2.5.2.1 is present in front of the Control protocol message.
- For a Control protocol message of size smaller than the payload of the CPP, the CPP is padded with PadBytes with format as specified in 2.2.5.2.3.

Each CPP independently occupies a single Control Channel MAC packet. Figure 2.2.5.1.1-1 illustrates the structure of the CPP.

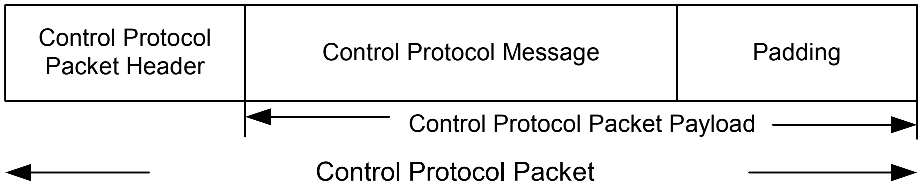

Figure 2.2.5.1.1-1 Control Protocol Packet Structure

The protocol uses the CPPs to construct the Control protocol capsule. A Control protocol capsule is defined as a group of CPPs transmitted or received in a single superframe.

The protocol in the network shall construct the Control protocol capsule as follows:

- It shall concatenate complete CPPs to form a Control protocol capsule.
- The number of CPPs in a Control protocol capsule shall be limited to the number of complete CPPs that can be transmitted over one superframe[3].
- While assembling a capsule,
  - First, the CPPs shall be separated based on the BinIDs.
  - Next, for BinID = 0, CPPs corresponding to the same MessageTypeID (see 2.2.5.2.1) shall be grouped together in the ascending order of CPPNumber.
  - Similarly, for BinID = 1, CPPs corresponding to the same MessageTypeID shall be grouped together in the ascending order of CPPNumber.
  - Next, the CPPs with BinID =0 shall be placed in capsule followed by the CPPs with BinID = 1 as illustrated in Figure 2.2.5.1.1-2.
- Each Control protocol capsule is carried in a Control Channel MAC protocol capsule.

---

[3] Payload is determined by the transmit mode assigned to the Control Channel and the number of OFDM symbols allocated to it.

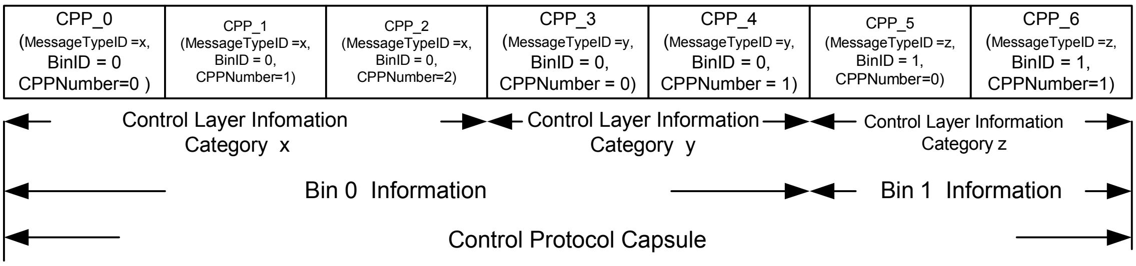

Figure 2.2.5.1.1-2 Example of Control Protocol Capsule Structure

Two 16-bit sequence numbers, namely Bin0_ControlSequenceNumber and Bin1_ControlSequenceNumber, are maintained for each Control protocol capsule. These identify the collective state of all CPPs belonging to Bin 0 and Bin1 in each Control protocol capsule.

If the Control information spans multiple capsules (up to a maximum of 7), it is transmitted over multiple superframes. The CPPNumbers associated with a MessageTypeID are not reset at Control protocol capsule boundaries. The Control protocol capsules are delivered to (network) and received from (device) the Control Channel MAC protocol in increasing order of ControlCapsuleID values.

2.2.5.1.2 Command Processing

2.2.5.1.2.1 Activate (device only)

If this protocol receives the *Activate* command in the Active State, it shall ignore it.

If the protocol receives an *Activate* command in the Inactive State:

- The device shall transition to the Active State.

2.2.5.1.2.2 Deactivate (device only)

If this protocol receives the *Deactivate* command in the Inactive State, it shall ignore it.

If the protocol receives a *Deactivate* command in the Active State:

- The device shall transition to the Inactive state.

2.2.5.1.2.3 UpdateControlInfo

If the protocol receives this command in the Active State,

- The network shall update the Control information from the Upper layer and return an *UpdateComplete* indication to the Upper layer.

2.2.5.1.2.4 SendControlChannelMACPayload

If the protocol in the network receives this command, it shall deliver a Control protocol capsule to the Control Channel MAC protocol for transmission in the next superframe.

2.2.5.1.3 Inactive State

When the protocol is in the Inactive State, the device shall wait for an *Activate* command.

2.2.5.1.4 Active State

2.2.5.1.4.1 Forward Link Only Network Requirements

The Control protocol shall process the Control information as follows:

- The control protocol shall form one or more Control protocol messages to carry the Control information.
- Control protocol messages shall be assigned to one of two bins, namely Bin0 and Bin1. The exact assignment of messages to bins is implementation dependent[4].
- The Control protocol message size shall be selected so that a complete Control protocol message shall be contained within the payload of a Control protocol packet. If the size of the Control protocol message is less than the size of the CPP payload, unoccupied bits in the payload shall be filled with PadByte specified in 2.2.5.2.3.
- An integer number of CPPs shall be concatenated to form a Control protocol capsule for transmission over one superframe.
- If the CPPs needed to transmit Control information exceed the payload available in a single superframe, CPPs shall be distributed across multiple Control protocol capsules, which are sent over multiple superframes.
- If the CPPs needed to transmit Control information do not fully occupy the payload available in a superframe, the Control protocol shall form additional CPPs with Filler message as per the format specified in 2.2.5.2.2.3. The number of CPPs containing Filler message shall be such that the resulting Control protocol capsule fully occupies the payload for the superframe.
- In forming the Control protocol capsule,
    - First the CPPs having the same message IDs shall be grouped together in the ascending order of CPPNumber.
    - Next, the CPPs with the same BinID shall be grouped together.
    - Next, the CPPs containing the Filler message shall be included. In the CPPs carrying Filler message, the BinID is not relevant, since these messages do not belong to any bin.
- The protocol shall assign a 3-bit ControlCapsuleID to each Control Channel MAC protocol capsule.
- The Control capsules shall be forwarded to the Control Channel MAC protocol in the ascending order of ControlCapsuleID. The maximum assigned value of ControlCapsuleID determines the number of superframes used to transmit the entire Control information once.
- For each ControlCapsuleID, the protocol shall maintain two 16-bit sequence numbers, namely Bin0_ControlSequenceNumber and Bin1_ControlSequenceNumber. These identify all the CPPs belonging to Bin0 and Bin1 in each Control protocol capsule. If any of the CPPs in any bin in a control protocol capsule change, the ControlSequenceNumber for that bin in the capsule shall be incremented by 1 (modulo 2^{16}) and the protocol shall send a *ToggleSystemParameterUpdateFlag* command to the Data Channel MAC protocol.

Upon receiving a *SendControlChannelMACPayload* command from the Control Channel MAC protocol, the control protocol shall perform the following (order not mandatory)

- Send an *UpdateControlCapsuleID* command to the OIS MAC protocol, if there is any change in the assigned ControlCapsuleID.
- Send a *ToggleSystemParametersUpdateFlag* command to the Data Channel MAC protocol, if either Bin0_ControlSequenceNumber or Bin1_ControlSequenceNumber in the control protocol capsule has changed.

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[4] One example of the division criteria is to assign Control protocol messages expected to change frequently to one bin, and assigning the infrequently changing Control protocol messages to other bin. The control protocol capsule may contain CPPs only from one control bin.

- Issue an *UpdateControlSequenceNumber* command to the OIS MAC protocol, if either Bin0_ControlSequenceNumber or Bin1_ControlSequenceNumber in the control protocol capsule has changed.
- Forward the Control protocol capsule to the Control Channel MAC protocol for transmission in the next superframe.

2.2.5.1.4.2 Forward Link Only Device Requirements

In Active State, the control protocol shall do the following:

- If the control sequence number that has changed corresponds to one of the two bins of the capsule being transmitted in the current superframe, the Control protocol shall send an *Activate* command to the Control Channel MAC protocol.
- Upon receiving a *ControlChannelDataAvailable* indication from the Control Channel MAC protocol, the control protocol shall process the Control protocol capsule as follows:
    - It shall maintain a list of correctly received CPPs for every MessageTypeID, except for the Filler message. The protocol shall discard all the CPPs containing Filler messages.
    - If all CPPs in the capsule are not received, the control protocol shall wait for the Control Channel MAC protocol to receive this Control protocol capsule again
    - It shall update the list of correctly received CPPs for every MessageTypeID. This shall be repeated till all the CPPs are correctly received[5].
    - The correctly received CPPs shall be extracted. The message part of the CPP shall be used to refresh the Control protocol public data.
    - When all the CPPs in a control protocol capsule have been successfully received, update the stored Bin0 and Bin1 control sequence numbers for that capsule with the revised sequence numbers available as public data from the OIS Channel MAC protocol.
    - When all the CPPs in all the control protocol capsules have been successfully received, the control protocol shall send a *Deactivate* command to the Control Channel MAC protocol and *ControlInfoUpdated* command to the Stream layer.
- The Control protocol shall process the Control protocol packet as follows:
    - The length of the CPP header is indicated by the CPPHdrLength field of the SystemParameters message (see 4.2.5.1). Following this header the Control protocol message is located. The device shall ignore any unused portion of the CPP header after the device has processed all the valid fields in this header.
    - Upon extracting the Flow Description message from the CPPs, it shall update the relevant parameters in the Control protocol public data (see 2.2.2.3).
    - Upon extracting the Extended Flow Description message from the CPPs, it shall update the relevant parameters in the Control protocol public data (see 2.2.2.3).
    - Upon extracting the Extended Neighbor List Description message from the CPPs, it shall update the relevant parameters in the Control protocol public data (see 2.2.2.3).
    - Upon extracting the Forward Link Only Messaging Transport Fragment message from the CPPs, it shall update the relevant parameters in the Control protocol public data (see 2.2.2.3).

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[5] In some implementation the device may choose to give up trying to receive the CPPs without errors. It may then attempt it next time the SystemParameters message is read.

2.2.5.2 Header and Message Formats

2.2.5.2.1 Control Protocol Packet Header

The Control protocol shall set the Control protocol packet header as shown in Table 2.2.5.2.1-1:

Table 2.2.5.2.1-1: Control protocol packet header specs

Field	Length (bits)
Fill	0 or 8
MessageTypeID	8
Bin ID	1
CPPNumber	8
TotalCPPCount	8
NumPadBytes	7

Fill[6]	Filler field for Control Channel MAC protocol header. This field shall be present for the first CPP in a Control protocol capsule and shall be set to zero. Otherwise, this field shall be omitted.
MessageTypeID	The message type identifier. It shall be set based on the type of information this message carries. The valid values are listed in Table 2.2.5.2.1-2.

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[6] Control Channel MAC protocol overwrites this field with the Control Channel MAC Layer capsule Header as described in 4.4.4.4.1

Table 2.2.5.2.1-2 MessageTypeID Field Values

Value	Meaning
0x00	Flow Description message
0x01	Not available for use
0x02	Not available for use
0x03	Filler message
0x04	Extended Neighbor List Description Message
0x05	Forward Link Only Messaging Transport Fragment [4]
0x06	Extended Flow Description Message
0x07-0xEE	Reserved for future use
0xEF-0xFF	Not available for use

BinID	This corresponds to one of the two logical Control protocol Bins to which the message carried in the CPP payload is assigned by the network. The network shall set this field to the bin identifier (0 or 1) for the content carried in the CPP. If the MessageTypeID field is 0x03 (Filler message), this field may be assigned any value and is ignored by the device.
CPPNumber	A unique number assigned to the CPP associated with the Control protocol information identified by the MessageTypeID for this Bin. The network shall set its value ranging from 0 through TotalCPPCount - 1.
TotalCPPCount	The total number of CPPs that are associated with the Control protocol information identified by the MessageTypeID for this Bin. Network shall set this field to the total number of CPPs carrying the messages of MessageTypeID.
NumPadBytes	The number of padding bytes included in this CPP. The network shall set this field to the number of PadBytes as specified in 2.2.5.2.3 carried in the CPP.

2.2.5.2.2 Control Protocol Messages

The following messages are defined for the Control protocol.

2.2.5.2.2.1 Flow Description Message and Extended Flow Description Message

The Flow Description message and the Extended Flow Description message have the same format.

The Flow Description message shall include the flow description information of flows that are assigned to MLCs configured with the transmit modes 0 through 4 and 6 through 11 (see 5.2.2.6), and whose MLC locations are listed in the MLC Records Table in the SystemParameters message of the OIS (see 4.2.5.1)[7].

The Extended Flow Description message shall include the flow description information of flows that are assigned to MLCs configured with the transmit modes 64 through 72 and 80 through 91 (see 5.2.2.6). The location of the MLCs associated with these flows are listed in the Extended MLC Records Table in the SystemParameters message of the OIS (see 4.2.5.1).

The Extended Flow Description message shall also include the flow description information of flows that are assigned to MLCs configured with the transmit modes 0 through 4 and 6 through 11 (see 5.2.2.6), and whose MLC locations are listed in the Extended MLC Records Table in the SystemParameters message of the OIS (see 4.2.5.1) [8].

The Flow Description Message and the Extended Flow Description Message have the following format:

Field	**Length (bits)**
CPPHeader	32 or 40
FlowBlobLength	8
FlowCount	7
Reserved0	1

FlowCount occurrences of the remaining fields

FlowID_bits_4_thru_19_SameAsBefore	1
FlowID_bits_4_thru_19	0 or 16
FlowID_bits_0_thru_3	4
RFChannelID	8
MLCIDSameAsBefore	1
MLC_ID	0 or 8
TransmitMode_Field1	0 or 4
TransmitMode_Field2	0 or 4
FlowBlob	FlowBlobLength
StreamID	2
StreamResidualErrorProcessing	2
StreamUsesBothComponents	1

Reserved1	Variable (0-7)

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[7] The flows described in the Flow Description Message are the flows that are decodable by devices compliant with previous revisions of this specification.

[8] The flows described in the Extended Flow Description Message are the flows that are either carried by MLCs configured with PHY Type 2 transmit modes, or that are carried by MLCs configured with PHY Type 1 transmit modes but whose location records are specified in the Extended MLC Records Table.

CPPHeader	The CPP header shall be set as described in 2.2.5.2.1.
FlowBlobLength	Length of the FlowBlob (flow information block) field. The network shall set this field to the size of the FlowBlob field included in this message in integer number of bits.
FlowCount	The number of flows described by the CPP. The network shall set this field to number of flows that follow this field in the Flow Description message CPP.
Reserved0	This field shall be set to 0.
FlowID_bits_4_thru_19_SameAsBefore	Flag to indicate if the FlowID_bits_4_thru_19 field for this flow is the same as the previous flow. The network shall set this field to ‘0’ for the first flow in the Flow Description message CPP. Otherwise, if a flow described in a CPP has the same FlowID_bits_4_thru_19 as the previous flow, this field shall be set to ‘1’.
FlowID_bits_4_thru_19	This field contains the upper-16 bits (bits 4 through 19) of the identifier (FlowID) for the flow. If FlowID_bits_4_thru_19_SameAsBefore field is set to ‘1’, the network shall omit this field. Otherwise, this field shall be set to the upper 16-bits of the flow ID.
FlowID_bits_0_thru_3	The network shall set this field to the lower 4-bits of the FlowID.
RFChannelID	Identifier for the RF Channel carrying the flow. The details of RFChannelID are carried in Extended Neighbor List Description Message (see 2.2.5.2.2.2).
MLCIDSameAsBefore	Flag to indicate if MLCID for this flow is same as the previous flow. The network shall set this field to ‘0’ for the first flow in the Flow Description message CPP. Otherwise, if this flow has the same MLC ID as the previous flow, this field shall be set to ‘1’.
MLC_ID	If MLCIDSameAsBefore field is set to ‘1’, the network shall omit this field. Otherwise, this field shall contain a unique identifier of the MLC.
TransmitMode_Field1	If MLCIDSameAsBefore field is set to ‘1’, the network shall omit this field. Otherwise, if the MLC is configured with a PHY Type 1 transmit mode, the network shall set this field to the PHY Type 1 Physical layer transmit mode used to transmit the MLC. Values for the PHY Type 1 Physical layer transmit modes are listed inTable 5.2.2.6-2. If the MLC is configured with a PHY Type 2 transmit mode, the network shall set this field to the 4 least significant bits of the PHY Type 2 Physical layer transmit mode used to

transmit the MLC. Values for the PHY Type 2 Physical layer transmit modes are listed in Table 5.2.2.6-3.

TransmitMode_Field2	If MLCIDSameAsBefore field is set to ‘1’, the network shall omit this field. Otherwise, if the MLC is configured with a PHY Type 1 transmit mode, the network shall set this field according to the outer code rate applied to the MLC. Values for this field are listed in Table 2.2.5.2.2.1-1. If the MLC is configured with a PHY Type 2 transmit mode, the network shall set this field to the 4 most significant bits of the PHY Type 2 Physical layer transmit mode used to transmit the MLC. Values for the PHY Type 2 Physical layer transmit modes are listed in Table 5.2.2.6-3.

Table 2.2.5.2.2.1-1 TransmitMode_Field2 Values for MLCs Configured with PHY Type 1

Value	Meaning
‘0000’	None
‘0001’	Reed-Solomon encoding rate 7/8
‘0010’	Reed-Solomon encoding rate ¾
‘0011’	Reed-Solomon encoding rate ½
All other values are reserved for future use.	

FlowBlob	This field carries the flow information used by the upper layers. The network shall set this field as per the requirements of upper layers.
StreamID	This 2-bit field is the stream identifier. The network shall set this field to the values specified in Table 2.2.5.2.2.1-2

Table 2.2.5.2.2.1-2 StreamID Field Values

Value	Meaning
‘00’	Stream 0
‘01’	Stream 1
‘10’	Stream 2
All other values are reserved for future use.	

StreamResidualErrorProcessing	This field specifies the Stream layer residual error processing at the device (see 3.2.1). The network shall set this field as per the values listed in Table 2.2.5.2.2.1-3

Table 2.2.5.2.2.1-3 StreamResidualErrorProcessing Field Values

Value	Meaning
‘00’	None
‘01’	Drop
All other values are reserved for future use.	

StreamUsesBothComponents

This field specifies if stream contains both the enhancement and base components or just the base component. The network shall set this field to ‘0’ if stream contains only the base component. The network shall set this field to ‘1’ if stream contains both the base and enhancement components. If the MLC that this stream belongs to is using a non-layered transmit mode, then the network may set this field to any value and this field is ignored by the device.

Reserved — This variable length field is added to make the Flow Description message octet aligned. This field shall be set to 0.

2.2.5.2.2.2 Extended Neighbor List Description Message

This message carries the infrastructure parameters of the neighboring LOIs for a given LOI. The message shall have the following format:

Field	Length (bits)
CPPHeader	32 or 40
SPCInfoLength	5
Reserved0	3
LOICount	8

LOICount occurrences of the following LOI record

ReferenceLOI_ID	16
NeighborLOICount	6

NeighborLOICount occurrences of the following NeighborLOI record

Neighbor_LOI_SameAsReferenceLOI	1
NeighborLOI_ID	0 or 16
FrequencyCount	4

FrequencyCount occurrences of the following Frequency Record

RFChannelID	0 or 8
Frequency	29
ChannelPlan	3
SPCInfo	SPCInfoLength
WID	4
LID	4

Reserved1	Variable (0-7)

CPPHeader	The CPP header shall be set as described in 2.2.5.2.1.
SPCInfoLength	Length of the SPCInfo field. Network shall set this field to the size of the SPCInfo field included in this message in integer number of bits. Allowed values for this field are 0, 3, 5, 8, 10, and 12-16.
Reserved0	This field shall be set to 0.
LOICount	The number of Local-area Operational Infrastructure records included in this message. The network shall set this field to the number of LOI records included in the message.
ReferenceLOI_ID	This field contains the ID of the Local-area Operational Infrastructure associated with this LOI Record. The network shall set this field to the identifier assigned to the Local-area Operational Infrastructure.
NeighborLOICount	The number of NeighborLOI records included in the LOI record. The list of NeighborLOI records includes records for the neighboring LOIs of associated ReferenceLOI_ID as well as a record for the ReferenceLOI_ID itself. The network shall set this field to the number of NeighborLOI records included in the LOI record.
Neighbor_LOI_SameAsReferenceLOI	Flag to indicate whether NeighborLOI_ID represents the LOI identified by the ReferenceLOI_ID in associated LOI record. The network shall set this flag to ‘1’ if the NeighborLOI record describes the LOI identified by the ReferenceLOI_ID in associated LOI record. Otherwise, the network shall set this flag to ‘0’.

NeighborLOI_ID	This field contains the ID of the Local-area Operational Infrastructure which is neighbor to the LOI identified by the ReferenceLOI_ID in associated LOI record. The network shall omit this field if Neighbor_LOI_SameAsReferenceLOI flag is set to ‘1’, because in that case the NeighborLOI_ID will be same as ReferenceLOI_ID in associated LOI record.
FrequencyCount	The number of Frequency records included in the NeighborLOI record. The network shall set this field to the number of Frequency records included in the NeighborLOI record. If a given LOI is included as neighbor LOI more than once in this message, the network should include Frequency records only once for that LOI to optimize bandwidth. If this optimization is supported, the network shall set the FrequencyCount field to ‘0’ for all those occurrences of that LOI which do not specify Frequency records. The network shall always include Frequency records for the NeighborLOI record corresponding to the LOI identified by the ReferenceLOI_ID in associated LOI record. If FrequencyCount field is set to ‘0’, device shall determine Frequency records for associated neighbor LOI from its occurrence in other parts of this message.
RFChannelID	The network shall include this field only if Neighbor_LOI_SameAsReferenceLOI field is set to ‘1’. This field is a unique identifier for the RF Channel (Frequency and Channel Plan) in the local area specified by the ReferenceLOI_ID.
Frequency	The network shall set this field to the frequency offset from 0 Hz to the carrier center frequency in units of 50 Hz. This is calculated by the equation below: Frequency = C/50, where C is the carrier center frequency in Hz. The carrier center frequency range supported is from 0 Hz to 26.84354555 GHz ($(2^{29}-1)$ x 50 Hz).
ChannelPlan	The network shall set this field to the channel plan (or Channel Bandwidth) associated with the FLO RF identified by the Frequency field. The values for this field are listed in Table 2.2.5.2.2-4.

Table 2.2.5.2.2-4 ChannelPlan Field Values

Value	Meaning
‘000’	5 MHz channel
‘001’	6 MHz channel
‘010’	7 MHz channel
‘011’	8 MHz channel
	All other values are reserved for future use.

SPCInfo	This field conveys the SPC parameters (see 5.2.2.10.1.7) associated with the RF identified by the Frequency field. The network shall omit this field if SPCInfoLength field is set to ‘0’. When present, the network shall set this field to the SPCInfoLength number of LSB bits of the 16 bits SPC payload (see Table 5.2.2.10.1.6.3.7-1) associated with the RF identified by the Frequency field. This field can be of bit size 0, 3, 5, 8, 10, 12, or more (up to a maximum of 16 bits). Currently only 0, 3, 5, 8, 10, and 12 bit long SPCInfo field are defined. A 3 bit SPCInfo field conveys $FGI_{Fraction}$ parameter. A 5 bit SPCInfo field conveys $FGI_{Fraction}$ and Slot to Interlace mapping parameters. An 8 bit SPCInfo field conveys $FGI_{Fraction}$, Slot to Interlace mapping, and FFT size parameters. A 10 bit SPCInfo field conveys $FGI_{Fraction}$, Slot to Interlace mapping, FFT size parameters, and the data channel Physical layer types of the superframe. A 12 bit SPCInfo field conveys $FGI_{Fraction}$, Slot to Interlace mapping, FFT size parameters, the data channel Physical layer types of the superframe, and the PPC status.
WID	The network shall set this field to the Wide-Area Differentiator associated associated with the RF identified by the Frequency field.
LID	The network shall set this field to the Local-Area Differentiator associated with the RF identified by the Frequency field.
Reserved1	This is a variable length field added to make the Extended Neighbor List Description message octet aligned. Network shall set the bits in this field to ‘0’.

2.2.5.2.2.3 Forward Link Only Messaging Transport Fragment

This message type is used to carry Forward Link Only Messaging Transport fragments as defined in [4].

2.2.5.2.2.4 Filler Message

This message is used to fill the unused portion of the Control protocol capsule payload after all the Control protocol messages carrying Control information have been included.

This message does not belong to any bin. Therefore the BinID field in the CPP header of this message is included but not used. The NumPadBytes field in the CPP header of this message shall be set to 0.

Field	**Length (bits)**
CPPHeader	32 or 40
FillerOctets	944 or 936

CPPHeader	The CPP header shall be set as described in 2.2.5.2.1.
FillerOctets	The network shall set all the bits in this field to ‘0’.

FillerOctects length shall be 936 bits if the Filler message is the first message in the Control Protocol Capsule; otherwise it shall be 944 bits. The corresponding CPPHeader length shall be 40 and 32, respectively.

2.2.5.2.3 PadByte

The control protocol in the network shall add sufficient padding octets to fill any unoccupied portion of the CPP. The format of PadByte is as follows:

Field	**Value**
PadByte	0x00

No text.

3 STREAM LAYER

3.1 Introduction

The Stream layer resides between the MAC layer and the Upper/Application layer in the Forward Link Only protocol stack (see Figure 1.6.2-1). Data from the Upper layer is carried in one or more flows. The Stream layer provides access to the Forward Link Only Air Interface protocol stack for the flows to and from the Upper layer. A flow can consist of one component (referred to as the base component) or two components (referred to as base and enhancement components). When a flow has two components, the enhancement component is tightly coupled with the base component. For example, both components are addressed using the same flow ID, are delivered to the same Upper layer entity in the device and receive the same delay and error treatment in the Stream layer.

The primary function of the Stream layer is to multiplex/demultiplex up to three flows to/from a single MLC.

3.1.1 General Overview

The Stream layer provides the following functions:

- Provides an interface to bind Upper layer flows to streams in an MLC. Each MLC can support three independent data streams.
- Multiplexes up to three flows from the Upper layer into one MLC.
- Accommodates delay constraints of an Upper layer flow.
- Provides for residual error handling for an Upper layer flow.
- Provides for independent handling of base and enhancement components of an Upper layer flow.

3.2 Stream Protocol

3.2.1 Overview

The Stream protocol provides the functionality of the Stream layer. It multiplexes Upper layer flows into a single MLC. These Upper layer flows are transported as “streams” in an MLC. Up to three streams (referred to as stream 0, 1 and 2) are multiplexed into one MLC. Stream 0 is always present in an MLC if there is flow data to be sent for stream 1 and/or stream 2. In other words, if there is no flow data to be sent for any of the streams, stream 0 is not sent.

An Upper layer flow can consist of a base component and an enhancement component. If both components are present, both components are carried by the same stream. Stream 0 only carries a base component even when the associated MLC is configured for a layered transmit mode (see 5.2.2.6). The other two streams (streams 1 and 2) can carry both base and enhancement components. When a stream carries an enhancement component, the Upper layer for that flow is required to exactly match the sizes of the base and enhancement components.

The Stream protocol supports two interface modes:

- Octet flow mode in which the Stream protocol in the network receives a stream of octets from the Upper layer and the peer protocol in the device delivers a stream of octets.
- Transparent or Block flow mode in which the Stream protocol in the network receives a stream of fixed sized octet blocks and the peer protocol in the device delivers these fixed sized octet blocks to the Upper layer.

The Stream protocol provides the TransparentModeFlag attribute to select the interface mode for each Upper layer flow. When this attribute is set to ‘1’, the Stream protocol receives a stream of fixed, 122 octet blocks, each of which is carried by a separate Physical layer packet. This allows the Upper layer visibility to packet boundaries at the lower Forward Link Only protocol layers. This Transparent or Block flow mode (also referred to as the block-oriented mode) is only supported for streams 1 and 2.

If the TransparentModeFlag attribute is set to '0' for a flow, the Stream protocol processes the data from the Upper layer flow as a stream of octets. This interface is appropriate if the Upper layer is not concerned with the formation of lower layer packets. Stream 0 always uses this Octet flow mode (also referred to as the octet-oriented mode).

Streams 1 and 2 use either of the two modes, the Block flow mode or the Octet flow mode.

The Stream protocol provides an interface to specify Stream layer residual error processing for an Upper layer flow using the ResidualErrorProcessing attribute. This selection applies to both the base component and the enhancement component (when present) of a flow. Choices include:

- None – specifies that the flow carried by the stream is to be delivered to the Upper layer entity with no additional processing. Octets of the flow received in packets containing errors are delivered to the Upper layer entity.
- Drop – specifies that the octets of the flow received in packets containing errors are to be discarded. The MAC layer at the device indicates a MAC layer packet error based on the FCS (see 5.1.4) of the MAC layer packet, post RS decoding (see 4.6).

The Stream protocol provides an interface to specify delay constraints for an Upper layer flow. The delay constraint is specified in terms of three attributes, namely DelayConstraintType, DelayConstraintValue and StreamElasticity:

- DelayConstraintType specifies the delay constraint type for a flow. This selection applies to both the base component and enhancement component (when present) of a flow. Choices include:
    - RealTime – specifies that the flow be delayed by a constant value.
    - MaxDelay – specifies that the flow have a maximum delay constraint.
    - None – specifies that the flow be sent only when extra MLC bandwidth is available.
- DelayConstraintValue specifies the value of the delay constraint for an Upper layer flow when DelayConstraintType is RealTime or MaxDelay.
- StreamElasticity specifies how to handle the flow when the delay constraints cannot be met. This selection applies to both the base and enhancement (when present) components of a flow. Choices include:
    - Elastic – specifies that the source reduces the data rate upon request.
    - Drop – specifies that flow octets can be dropped.
    - Fragment – specifies that all or part of the octets can be delayed.

This document assumes that there is one instance of this protocol in the network for each active Data Channel MLC. In the device there is one instance of this protocol for each MLC that the device is decoding.

This protocol operates in one of two states:

- Inactive State: In this state the protocol waits for an *Activate* command.
- Active State: In this state the protocol in the network packetizes up to three flows, multiplexes these packets for transmission in the associated MLC and sends them to the MAC layer. The protocol in the device receives Stream layer packets from the MAC layer, handles residual transmission errors and delivers the resulting octet or octet block flows to the Upper layer.

The protocol states and allowed transitions between the states are shown in Figure 3.2.1-1.

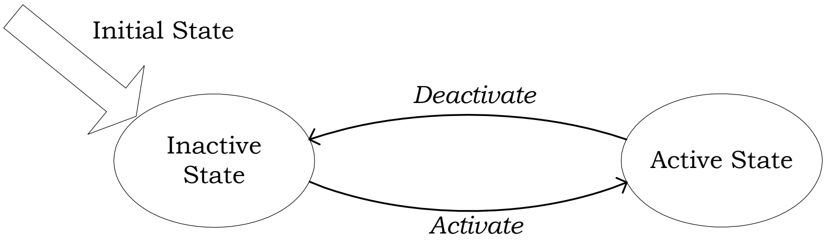

Figure 3.2.1-1 Stream Protocol State Diagram

3.2.2 Primitives and Public Data

3.2.2.1 Commands

The Stream protocol defines the following commands:

- *Activate*
- *Deactivate*
- *ReadyStreamPackets* (network only)
- *SendPackets* (network only)
- *ReceiveOctets* (network only)

3.2.2.1.1 Activate command

The *Activate* command causes the protocol to transition to the Active State. This command incorporates the following parameters:

- FlowIDs bound to streams 0, stream 1 and stream 2 (if applicable).
- For each FlowID the network includes the following attributes
    - Associated StreamID
    - ResidualErrorProcessing
    - DelayConstraintType
    - DelayConstraintValue
    - StreamElasticity
    - TransparentModeFlag
    - StreamUsesBothComponents[9].

3.2.2.1.2 Deactivate

This command causes the protocol to transition to the Inactive State.

3.2.2.1.3 ReadyStreamPackets (network only)

The *ReadyStreamPackets* command causes the protocol at the network to calculate the total quantity of data across all streams that have data ready to transmit for the next superframe. If both base and enhancement components are present in a flow, the protocol takes into

---

[9] This attribute indicates if the associated stream carries both the base and the enhancement components, as opposed to only the base component.

account only the number of octets required by the base component. It returns the total quantity of data across all streams in units of 122 octet blocks.

3.2.2.1.4 SendPackets (network only)

The *SendPackets* command causes the protocol at the network to send stream packets for all the streams associated with the Stream protocol to the associated Data Channel MAC layer protocol instance. This command supports the following parameters:

- Total number of 122 octet blocks available to the MLC

3.2.2.1.5 ReceiveOctets (network only)

The *ReceiveOctets* command causes the protocol at the network to receive data from one of the bound Upper layer flows. This command supports the following parameters:

- StreamID
- Number of octets
- Pointer to buffer containing the octets
- Data type (For layered MLC identifies if base or enhancement octets)

3.2.2.2 Return Indications

This protocol defines the following return indications:

- *OctetsReceived* (device only)
- *OctetsDropped*

3.2.2.2.1 OctetsReceived

The protocol in the device issues this indication when it has received and processed data for a bounded Upper layer flow.

This indication contains the following parameter:

- StreamID

3.2.2.2.2 OctetsDropped

The protocol in the network issues this indication when it drops octets received from an Upper layer flow due to insufficient air-link resources.

The protocol in the device issues this indication when it drops octets received in packets with unrecoverable errors.

This indication contains the following parameter:

- StreamID

3.2.2.3 Public Data

This protocol does not make any data public.

3.2.3 Protocol Data Unit

The protocol data unit for this protocol is a Stream layer packet. The Stream protocol processes one Stream layer packet for each stream included in each superframe.

3.2.4 Procedures

3.2.4.1 Data Encapsulation

Figure 3.2.4.1-1 illustrates the relationship between Upper layer flows and Stream layer packets for stream 0. The flow carried by stream 0 is always octet-oriented, is always the last stream in the superframe and only carries a base component.

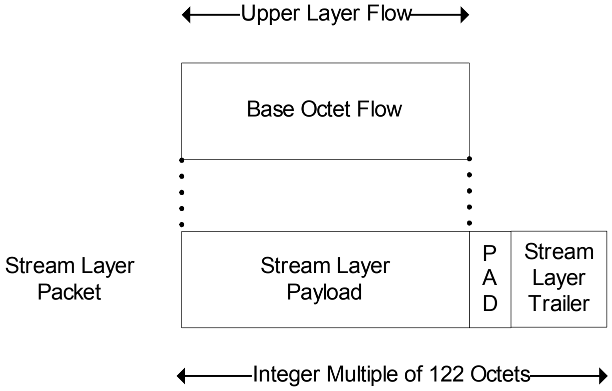

Figure 3.2.4.1-1 Stream Layer Encapsulation for Stream 0

Figure 3.2.4.1-2 illustrates the relationship between Upper layer flow and Stream layer packet for the case when a block-oriented flow with only a base component is carried by stream 1 or stream 2.

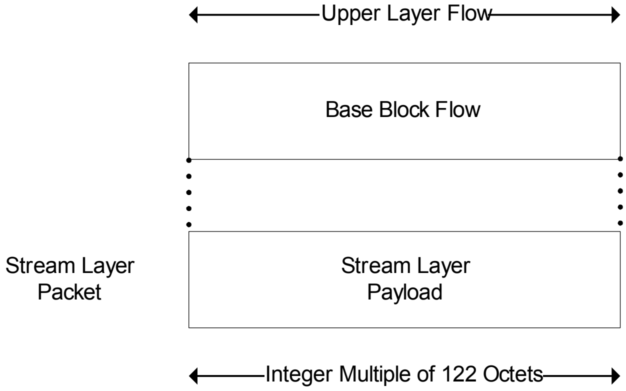

Figure 3.2.4.1-2 Stream Layer Encapsulation for Stream 1 or 2 Carrying a Block-oriented Flow with a Base Component Only

Figure 3.2.4.1-3 illustrates the relationship between Upper layer flow and Stream layer packet for the case when a block-oriented flow with both base and enhancement components is carried by stream 1 or stream 2.

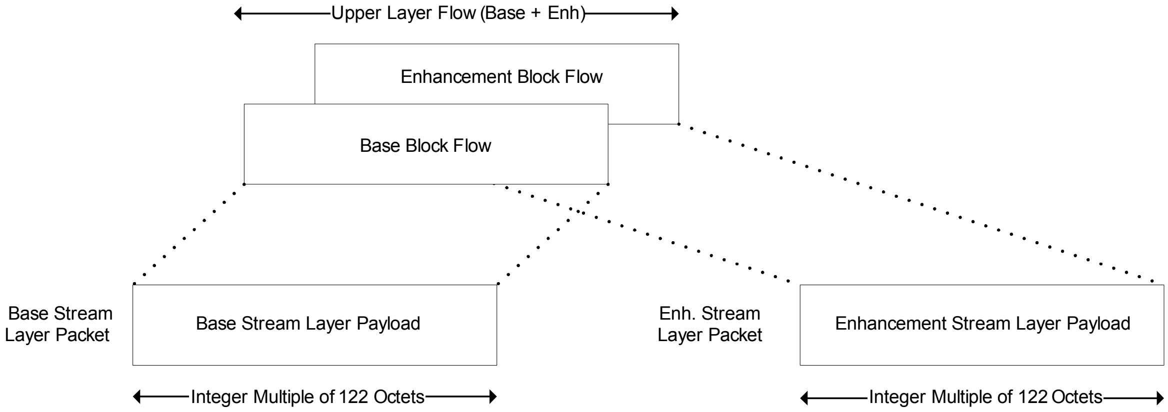

Figure 3.2.4.1-3 Stream Layer Encapsulation for Stream 1 or 2 Carrying a Block-oriented Flow with Both Base and Enhancement Components

Figure 3.2.4.1-4 illustrates the relationship between Upper layer flow and Stream layer packet for the case when an octet-oriented flow with only a base component is carried by stream 1 or stream 2.

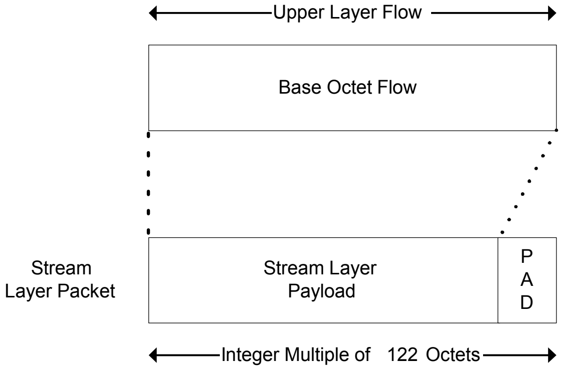

Figure 3.2.4.1-4 Stream Layer Encapsulation for Stream 1 or 2 Carrying an Octet-oriented Flow with a Base Component Only

Figure 3.2.4.1-5 illustrates the relationship between Upper layer flow and Stream layer packet for the case when an octet-oriented flow with both base and enhancement components is carried by stream 1 or stream 2.

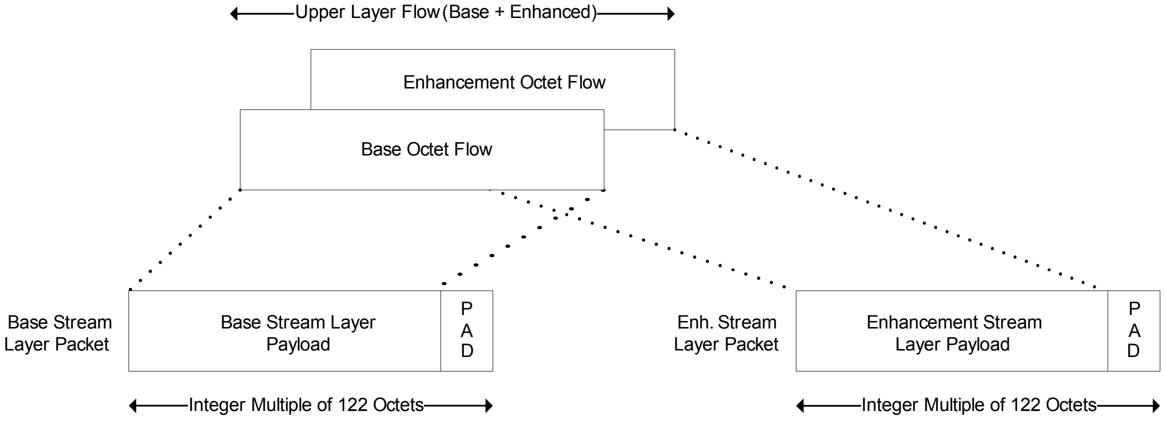

Figure 3.2.4.1-5 Stream Layer Encapsulation for Stream 1 or 2 Carrying an Octet-oriented Flow with Base and Enhancement Components

3.2.4.2 Packetization (network only)

In forming a Stream layer packet for a given flow the protocol shall satisfy the following requirement:

- If the Stream layer packet is for stream 0, the packet shall include the Stream layer trailer.
- If the Stream layer packet is for stream 1 or 2, it shall not include any trailer.
- In all cases, a Stream layer packet length shall be an integer multiple of 122 octets.

The protocol satisfies these sizing constraints by adding padding octets. Padding octets are only needed for streams using octet mode. Number of padding octets added for each stream shall be carried in the Stream layer trailer described in 3.2.5.1. The number of padding octets added to a stream carrying a block-oriented flow shall always be zero.

Correct operation of this protocol requires that the Upper layer entity provides equal amount of payload for base and enhancement component. This results in equal amount of padding for base and enhancement component.

3.2.4.3 Arbitration (network only)

The priority of each of the competing streams is a function of the delay constraints of the flows carried by that stream.

- A stream only carrying a flow with delay constraint of “None” shall always get lowest priority with ties resolved in a round-robin fashion
- A stream carrying a flow with a delay constraint of “max delay” shall get a lower priority than a stream carrying a flow with a “real-time” delay constraint except when the maximum delay constraint is in jeopardy of being violated.

When a flow delay constraint cannot be satisfied, the protocol can either discard (i.e., “Drop”) the Stream layer packet or request that the Upper layer entity reduce the size of the payload (“Elastic”) depending on the elasticity configuration of the flow. The protocol shall issue the *OctetsDropped* return indication if octets are dropped.

If the protocol can fit only part of the flow octets into the multiplex in any given superframe and the stream configuration allows fragmentation, fewer of the flow octets shall be sent.

3.2.4.4 Forward Link Only Network Requirements

The protocol in the network receives flows from the Upper layer and shall buffer them separately.

Upon receipt of the *ReadyStreamPackets* command the protocol shall do the following:

- Form one or two (if the flow has an enhancement component) Stream layer packets for each of the flows by executing the Packetization procedure 3.2.4.2.
- If there is no flow data for stream 0 but there is flow data for either stream 1 or stream 2, the stream protocol shall form a Stream layer packet for stream 0 by executing the Packetization procedure 3.2.4.2.
- Compute the quantity of data for all streams that have payload to send and return the amount of data in units of 122 octets to the Data Channel MAC protocol.

Upon receipt of *SendPackets* command (from the Data Channel MAC protocol), the protocol shall do the following:

- If the requested number of 122 octet blocks in the *SendPackets* command is not enough to send all Stream layer packets that are ready for transmission, the protocol shall perform the Arbitration procedure described in 3.2.4.3. Following the Arbitration procedure, the Packetization procedure (see 3.2.4.2) shall be performed.
- Next the fields in the Stream layer trailer (see 3.2.5.1) shall be populated and the protocol shall deliver the Stream layer packets to the associated Data Channel MAC protocol. The following parameters shall be conveyed to the Data Channel MAC protocol while delivering Stream layer packet(s) for each stream
    - StreamID
    - Whether the stream also provides enhancement component
    - Pointers to the buffers containing Stream layer packets - base and enhancement component (if applicable).

3.2.4.5 Forward Link Only Device Requirements

The Stream protocol at the device in the Active State receives Stream layer packets from the MAC layer along with the size of each packet. The protocol shall read the Stream layer trailer located at the end of the last Stream layer packet. The length of the Stream layer trailer is indicated by the StreamLayerTrailerLength field of the SystemParameters message (see 4.2.5.1). The device shall ignore any unused portion of the Stream layer trailer after the device has processed all the valid fields in this trailer.

The padding length for each stream is indicated by the Stream layer trailer.

Next the protocol shall process each Stream layer packet as follows:

- If the octets carrying the Stream layer trailer are not marked as suspect, it shall determine the Stream layer payload by discarding the padding octets indicated by the pad length field of the Stream layer trailer corresponding to the stream.
- If the octets carrying the Stream layer trailer are marked as suspect, it shall determine the length of the Stream layer payload by assuming no padding (122 octets). This can result in extra octets being passed up to the Upper layer entity; however, this only occurs at the end of the data received for a flow in a superframe.
- Put the number of octets resulting from the length of the Stream layer packet payload calculation above in an Upper layer interface buffer. Suspect octet indications shall also be put into the interface buffer.
- Issue the *OctetsReceived* return indication to convey that stream octets are ready.

If the stream was configured to carry both the base and enhancement components, the protocol shall perform the above procedure separately for the base and the enhancement component Stream layer packets. The padding length mentioned in Stream layer trailer is applicable to both the base and enhancement components.

If the protocol receives *ControlInfoUpdated* indication it shall verify if the change in Control information affects the MLC that is associated with this instance of Stream protocol. If so, the present association between the Stream protocol and that MLC shall be terminated and a new association with the correct MLC shall be instantiated.

3.2.5 Trailer Formats

3.2.5.1 Stream Layer Trailer

This Stream layer trailer is only present in the Stream layer packet for stream 0 to be sent in a given super frame. The format of Stream layer trailer is given in Table 3.2.5.1-1:

Table 3.2.5.1-1 Stream Layer Trailer

Field	**Length (bits)**
Stream0PadLength	7
Stream1PadLength	7
Stream2PadLength	7
Reserved	3
FillDataMACTrailer	56

Stream0PadLength	This field specifies the pad bytes added to the Stream 0 packet. The network shall set this field to the number of octets that were added as padding to the Stream 0 packet.
Stream1PadLength	This field specifies the pad bytes added to the Stream 1 packet. The network shall set this field to the number of octets that were added as padding to the Stream 1 packet.
Stream2PadLength	This field specifies the pad bytes added to the Stream 2 packet. The network shall set this field to the number of octets that were added as padding to the Stream 2 packet.
Reserved	This is a reserved field to make the trailer octet aligned. The network shall set this field to '000'.
FillDataMACTrailer	Filler field for Data Channel MAC protocol trailer. The size of this field is equal to the trailer specified in 4.3.5.1. The stream layer shall set this field to all zeroes.

3.2.5.2 Pad

The protocol in the network adds padding bytes as shown below.

Field	**Value**
PadByte	0x00

The Stream protocol in the network shall add pad octets to the end of a Stream layer packet as described in 3.2.4.2.

The Stream protocol in the device shall ignore these octets.

No text.

4 MAC LAYER

4.1 Introduction

The MAC layer defines the operation of Wide-area and Local-area OIS Channels, Wide-area and Local-area Control Channels and Data Channels. The MAC layer also multiplexes MLCs for transmission at the Forward Link Only network and de-multiplexes them at the Forward Link Only device. The MLC multiplexing function is described at a high level in 4.8. The MAC layer contains the following three protocols:

- OIS Channel MAC Protocol: This protocol contains the rules governing how the Forward Link Only network builds the messages transmitted in the OIS Channels and how the Forward Link Only device receives and processes these messages.
- Data Channel MAC Protocol: This protocol contains the rules governing how the Forward Link Only network builds the MAC layer packets for transmission of service carrying data on the Wide-area and Local-area Data Channels and how the Forward Link Only device receives and processes these packets.
- Control Channel MAC Protocol: This protocol contains the rules governing how the Forward Link Only network builds the MAC layer packets for transmission of Forward Link Only Control information on the Wide-area and Local-area Control Channels and how the Forward Link Only device receives and processes these packets.

The Data Channel and Control Channel are defined at the MAC layer. At the Physical layer both of these channel types are carried on the same Data Channel (see5.2.2.10).

4.1.1 Data Encapsulation

The content of an MLC for one superframe is encapsulated in an entity referred to as MAC protocol capsule. MAC protocol capsule is carried in MAC layer packets. One MAC layer packet is 122 octets in size, carries data that belongs to only one stream, and forms the payload of one Physical layer packet (PLP). The optional use of Reed-Solomon parity MAC packets depends on the transmit mode of the MLC (see 5.2.2.6).

4.1.1.1 OIS Channel MAC Protocol Encapsulation

Figure 4.1.1.1-1 depicts how the OIS Channel MAC protocol encapsulates the SystemParameters message. There is no OIS Channel MAC protocol header involved for OIS Channel encapsulation. The OIS Channel shall be configured for transmit mode 5. Reed-Solomon parity MAC packets are not present for mode 5.

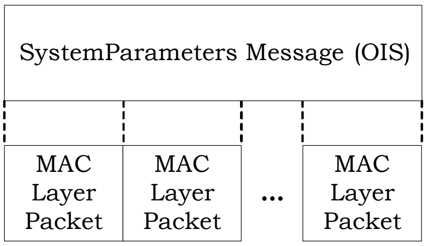

Figure 4.1.1.1-1 OIS Channel MAC Protocol Encapsulation

4.1.1.2 Data Channel MAC Protocol Encapsulation for MLCs Configured for Non-Layered Modes

Figure 4.1.1.2-1 depicts how the Data Channel MAC protocol encapsulates Stream layer packets within a Data Channel MAC protocol capsule. This figure is specific to an MLC carrying payload from all three streams and configured for non-layered transmit modes. The stream 0 packet contains the Stream layer trailer and an empty field that accommodates MAC capsule trailer. The Data Channel MAC protocol capsule is carried by multiple MAC layer packets. Reed-Solomon parity packets are optional for modes 0 through 4 depending on the configured Reed-Solomon outer code rate (see 2.2.5.2.2.1), and are not present for modes 64 through 72.

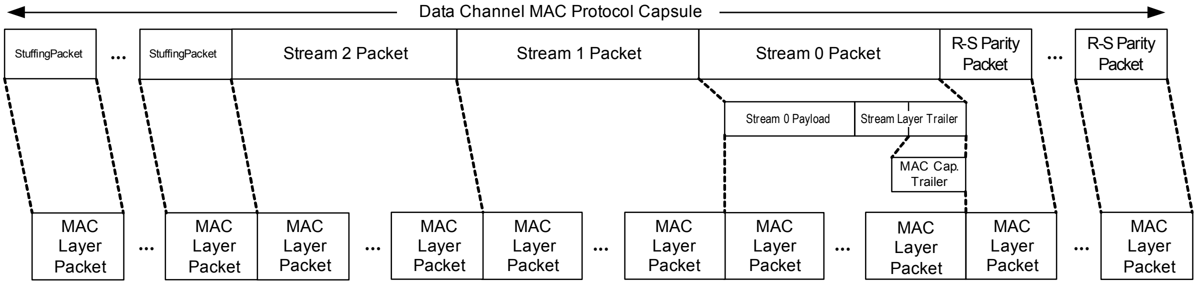

Figure 4.1.1.2-1 Data Channel MAC Protocol Encapsulation for Non-layered Transmit Mode

4.1.1.3 Data Channel MAC Protocol Encapsulation for Layered Modes

Figure 4.1.1.3-1 depicts how the Data Channel MAC protocol encapsulates Stream layer packets for base and enhancement components to form the Data Channel MAC protocol capsule. This figure is specific to a MLC configured for layered modes of operation with both stream 1 and stream 2 carrying a base component as well as an enhancement component. The base component Data Channel MAC protocol capsule encapsulates the base component of an MLC for one superframe. Similarly the enhancement component Data Channel MAC protocol capsule encapsulates the enhancement component of an MLC for one superframe. Reed-Solomon parity packets are optional for modes 6 through 11 depending on the configured Reed-Solomon outer code rate (see 2.2.5.2.2.1), and are not present for modes 80 through 91.

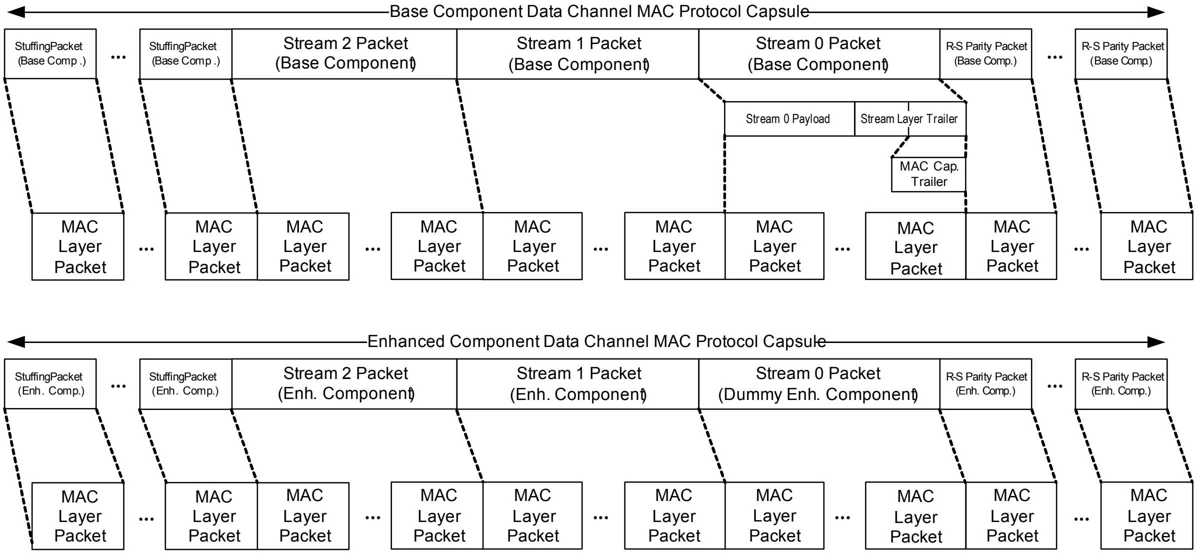

Figure 4.1.1.3-1 Data Channel MAC Protocol Encapsulation for Layered Transmit Mode

For stream 0, Stream layer packet provides information that is carried only in the base component Data Channel MAC protocol capsule. The Data Channel MAC protocol inserts dummy enhancement packets in the enhancement component Data Channel MAC protocol capsule corresponding to stream 0 packet. Details of this are described later in 4.3.4.5.1.

The size of the base component Data Channel MAC protocol capsule is exactly the same as the size of the enhancement component Data Channel MAC protocol capsule.

4.1.1.4 Data Channel MAC Protocol Encapsulation for the Control Channel

Figure 4.1.1.4-1 depicts how the Control Channel MAC protocol encapsulates Control protocol capsule within a Control Channel MAC protocol capsule. The Control Channel MAC protocol capsule is carried in multiple MAC layer packets. The MLC for the Control Channel is always configured for a non-layered mode of operation, that is, transmit modes 0 through 4, or transmit modes 64 through 72. Reed-Solomon parity packets are optional for modes 0 through 4, and are not present for modes 64 through 72.

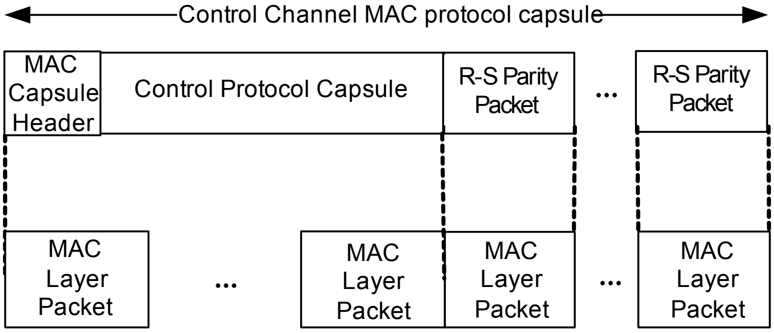

Figure 4.1.1.4-1 Control Channel MAC Protocol Encapsulation

4.1.2 Time Reference

All of the protocols in this chapter are specified with reference to a common time of the start of transmission of a superframe, T_{SF_Start} (in seconds), known as upcoming superframe when referred from the superframe starting at either $T_{SF\_Start} - 2$ as shown in Figure 4.1.2-1, or at $T_{SF\_Start} - 3$. The 1 or 2 second gap between the current superframe and the upcoming superframe depends on the network MLC multiplexing timing requirements (see 4.3.4.5.1).

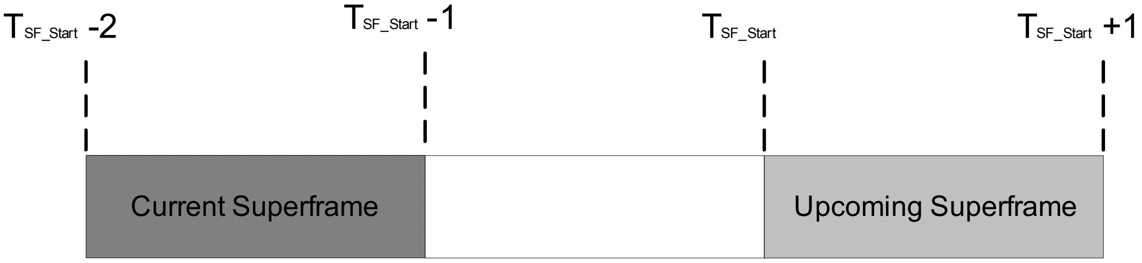

Figure 4.1.2-1 MAC Layer Procedure Time Reference

4.2 OIS Channel MAC Protocol

4.2.1 Overview

The OIS Channel MAC protocol provides the procedures and messages required for the network to build and transmit the contents of the Wide-area OIS Channel and the Local-area OIS Channel, and for the device to receive and process these contents. This document assumes that the network and each device have one instance of this protocol.

This protocol can be in one of the two states as shown in Figure 4.2.1-1:

- Inactive State: In this state the protocol waits for an *Activate* command. This state only applies to the device[10].
- Active State: In this state the network transmits and the device receives the OIS Channel.

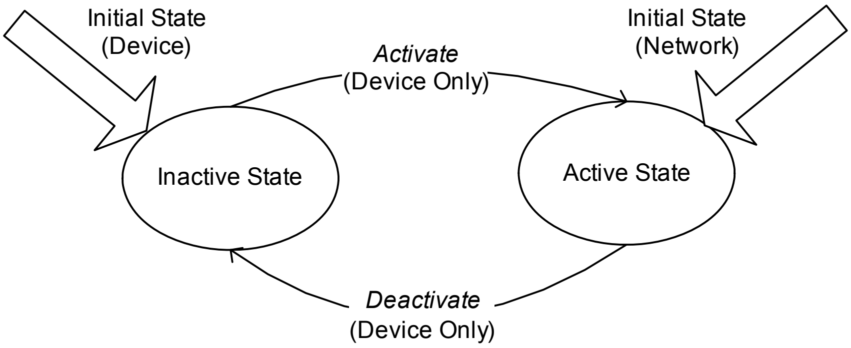

Figure 4.2.1-1 OIS Channel MAC Protocol State Diagram

4.2.2 Primitives and Public Data

4.2.2.1 Commands

This protocol defines the following commands:

- *Activate*
- *Deactivate*
- *AllocateMLC (network only)*
- *UpdateControlCapsuleID (network only)*
- *UpdateControlSequenceNumbers (network only)*

4.2.2.1.1 Activate

This command causes the protocol to transition to the Active state.

4.2.2.1.2 Deactivate

This command causes the protocol to transition to the Inactive state.

4.2.2.1.3 AllocateMLC

This command causes the protocol to update the MLC location information on the OIS Channels.

4.2.2.1.4 UpdateControlCapsuleID

This command causes the protocol to update the Control protocol capsule ID being transmitted on the OIS Channel.

---

[10] Inactive state occurs when the device has not acquired the network or is not monitoring the OIS Channel.

4.2.2.1.5 UpdateControlSequenceNumbers

This command causes the protocol to update the Control Sequence numbers being transmitted on the OIS Channel starting from the next superframe.

4.2.2.2 Return Indications

This protocol returns the following indications:

- *SupervisionFailed (device only)*
- *LocalArea_ParametersRefreshed (device only)*
- *WideArea_ParametersRefreshed (device only)*

4.2.2.2.1 SupervisionFailed

The protocol in the devices sends this indication when it is unable to monitor any message on the OIS Channel.

4.2.2.2.2 LocalArea_ParametersRefreshed

This indication is sent when the protocol updates the parameters in the OIS Channel MAC protocol Local-area public data.

4.2.2.2.3 WideArea_ParametersRefreshed

This indication is sent when the protocol updates the parameters in the OIS Channel MAC protocol Wide-area public data.

4.2.2.3 Public Data

This protocol shall make the following data public*:*

- All data in the SystemParameters message

4.2.3 Protocol Data Unit

The transmission unit of this protocol is a SystemParameters message described in 4.2.5.1.

4.2.4 Procedure and Messages

4.2.4.1 Protocol Initialization

The device shall start this protocol in the Inactive State.

The network shall start this protocol in the Active State.

4.2.4.2 Command Processing

4.2.4.2.1 Activate

If this protocol receives the *Activate* command in the Active State, the protocol shall ignore the command.

If the protocol receives an *Activate* command in the Inactive State:

- The device shall transition to the Active State.

4.2.4.2.2 Deactivate

If this protocol receives a *Deactivate* command in the Inactive State, the protocol shall ignore the command.

If this protocol receives the command in the Active State:

- The protocol in the device shall transition to the Inactive State.
- The protocol in the network shall ignore it.

4.2.4.2.3 AllocateMLC

If the protocol receives this command in the Active State, the protocol shall update the following fields of SystemParameters message (see 4.2.5.1) to be transmitted at T_{SF_Start}

- NumMLCRecords
- If the MLC is associated with a MLC Location Record (see 4.2.5.1), then for the corresponding MLC Location Record:
    - If MLCPresent=1,
        - StartOffset
        - SlotInfo
        - StreamLengths
    - If MLCPresent = 0,
        - NextSuperframeOffset
- If the MLC is associated with an Extended MLC Location Record (see 4.2.5.1), then for the corresponding Extended MLC Location Record:
    - If MLCPresent=1,
        - StartOffset
        - SlotInfo
        - ExtendedStreamLengths
    - If MLCPresent = 0,
        - NextSuperframeOffset

4.2.4.2.4 UpdateControlCapsuleID

If the protocol receives this command in the Active State, the protocol shall update the following fields of SystemParameters message

- ControlProtocolCapsuleID
- Bin0_ControlSequenceNumber
- Bin1_ControlSequenceNumber
- NumControlSequencePairs

The value of NumControlSequencePairs field shall be equal to the number of Control protocol capsules currently being transmitted by the network. The protocol shall take the control sequence numbers from the public data of Control protocol and place them in the above fields starting from the Control protocol capsule with lowest value of ControlProtocolCapsuleID. The sequence number belonging to Bin 0 and Bin 1 of a Control protocol capsule shall be placed in Bin0_ControlSequenceNumber and Bin1_ControlSequenceNumber, respectively.

4.2.4.2.5 UpdateControlSequenceNumbers

If the protocol receives this command in the active state the protocol shall update the following fields of SystemParameters message

- Bin0_ControlSequenceNumber
- Bin1_ControlSequenceNumber

4.2.4.3 Inactive State

When the protocol in the network or device is in the Inactive State it shall wait for the *Activate* command.

4.2.4.4 Active State

4.2.4.4.1 Forward Link Only Network Requirements

The procedures in this section are specified with respect to the superframe scheduled to be transmitted at time T_{SF_Start} (in seconds), referred to as upcoming superframe. The network shall perform the following procedures once for every superframe:

- The network shall send a SystemParameters message specified in 4.2.5.1, containing parameters for the Wide-area Data Channel content scheduled for the upcoming superframe during the Wide-area OIS Channel of that superframe.
- The network shall also send a SystemParameters message specified in 4.2.5.1, containing the parameters for the Local-area Data Channel content scheduled for the upcoming superframe during the Local-area OIS Channel of that superframe.
- The network shall fill any unused portion of the OIS Channel with reserved padding bits of all zeroes as specified in the message format of SystemParameters message (4.2.5.1) to make the total message size 122*7 octets.

4.2.4.4.2 Forward Link Only Device Requirements

When this protocol is in the Active State, the device shall monitor both the Local-area and Wide-area OIS Channels for SystemParameters messages and make all data in these messages available as public data.

Upon receiving the SystemParameters message, the protocol shall discard any padding bits inserted by the network (see 4.2.4.4.1).

If any of the fields contained in the SystemParameters message is out of range, the protocol shall discard the message.

The protocol shall ignore the fields LTM_OFF and DAYLT for the Wide-area OIS Channel.

Before reading the fields in the SystemParameters message, the device shall check if the MinProtocolVersion in the message is higher than the protocol version supported by the device. If so, the device shall discard the SystemParameters message.

Each time the protocol updates the Local-area and Wide-area parameters in the public data, it shall issue the *LocalArea_ParametersRefreshed* and *WideArea_ParametersRefreshed* return indications, respectively.

If the ControlChannelAllocation field carries a non zero value, the protocol shall store the value of Bin0_ControlSequenceNumber and Bin1_ControlSequenceNumber fields received in the SystemParameters message. If the ControlChannelAllocation field carries a non zero value and the value of Bin0_ControlSequenceNumber or Bin1_ControlSequenceNumber has changed from the last value stored, the protocol shall send *Activate* command to the Control protocol.

The protocol shall store the value of InfrastructureID field received in the SystemParameters message. If the value of InfrastructureID has changed from the last value stored, the protocol shall send *Activate* command to the Control protocol.

4.2.5 Message Formats

4.2.5.1 SystemParameters

The format of the SystemParameters message sent on the Wide-area OIS Channel as well as the Local-area OIS Channel shall be as follows:

Table 4.2.5.1-SystemParameters Message

Field	**Length (bits)**
SYS_TIME	32
LP_SEC	8
LTM_OFF	6
DAYLT	1
NetworkID	16
InfrastructureID	16
ProtocolVersion	8
MinProtocolVersion	8
MinMonitorCycleIndex	4
NumPPCSymbols	2
NumMACTimeUnits	9
DataMACTrailerLength	4
ControlMACHdrLength	2
StreamLayerTrailerLength	4
CPPHdrLength	3
ControlChannelTxMode_Field1	4
ControlChannelTxMode_Field2	4
ControlChannelAllocation	3
ControlChannelStartOffset	9
ControlChannelSlotInfo	7
ControlProtocolCapsuleID	3
NumControlSequencePairs	3
MLCRecordsTableAbsent	1
Reserved	3
Include NumControlSequencePairs of the following two fields:	
Bin0_ControlSequenceNumber	16
Bin1_ControlSequenceNumber	16
If MLCRecordsTableAbsent = ‘0’, include the following two fields:	

Field	**Length (bits)**
StartMLC	8
NumMLCRecords	8

If MLCRecordsTableAbsent = ‘0’, include NumMLCRecords of the following fields:

MLCPresent	1

If MLCPresent = ‘1’, include the following fields:

StartOffset	9
SlotInfo	7
StreamLengths	23

If MLCPresent = ‘0’, include the following fields:

NextSuperframeOffset	10
FixedLengthReserved1	29

StartExtendedMLC	8
NumExtendedMLCRecords	8

Include NumExtendedMLCRecords of the following fields:

ExtendedMLCPresent	1

If ExtendedMLCPresent = ‘1’, include the following fields:

StartOffset	9
SlotInfo	7
ExtendedStreamLengths	25

If ExtendedMLCPresent = ‘0’, include the following fields:

NextSuperframeOffset	10
FixedLengthReserved2	31

ReservedPaddingBits	Variable

SYS_TIME	This field is set to the System Time at the beginning of the superframe for which this message is transmitted in one second resolution in GPS format. The network shall set this field to GPS time at the start of transmission of the superframe.
LP_SEC	This field indicates the number of leap seconds that have occurred since the start of System Time. The network shall set this field to the number of leap seconds that have occurred since the start of System Time, as of the time given by the SYS_TIME field.

LTM_OFF	Offset[11] of local time from System Time. If the message is sent on the Wide-area OIS Channel the network may set it to any value. If the message is sent on the Local-area OIS Channel the network shall set this field to two’s complement offset of local time from System Time in units of 30 minutes.
DAYLT	Daylight[12] Saving Time[13] indicator. If the message is sent on the Wide-area OIS Channel the network may set it to any value. If the message is sent on the local-area OIS Channel and the Daylight Saving Time is in effect the network shall set this field to ‘1’; otherwise, network shall set this field to ‘0’.
NetworkID	This field contains the ID of the Forward Link Only network. The network shall set this field to the Forward Link Only network identifier as assigned by the appropriate organization responsible for the assignment or coordination of these network IDs.
InfrastructureID	This field contains the ID of the Wide-area infrastructure identifier (WOI_ID) or Local-area infrastructure identifier (LOI_ID) that sourced the message. If the message is sent on the Wide-area OIS Channel, the network shall set this field to the identifier assigned to the Wide-area infrastructure. If the message is sent on the Local-area OIS Channel the network shall set this field to the identifier assigned to the local-area infrastructure.
ProtocolVersion	This field contains the current version of the Forward Link Only system protocol supported by the infrastructure. The network shall set this field to ‘2’, that is the version assigned to the Forward Link Only air interface protocol specified in this revision of the document.
MinProtocolVersion	This field contains the minimum version of the Forward Link Only system protocol supported by the infrastructure. The network shall set this field to the minimum Forward Link Only air interface protocol version supported by the network.
MinMonitorCycleIndex	This field contains the minimum monitor cycle index used by the Forward Link Only device to derive time period to monitor

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[11] When a wide-area spans two or more time zones, this information may not be accurate in all time zones.

[12] When a Wide-area covers an area not all of which uses day light savings time, the receiver appropriately corrects this information.

[13] If the geographical area covered under Wide-area does not observe Day Light Savings time in its entirety, this information is appropriately corrected by the receiver.

the OIS Channel[14]. The OIS monitor time period is given as follows:

OIS monitor time period = $5 * 2^{\mathrm{MinMonitorCycleIndex}}$

The network shall set this field to one of the values listed in Table 4.2.5.1-1.

Table 4.2.5.1-1 OIS Monitor Time Period

Value	OIS monitor time period (in seconds)
‘0000’	5
‘0001’	10
’0010’	20
‘0011’	40
‘0100’	80
‘0101’	160
‘0110’	320
‘0111’	640
‘1000’	1280
‘1001’	2560
‘1010’	5120
‘1011’	10240
‘1100’	20480
‘1101’	40960
‘1110’	81920
‘1111’	163840

NumPPCSymbols This field indicates the number of OFDM symbols used to carry the Positioning Pilot Channel OFDM symbols located at the end of a superframe. The network shall set this field to one of the values in Table 4.2.5.1-2. When the PPC is absent, the number of PPC OFDM symbols shall be zero. When the PPC is present, the number of PPC OFDM symbols shall be as specified in Table 5.2.2.10.1.5.7-1.

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[14] The implementation at the device may allow it to monitor OIS channel independent of MinMonitorCycleIndex.

Table 4.2.5.1-2 Number of PPC OFDM Symbols

Value	Number of PPC OFDM Symbols
‘00’	0
‘01’	Not available for use
’10’	Not available for use
‘11’	See Table 5.2.2.10.1.5.7-1

NumMACTimeUnits	This field contains the number of MAC time units used to carry the data symbols in a frame. If this message is sent on the Wide-area OIS Channel, the network shall set this field to the number of Wide-area Data MAC time units per frame. If this message is sent on the Local-area OIS Channel, the network shall set this field to the number of Local-area Data MAC time units per frame.
DataMACTrailerLength	This field specifies the length of Data Channel MAC protocol capsule trailer in octets as specified in 4.3.5.1. The network shall set this field to the length of the Data Channel MAC protocol capsule trailer of the Forward Link Only air interface.
ControlMACHdrLength	This field specifies the length of Control Channel MAC protocol capsule header, in octets, as specified in 4.4.5.1. The network shall set this field to the length of the Control Channel MAC protocol capsule header of the Forward Link Only air interface.
StreamLayerTrailerLength	This field specifies the length of Stream layer trailer, in octets, as specified in 3.2.5.1. The network shall set this field to the length of the Stream layer packet trailer of the Forward Link Only air interface.
CPPHdrLength	This field specifies the length of Control protocol packet header in octets, excluding the Fill field. The CPP header is specified in 2.2.5.2.1. The network shall set this field to the length of the CPP header, excluding the ‘Fill’ field, of the Forward Link Only air interface.

ControlChannelTxMode_Field1

If a PHY Type 1 transmit mode is used for the control channel MLC, the network shall set this field to the PHY Type 1 Physical layer transmit mode used to transmit the control channel MLC. Values for the PHY Type 1 Physical layer

	transmit modes are listed in Table 5.2.2.6-2. If a PHY Type 2 transmit mode is used for the control channel MLC, the network shall set this field to the 4 least significant bits of the PHY Type 2 Physical layer transmit mode used to transmit the control channel MLC. Values for the PHY Type 2 Physical layer transmit modes are listed in Table 5.2.2.6-3.
ControlChannelTxMode_Field2	If a PHY Type 1 transmit mode is used for the control channel MLC, the network shall set this field according to the outer code rate applied to the control channel MLC. Values for the applied outer code rate are listed in Table 2.2.5.2.2.1-1. If a PHY Type 2 transmit mode is used for the MLC, the network shall set this field to the 4 most significant bits of the PHY Type 2 Physical layer transmit mode used to transmit the MLC. Values for the PHY Type 2 Physical layer transmit modes are listed in Table 5.2.2.6-3.
ControlChannelAllocation	This field contains the number of MAC time units reserved for the Control Channel. The network shall set this field to the number of MAC time units reserved in one frame of a superframe to carry the Control Channel.
ControlChannelStartOffset	This field specifies the offset in MAC time units to the start of the Control Channel MLC as calculated from the first MAC time units of a frame. The network shall set this field to the offset in MAC time units to the start of the Control Channel MLC from the first MAC time units of a frame.
ControlChannelSlotInfo	This field contains values of the following three parameters: • The lowest slot that the Control Channel occupies in each frame of the superframe. • The highest slot that the Control Channel occupies in each frame of the superframe. • The first slot that the Control Channel occupies in each frame of the superframe. The network shall set this field to the encoded value as specified in 4.2.5.1.1.
ControlProtocolCapsuleID	This field contains the numerical ID assigned to Control protocol capsule being carried in the current superframe. The

	values of this field range from 0 to (NumCPCapsules - 1), where NumCPCapsules can range from 1 through 7. The network shall set this field to the numerical ID assigned to the Control protocol capsule being transmitted in the same superframe as this message.
NumControlSequencePairs	This field is set to the number of Control Sequence Number pairs following this field. One Control Sequence Number pair is sent per Control protocol capsule, starting from the first capsule. (see 2.2.5). The network shall set this field to the number of Control Sequence Number pairs.
MLCRecordsTableAbsent	This field indicates whether the MLC Records Table and the associated fields are absent. A value of '0' indicates that the StartMLC, and NumMLCRecords fields are present in the SystemParameters message. A value of '0' also indicates that the MLC Records Table is present if NumMLCRecords is greater than 0. A value of '1' indicates that the StartMLC and NumMLCRecords fields, as well as the MLC Records Table are not present in the SystemParameters message.Reserved The minimum number of bits necessary to make the length of the fixed fields in SystemParameters message an integer number of octets, is added in this field. The network shall set the value of these bits to '0' and the receiver shall ignore them.
Bin0_ControlSequenceNumber	This field contains the 16-bit Control Sequence Number corresponding to Bin 0 of the Control protocol capsule being sent by the Control protocol. The network shall set this field to the Control Sequence Number corresponding to Bin 0 of the associated Control protocol capsule.
Bin1_ControlSequenceNumber	This field contains the 16-bit Control Sequence Number corresponding to Bin 1 of the Control protocol capsule being sent by the Control protocol. The network shall set this field to the Control Sequence Number corresponding to Bin 1 of the associated Control protocol capsule.

If MLCRecordsTableAbsent = '0', the following two fields shall be included

StartMLC	This field specifies the ID of the first MLC that the location is given for in the table to follow. The network shall set this field to the identifier of the first MLC carried in the MLC Records Table following the NumMLCRecords field.

NumMLCRecords	This field specifies the number of MLC Records that are given in the following table. The network shall set this field to the number of MLC Location Records included in the MLC Records Table following this field. The MLC Records Table shall carry the location records of MLCs associated with flows described in Flow Description Messages on the control channel. The maximum number of MAC packets supported on the large stream in a MLC Location Record is 2047 MAC packets.

If MLCRecordsTableAbsent = ‘0’, the MLC Records Table consisting of NumMLCRecords MLC Location Records containing the following fields shall be included.

MLCPresent	This field shall be set to ‘1’ if the MLC with ID equal to the StartMLC plus current record offset in the MLC Records Table is present in the superframe.

If MLCPresent = ‘1’, the following fields shall be included:

StartOffset	This field specifies the offset in MAC time units to the start of this MLC as calculated from the first MAC time unit of a frame. The network shall set this field to the offset in MAC time units to the start of this MLC.
SlotInfo	This field shall contain values for the following three parameters: • The lowest slot - This is the lowest value of the slot index allocated to an MLC in every MAC time units it spans in a frame, with the possible exception of the first MAC time units it spans in that frame. The network shall set this parameter to the lowest slot that the MLC occupies in each frame of the superframe. • The highest slot – This is the highest value of the slot index allocated to an MLC in every MAC time units it spans in a frame, with the possible exception of the last MAC time units it spans in that frame. The network shall set this parameter to the highest slot that the MLC occupies in each frame of the superframe. • The first slot – This is the lowest value of the slot index allocated to an MLC in the first MAC time units it spans in a frame, with its value ranging from the lowest slot to the highest slot. The network shall set this parameter to the first slot that the MLC occupies in each frame of the superframe. The network shall set this field to the encoded value as specified in 4.2.5.1.1.

StreamLengths	This field contains the length of each stream that is carried in this MLC in this superframe. The network shall set this field as described below:

Bits 0-1: Stream ID – length association. These bits provide the combination of payload that can be carried by respective streams. The network shall set the values for these bits as given in Table 4.2.5.1-3.

Table 4.2.5.1-3 Stream ID – Length Association

Bit Values	Stream 0	Stream 1	Stream 2
'00'	Small	Medium	Large
'01'	Small	Large	Medium
'10'	Medium	Small	Large
'11'	Medium	Large	Small

Bits 2-3: These bits specify the length of the small stream in MAC layer packets (4 max). When the small stream is associated with stream 0, the network shall set the values of these bits as follows:

'00' – 1 MAC layer packet

'01' – 2 MAC layer packets

'10' – 3 MAC layer packets

'11' – 4 MAC layer packets

When the small stream is associated with a stream other than stream 0, the network shall set the values of these bits as follows.

'00' – 0 MAC layer packet

'01' – 1 MAC layer packets

'10' – 2 MAC layer packets

'11' – 3 MAC layer packets

Bits 4-11: The network shall set these bits to the length of the medium stream in MAC layer packets (255 max)

Bits 12-22: The network shall set these bits to the length of the large stream in MAC layer packets (2047 max)

If MLCPresent = '0', the following field is included instead:

NextSuperframeOffset	If this field contains a non-zero value, it specifies the minimum superframe offset from the next superframe where the continuation[15] of this MLC occurs. If this field contains a

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[15] The continuation of the MLC may not actually be in the superframe specified by the offset; however, it is guaranteed not to occur earlier.

	value of ‘0’, the next occurrence of this MLC can appear in any superframe after the current superframe (i.e., no guarantee of when the MLC occurs next is given). The network shall set this field to the minimum superframe offset from the next superframe where the continuation of this MLC could occur.
FixedLengthReserved1	This field is inserted to make the MLC location record fields for all the MLCs in the MLC Records Table the same length, regardless of the values of MLCPresent field (i.e. whether the MLC_ID is indicated as present or absent in the MLC Records Table). The network shall set all the bits of this field to ‘0’.
StartExtendedMLC	This field specifies the ID of the first MLC that the location is given for in the table to follow. The network shall set this field to the identifier of the first MLC carried in the Extended MLC Records table following the NumExtendedMLCRecords field.
NumExtendedMLCRecords	This field specifies the number of Extended MLC Records that are given in the following table. The network shall set this field to the number of Extended MLC Records included in the Extended MLC Records Table following this field. The Extended MLC Records Table shall carry the extended location records of the MLCs associated with flows described in Extended Flow Description Messages on the control channel.

Next, the Extended MLC Records Table consisting of NumExtendedMLCRecords Extended MLC Location Records containing the following fields shall be included.

ExtendedMLCPresent	This field shall be set to ‘1’ if the MLC with ID equal to the ExtendedStartMLC plus current record offset in the Extended MLC Records Table is present in the superframe.

If ExtendedMLCPresent = ‘1’, the following fields shall be included:

StartOffset	This field has the same usage as the StartOffset field in a MLC Location Record.
SlotInfo	This field has the same usage as the SlotInfo field in a MLC Location Record.
ExtendedStreamLengths	This field contains the length of each stream that is carried in this MLC in this superframe. The network shall set this field as described below: Bits 0-1: Stream ID – length association. The usage of these bits is the same as the usage of bits 0-1 in the StreamLengths field of a MLC Location Record. Bits 2-3: The usage of these bits is the same as the usage of bits 2-3 in the StreamLengths field of a MLC Location Record. Bits 4-11: The usage of these bits is the same as the usage of bits 4-11 in the StreamLengths field of a MLC Location Record.

	Bits 12-24: The network shall set these bits to the length in MAC layer packets of the large stream (8191 MAC packets max).

If ExtendedMLCPresent = ‘0’, the following field is included instead:

NextSuperframeOffset	This field has the same usage as the NextSuperframeOffset field in a MLC location record.
FixedLengthReserved2	This field is inserted to make the Extended MLC Location Record fields for all the MLCs in the Extended MLC Records Table the same length, regardless of the values of the ExtendedMLCPresent field (i.e. whether the MLC_ID is indicated as present or absent in the Extended MLC Records Table). The network shall set all the bits of this field to ‘0’.
ReservedPaddingBits	Variable number of ReservedPaddingBits is used to fill out the unused portion of the fixed size SystemParameters message to 122*7*8 bits. The network shall fill this field with all zeroes.

4.2.5.1.1 SlotInfo Field Encoding

The lowest slot number occupied by an MLC is 1 and the highest slot number is 7. The lowest slot (MinSlot), first slot (StartSlot) and highest slot (MaxSlot) values for any MLC satisfy the following constraint:

$$1 \le \text{MinSlot} \le \text{StartSlot} \le \text{MaxSlot} < 8$$

This constraint is exploited to reduce the number of bits required to convey this information as follows:

Let DeltaStart = StartSlot – MinSlot

and DeltaMax = MaxSlot – StartSlot

Given the values for MinSlot, DeltaStart and DeltaMax, StartSlot and MaxSlot can be determined. There are only 84 combinations of values of MinSlot, DeltaStart and DeltaMax that satisfy the above constraint. Therefore these values can be encoded using 7 bits.

The encoding shall be as expressed in Table 4.2.5.1.1-1.

Table 4.2.5.1.1-1 SlotInfo Field Encoding

MinSlot	Delta Start	Delta Max	Code
1	0	0	0
1	0	1	1
1	0	2	2
1	0	3	3
1	0	4	4
1	0	5	5
1	0	6	6
1	1	0	7
1	1	1	8
1	1	2	9
1	1	3	10
1	1	4	11
1	1	5	12
1	2	0	13
1	2	1	14
1	2	2	15
1	2	3	16
1	2	4	17
1	3	0	18
1	3	1	19
1	3	2	20
1	3	3	21
1	4	0	22
1	4	1	23
1	4	2	24
1	5	0	25
1	5	1	26
1	6	0	27
2	0	0	28
2	0	1	29
2	0	2	30
2	0	3	31
2	0	4	32
2	0	5	33
2	1	0	34
2	1	1	35
2	1	2	36
2	1	3	37
2	1	4	38
2	2	0	39
2	2	1	40
2	2	2	41
2	2	3	42
2	3	0	43
2	3	1	44
2	3	2	45
2	4	0	46
2	4	1	47
2	5	0	48
3	0	0	49
3	0	1	50
3	0	2	51
3	0	3	52
3	0	4	53
3	1	0	54
3	1	1	55
3	1	2	56
3	1	3	57
3	2	0	58
3	2	1	59
3	2	2	60
3	3	0	61
3	3	1	62
3	4	0	63
4	0	0	64
4	0	1	65
4	0	2	66
4	0	3	67
4	1	0	68
4	1	1	69
4	1	2	70
4	2	0	71
4	2	1	72
4	3	0	73
5	0	0	74
5	0	1	75
5	0	2	76
5	1	0	77
5	1	1	78
5	2	0	79
6	0	0	80
6	0	1	81
6	1	0	82
7	0	0	83

4.3 Data Channel MAC Protocol

4.3.1 Overview

The Data Channel MAC protocol encapsulates the content of one MLC within each superframe in which the MLC is present.

The document assumes that both the network and the device can each have multiple instances of this protocol.

This protocol operates in one of the two states:

- Inactive State: in this state the protocol waits for an *Activate* command.
- Active State: in this state the network transmits and the device receives a MLC on the Data Channel.

The protocol states and allowed transitions between the states are shown in Figure 4.3.1-1.

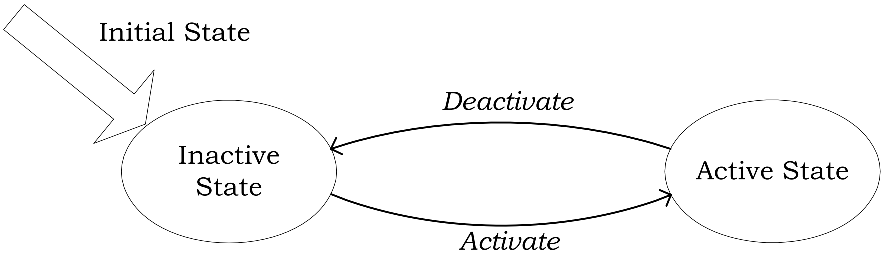

Figure 4.3.1-1 Data Channel MAC Protocol State Diagram

4.3.2 Primitives and Public Data

4.3.2.1 Commands

This protocol defines the following commands:

- *Activate*
- *Deactivate*
- *ToggleSystemParametersUpdateFlag (network only)*

4.3.2.1.1 Activate Command

It is used to cause the protocol to transition to the Active state. The *Activate* command includes the following parameters:

- MLC ID with which the protocol instance is to be associated

4.3.2.1.2 ToggleSystemParametersUpdateFlag Command

This command causes the protocol to toggle the value of SystemParametersUpdateFlag being transmitted in the Data Channel MAC protocol capsule trailer starting from next superframe.

4.3.2.2 Return Indications

- *SupervisionFailed (device only)*
- *MLC_LocationMissed (device only)*

4.3.2.2.1 SupervisionFailed (device only)

This indication is sent when the protocol is unable to monitor any message on the Data Channel.

4.3.2.2.2 MLC_LocationMissed (device only)

This indication is sent when the protocol initiates the acquisition of a MLC.

4.3.2.3 Public Data

This protocol shall make the following data public:

- ID of the MLC with which the protocol in the Active State is associated.

4.3.3 Protocol Data Unit

The transmission unit of this protocol is a MAC layer packet.

4.3.4 Procedures and messages

4.3.4.1 Protocol Initialization

This protocol should be started in the Inactive State.

4.3.4.2 Command Processing

4.3.4.2.1 Activate

If this protocol receives the *Activate* command in the Active State, the protocol shall ignore the command.

If the protocol receives an *Activate* command in the Inactive State it shall update its MLC ID in the public data with the value passed with the command as a parameter and transition to the Active State.

4.3.4.2.2 Deactivate

If this protocol receives a *Deactivate* command in the Inactive State, the protocol shall ignore the command.

If this protocol receives the *Deactivate* command in the Active State the protocol shall set the value of MLC ID in the public data to 0xFF and transition to the Inactive State.

4.3.4.3 ToggleSystemParametersUpdateFlag

If this protocol receives a *ToggleSystemParametersUpdateFlag* command in the Active State, the protocol shall toggle the value of the SystemParametersUpdateFlag field in the Data Channel MAC protocol capsule trailer.

4.3.4.4 Inactive State

When the protocol in the network or device is in the Inactive State, it shall wait for the *Activate* command.

4.3.4.5 Active State

4.3.4.5.1 Forward Link Only Network Requirements

The procedures in this section are specified with respect to the superframe scheduled to be transmitted at time T_{SF_Start} (in seconds), referred to as upcoming superframe. The network shall perform the following procedures once for every superframe:

- The protocol shall issue the *ReadyStreamPackets* command to the associated Stream protocol instance.
- The protocol shall use the information received from the Stream protocol and invoke the MAC layer MLC multiplexing function (4.8) to allocate air link resources for the MLC in the upcoming superframe scheduled for T_{SF_Start}. If the NextSuperframeOffsetFlag field in the MAC trailer of all MLCs in the superframe is set to 0 (see 4.3.5.1), the MAC layer shall perform the MLC multiplexing function at least one superframe in advance of actual transmission time, i.e. at $T_{SF\_Start} - 1$ or earlier (4.8.2). If the NextSuperframeOffsetFlag field in the MAC trailer of any MLC in the superframe is set to 1 (see 4.3.5.1), the MAC layer shall perform the MLC multiplexing function at least two superframes in advance of actual transmission time, i.e. at $T_{SF\_Start} - 2$ or earlier. Define the variable *SchedulingOffset* for use in the rest of this subsection. *SchedulingOffset* is set to 2 if the value of the NextSuperframeOffsetFlag field in the MAC trailer of at least one MLC is 1. *SchedulingOffset* is set to 1 otherwise.
- The Data Channel MAC protocol shall issue the *SendPackets* command to the associated Stream protocol and pass the number of 122 octet blocks allocated as a parameter.
- The Data Channel MAC protocol expects Stream layer packets to be returned for the corresponding base and enhancement, if applicable, components of the stream in response to the *SendPackets* command.
- The protocol shall then form a base component Data Channel MAC protocol capsule for transmission at T_{SF_Start} as follows:
    - Concatenate the base component Stream layer packets in descending order of stream ID (passed by the Stream protocol as side information) forming the payload of the base component MAC layer capsule.
    - If the MLC is configured with a PHY Type 1 transmit mode, and if the base component MAC layer capsule length is not an integer multiple of the Reed-Solomon information block size, K (see 4.6.2), the protocol shall pad the capsule with StuffingPackets (4.3.5.2) to the next such multiple. These StuffingPackets shall be placed ahead of the payload of the base component MAC protocol capsule formed above (Figure 4.1.1.2-1).
    - If the MLC is configured with a PHY Type 2 transmit mode, and if the base component MAC layer capsule length is not an integer multiple of 16, the protocol shall pad the capsule with StuffingPackets (4.3.5.2) to the next such multiple. These StuffingPackets shall be placed ahead of the payload of the base component MAC protocol capsule formed above (Figure 4.1.1.2-1).
    - The protocol shall save the above formed base component Data Channel MAC protocol capsule.
- If the MLC is configured for a layered transmit mode, the protocol shall also form an enhancement component Data Channel MAC protocol capsule for transmission at T_{SF_Start} as follows:
    - For each base component Stream layer packet received from the Stream protocol without a corresponding enhancement component Stream layer packet the protocol shall form an enhancement component packet that entirely consists of StuffingPackets and is equal to the base component packet in size.
    - Concatenate the enhancement component Stream layer packets in descending order of Stream ID forming the payload of the enhancement component MAC protocol capsule.
    - For the StuffingPackets added while padding the base component Data Channel MAC protocol capsule, corresponding StuffingPackets shall be added to the enhancement component MAC protocol capsule and placed

  - ahead of the payload of the enhancement component MAC protocol capsule formed above (Figure 4.1.1.3-1).
  - The protocol shall save the above formed enhancement component Data Channel MAC protocol capsule.

- The protocol shall form a Data Channel MAC protocol capsule trailer (see 4.3.5.1) using the results from the MLC Multiplex Function execution for the superframe to start transmission at $T_{SF\_Start.}$ The protocol shall then use this Data Channel MAC protocol capsule trailer to overwrite the FillDataMACTrailer field of the Stream layer trailer (3.2.5.1) in the stream 0 packet of the base component Data Channel MAC protocol capsule scheduled for transmission at T_{SF_Start} – *SchedulingOffset*. If there is no Data Channel MAC protocol capsule(s) saved for T_{SF_Start} – *SchedulingOffset*, this step shall be ignored.
- The protocol shall then segment both the base component and enhancement component (if present) MAC layer capsule (saved in previous superframe), scheduled for transmission at T_{SF_Start} - *SchedulingOffset*, into 122 octet MAC layer packets. If there is no Data Channel MAC protocol capsule(s) saved for transmission at T_{SF_Start} – *SchedulingOffset*, this step shall be ignored.
- If the MLC is configured with a PHY Type 1 transmit mode, then the network shall carry out the following additional steps:
  - The protocol shall then execute the interleaving procedure specified in 4.5.1 on the base component and enhancement component (if present) MAC layer capsule scheduled for transmission at T_{SF_Start} – *SchedulingOffset*. The interleaving procedure shall be performed independently on base component and enhancement component. If there is no Data Channel MAC protocol capsule(s) saved for transmission at T_{SF_Start} – *SchedulingOffset*, this step shall be ignored.
  - The protocol shall then perform the Reed-Solomon encoding procedure described in 4.6 on the MAC layer capsule in the interleaving buffer returned above, scheduled for transmission at T_{SF_Start} - *SchedulingOffset*,. For the layered mode, Reed-Solomon encoding procedure shall be performed independently on the base component MAC layer capsule and the enhancement component MAC layer capsule. The Reed-Solomon parity packets shall be placed at the end of the payload of the corresponding base or enhancement component MAC protocol capsule, as shown in Figure 4.1.1.3-1. If there is no Data Channel MAC protocol capsule(s) saved for transmission at T_{SF_Start} – *SchedulingOffset*, this step shall be ignored.
- After encoding, the protocol shall pass both the MAC layer packets and any parity packets formed as a result of the Reed-Solomon encoding procedure to the Physical layer for transmission at T_{SF_Start} – *SchedulingOffset*. The protocol shall pass additional side information along with each enhancement component MAC layer packet and each enhancement component parity packet specifying whether the packet shall be transmitted over the air[16,17]. If there is no Data Channel MAC protocol capsule(s) saved for transmission at T_{SF_Start} – *SchedulingOffset*, this step shall be ignored.

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[16] A MAC layer packet or parity packet that is not transmitted over the air is still passed to and processed within the Physical layer.

[17] The enhancement MAC layer packet is not transmitted over the air if it is a StuffingPacket, while an enhancement parity packet is not transmitted over the air if the error control block (see 4.6.2) that it is a part of contains a StuffingPacket in each of the top K rows.

4.3.4.5.2 Forward Link Only Device Requirements

The protocol shall execute the MLC Acquisition procedure (4.3.4.5.2.2) to determine where the MLC is located in the Data Channel, which streams are present and how many MAC layer packets to expect for each stream in the superframe.

The protocol shall then repeatedly execute the MAC layer capsule processing procedure described in 4.3.4.5.2.1.

4.3.4.5.2.1 Data Channel MAC Protocol Capsule Processing Procedure

The protocol shall perform the following:

- Request to receive MAC layer packets for the associated MLC from the Physical layer passing the MLC location information for the superframe.
- Set a T_{MLC_Acq} timer with the value T_{MLC_Timout} and wait for MAC layer packets to arrive from the Physical layer. If the T_{MLC_Acq} timer expires before the protocol receives the first MAC layer packet from the Physical layer, the protocol shall issue the *SupervisionFailed* return indication and transitions to the Inactive State.
- If the MLC is configured with a PHY Type 1 transmit mode, the device shall execute the following additional steps:
  - Buffer base and enhancement component MAC layer packets received from the Physical layer separately to form independent error control block for Reed-Solomon decoding.
  - Replace enhancement component MAC layer packets for streams configured not to contain an enhancement component with StuffingPackets (4.3.5.2).
  - Perform Reed-Solomon decoding, if needed, on the error control blocks.
  - If all K information elements of a Reed-Solomon error control block contain StuffingPackets, discard the error control block without performing Reed-Solomon decoding[18].Perform the de-interleaving procedure specified in 4.5.2. The de-interleaving procedure shall be performed independently on base component MAC layer packets and enhancement component MAC layer packets (if present).
- The protocol shall then process the MAC layer capsule as follows:
  - The last MAC layer packet of the MAC layer capsule (or the base component MAC layer capsule in case of layered mode), shall be processed as described in 4.3.4.5.2.3 before continuing to the steps below.
  - The protocol shall pass the number of base component MAC layer packet payloads specified in the StreamLengths or ExtendedStreamLengths fields to the associated Stream protocol instance along with the corresponding stream ID and error indications.
  - If the MLC is configured for a layered transmit mode, for each stream configured to have an enhancement component, the protocol shall pass the number of enhancement component MAC layer packet payloads specified in the StreamLengths or ExtendedStreamLengths fields to the associated Stream protocol instance along with the corresponding stream ID and error indications.
  - All StuffingPackets shall be discarded.

If the MAC layer packet containing the MAC layer capsule trailer contains errors, the protocol shall execute the MLC Acquisition procedure described in 4.3.4.5.2.2.

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[18] The details of the Reed-Solomon decoding are beyond the scope of this specification.

If the ContinueNextSuperFrame field of the MAC layer capsule trailer received in this or in the previous superframe indicates that the MLC does continue in the next superframe, the protocol shall repeat the MAC layer capsule processing procedure in the next superframe based on the MLC location information contained in the corresponding MAC layer capsule trailer.

4.3.4.5.2.2 MLC Acquisition Procedure

The protocol shall perform the following:

- Issue the *MLC_LocationMissed* indication
- Wait for the *LocalArea_ParametersRefreshed* or the *WideArea_ParametersRefreshed* indication from the OIS Channel MAC protocol (depending on whether the associated MLC is from the Local-area Data channel or Wide-area data channel)
- When the protocol receives the *LocalArea_ParametersRefreshed* or the *WideArea_ParametersRefreshed* indication from the OIS Channel MAC protocol, it shall read the MLCPresent field, or the ExtendedMLCPresent field from the public data of the OIS Channel MAC protocol for the associated MLC
- If the value of the MLCPresent field, or ExtendedMLCPresent field is equal to ‘1’, the protocol shall read the MLC location information (following fields) from the public data of the OIS Channel MAC protocol for the associated MLC
    - StartOffset
    - SlotInfo
    - StreamLengths or ExtendedStreamLengths
- If the value of the MLCPresent or ExtendedMLCPresent field is equal to ‘0’, the protocol shall read the NextSuperframeOffset field from the public data of the OIS Channel MAC protocol for the associated MLC and execute this procedure after the number of superframes specified by this field.

4.3.4.5.2.3 Last MAC Layer Packet Processing Procedure

If this is the last MAC layer packet of the MAC layer capsule, it contains the MAC layer capsule trailer (see 4.3.5.1).

For layered mode, the last MAC layer packet of only the base component MAC layer capsule contains the trailer, which is processed. For the enhancement component MAC layer capsule, the trailer contains stuffing bits and these bits shall be discarded. The length of the MAC layer capsule trailer is indicated by the DataMACTrailerLength field of the SystemParameters message (4.2.5.1). Preceding this trailer the MAC layer capsule payload is located. The device shall discard any unused portion of the MAC layer capsule trailer after the device has processed all the valid fields in this header.

If the MLC continues in the next superframe, the location that the MLC occurs in and the lengths of the streams that it carries are also included in the trailer. The protocol verifies that the MLC_ID matches that of the associated MLC. If these are not the same, the protocol shall issue the *SupervisionFailed* return indication and transition to the Inactive State. Otherwise, the protocol shall save the MLC location and stream lengths information and then strip and discard the MAC layer capsule trailer.

The protocol shall compare the SystemParametersUpdateFlag in MAC layer capsule trailer with the value received in the last superframe. If it indicates a change, the device shall send an *Activate* command to the OIS Channel MAC Protocol for the next superframe if the NextSuperframeOffsetFlag is 0, or for the second next superframe if the NextSuperframeOffsetFlag is 1.

4.3.5 Trailer Formats

4.3.5.1 Data Channel MAC Protocol Capsule Trailer

The Data Channel MAC protocol capsule trailer has a fixed sized format[19]. The length of this trailer and the field FillDataMACTrailer specified in 3.2.5.1 are the same. The format of the Data channel MAC trailer is different depending on whether the MLC is associated with a MLC Location Record, or with an Extended MLC Location Record in the SystemParameters message of the OIS (see 4.2.5.1).

The Data channel MAC protocol capsule trailer for an MLC that is associated with a MLC Location Record is specified in Table 4.3.5.1-1:

Table 4.3.5.1-1 Data Channel MAC Protocol Capsule Trailer for an MLC Associated with a MLC Location Record

Field	Length (bits)
MLC_ID	8
SystemParametersUpdateFlag	1
NextSuperframeOffsetFlag	1
Reserved	6
ContinueNextSuperFrame	1
If ContinueNextSuperFrame = '1' include the following three fields:	
NextSuperframeStartOffset	9
NextSuperframeSlotInfo	7
NextSuperframeStreamLengths	23
If ContinueNextSuperFrame = '0' include the following two fields:	
NextSuperframeOffset	10
FixedLengthReserved	29

MLC_ID	This field contains the MLC ID. The network shall set this field to the MLC ID of the MLC associated with the Data Channel MAC protocol instance.
SystemParametersUpdateFlag	This flag indicates to the device that the device needs to get and process the SystemParameters message. The network shall toggle this field when one or more fields carried in the SystemParameters message, that the device needs to read in next superframe, changes.

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[19] New fields may be appended to the header in future revisions of this document.

NextSuperframeOffsetFlag	This field shall be set to 0 indicating that the next superframe referenced in the rest of the fields is the superframe that is transmitted 1 superframe after the one in which this trailer is embedded[20].
Reserved	This field is inserted to preserve the MLC capsule payload octet alignment. The network shall set these bits to ‘0’ and the receiver shall ignore them.
ContinueNextSuperFrame	This field indicates if data is transmitted for the MLC associated with the Data Channel MAC protocol in the next superframe. The network shall set this flag to ‘1’ if data is scheduled to be transmitted for the MLC in the next superframe, Otherwise the network shall set this field to ‘0’.

If ContinueNextSuperFrame = ‘1’, the following fields are included:

NextSuperframeStartOffset	This field contains the offset in MAC time units to the start of this MLC as calculated from the first MAC time unit of a frame. The network shall set this field to the offset in MAC time units to the start of this MLC.
NextSuperframeSlotInfo	This field shall contain values for the following three parameters: • The lowest slot that the MLC occupies in each frame of the superframe. • The highest slot that the MLC occupies in each frame of the superframe. • The first slot that the MLC occupies in the first MAC time unit allocated to it, in each frame of the superframe. This network shall set this field to the encoded value as specified in 4.2.5.1.1.
NextSuperframeStreamLengths	This field contains the lengths of each stream that is carried in the MLC in next superframe. The format of this field is same as the StreamLengths field in SystemParameters message as described in 4.2.5.1. The network shall set this field to the length of streams carried in the next superframe for this MLC.

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[20] This is the superframe that is transmitted immediately after the superframe containing the MAC trailer.

If ContinueNextSuperFrame = ‘0’, the following fields are included instead:

NextSuperframeOffset	If this field contains a non-zero value, it specifies the minimum superframe offset from the next superframe where the continuation[21] of this MLC occurs. If this field contains a value of ‘0’, the next occurrence of this MLC can appear in any superframe after the current superframe (i.e., no guarantee of when the MLC occurs next is given). The network shall set this field to the minimum superframe offset from the next superframe where the continuation of this MLC would occur.
FixedLengthReserved	This field is inserted to make the MLC header fixed length. This is important to allow the MAC layer processing to recover from an erasure of the MLC header. The network shall set these bits to ‘0’ and the device shall ignore them.

The Data channel MAC protocol capsule trailer for an MLC that is associated with an Extended MLC Location Record is specified in Table 4.3.5.1-1:

Table 4.3.5.1-2 Data Channel MAC Protocol Capsule Trailer for an MLC Associated with an extended MLC Location Record

Field	Length (bits)
MLC_ID	8
SystemParametersUpdateFlag	1
NextSuperframeOffsetFlag	1
Reserved	4
ContinueNextSuperFrame	1

If ContinueNextSuperFrame = ‘1’ include the following three fields:

NextSuperframeStartOffset	9
NextSuperframeSlotInfo	7
NextSuperframeExtendedStreamLengths	25

If ContinueNextSuperFrame = ‘0’ include the following two fields:

NextSuperframeOffset	10
FixedLengthReserved	31

The MAC protocol capsule trailer for an MLC associated with an extended MLC record is similar to the one associated with a MLC location record, except for the change in the lengths of the Reserved and FixedLengthReserved fields, and for the changes in the two following fields:

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[21] The continuation of the MLC may not actually be in the superframe specified by the offset; however, it is guaranteed not to occur earlier.

NextSuperframeOffsetFlag	This field indicates the offset of the next superframe for which location information is included in the trailer. If the value of this field is 0, then the next superframe referenced in the rest of the fields is the superframe that is transmitted 1 superframe after the superframe in which this trailer is embedded. If the value of this field is 1, then the next superframe referenced in the rest of the fields is the superframe that is transmitted 2 superframes after the one in which this trailer is embedded.
NextSuperframeExtendedStreamLengths	
	This field replaces the NextSuperframeStreamLengths field. It contains the lengths of each stream that is carried in the MLC in the next superframe. The format of this field is the same as the ExtendedStreamLengths field in the SystemParameters message as described in 4.2.5.1. The network shall set this field to the length of the streams carried in the next superframe for this MLC.

4.3.5.2 StuffingPacket

StuffingPacket is used during creation of base and enhancement component Data Channel MAC protocol capsule as described in 4.3.4.5.1. Size of the StuffingPacket is same as the size of Data Channel MAC protocol packet (122 octets).

Table 4.3.5.2-1 StuffingPacket for Enhancement Component MAC Layer Capsule

Field	Value
LENGTH_DATA_MAC_PACKET occurrences (122) of the following field	
StuffingOctet	0x00

StuffingOctet	This is the only field present in the StuffingPacket and the network shall set it to a value of zero.

4.4 Control Channel MAC Protocol

4.4.1 Overview

The Control Channel MAC protocol provides encapsulation of the content of Wide-area and Local-area Control Channel MLC. The primary difference between the Control Channels and the Data Channels is that

- Control Channels always occur in a constant location in the superframe.
- Control Channel has a constant allocation or at least an allocation that does not change frequently.
- Control Channel does not have any streams associated with the data being carried in its MLC.

This protocol operates in one of two states:

- Inactive State: in this state the protocol waits for an *Activate* command.

- Active State: in this state the network transmits and the device receives the Control Channel.

The protocol states and allowed transitions between the states are shown in Figure 4.4.1-1.

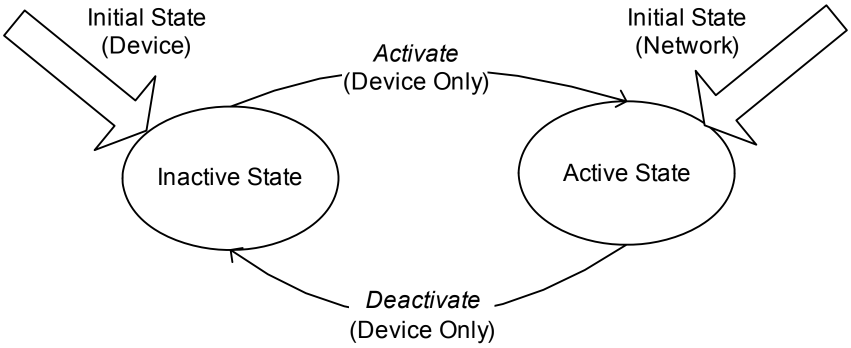

Figure 4.4.1-1 Control Channel MAC Protocol State Diagram

4.4.2 Primitives and Public Data

4.4.2.1 Commands

This protocol defines the following commands:

- *Activate (device only)*
- *Deactivate (device only)*

4.4.2.1.1 Activate Command

This command causes the protocol to transition to Active state. The *Activate* command arrives with the following parameter:

- CONTROL_CHANNEL_MLC_ID – This is the ID of the MLC with which the protocol instance is to be associated. MLC_ID of '0' is reserved for CONTROL_CHANNEL_MLC_ID (4.4.4.4.1).

4.4.2.1.2 Deactivate Command

This command causes the protocol to transition to Inactive state.

4.4.2.2 Return Indications

- *SupervisionFailed (device only)*
- *MLC_LocationMissed (device only)*
- *ControlChannelDataAvailable (device only)*

4.4.2.3 Public Data

This protocol shall make the following data public:

- CONTROL_CHANNEL_MLC_ID – The ID of the MLC that the active state protocol is associated with. In Active State, this ID is assigned a value of '0'. If the protocol is in the Inactive State, this data has the value 0xFF.
- LENGTH_CONTROL_CHANNEL_MAC_CAPSULE_HEADER

4.4.3 Protocol Data Unit

The transmission unit of this protocol is a Control Channel MAC protocol packet.

The protocol shall construct a Control Channel MAC protocol packet as follows:

- Take one Control protocol capsule carrying Control protocol packets.
- Overwrite the Control protocol capsule (starting from the first bit) with a Control Channel MAC protocol capsule header with format specified in 4.4.5.1, producing a Control Channel MAC protocol capsule.
- Partition the Control Channel MAC protocol capsule into fragments of length 122 octets called Control Channel MAC protocol packet.

4.4.4 Procedures

4.4.4.1 Protocol Initialization

The network shall start this protocol in Active State.

This device shall start this protocol in the Inactive State.

4.4.4.2 Command Processing

4.4.4.2.1 Activate

If this protocol receives the *Activate* command in the Active State, it shall ignore it.

If the protocol receives the *Activate* command in the Inactive State, it shall update its MLC ID in the public data with the value passed as the command parameter and transition to the Active State.

4.4.4.2.2 Deactivate

If this protocol receives a *Deactivate* command in the Inactive State, it shall ignore it.

If this protocol receives the *Deactivate* command in the Active State, the protocol shall set the value of MLC ID in the public data to 0xFF and transition to the Inactive State.

4.4.4.3 Inactive State

When the protocol in the network or device is in the Inactive State it shall wait for the *Activate* command.

4.4.4.4 Active State

4.4.4.4.1 Forward Link Only Network Requirements

The procedures in this section are specified with respect to the superframe scheduled to be transmitted at time T_{SF_Start} (in seconds), referred to as upcoming superframe. The network shall perform the following procedures once for every superframe:

- The protocol shall issue a *SendControlChannelMACPayload* command to the Control protocol.
- The protocol shall wait for the indication *ControlChannelMACPayloadAvailable* from Control protocol. The Control protocol returns the Control protocol capsule along with the indication.
- The protocol shall form a Control Channel MAC protocol capsule to be transmitted at T_{SF_Start} using the Control protocol capsule as follows:
    - Form a Control Channel MAC protocol capsule header (see 4.4.5.1) using a reserved value of ‘0’ for the CONTROL_CHANNEL_MLC_ID.
    - Overwrite the Fill field of the Control protocol packet header, present in the first CPP of the Control protocol capsule, with the Control Channel MAC protocol capsule header.

- The protocol shall then segment the Control Channel MAC protocol capsule into 122 octet MAC layer packets.
- If the control channel MLC is configured with a PHY Type 1 Physical layer transmit mode, the network shall execute the interleaving and Reed-Solomon encoding procedures as follows:
    - The protocol shall execute the interleaving procedure specified in 4.5.1 on the Control Channel MAC protocol capsule scheduled for transmission at T_{SF_Start}.
    - The protocol shall then perform the Reed-Solomon encoding procedure described in 4.6 on the Control Channel MAC protocol capsule returned in the interleaving buffer above. After encoding, both the MAC layer packets and the parity packets shall be passed to the Physical layer to be transmitted at T_{SF_Start}.
- If the control channel MLC is configured with a PHY Type 2 Physical layer transmit mode, the network shall forward the MAC layer packets to the Physical layer to be transmitted at T_{SF_Start}.

4.4.4.4.2 Forward Link Only Device Requirements

The protocol shall execute the Control Channel Acquisition procedure in 4.4.4.4.2.2 at least once to determine the location of the Control Channel MLC.

The protocol shall repeatedly execute the Control Channel MAC protocol capsule processing procedure described in 4.4.4.4.2.1.

4.4.4.4.2.1 Control Channel MAC Protocol Capsule Processing Procedure

The protocol shall perform the following:

- Request to receive MAC layer packets for the Control Channel MLC from the Physical layer passing the MLC location information for the superframe.
- Set a timer, T_{MLC_Acq}, with the value T_{MLC_Timout} and wait for MAC layer packets to arrive from the Physical layer. If the T_{MLC_Acq} timer expires before the protocol receives the first MAC layer packet from the Physical layer, the protocol shall issue the *SupervisionFailed* return indication and transition to the Inactive State.
- If the control channel MLC is configured with a PHY Type 1 transmit mode, then the protocol shall execute the following additional steps:
    - Buffer MAC layer packets received from the Physical layer to form error control blocks.
    - Perform Reed-Solomon decoding[22], if needed, on the error control blocks.
    - After Reed-Solomon decoding, the protocol shall perform the de-interleaving procedure specified in 4.5.2.
- The protocol shall process the Control Channel MAC protocol capsule received aboveas follows:
- The first MAC layer packet of the Control Channel MAC protocol capsule shall be processed as described in 4.4.4.4.2.3 before continuing to the step below.
- The Control Channel MAC packets including the first MAC layer packet shall be delivered to the Control protocol using the indication *ControlChannelDataAvailable*.

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[22] The details of the Reed-Solomon decoding are beyond the scope of this specification.

4.4.4.4.2.2 Control Channel Acquisition Procedure

The protocol shall issue the *MLC_LocationMissed* indication and wait for the *LocalArea_ParametersRefreshed* or the *WideArea_ParametersRefreshed* indication from the OIS Channel MAC protocol.

If the protocol receives a *LocalArea_ParametersRefreshed* or the *WideArea_ParametersRefreshed* indication, it shall read and store the following fields from the public data of the OIS Channel MAC protocol:

- ControlChannelTxMode_Field1
- ControlChannelTxMode_Field2
- ControlChannelAllocation
- ControlChannelStartOffset
- ControlChannelSlotInfo

4.4.4.4.2.3 First MAC Layer Packet Processing Procedure

The protocol shall compare the MLC_ID field in the Control Channel MAC protocol capsule header (see 4.4.5.1) to CONTROL_CHANNEL_MLC_ID. If the values do not agree, the protocol shall do the following:

- Discard the MAC layer packets received for the superframe.
- Issue the *SupervisionFailed* return indication
- Perform the Control Channel Acquisition Procedure (4.4.4.4.2.2)

The protocol shall ignore any other octets of the Control Channel MAC protocol capsule header as indicated by the ControlMACHdrLength field of the SystemParameters message (see 4.2.5.1).

4.4.5 Header Formats

4.4.5.1 Control Channel MAC Protocol Capsule Header

The Control Channel MAC protocol capsule header is a fixed sized format[23]. The length of this header and the Fill field specified in 2.2.5.2.1 is the same. This is described in the following table:

Field	Length (bits)
MLC_ID	8

MLC_ID	This field contains the CONTROL_CHANNEL_MLC_ID. The network shall set this field to ‘0’.

4.5 MAC Layer Interleaving and De-interleaving for MLCs Configured with PHY Type 1 Transmit Modes

This subsection applies to MAC layer processing of MLCs configured with PHY Type 1 transmit modes.MAC layer interleaving at the network takes an integer multiple of K MAC layer packets as input and returns these MAC layer packets in an interleaving buffer of

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[23] New fields may be appended to the header in future revisions of this document.

same size as output. Here, K is the Reed-Solomon information block size and its values are specified in Table 2.2.5.2.2.1-1.

Similarly, MAC layer at the device takes an integer multiple of K MAC layer packets as input and returns these MAC layer packets in a de-interleaving buffer of same size as output.

If the number of MAC layer packets provided as input is equal to K, then they are returned immediately without performing the interleaving or de-interleaving procedure described below.

4.5.1 MAC Layer Interleaving Procedure (network only)

Figure 4.5.1-1 shows an example of the MAC layer interleaving procedure. In this example, the interleaving procedure takes K x n MAC layer packets as input, where K is the Reed-Solomon information block size (see 4.6.2) with a value of 12 (rows) and n is the number of information blocks[24] with a value of 2 (columns),

The network shall form an interleaving buffer as follows:

- Allocate an interleaving buffer of size K x n that can accommodate n columns of K MAC layer packets (rows) each.
- Take the MAC layer packets from the input buffer column-wise and place them in the interleaving buffer row-wise.
- Continue till all the MAC layer packets from the input buffer are placed in the interleaving buffer.

The network shall then return the interleaving buffer.

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[24] The maximum value of n (n_{max}) is given by $\left\lceil \frac{SumMaxStreamLengths}{K} \right\rceil$ where, $SumMaxStreamLengths$ is the sum of the maximum length (in units of MAC layer packets) allowed for each stream in a MLC, and $\lceil x \rceil$ is the smallest integer that is greater than or equal to x. The stream lengths are defined in the StreamLengths field of 4.2.5.1 and Table 4.2.5.1-3.

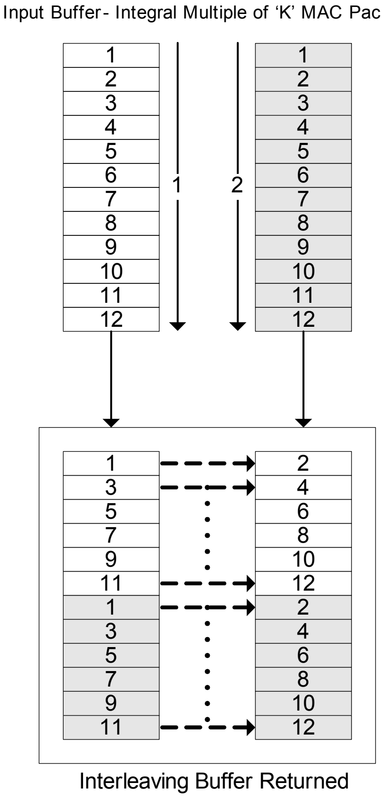

Figure 4.5.1-1 Example of MAC Layer Interleaving

4.5.2 MAC Layer De-interleaving Procedure (device only)

Figure 4.5.2-1 shows an example of the MAC layer de-interleaving procedure. In this example, the de-interleaving procedure takes K x n MAC layer packets as input, where K is the Reed-Solomon information block size (see 4.6.2) with a value of 12 (rows) and n is the number of information blocks[25] with a value of 2 (columns),

The network shall form a de-interleaving buffer as follows:

- Allocate a de-interleaving buffer of size K x n that can accommodate n columns of K MAC layer packets (rows) each.
- Take the MAC layer packets from the input buffer row-wise and place them in the de-interleaving buffer column-wise.
- Continue till all the MAC layer packets from the input buffer are placed in the de-interleaving buffer.

The device shall then return the de-interleaving buffer.

---

[25] The maximum value of n (n_{max}) is given by $\left\lceil \frac{SumMaxStreamLengths}{K} \right\rceil$ where, $SumMaxStreamLengths$ is the sum of the maximum length (in units of MAC layer packets) allowed for each stream in a MLC, and $\lceil x \rceil$ is the smallest integer that is greater than or equal to x. The stream lengths are defined in the StreamLengths field of 4.2.5.1 and Table 4.2.5.1-3.

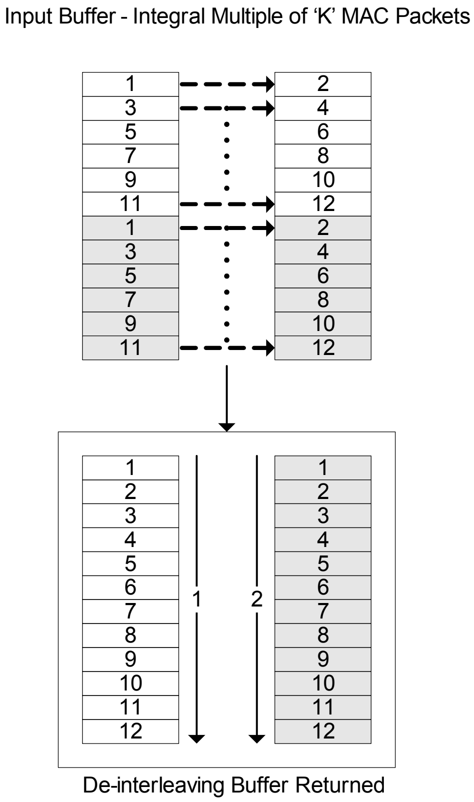

Figure 4.5.2-1 Example of MAC Layer De-interleaving

4.6 Reed-Solomon Encoding Procedure for MLCs Configured with PHY Type 1 Transmit Modes

This subsection applies to MAC layer processing of MLCs configured with PHY Type 1 transmit modes.

4.6.1 Introduction

Figure 4.6.1-1 provides the structure of a Reed-Solomon error control block. An error control block is formed of N rows and 122 octet columns. The top K rows of the error control block each contain a single MAC layer packet. The bottom R = N – K rows of the error control block contain Reed-Solomon parity octets.

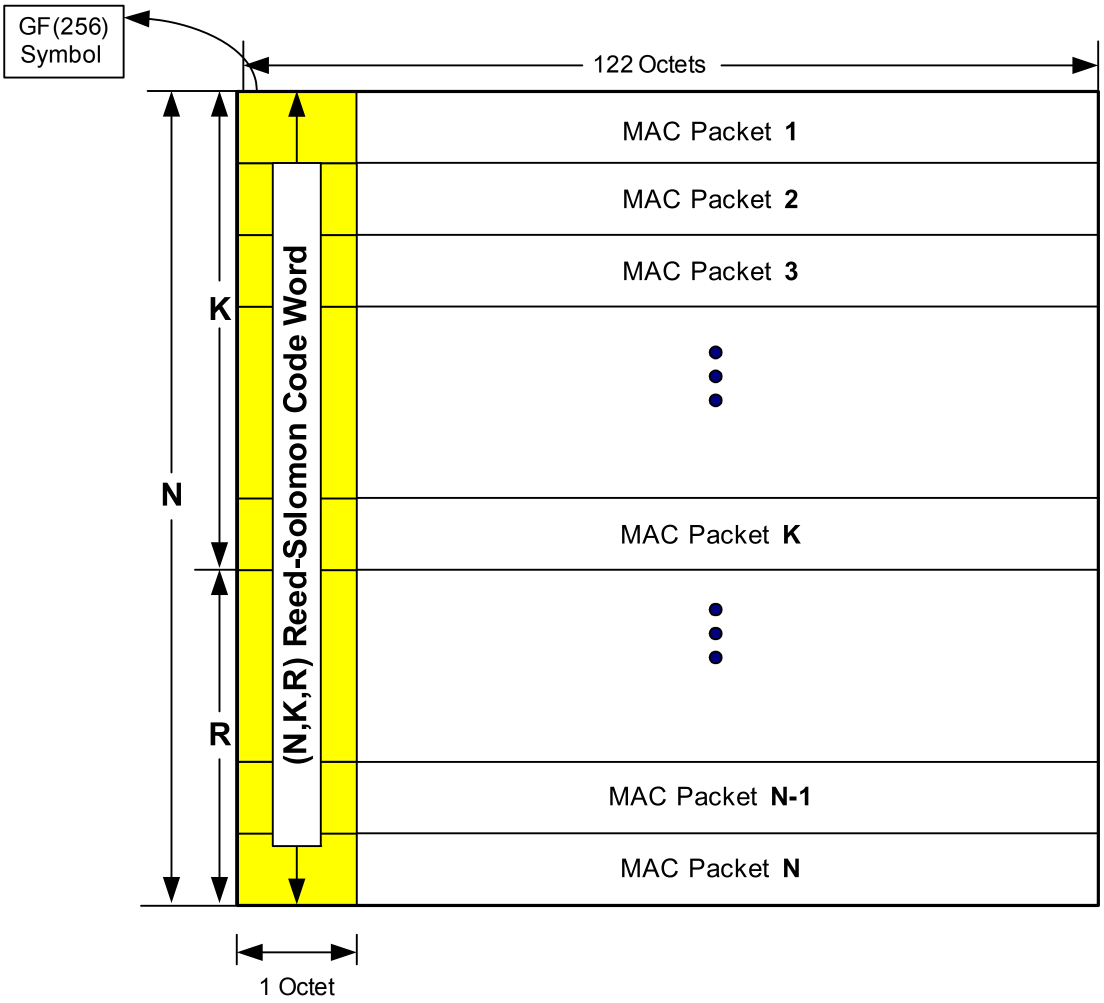

Figure 4.6.1-1 Reed-Solomon Error Control Block Structure

4.6.2 Generation of Reed-Solomon Error Control Block

The network shall form a Reed-Solomon error control block for each MLC.

Each error control function shall fill MAC packets into the error control block in rows. The network shall apply Reed-Solomon coding along columns of the error control block. The access network shall transmit error control block on the MLC in rows.

Each error control block shall contain N row and 122 octet columns.

The top K rows of the error control block shall contain payload from the served protocols. The bottom R = N – K rows of the error control block shall contain Reed-Solomon parity octets.

The length of each Reed-Solomon code word shall be N octets.

Each error control block shall consist of 122 Reed-Solomon code words.

The Reed-Solomon code is specified as a (N,K,R) code. N, K and R are defined as follows:

N = Number of octets in a Reed-Solomon code word. The value of N shall be 16.

K = Number of data octets in a Reed-Solomon code word.

The value of K shall be defined as 8, 12, 14 or 16.

R = N – K = Number of parity octets in a Reed-Solomon code word. The value of R shall be 8, 4, 2 or 0.

Each row of the error control block shall form the payload for one Physical layer packet.

4.6.3 Reed-Solomon Code Generator

The Reed-Solomon block code is used as an outer code. It uses 8-bit symbols and operates in the Galois Field GF(2^8). The primitive element α for this field is defined by

$$\alpha^8 + \alpha^4 + \alpha^3 + \alpha^2 + 1 = 0. \#$$

The j^{th} code symbol (j = 0, 1, …, N-1), v_j, shall be defined by:

$$v_j = \begin{cases} u_j & 0 \le j \le K-1 \\ \sum_{i=0}^{K-1} u_i \times p_{i,j} & K \le j \le N-1 \end{cases} \#$$

where

- N and K are parameters of the (N, K, R) Reed-Solomon code.
- u_i is the i^{th} symbol of a block of K information symbols.
- $p_{i,j}$ is the entry of the i^{th} row and j^{th} column in the parity matrix of the code, and
- $\times$ and $\sum$ indicate multiplication and summation over $\mathrm{GF}(2^8)$ respectively.

4.6.3.1 (16, 16, 0) Reed-Solomon Code

The (16, 16, 0) code generates 16 code symbols for each block of 16 information symbols input to the encoder. The 16 code symbols are identical to the 16 information symbols. This corresponds to the case of no Reed-Solomon encoding.

4.6.3.2 (16, 8, 8) Reed-Solomon Code

The (16, 8, 8) code generates 16 code symbols for each block of 8 information symbols input to the encoder. The first 8 symbols are the information symbols and the remaining 8 symbols are parity symbols.

The generator polynomial for the (16, 8, 8) code is

$$g(X) = 1 + \alpha^{44}X + \alpha^{231}X^2 + \alpha^{70}X^3 + \alpha^{235}X^4 + \alpha^{70}X^5 + \alpha^{231}X^6 + \alpha^{44}X^7 + X^8 \#$$

The parity matrix for the (16, 8, 8) Reed-Solomon block code shall be as specified in Table 4.6.3.2-1.

Table 4.6.3.2-1 Parity Matrix for the (16,8 8) Outer Code

Row Index i	$\mathbf{p_{i,8}}$	$\mathbf{p_{i,9}}$	$\mathbf{p_{i,10}}$	$\mathbf{p_{i,11}}$	$\mathbf{p_{i,12}}$	$\mathbf{p_{i,13}}$	$\mathbf{p_{i,14}}$	$\mathbf{p_{i,15}}$
0	2	39	150	223	214	201	65	45
1	45	169	6	147	51	128	145	64
2	64	100	24	146	118	108	215	32
3	32	191	27	236	189	247	12	174
4	174	93	52	173	213	252	85	160
5	160	240	214	203	155	26	95	238
6	238	22	157	161	236	19	175	44
7	44	231	70	235	70	231	44	0

Note: This table lists the power h of the entry on the i^{th} row and j^{th} column in the parity matrix, $p_{i,j} = \alpha^h$, where α is the primitive element of GF(256) and i = 0, ..., 7, and j = 8, 9, ...15. For example, the entry of 2 in the upper left-hand corner indicates $p_{0,8} = \alpha^2$.

4.6.3.3 (16, 12, 4) Reed-Solomon Code

The (16, 12, 4) code generates 16 code symbols for each block of 12 information symbols input to the encoder. The first 12 symbols are the information symbols and the remaining 4 symbols are parity symbols.

The generator polynomial for the (16,12,4) code is

$$g(X) = 1 + \alpha^{201} X + \alpha^{246} X^2 + \alpha^{201} X^3 + X^4 . \#$$

The parity matrix for the (16, 12, 4) Reed-Solomon block code shall be as specified in Table 4.6.3-2.

Table 4.6.3-2 Parity Matrix for the (16,12,4) Outer Code

Row Index i	$p_{i,12}$	$p_{i,13}$	$p_{i,14}$	$p_{i,15}$
0	40	138	141	8
1	8	196	97	158
2	158	4	250	209
3	209	123	27	76
4	76	226	198	160
5	160	142	95	125
6	125	19	59	70
7	70	87	39	137
8	137	169	244	254
9	254	192	27	160
10	160	57	53	201
11	201	246	201	0

Note: This table lists the power h of the entry on the i^{th} row and j^{th} column in the parity matrix, $p_{i,j} = \alpha^h$, where α is the primitive element of GF(256) and i = 0, ..., 11, and j = 12, 13, 14, and 15. For example, the entry of 40 in the upper left-hand corner indicates $p_{0,12} = \alpha^{40}$

4.6.3.4 (16, 14, 2) Reed-Solomon Code

The (16, 14, 2) code generates 16 code symbols for each block of 14 information symbols input to the encoder. The first 14 symbols are the information symbols and the remaining 2 symbols are parity symbols.

The generator polynomial for the (16,14,2) code is

$$g(X) = 1 + \alpha^{152} X + X^2. \#$$

The parity matrix for the (16, 14, 2) Reed-Solomon block code shall be as specified in Table 4.6.3.4-1.

Table 4.6.3.4-1 Parity Matrix for the (16,14,2) Outer Code

Row Index i	$p_{i,14}$	$p_{i,15}$
0	1	65
1	65	68
2	68	224
3	224	215
4	215	119
5	119	91
6	91	44
7	44	84
8	84	36
9	36	111
10	111	201
11	201	197
12	197	152
13	152	0

Note: This table lists the power h of the entry on the ith row and jth column in the parity matrix, $p_{i,j} = \alpha^h$, where α is the primitive element of GF(256) and i = 0, ..., 13, and j = 14 and 15. For example, the entry of 1 in the upper left-hand corner indicates $p_{0,14} = \alpha^1$

4.7 Sequencing of Packets from RS Code Block to Physical Layer for MLCs Configured with PHY Type 1 Transmit Modes

This subsection applies to MAC layer processing of MLCs configured with PHY Type 1 transmit modes.

4.7.1 Sequencing of Packets from a Single Reed-Solomon Error Control Block

Each Reed-Solomon error control block is split into 4 equal sub-blocks and each sub-block is sent to the Physical layer for transmission in a unique frame within a superframe. Each sub-block consists of 1/4th of the rows in the Reed-Solomon Error Control block, i. e., 4 MAC layer packets. This is illustrated in Figure 4.7.1-1.

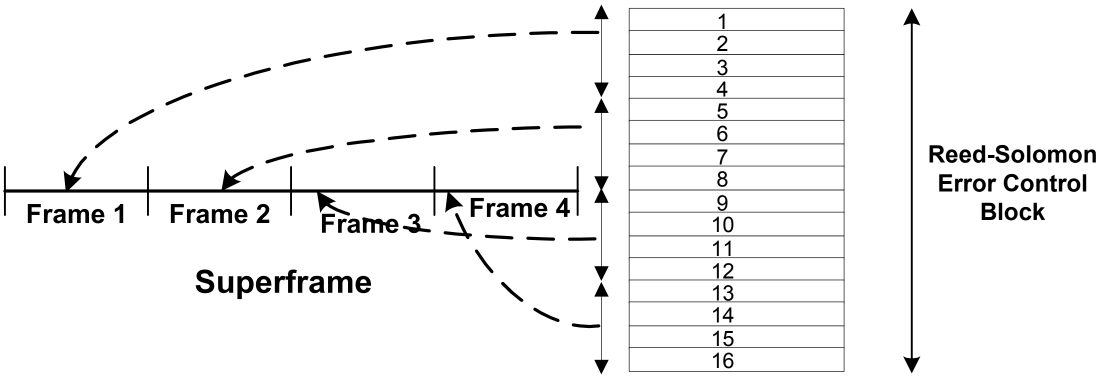

Figure 4.7.1-1 Sequencing of Packets of a Single Reed-Solomon Error Control Block

4.7.2 Sequencing of Packets from Multiple Reed-Solomon Error Control Blocks

When multiple error control blocks need to be transmitted in a superframe, then the process is repeated for each error control block. This is illustrated in Figure 4.7.2-1 for the case of 2 error control blocks. In Figure 4.7.2-1, a sub-block from each error control block is sent in every frame with all of the sub-blocks assigned to a frame transmitted contiguously**.** The following algorithm is utilized while sequencing MAC packets to the Physical layer: Let the MAC packets in an error control block be denoted by m-n, where m refers to the error control block number and n refers to MAC packet number within an error control block. In a single frame, n varies from 1 to 4, while m ranges from 1 to G (G is the number of error control blocks sent in a superframe; G=2 for the example in Figure 4.7.2-1).

The MAC packets shall be sent to the Physical layer in the order 1-1, 2-1, 1-2, 2-2, 1-3, 2-3, 1-4, 2-4, 1-5, 2-5, 1-6, 2-6, 1-7, 2-7, 1-8 and 2-8. The interleaving of MAC packets increases the time diversity across individual Reed-Solomon error control blocks, which can be significant for large values of G.

On the receive side, the MAC packets received from the Physical layer are in the same order. That is, they are received in the order 1-1, 2-1, 1-2, 2-2, 1-3, 2-3, 1-4, 2-4, 1-5, 2-5, 1-6, 2-6, 1-7, 2-7, 1-8 and 2-8. The MAC layer shall accumulate one sub-block belonging to each error control block from every frame.

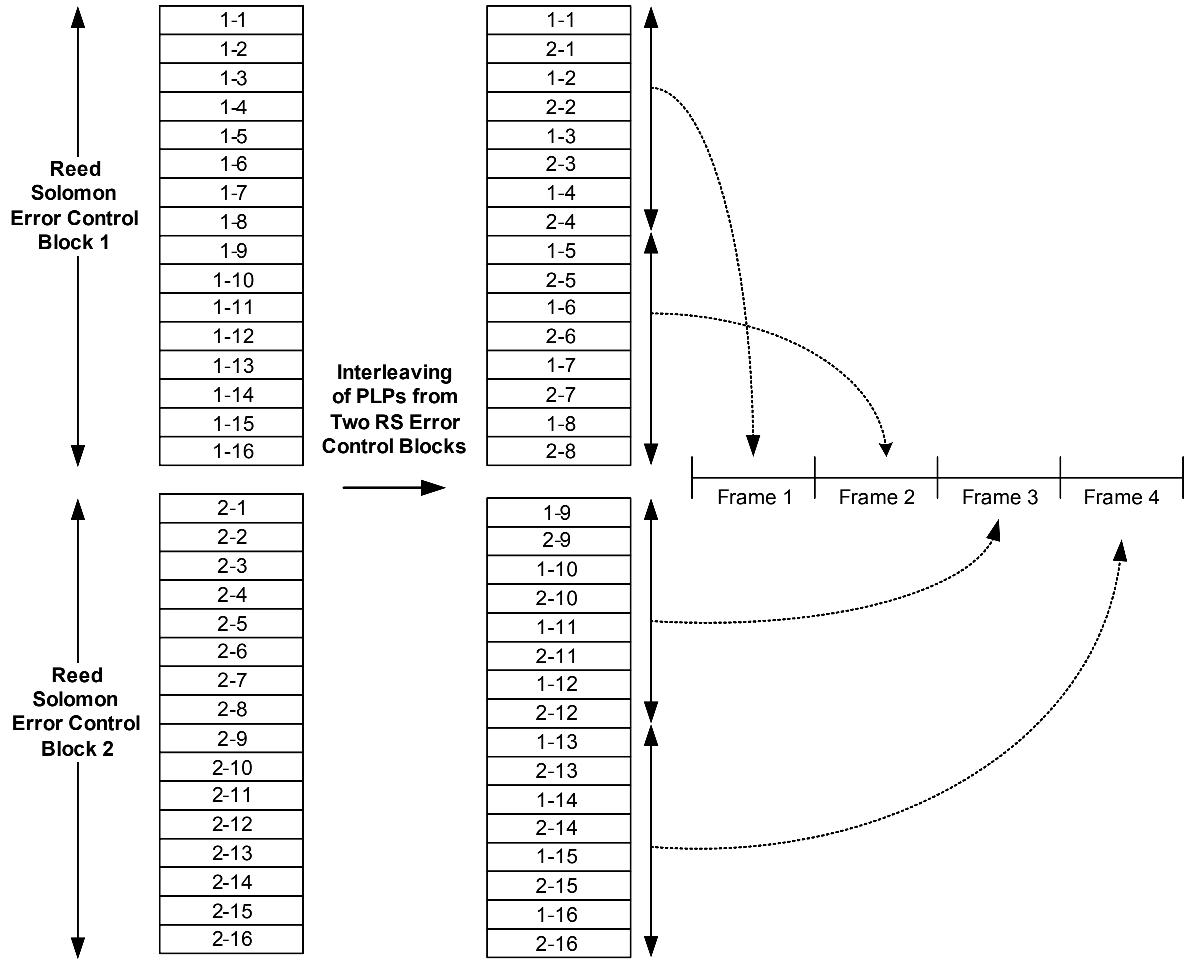

Figure 4.7.2-1 Sequencing of MAC Packets from 2 Reed-Solomon Error Control Blocks

4.8 MLC Multiplexing Function

4.8.1 Introduction

The MAC layer at the Forward Link Only network allocates air-link resources to MLCs in the MLC multiplexing function. While the details of the algorithms used to perform this function is beyond the scope of this specification, this section specifies high level requirements for the function and how it interacts with other protocols.

In order to describe the MLC multiplexing function some background information on the Forward Link Only Physical layer beyond that provided in 1 is required. The following simplified Physical layer description provides the background necessary to describe these functions. See 5 for a complete description of the Physical layer.

For the purposes of this discussion the Forward Link Only Physical layer can be thought of as a sequence of superframes in time. Each superframe consists of TDM Pilot Channels, OIS Channels, FDM Pilot Channels and Data Channels. However, only the Data Channels are pertinent to the topic of slot allocation. There are two Data Channels; the Wide-area Data Channel and the Local-area Data Channel. The MLC multiplexing function is identical for the Wide-area and Local-area Data Channels so the specific Data Channel is ignored in the following description.

The Data Channel in each superframe is divided into four, equal-duration frames. Each frame consists of a sequence of MAC time units. A portion (MAC time units *m* through *n*) of one such Data Channel frame is depicted in Figure 4.8.1-1. The sub-carriers of each MAC time unit are divided into seven *slots*. This *slot* is the unit that the MAC layer MLC multiplexing function allocates to MLCs.

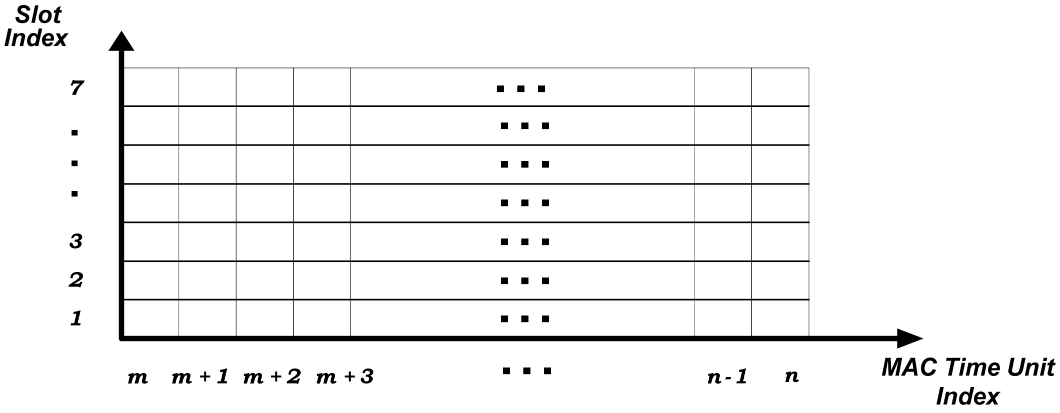

Figure 4.8.1-1 Portion of Data Channel Frame

Once the Multiplexing Function allocates slots for a superframe the location of each MLC is conveyed to the Data Channel MAC protocol instances for inclusion in the Data Channel MAC protocol capsule trailers (see 4.3.5.1) and to the OIS MAC protocol for inclusion into the SystemParameters message.

4.8.2 Requirements

The MLC multiplexing function shall receive resources requested for an MLC upon invocation.

The MLC multiplexing function shall allocate a set of slots of the superframe exclusively to an MLC.

The MLC multiplexing function shall allocate slots to an MLC with respect to the MAC time units in a single frame, and this allocation of slots shall be repeated for the remaining (three) frames of a superframe.

The MLC multiplexing function shall allocate slots to an MLC in an increasing order of contiguous MAC time units, and, within each MAC time unit, in an increasing order of consecutive slot indices.

The MLC multiplexing function shall allocate slots to each MLC listed in the MLC Records table such that the MLC location can be described in the format of the MLC Location Record structure in 4.2.5.1.

The MLC multiplexing function shall allocate slots to each MLC listed in the Extended MLC Records table such that the MLC location can be described in the format of the Extended MLC Location Record structure in 4.2.5.1.

The MLC multiplexing function shall convey the location of the slots allocated to the MLC for the superframe to be transmitted at T_{SF_Start} to the corresponding Data Channel MAC protocol instance[26].

The MLC multiplexing function shall convey the location of the slots allocated to each MLCs to be transmitted in superframe T_{SF_Start} to the OIS Channel MAC protocol..

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[26] The Data Channel MAC protocol will use this slot information to populate the Data Channel MAC protocol capsule trailer formed for the superframe to be transmitted at $T_{SF\_Start} – 1$, or $T_{SF\_Start} – 2$ depending on the latency of the MAC trailer location information.

No Text

5 PHYSICAL LAYER

This section includes the specification of the Forward Link Only Physical layer. There are two options for the Forward Link Only Physical layer for the Data Channel. The two Data Channel Physical layer options are referred to as PHY Type 1 and PHY Type 2. The Forward Link Only network and the Forward Link Only device shall support at least one of the two Physical layer options for the Data Channel.

5.1 Physical Layer Packets

5.1.1 Overview

The transmission unit of the Physical layer is a Physical layer packet. A Physical layer packet has a length of 1000 bits. A Physical layer packet carries one MAC layer packet.

5.1.2 Physical Layer Packet Format

The Physical layer packet shall use the following format:

Field	**Length (bits)**
MAC Layer Packet	976
FCS	16
Reserved	2
TAIL	6

MAC Layer Packet - MAC layer packet from the OIS, Data or Control Channel MAC protocol

FCS - Frame check sequence (see 5.1.4)

Reserved - The Forward Link Only network shall set this field to zero. The Forward Link Only device shall ignore this field.

TAIL - Encoder tail bits. This field shall be set to all ‘0’s.

Figure 5.1.2-1 illustrates the format of the Physical layer packet.

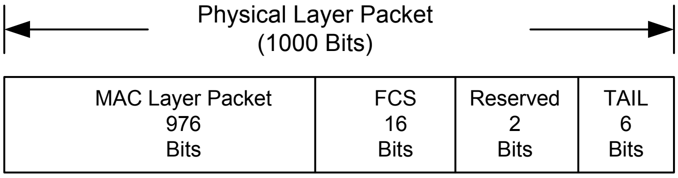

Figure 5.1.2-1 Physical Layer Packet Format

5.1.3 Bit Transmission Order

Each field of the Physical layer packet shall be transmitted in sequence such that the most significant bit (MSB) is transmitted first and the least significant bit (LSB) is transmitted last[27]. The MSB is the left-most bit in the figures of the document.

5.1.4 Computation of the FCS Bits

The FCS computation described here shall be used for computing the FCS field in the Physical layer packet.

The FCS shall be a CRC calculated using the standard CRC-CCITT generator polynomial:

$$g(x) = x^{16} + x^{12} + x^{5} + 1.$$

The FCS shall be equal to the value computed according to the following procedure as shown in Figure 5.1.4-1:

- All shift-register elements shall be initialized to ‘1’s[28].
- The switches shall be set in the up position.
- The register shall be clocked once for each bit of the Physical layer packet except for the FCS, Reserved and TAIL bits. The Physical layer packet shall be read from the MSB to LSB.
- The switches shall be set in the down position so that the output is a modulo-2 addition with a ‘0’ and the successive shift-register inputs are ‘0’s.
- The register shall be clocked an additional 16 times for the 16 FCS bits.
- The output bits constitute all fields of the Physical layer packets except the Reserved and TAIL fields.

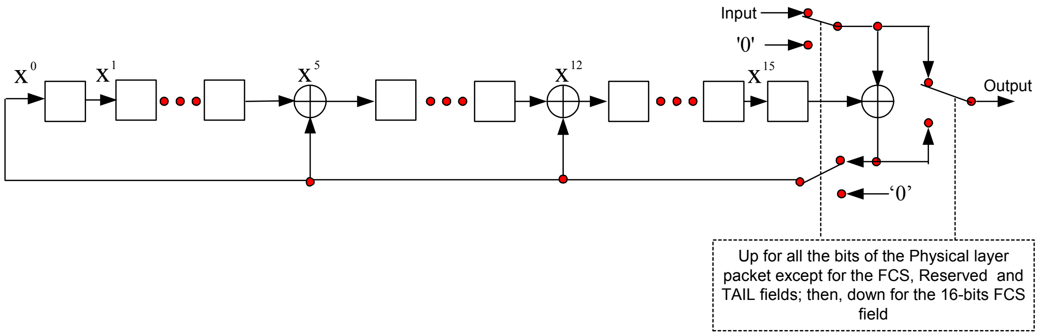

Figure 5.1.4-1 FCS Computation for the Physical Layer Packet

5.2 Forward Link Only Transmitter Requirements

This section defines requirements specific to the Forward Link Only transmitter.

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[27] When mapping the MAC layer packet into the Physical layer packet, the first bit of the MAC layer packet (see Figure 1.10-2) is assigned to the most significant bit (MSB) of the Physical layer packet.

[28] Initialization of the register to ones causes the CRC for all-zero data to be non-zero. This initialization shall be performed prior to starting the FCS computation for each Physical layer packet.

5.2.1 Frequency Parameters

5.2.1.1 Transmit Bandwidth and Frequency

The transmitter shall operate in at least one RF channel bandwidth of 5, 6, 7, or 8 MHz and at least one carrier center frequency between 0 Hz and 26.84354555 GHz. The frequency employed shall be specified in the Extended Neighbor List Description Message, as described in Section 2.2.5.2.2.2. Each allocation of carrier center frequency and RF channel bandwidth is called a Forward Link Only RF Channel.

5.2.1.2 Frequency Tolerance

For carrier center frequencies between 470 and 862 MHz, the maximum frequency difference between the actual transmit carrier frequency and the specified transmit frequency shall be as specified in [2]. For other carrier center frequencies, the frequency tolerance requirements will be specified in future revisions of [2].

5.2.1.3 Power Output Characteristics

The transmit ERP shall conform to the regulatory requirements prevailing in the region of deployment of Forward Link Only systems. For operation in the U.S. and in the Forward Link Only RF Channels with carrier center frequencies between 701 MHz and 743 MHz, the transmit ERP shall be less than 46.98 dBW[29] (see [1]).

5.2.2 OFDM Modulation Characteristics

5.2.2.1 Overview

The modulation used on the air-link is Orthogonal Frequency Division Multiplexing (OFDM). The smallest transmission interval corresponds to one OFDM symbol period. The OFDM transmit symbol is comprised of many separately modulated sub-carriers.

5.2.2.2 Sub-carriers

The Forward Link Only system shall use N_{FFT} sub-carriers, numbered 0 through N_{FFT} - 1. The value of N_{FFT} can be 1024, 2048, 4096, or 8192. The Forward Link Only transmitter shall support at least one of the four possible values of N_{FFT}. N_{FFT} is also referred to as the FFT size and the possible values are abbreviated to 1K, 2K, 4K, and 8K for 1024, 2048, 4096 and 8192, respectively. Correspondingly, the OFDM symbols for the different FFT sizes are referred to as 1K, 2K, 4K and 8K OFDM symbols.

5.2.2.2.1 Sub-carrier Groups

The N_{FFT} sub-carriers are divided into two separate groups as follows:

5.2.2.2.1.1 Guard Sub-carriers

Of the available N_{FFT} sub-carriers, some of the sub-carriers are unused. These unused sub-carriers are called guard sub-carriers and the number of guard sub-carriers, denoted by G, shall be

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[29] This corresponds to 50 kW.

$$G = 96 \times \left(\frac{N_{FFT}}{4096} \right)$$

No energy shall be transmitted on the guard sub-carriers. Sub-carriers numbered 0 through (G/2) - 1, $N_{FFT}/2$, and N_{FFT} - (G/2) + 1 through N_{FFT} - 1 shall be used as guard sub-carriers. For example, for the 4K FFT size, G = 96 and the guard sub-carriers are numbered 0 through 47, 2048, and 4049 through 4095.

5.2.2.2.1.2 Active Sub-carriers

The active sub-carriers shall be a group of N_{FFT}-G sub-carriers with indices
$i \in \{G/2,\ (G/2) + 1, \ldots,\ (N_{FFT}/2) - 1,\ (N_{FFT}/2) + 1,\ (N_{FFT}/2) + 2, \ldots,\ N_{FFT} - (G/2)\}$.

For example, for the 4K FFT size, the active sub-carriers indices are
$i \in \{48,\ 49, \ldots,\ 2047,\ 2049,\ 2050, \ldots,\ 4048\}$

Each active sub-carrier shall carry a modulation symbol.

5.2.2.2.2 Sub-carrier Spacing

In the Forward Link Only system, the N_{FFT} sub-carriers shall span a bandwidth, denoted by B, given by

$$B = 0.925 \times W$$

where W is the RF channel bandwidth (= 5, 6, 7 or 8 MHz). The Bandwidth B is centered around the carrier center frequency of the Forward Link Only transmit band. The sub-carrier spacing, $(\Delta f)_{SC}$, shall be given by:

$$(\Delta f)_{SC} = \frac{B}{N_{FFT}}$$

For example, for the 4K FFT size and a 6 MHz RF Channel bandwidth, B = 5.55 MHz and

$$(\Delta f)_{SC} = \frac{5.55 \times 10^6}{4096} = 1.35498046875 \text{ kHz}$$

5.2.2.2.3 Sub-carrier Frequency

The frequency of the sub-carrier with index *i* shall be computed as per the following equation:

$$f_{SC}(i) = f_C + (i - N_{FFT}/2) \times (\Delta f)_{SC}$$

where

f_C is the carrier center frequency for the Forward Link Only RF Channel.

$(\Delta f)_{SC}$ is the sub-carrier spacing.

$i \in \{0,\ 1, \ldots,\ N_{FFT} - 1\}$.

5.2.2.2.4 Sub-carrier Interlaces

The active sub-carriers shall be sub-divided into 8 interlaces indexed from 0 through 7. The sub-carriers in an interlace shall be spaced [$8 \times (\Delta f)_{SC}$] apart[30] in frequency, with $(\Delta f)_{SC}$ being the sub-carrier spacing. The number of sub-carriers in an interlace is denoted by $N_{Interlace}$ and it shall be related to the FFT size and the number of guard sub-carriers as

$$N_{\text{Interlace}} = \frac{N_{\text{FFT}} - G}{8}$$

Thus, an interlace consists of 125, 250, 500, 1000 sub-carriers for the 1K, 2K, 4K and 8K FFT sizes, respectively.

The sub-carriers in each interlace shall span a bandwidth B out of the Forward Link Only RF Channel bandwidth. An active sub-carrier with sub-carrier index i shall be allocated[31] to interlace with index j, denoted by I_j, where $j = i \bmod 8$. The sub-carrier indices in each interlace shall be arranged sequentially in ascending order, with indices in the range[32] 0, 1, ..., $N_{Interlace}$ - 1. For example, for a 4K FFT size, the numbering of sub-carriers in an interlace shall be in the range 0, 1,..., 499.

5.2.2.3 Frame and Channel Structure

The transmitted OFDM symbols are organized into superframes. Each superframe shall have duration T_{SF} equal to 1s. The OFDM symbol consists of a number of time-domain baseband samples, called *OFDM chips.* These chips shall be transmitted at a chip rate of B samples per second, where B is the bandwidth occupied by the N_{FFT} sub-carriers. The total OFDM symbol interval $T_s^{'}$ is comprised of five parts: a useful part with duration T_U, a flat guard interval with duration T_{FGI}, a post-fix interval with duration T_{PFI} and two windowed intervals of duration T_{WGI} on the two sides, as illustrated in Figure 5.2.2.3-1. There shall be an overlap of T_{WGI} between consecutive OFDM symbols (see Figure 5.2.2.12.3-1). The post-fix interval is present only for the TDM Pilot 2 Channel OFDM symbol (see 5.2.2.10.1.4.7) and the last Local Transition Pilot Channel (LTPC) OFDM symbol (see 5.2.2.10.1.5.7). For all other OFDM symbols, T_{PFI} shall be equal to zero.

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[30] With the exception of interlace zero, where two sub-carriers in the middle of this interlace are separated by $16 \times (\Delta f)_{SC}$, since the sub-carrier with index $N_{FFT}/2$ is not used.

[31] With the exception of the sub-carrier with index 1012 for the 1K FFT size, which is not assigned to interlace 4. Instead, no energy shall be sent on sub-carrier index 1012 for the 1K FFT size.

[32] With the exception that the maximum sub-carrier index in interlace 0 for the 1K FFT size shall be 123, i.e., $N_{Interlace}$ - 2. Hence, the modulation symbol assigned to sub-carrier index 124 in interlace 0 for the 1K FFT size shall not be transmitted.

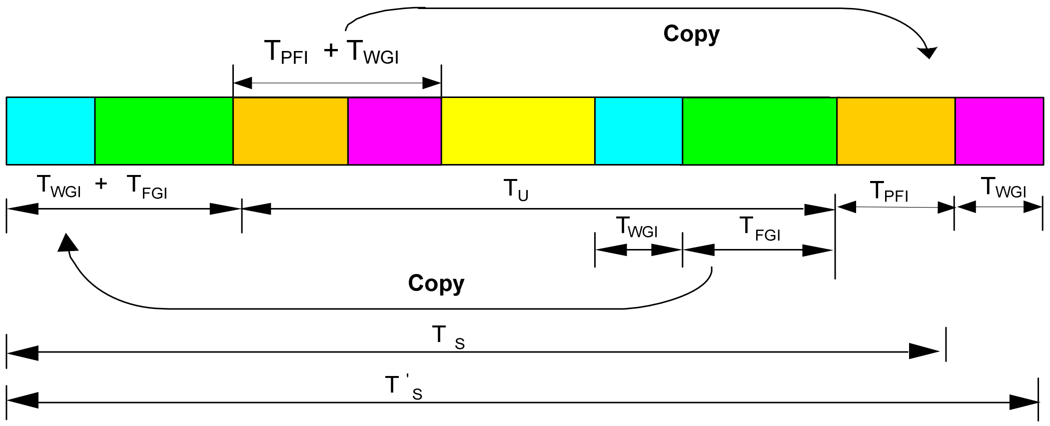

Figure 5.2.2.3-1 OFDM Symbol Duration

The effective OFDM symbol interval shall be $T_s = T_{WGI} + T_{FGI} + T_U + T_{PFI}$,

$$\text{where} \begin{cases} T_U = \mathrm{N_{FFT}}\ \text{chips} = \dfrac{\mathrm{N_{FFT}}}{\mathrm{B}}\ \mu s \\ T_{FGI} = \mathrm{FGI_{Fraction}} \times \mathrm{N_{FFT}}\ \text{chips} = \mathrm{FGI_{Fraction}} \times \dfrac{\mathrm{N_{FFT}}}{\mathrm{B}}\ \mu s \\ T_{WGI} = 17\ \text{chips} = \dfrac{17}{\mathrm{B}}\ \mu s \end{cases}$$

and $T_{PFI} = 0$ for all OFDM symbols except the TDM Pilot 2 Channel and the last LTPC OFDM symbol. Here, $\mathrm{FGI_{Fraction}}$ denotes the fraction of useful duration (T_U) allocated to the flat guard interval. For each FFT size, the values of $\mathrm{FGI_{Fraction}}$ that shall be supported are 1/16, 1/8, 3/16, 1/4 and[33] 1/2. The windowed guard interval shall be 17 chips for all choices of FFT size, chip rate and the flat guard interval.

For example, for the 4K FFT size, with $\mathrm{FGI_{Fraction}}$ equal to 1/8, the OFDM symbol interval for the Data Channel (see Figure 5.2.2.3-2) consists of

$$\begin{cases} T_U = 738.018018...\ \mu s \\ T_{FGI} = 92.252252...\ \mu s \\ T_{WGI} = 3.063063...\ \mu s \\ T_s = 833.3333...\ \mu s \\ T_{PFI} = 0 \end{cases}$$

The supported values of the OFDM symbol parameters are summarized in Table 5.2.2.3-1#

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[33] The value of 1/2 is used only for the Positioning Pilot Channel (see 5.2.2.10.1.6).

Table 5.2.2.3-1 Summary of OFDM Symbol Parameters

Parameter	Symbol	Values
FFT size	N_{FFT}	(1024, 2048, 4096, 8192)
Chip rate (MHz)	B	(4.625, 5.55, 6.475, 7.4)
Flat Guard Interval fraction	$FGI_{Fraction}$	(1/16, 1/8, 3/16, 1/4, 1/2)

The total OFDM symbol duration shall be $T_s' = T_s + T_{WGI}$. The effective OFDM symbol duration (T_s) shall henceforth be referred to as the OFDM symbol interval. During an OFDM symbol interval, a modulation symbol shall be carried on each of the active sub-carriers.

The Forward Link Only Physical layer channels (see Figure 1.5-1) are the TDM Pilot Channel, the FDM Pilot Channel, the OIS Channel, and the Data Channel. The TDM Pilot Channel, the OIS Channel, and the Data Channel shall be time division multiplexed over a superframe. The FDM Pilot Channel shall be frequency division multiplexed with the OIS Channel and the Data Channel over a superframe as illustrated in Figure 5.2.2.3-2.

The TDM Pilot Channel is comprised of the following sub-channels: TDM Pilot 1 Channel, the Wide-area Identification Channel (WIC), the Local-area Identification Channel (LIC), the TDM Pilot 2 Channel, the Transition Pilot Channel (TPC), the Positioning Pilot Channel (PPC) and the Signaling Parameter Channel (SPC). The TDM Pilot 1 Channel, the WIC, the LIC and the TDM Pilot 2 Channel appear at the beginning of a superframe. A Transition Pilot Channel (TPC) shall precede and follow each Wide-area and Local-area Data or OIS Channel transmission. The TPC flanking the Wide-area Channel (Wide-area OIS or Wide-area Data) is called the Wide-area Transition Pilot Channel (WTPC). The TPC flanking the Local-area channel (Local-area OIS or Local-area Data Channel) transmission is called the Local-area Transition Pilot Channel (LTPC). The PPC can be present or absent and this status shall be signaled over the OIS Channel. The SPC is transmitted at the end of the superframe.

The OIS Channel shall immediately follow the first WTPC in a superframe. The OIS Channel is comprised of the Wide-area OIS Channel and the Local-area OIS Channel. For a specified FFT size, the Wide-area OIS Channel and the Local-area OIS Channel shall each have the same duration.

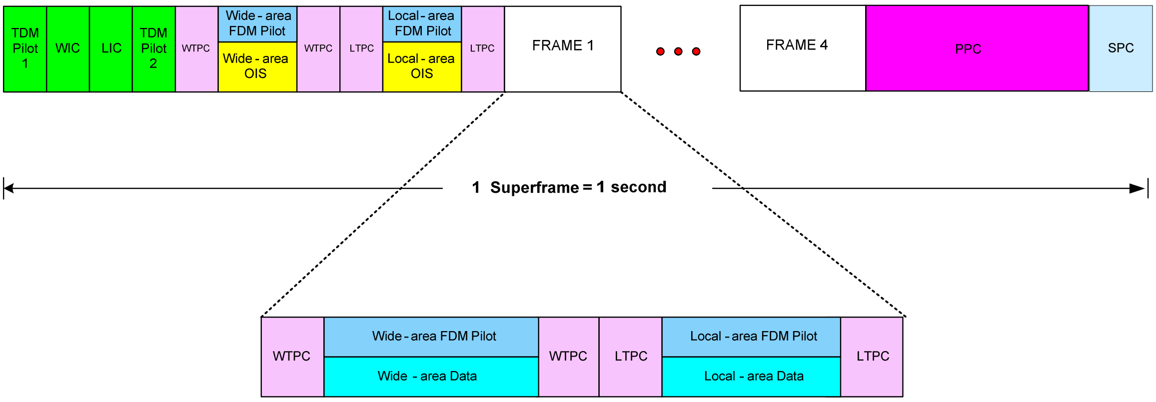

Figure 5.2.2.3-2 Forward Link Only SuperFrame and Channel Structure

The Data Channel transmissions and the TPC transmissions immediately preceding or following each Data Channel transmission are divided into 4 frames. The Data Channel during each frame shall be time division multiplexed between the Wide-area Data Channel and the Local-area Data Channel. For each combination of N_{FFT}, B and $FGI_{Fraction}$ in Table 5.2.2.3-1, the duration of the frames shall be as specified in 6.1.

The Physical layer packets transmitted over the OIS Channel are called OIS packets and the Physical layer packets transmitted over the Data Channel are called Data packets.

5.2.2.4 Flow Components and Layered Modulation

The audio or video content associated with a flow multicast over the Forward Link Only network may be sent in two components, i.e. a base (B) component that enjoys widespread reception and an enhancement (E) component that improves upon the audio-visual experience provided by the base component over a more limited coverage area. The base and the enhancement component Physical layer packets are jointly mapped to modulation symbols. This Forward Link Only feature is known as layered modulation.

5.2.2.5 Multicast Logical Channel

The Data packets transmitted by the Physical layer are associated with one or more virtual channels called Multicast Logical Channels (MLC). An MLC is a decodable component of a Forward Link Only service that is of independent reception interest to a Forward Link Only device. A service may be sent over multiple MLCs. However, the base and enhancement component of an audio or video flow associated with a service shall be transmitted over a single MLC.

5.2.2.6 Forward Link Only Transmit Modes

The combination of modulation type, the inner code rate and PHY Type is called the "transmit mode". The Forward Link Only system shall support the eleven transmit modes for the Data channel listed in Table 5.2.2.6-2 when the Physical layer corresponds to PHY Type 1. When the Physical layer option corresponds to PHY Type 2, the Forward Link Only system shall support the twenty one transmit modes for the Data channel listed in Table 5.2.2.6-3. The transmit mode for the OIS Channel shall always be set to mode 5. In the Forward Link Only network, the transmit mode is fixed when an MLC is instantiated and is changed infrequently. This restriction is imposed in order to maintain a constant coverage area for each MLC.

Table 5.2.2.6-1 Forward Link Only OIS Channel Transmit Mode

Mode Number	**Modulation (see 5.2.2.10.6.1.6.1, 5.2.2.10.6.1.6.2, 5.2.2.10.7.1.6.3)**	**Turbo Code Rate (see 5.2.2.10.6.1.1 & 5.2.2.10.2.1)**
5	QPSK	1/5

Table 5.2.2.6-2 Forward Link Only Data Channel Transmit Modes for PHY Type 1

Mode Number	Modulation (see 5.2.2.10.6.1.6.1, 5.2.2.10.6.1.6.2, 5.2.2.10.7.1.6.3)	Turbo Code Rate (see 5.2.2.10.6.1.1 & 5.2.2.10.2.1)
0	QPSK	1/3
1	QPSK	1/2
2	16-QAM	1/3
3	16-QAM	1/2
4	16-QAM	2/3
6	Layered Modulation with energy ratio 4	1/3
7	Layered Modulation with energy ratio 4	1/2
8	Layered Modulation with energy ratio 4	2/3
9	Layered Modulation with energy ratio 6.25	1/3
10	Layered Modulation with energy ratio 6.25	1/2
11	Layered Modulation with energy ratio 6.25	2/3

Table 5.2.2.6-3 Forward Link Only Data Channel Transmit Modes for PHY Type 2

Mode Number	**Modulation (see 5.2.2.10.6.2.10.1, 5.2.2.10.6.2.10.2, 5.2.2.10.6.2.10.3)**	**Turbo Code Rate (see 5.2.2.10.6.2.1 & 5.2.2.10.2.1)**
64	QPSK	1/3
65	QPSK	4/11
66	QPSK	2/5
67	QPSK	1/2
68	16-QAM	2/7
69	16-QAM	1/3
70	16-QAM	2/5
71	16-QAM	1/2
72	16-QAM	2/3
80	Layered Modulation with energy ratio 4	2/7
81	Layered Modulation with energy ratio 4	1/3
82	Layered Modulation with energy ratio 4	4/11
83	Layered Modulation with energy ratio 4	2/5
84	Layered Modulation with energy ratio 4	1/2
85	Layered Modulation with energy ratio 4	2/3
86	Layered Modulation with energy ratio 6.25	2/7
87	Layered Modulation with energy ratio 6.25	1/3
88	Layered Modulation with energy ratio 6.25	4/11
89	Layered Modulation with energy ratio 6.25	2/5
90	Layered Modulation with energy ratio 6.25	1/2
91	Layered Modulation with energy ratio 6.25	2/3

5.2.2.7 Forward Link Only MAC Time Units

In the MAC layer of the Forward Link Only Network, each frame is sub-divided into MAC time units for the purpose of scheduling the MLCs. For the 4K FFT size, one MAC time unit corresponds to one 4K OFDM symbol interval. For all FFT sizes, the correspondence between MAC time units and OFDM symbol intervals at the Physical layer is summarized in Table 5.2.2.7-1.

Table 5.2.2.7-1 Relationship between MAC Time Units and OFDM Symbol Intervals

FFT Size	Number of OFDM Symbol Intervals per MAC Time Unit	Notes
1024	4	The number of 1K OFDM symbols in a frame is constrained to be a multiple of 4, so that the frame has an integer number of MAC time units.
2048	2	The number of 2K OFDM symbols in a frame is constrained to be a multiple of 2, so that the frame has an integer number of MAC time units.
4096	1	MAC time units are the same as 4K OFDM symbols.
8192	½	Two consecutive MAC time units are mapped into one 8K OFDM symbol. The number of MAC time units in each of the wide-area and local-area data channels of a frame is constrained to be a multiple of 2, so that there are an integer number of OFDM symbols.

The notion of a MAC time unit is applicable only to the TPC, the OIS/FDM Pilot Channels, Data/FDM Pilot Channels and the PPC. The indexing for the MAC time units begins from the first WTPC MAC time unit[34], which has an index of 4. The index of the MAC time unit is henceforth referred to as the MAC time index. The indexing for the OFDM symbols begins from the WIC OFDM symbol, which has an index of 1. The OFDM symbol index increments for each OFDM symbol interval (T_s) [35] in the superframe. The relation between the OFDM symbol index and the MAC time index shall be as specified in 5.2.2.11.

5.2.2.8 Forward Link Only Slots

In the Forward Link Only network, the smallest unit of bandwidth allocated to a MLC over a MAC time unit corresponds to a group of 500 modulation symbols. This group of 500 modulation symbols is called a slot. The MLC multiplexing function in the MAC layer allocates slots to MLCs over one or more MAC time units during the data portion of the superframe. When the MLC multiplexing function allocates bandwidth for transmission to a MLC in a MAC time unit, it does so in integer units of slots.

There are 8 slots during every MAC time unit. These slots shall be numbered 0 through 7. The FDM Pilot Channel shall occupy 1 slot with index 0 and the OIS/Data Channel may occupy up to 7 slots with indices 1 through 7. Each slot shall be transmitted over 500 sub-

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[34] The first WTPC MAC time unit occurs after the TDM Pilot 2 Channel, as shown in Figure 5.2.2.3-2.

[35] It should be noted that, even with a fixed FFT size, the OFDM symbol interval can vary across the OFDM symbols in a super-frame.

carriers. These 500 sub-carriers belong to one or more interlaces, depending on the FFT size, as described in Table 5.2.2.8-1.

Table 5.2.2.8-1 Relationship between Slots and Interlaces

FFT Size	**Number of sub-carriers per Interlace ($N_{Interlace}$)**	**Number of Interlaces per Slot**	**Notes**
1024	125	4	The four interlaces that correspond to one slot are sent over four consecutive 1K OFDM symbols
2048	250	2	The two interlaces that correspond to one slot are sent over two consecutive 2K OFDM symbols
4096	500	1	Slots and interlaces have a one-to-one mapping in each 4K OFDM symbol
8192	1000	½	Two slots map to one interlace in each 8K OFDM symbol

The mapping from slots to interlaces varies from OFDM symbol to OFDM symbol and is described in 5.2.2.11.

5.2.2.9 Forward Link Only Data Rates

In the Forward Link Only system the calculation of data rates is complicated by the fact that different MLCs may utilize different modes. The computation of data rates is simplified by assuming that all MLCs use the same transmit mode. Table 5.2.2.9-1 gives the Physical layer data rates for the different Data Channel transmit modes for PHY Type 1 using a transmit bandwidth of 6 MHz and a flat guard interval fraction of 1/8, assuming all 7 data slots are used. Under the same assumptions of 6 MHz transmit bandwidth, flat guard interval fraction of 1/8 and assuming all 7 data slots are used, Table 5.2.2.9-2 gives the Data Channel Physical layer data rates for the different transmit modes for PHY Type 2. The Physical layer data rates are provided for all values of the bandwidth in Table 6.2-1 and Table 6.2-2.

Table 5.2.2.9-1 Forward Link Only Data Channel Transmit Modes for PHY Type 1 and Physical Layer Data Rates

Transmit Mode	Slots per Physical Layer Packet	Physical Layer Data Rate[36] (Mbps)
0	3	2.8
1	2	4.2
2	3/2	5.6
3	1	8.4
4	3/4	11.2
5	N/A[37]	
6	3	5.6
7	2	8.4
8	3/2	11.2
9	3	5.6
10	2	8.4
11	3/2	11.2

---

[36] The overhead due to the TDM Pilot channel and the outer code is not subtracted. This is the rate at which data is transmitted during the Data channel. For the layered modes 6 through 11, the rate quoted is the combined rate of the two components. The rate for each component will be half of this value.

[37] Transmit Mode 5 is only available for use for OIS Channel.

Table 5.2.2.9-2 Forward Link Only Data Channel Transmit Modes for PHY Type 2 and Physical Layer Data Rates

Transmit Mode	Slots per Physical Layer Packet	Physical Layer Data Rate[38] (Mbps)
64	3	2.8
65	11/4	3.05
66	5/2	3.36
67	2	4.2
68	7/4	4.8
69	3/2	5.6
70	5/4	6.72
71	1	8.4
72	3/4	11.2
80	7/2	4.8
81	3	5.6
82	11/4	6.11
83	5/2	6.72
84	2	8.4
85	3/2	11.2
86	7/2	4.8
87	3	5.6
88	11/4	6.11
89	5/2	6.72
90	2	8.4
91	3/2	11.2

5.2.2.10 Forward Link Only Physical Layer Channels

The Forward Link Only Physical layer is comprised of the following sub-channels:

- The TDM Pilot Channel.
- The Wide-area OIS Channel.
- The Local-area OIS Channel.
- The Wide-area FDM Pilot Channel.
- The Local-area FDM Pilot Channel.
- The Wide-area Data Channel.

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[38] The overhead due to the TDM Pilot channel is not subtracted. This is the rate at which data is transmitted during the Data channel. For the layered modes 80 through 91, the rate quoted is the combined rate of the two components. The rate for each component will be half of this value.

- The Local-area Data Channel.

5.2.2.10.1 TDM Pilot Channel

The TDM Pilot Channel is comprised of the following component channels.

5.2.2.10.1.1 TDM Pilot 1 Channel

The TDM Pilot 1 Channel shall consist of one 4K OFDM symbol[39] with a flat guard interval of 512 chips. The TDM Pilot 1 Channel shall span 4625 chips for all FFT sizes. It signals the start of a new superfame. It may be used by the Forward Link Only device for determining the coarse OFDM symbol timing, the superframe boundary, the FFT size and the carrier frequency offset.

The TDM Pilot 1 waveform shall be generated in the transmitter using the steps illustrated in Figure 5.2.2.10.1.1-1.

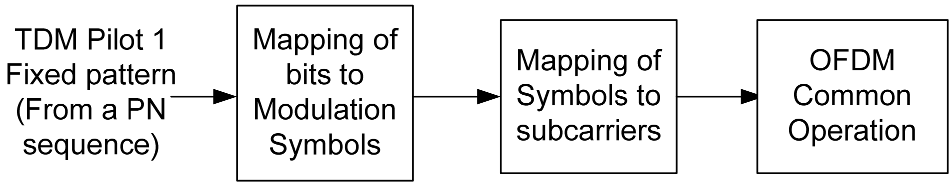

Figure 5.2.2.10.1.1-1 TDM Pilot 1 Fixed Pattern Processing in the Transmitter

5.2.2.10.1.1.1 TDM Pilot 1 Sub-carriers

The number of non-zero sub-carriers in the TDM Pilot 1 OFDM symbol, denoted by N_{TDM1}, shall be as shown in Table 5.2.2.10.1.1.1-1. These sub-carriers are uniformly spaced among the Active sub-carriers (see 5.2.2.2.1.2). The i^{th} TDM Pilot 1 sub-carrier shall correspond to the 4K sub-carrier index j, as defined in Table 5.2.2.10.1.1.1-1.

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[39] While the structure of the TDM Pilot 1 OFDM symbol is described using an FFT size of 4K, it can be generated using other FFT sizes of 1K, 2K or 8K, since it has at most 250 non-zero sub-carriers.

Table 5.2.2.10.1.1.1-1 TDM Pilot 1 Sub-carriers

FFT Size	Number of non-zero sub-carriers (N_{TDM1})	4K Sub-carrier indices (j)
1024	30	$j = \begin{cases} 128 + (i) \times 128, & \forall\ i \in \{0, 1, \ldots, 14\} \\ 128 + (i+1) \times 128, & \forall\ i \in \{15, \ldots, 29\} \end{cases}$
2048	62	$j = \begin{cases} 64 + (i) \times 64, & \forall\ i \in \{0, 1, \ldots, 30\} \\ 64 + (i+1) \times 64, & \forall\ i \in \{31, \ldots, 61\} \end{cases}$
4096	124	$j = \begin{cases} 64 + (i) \times 32, & \forall\ i \in \{0, 1, \ldots, 61\} \\ 64 + (i+1) \times 32, & \forall\ i \in \{62, \ldots, 123\} \end{cases}$
8192	250	$j = \begin{cases} 48 + (i) \times 16, & \forall\ i \in \{0, 1, \ldots, 124\} \\ 48 + (i+1) \times 16, & \forall\ i \in \{125, \ldots, 249\} \end{cases}$

The TDM Pilot 1 sub-carriers shall exclude the DC sub-carrier with index 2048.

5.2.2.10.1.1.2 TDM Pilot 1 Fixed Pattern

The TDM Pilot 1 sub-carriers shall be modulated with a fixed pattern. This pattern shall be generated using a 20-tap linear feedback shift register (LFSR) with generator sequence h(D) = $D^{20}+D^{17}+1$ and initial state '11110000100000000000'. Each output bit shall be obtained as follows: if the LFSR state is the vector $[s_{20}s_{19}s_{18}s_{17}s_{16}s_{15}s_{14}s_{13}s_{12}s_{11}s_{10}s_9s_8s_7s_6s_5s_4s_3s_2s_1]$ then, the output bit shall be $[s_{19} \oplus s_4]$, where $\oplus$ denotes modulo-2 addition[40]. The LFSR structure shall be as specified in Figure 5.2.2.10.1.1.2-1.

The fixed pattern shall correspond to the first 2 x N_{TDM1} output bits. The first 35-bits of the fixed pattern shall be '11010100100110110111001100101100001', with '110' appearing first.

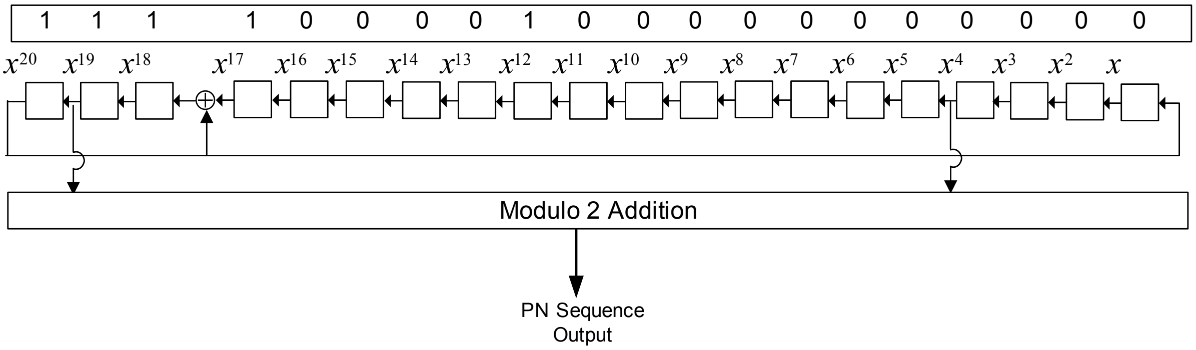

Figure 5.2.2.10.1.1.2-1 PN Sequence Generator for Modulating the TDM Pilot 1 Sub-carriers

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[40] This corresponds to the mask associated with slot 1 (see Table 5.2.2.10.1.2.3-1).

The TDM Pilot 1 fixed pattern of length 2 x N_{TDM1} bits is called the TDM Pilot 1 Information packet and is denoted as P1I. Each group of two consecutive bits in the P1I packet shall be used to generate QPSK modulation symbols.

5.2.2.10.1.1.3 Modulation Symbols Mapping

In the TDM Pilot 1 information packet, each group of two consecutive bits, P1I(2i) and P1I(2i+1), i = 0, 1,..., N_{TDM1} - 1, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1. The value of D shall be 8, $4\sqrt{2}$, 4 and $2\sqrt{2}$ for the 1K, 2K, 4K and 8K FFT sizes, respectively.[41]

Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

Table 5.2.2.10.1.1.3-1 QPSK Modulation Table

Input bits		**Modulation Symbols MS**	
s_1	**s_0**	**m_I**	**m_Q**
0	0	D	D
0	1	–D	D
1	0	D	-D
1	1	-D	-D

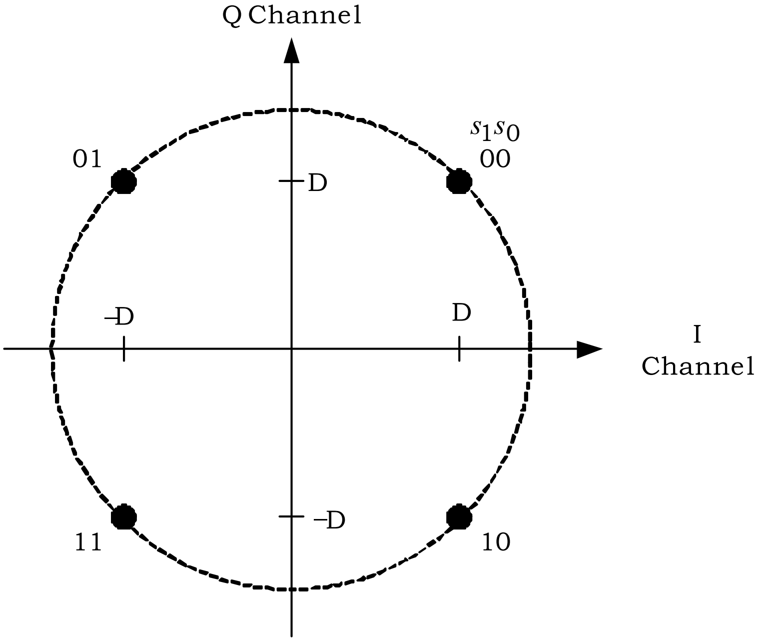

Figure 5.2.2.10.1.1.3-1 Signal Constellation for QPSK Modulation

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[41] This factor is calculated using the fact that only N_{TDM1} of the 4000 carriers are used:

$$D = \sqrt{\frac{1}{2} \times \frac{4000}{N_{TDM1}}} \approx 4\sqrt{\frac{4096}{N_{FFT}}}$$

5.2.2.10.1.1.4 Modulation Symbols to Sub-carrier Mapping

The i^{th} modulation symbol MS(i), i = 0, 1,..., N_{TDM1} - 1 shall be mapped to the sub-carrier with index *j* as specified in Table 5.2.2.10.1.1.1-1.

5.2.2.10.1.1.5 OFDM Common Operation

The modulated TDM Pilot 1 sub-carriers shall undergo common operations as specified in 5.2.2.12, with N_{FFT} = 4096.

5.2.2.10.1.2 Wide-area Identification Channel (WIC)

The Wide-area Identification Channel (WIC) shall consist of one 4K OFDM symbol[42] with a flat guard interval of 512 chips. The WIC shall span 4625 chips for all FFT sizes. It follows the TDM Pilot 1 Channel and the OFDM symbol index shall be equal to 1. This is an overhead channel that is used for conveying the Wide-area Differentiator information to Forward Link Only receivers. All transmit waveforms within a Wide-area[43] shall be scrambled using the 4-bit Wide-area Differentiator corresponding to that area.

For the WIC OFDM symbol in a superframe only 1 slot shall be allocated. The allocated slot shall use as input a 1000-bit fixed pattern, with each bit set to zero. The input bit pattern shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1. No processing shall be performed for the un-allocated slots.

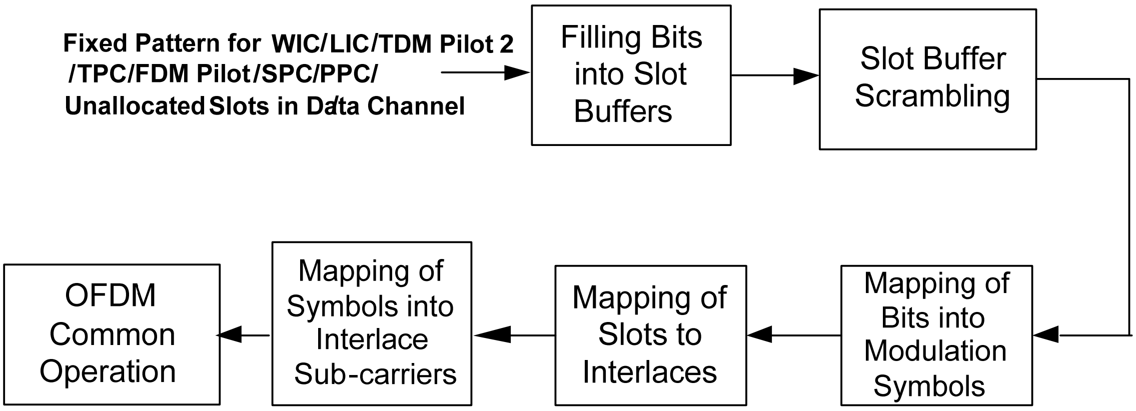

Figure 5.2.2.10.1.2-1 Fixed Pattern Processing in the Transmitter for TDM Pilot 2 /WIC/LIC/FDM Pilot/TPC/SPC/PPC/Un-allocated Slots in Data Channel

5.2.2.10.1.2.1 Slot Allocation

The WIC shall be allocated the slot with index 3. The allocated and un-allocated slots in the WIC OFDM symbol are illustrated in Figure 5.2.2.10.1.2.1-1. The selected slot index maps to interlace 0 for OFDM symbol index 1, using slot to interlace Mapping 1 (see 5.2.2.11.1).

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[42] For a fixed value of the WID, the WIC OFDM symbol is identical for all the FFT sizes. While the structure of the WIC OFDM symbol is described using an FFT size of 4K, it can be generated using other FFT sizes of 1K, 2K or 8K, since it has only 500 non-zero sub-carriers.

[43] Including Local-area channels but excluding the TDM Pilot 1 Channel and the SPC.

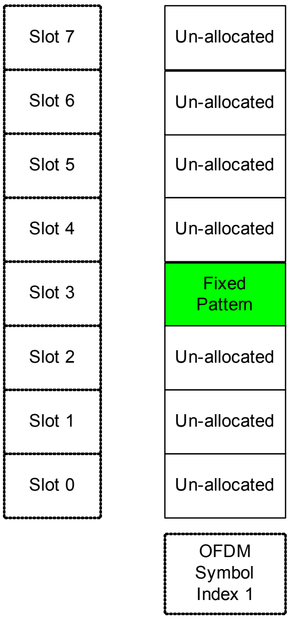

Figure 5.2.2.10.1.2.1-1 WIC Slot Allocation

5.2.2.10.1.2.2 Filling of Slot Buffer

The buffer for the allocated slot shall be completely filled with a fixed pattern consisting of 1000 bits, with each bit set to '0'. The buffers for the un-allocated slots shall be left empty.

For all the Physical Layer channels, the bits in an allocated slot shall be scrambled as specified below.

5.2.2.10.1.2.3 Slot Scrambling

The bits of each allocated slot buffer shall be XOR'd sequentially with the scrambler output bits to randomize the bits prior to modulation. The scrambled slot buffer corresponding to slot index i is denoted as SB(i), where $i \in \{0, 1, \ldots, 7\}$.

The scrambling sequence shall be equivalent to the one generated with a 20-tap linear feedback shift register (LFSR) with the generator sequence $h(D) = D^{20}+D^{17}+1$ and a 20 bit slot mask $[m_{19} \ldots m_0]$, as shown in Figure 5.2.2.10.1.2.3-1.

The LFSR shall be initialized to the state $[d_3d_2d_1d_0c_3c_2c_1c_0b_0a_{10}a_9a_8a_7a_6a_5a_4a_3a_2a_1a_0]$, which depends on the channel type (the TDM Pilot or the Wide-area or the Local-area Channel), and the scrambler seed index in a superframe. The scrambler seed index is the value of the 11 least significant bits of the initial state, $[a_{10}a_9 \ldots a_0]$.

Bits '$d_3d_2d_1d_0$' shall be set as follows:

- For all channels except the SPC, these bits shall be set to the 4-bit Wide-area Differentiator (WID).
- For the SPC, these bits are used to convey signaling parameters and shall be set as specified in 5.2.2.10.1.7.3.

Bits '$c_3c_2c_1c_0$' shall be set as follows:

- For the TDM Pilot 2 Channel, the Wide-area OIS Channel, the Wide-area FDM Pilot Channel, the Wide-area Data Channel, the WTPC, the WIC and the SPC, these bits shall be set to '0000'.

- For the Local-area OIS Channel, the LTPC, the LIC, the Local-area FDM Pilot Channel and the Local-area Data Channel, these bits shall be set to the 4-bit Local-area Differentiator (LID).
- For the PPC in the Inactive state (see 5.2.2.10.1.6.1), these bits shall be set to '0000'. For the PPC in the Identification state (see 5.2.2.10.1.6.2), these bits shall be set to '0000' for slot 1 and to the LID for slots 0, 2, 3, 4 and 6. For the PPC in the reserved state (see 5.2.2.10.1.6.3), these bits shall be set to the LID.

Bit b_0 is a reserved bit and shall be set to '1'.

Bits a_{10} through a_0 correspond to the scrambler seed index and shall be set as follows:

- For the WIC/LIC Channels, the scrambler seed index shall be set to be equal to the OFDM symbol index. The scrambler seed index shall be 1 for the WIC and 2 for the LIC.
- For the TDM Pilot 2 Channel, the scrambler seed index shall be 3 for 1K, 2K and 4K FFT sizes. For the 8K FFT size, the TDM Pilot 2 channel consists of 16 slots. For the first 8 slots, the scrambler seed index shall be 3. For the remaining 8 slots, the scrambler seed index shall be 4.
- For the TPC, OIS, Data and FDM Pilot channels, the scrambler seed index shall be equal to the MAC time index.
- For the PPC, the scrambler seed index shall be equal to the PPC MAC time index, see 5.2.2.10.1.6.
- For the first and second SPC OFDM symbols, the scrambler seed index shall be 0 and 1, respectively.

The scrambling sequence for each slot shall be generated by a modulo-2 inner product of the 20-bit state vector of the sequence generator and a 20-bit mask associated with that slot index as specified in Table 5.2.2.10.1.2.3-1.

Table 5.2.2.10.1.2.3-1 Mask Associated with Different Slots

Slot Index	m_{19}	m_{18}	m_{17}	m_{16}	m_{15}	m_{14}	m_{13}	m_{12}	m_{11}	m_{10}	m_9	m_8	m_7	m_6	m_5	m_4	m_3	m_2	m_1	m_0
0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
2	1	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	1
3	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0
6	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0
7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The shift register shall be reloaded with a new state $[d_3d_2d_1d_0c_3c_2c_1c_0b_0a_{10}a_9a_8a_7a_6a_5a_4a_3a_2a_1a_0]$ for each slot and for each new scrambler seed index.

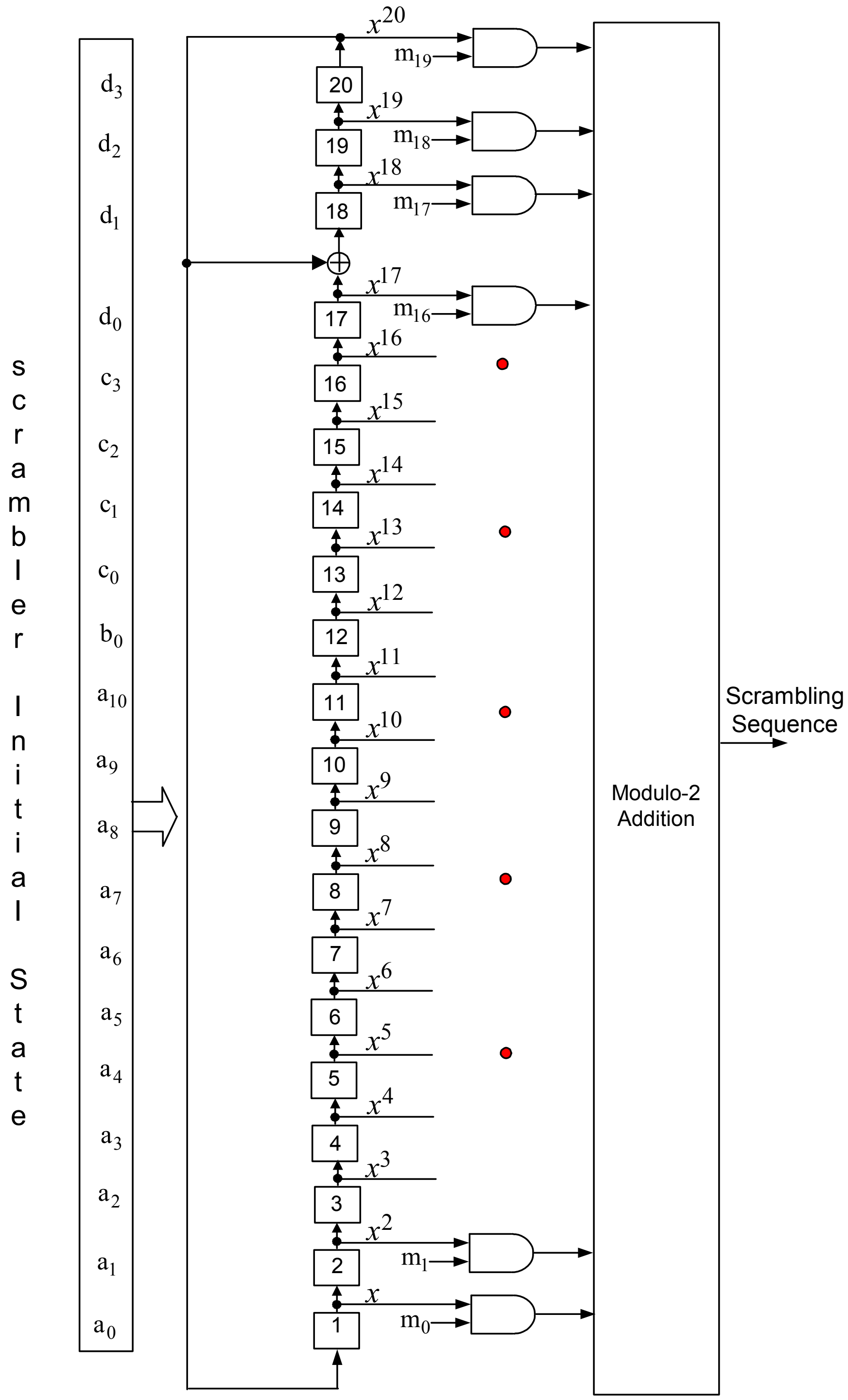

Figure 5.2.2.10.1.2.3-1 Slot Bit Scrambler

5.2.2.10.1.2.4 Modulation Symbol Mapping

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 3, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table

5.2.2.10.1.1.3-1 with[44] D = 2. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.2.5 Slot to Interlace Mapping

The mapping of slots to interlaces for the WIC OFDM symbol shall be as specified in 5.2.2.11.1.

5.2.2.10.1.2.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in the allocated slot shall be sequentially assigned to 500 interlace sub-carriers as follows: the ith complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the ith sub-carrier of that interlace.

5.2.2.10.1.2.7 OFDM Common Operation

The modulated WIC sub-carriers shall undergo common operations as specified in 5.2.2.12, with $N_{FFT} = 4096$.

5.2.2.10.1.3 Local-area Identification Channel (LIC)

The Local-area Identification Channel (LIC) shall consist of one 4K OFDM symbol[45] with a flat guard interval of 512 chips. The LIC shall span 4625 chips for all FFT sizes. It follows the WIC OFDM symbol and the OFDM symbol index shall be equal to 2. This is an overhead channel that is used for conveying the Local-area Differentiator information to Forward Link Only receivers. All Local-area transmit waveforms shall be scrambled using a 4-bit Local-area Differentiator, in conjunction with the Wide-area Differentiator, corresponding to that area.

For the LIC OFDM symbol in a superframe only a single slot shall be allocated. The allocated slot shall use a 1000-bit fixed pattern as input. These bits shall be set to zero. These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1. No processing shall be performed for the un-allocated slots.

5.2.2.10.1.3.1 Slot Allocation

The LIC shall be allocated the slot with index 5. The allocated and un-allocated slots in the LIC OFDM symbol are illustrated in Figure 5.2.2.10.1.3.1-1. The slot index chosen is the one that maps to interlace 0 for OFDM symbol index 2, for Slot to Interlace Mapping 1 (see 5.2.2.11.1).

---

[44] The value of D is chosen to keep the OFDM symbol energy constant, since only 500 of the 4000 available sub-carriers are used.

[45] For fixed values of the WID and LID, the LIC OFDM symbol is identical for all the FFT sizes. While the structure of the LIC OFDM symbol is described using an FFT size of 4K, it can be generated using other FFT sizes of 1K, 2K or 8K, since it has only 500 non-zero sub-carriers.

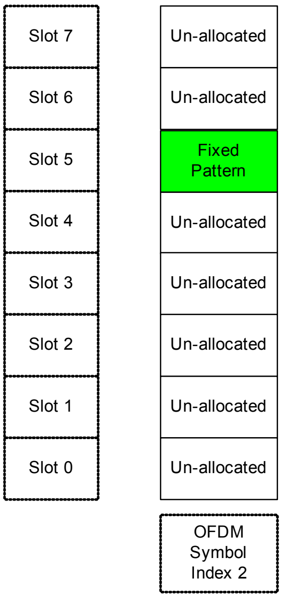

Figure 5.2.2.10.1.3.1-1 LIC Slot Allocation

5.2.2.10.1.3.2 Filling of Slot Buffer

The buffer for the allocated slot shall be completely filled with a fixed pattern consisting of 1000 bits, with each bit set to '0'. The buffers for the un-allocated slots shall be left empty.

5.2.2.10.1.3.3 Slot Scrambling

The bits of the LIC slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.3.4 Modulation Symbol Mapping

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 5, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with[46] D = 2. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.3.5 Slot to Interlace Mapping

The mapping of slots to interlaces for the LIC OFDM symbol shall be as specified in 5.2.2.11.1.

5.2.2.10.1.3.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in the allocated slot shall be sequentially assigned to 500 interlace sub-carriers as follows: the ith complex modulation symbol (where $i \in \{0, 1,\ldots, 499\}$) shall be mapped to the ith sub-carrier of that interlace.

---

[46] The value of D is chosen to keep the OFDM symbol energy constant, since only 500 of the 4000 available sub-carriers are used.

5.2.2.10.1.3.7 OFDM Common Operation

The modulated LIC sub-carriers shall undergo common operations as specified in 5.2.2.12, with $N_{FFT} = 4096$.

5.2.2.10.1.4 TDM Pilot 2 Channel

The TDM Pilot 2 Channel shall span one 1K, 2K, 4K or 8K OFDM symbol for FFT sizes of 1K, 2K, 4K or 8K, respectively. It follows the LIC OFDM symbol and the OFDM symbol index shall be equal to 3. For all FFT sizes, the TDM Pilot 2 Channel includes two identical periods. Each period shall span 1024, 2048, 2048 and 8192 chips for the 1K, 2K, 4K and 8K FFT sizes, respectively.[47] The TDM Pilot 2 Channel may be used for fine OFDM symbol timing corrections in the Forward Link Only receivers.

5.2.2.10.1.4.1 Slot Allocation

For the four FFT sizes, the number of slots and the indices of the allocated slots shall be as shown in Table 5.2.2.10.1.4.1-1.

Table 5.2.2.10.1.4.1-1 TDM Pilot 2 Channel: Slot allocation

FFT Size	Number of slots	Slot indices	Scrambler seed index
1024	2	1, 7	3
2048	4	0, 1, 2, 7	3
4096	4	0, 1, 2, 7	3
8192	16	0, 1, 2, 3,…,7	3, 4

Each allocated slot shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1. No processing shall be performed for the un-allocated slots.

The allocated and un-allocated slots in the TDM Pilot 2 Channel are illustrated in Figure 5.2.2.10.1.4.1-1.

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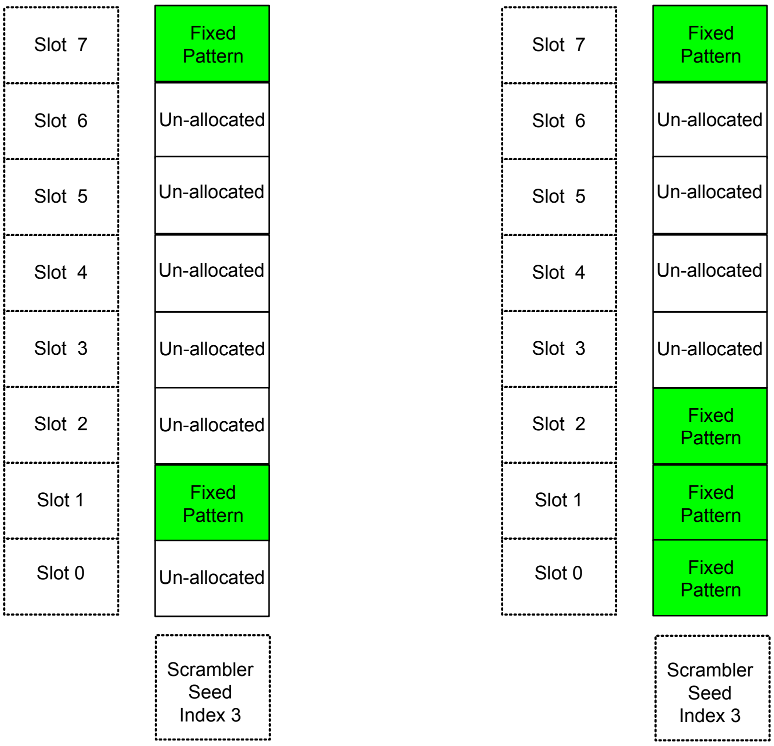
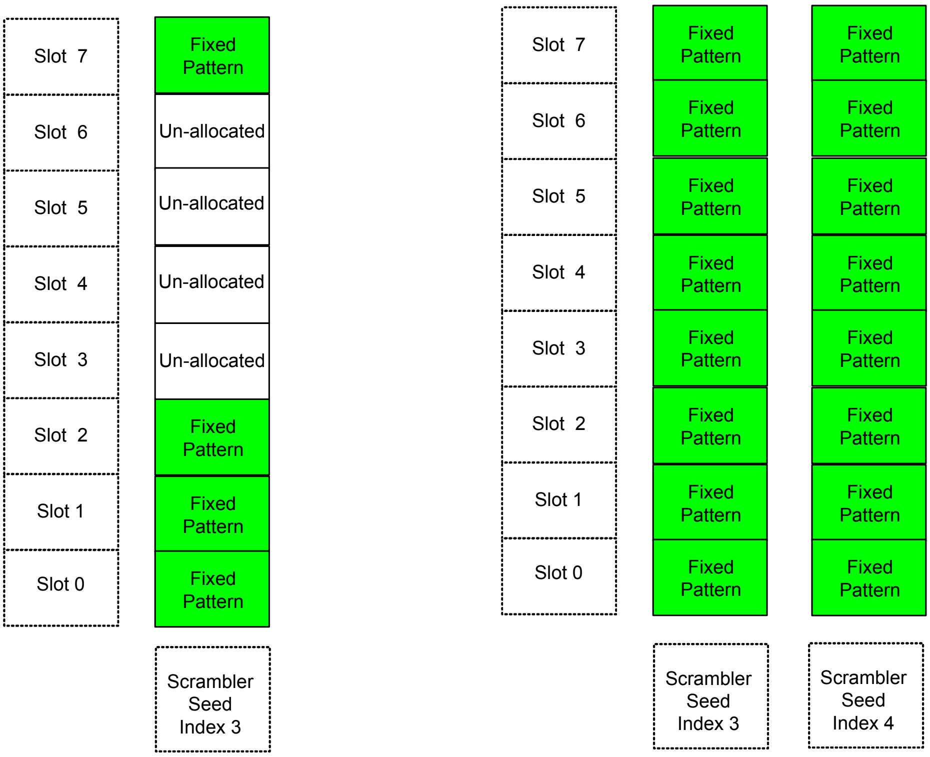
[47] For a fixed value of the WID, the TDM Pilot 2 Channel OFDM symbol is identical for the 2K and 4K FFT sizes.



1K FFT Size **2K FFT Size**



4K FFT Size **8K FFT Size**

Figure 5.2.2.10.1.4.1-1 TDM Pilot 2 Slot Allocation

5.2.2.10.1.4.2 Filling of Slot Buffer

The buffer for each allocated slot shall be completely filled with a fixed pattern consisting of 1000 bits, with each bit set to ‘0’. The buffers for the un-allocated slots shall be left empty.

5.2.2.10.1.4.3 Slot Scrambling

The bits of the TDM Pilot 2 Channel slot buffers shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.4.4 Modulation Symbol Mapping

Each group of two adjacent bits from the ith scrambled slot buffer, SB(i,2k) and SB(i, 2k + 1), k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1. The value of D shall be $1/\sqrt{2}$ for the 1K, 2K and 8K FFT sizes and 1 for the 4K FFT size.[48] Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.4.5 Slot to Interlace Mapping

The mapping of slots to interlaces for the TDM Pilot 2 Channel is specified in two steps, as shown in Figure 5.2.2.10.1.4.5-1. The slots are first mapped to 4K interlace indices. For the 1K and 2K FFT sizes, each 4K interlace is then mapped to four 1K and two 2K interlaces, respectively, in the same OFDM symbol. For the 8K FFT size, two 4K interlaces are then mapped into one 8K interlace.

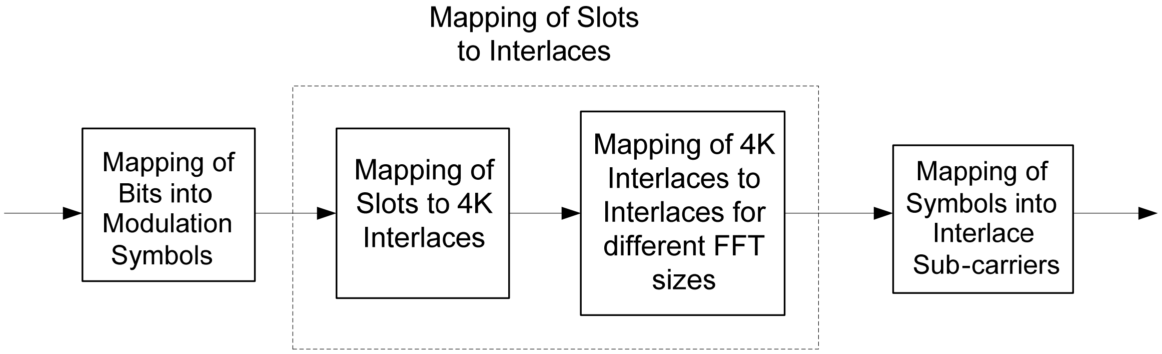


Figure 5.2.2.10.1.4.5-1 TDM Pilot 2 Slot to Interlace Mapping

The mapping of slots to 4K interlaces for the TDM Pilot 2 Channel shall be as specified in 5.2.2.11.1. The slot-to-interlace mapping shall use an OFDM symbol index of 3.

The resulting 4K interlace index shall be mapped to the other interlace indices for different FFT sizes as shown in Table 5.2.2.10.1.4.5-1.

---

[48] The value of D is chosen to keep the OFDM symbol energy constant.

Table 5.2.2.10.1.4.5-1 TDM Pilot 2 Channel: Interlaces used

FFT Size	Scrambler seed index	Slot indices	4K interlace indices	Actual interlace indices
1024	3	1, 7	4, 0	(1,3,5,7), (0,2,4,6)
2048	3	0, 1, 2, 7	6, 4, 2, 0	(3,7), (2,6), (1,5), (0,4)
4096	3	0, 1, 2, 7	6, 4, 2, 0	6, 4, 2, 0
8192	3 4	0,1,2,3,4,5,6,7 0,1,2,3,4,5,6,7	6,4,2,1,5,3,7,0 6,4,2,1,5,3,7,0	6,4,2,1,5,3,7,0 6,4,2,1,5,3,7,0

The interlace indices in Table 5.2.2.10.1.4.5-1 are listed in the same order as the slots, e.g., with the 1K FFT size, slot 1 is mapped to the 4K interlace with index 4, which corresponds to 1K interlace indices of 1, 3, 5 and 7. For the 8K FFT size, the two slots with same slot index but different scrambler seed indices are mapped to one 8K interlace (see Table 5.2.2.8-1), e.g., slot 0 from the first set of eight slots and slot 0 from the second set of eight slots are both mapped into interlace 6.

5.2.2.10.1.4.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in an allocated slot are sequentially assigned to interlace sub-carriers as described below.

For the 1K FFT size, let $[I_0(s), I_1(s), I_2(s), I_3(s)]$ denote the interlaces mapped to slot s. Then the ith complex modulation symbol (where $i \in \{0,\ 1, \ldots, 499\}$) shall be mapped to the jth sub-carrier of interlace $I_k(s)$, where

$$j = \left\lfloor \frac{i}{4} \right\rfloor, \quad k = i \bmod 4$$

and $\lfloor x \rfloor$ denotes the integer part of x.[49] If j = 124 and $I_k(s)$ = 0 (the last sub-carrier in interlace 0), the modulation symbol shall not be transmitted.

For the 2K FFT size, let $[(I_0(s), I_1(s)]$ denote the interlaces that are mapped to slot s. Then the ith complex modulation symbol (where $i \in \{0,\ 1, \ldots, 499\}$) shall be mapped to the jth sub-carrier of interlace $I_k(s)$, where

For s=0,1,2

$$j = \left\lfloor \frac{i}{2} \right\rfloor, \quad k = i \bmod 2$$

while for s=7,

---

[49] This notation for the integer part (or "floor" function) is used throughout this section.

$$j=\begin{cases}\left\lfloor \frac{i}{2} \right\rfloor, \mathrm{k}=i \bmod 2, & i<250\\ \left\lfloor \frac{i}{2} \right\rfloor, \mathrm{k}=(i+1) \bmod 2, & i\geq 250\end{cases}$$

For the 4K FFT size, the ith complex modulation symbol (where $i \in \{0,\ 1,\ldots,499\}$) shall be mapped to the ith sub-carrier of the mapped interlace.

For the 8K FFT size, the ith complex modulation symbol (where $i \in \{0,\ 1,\ldots,499\}$) shall be mapped to the jth sub-carrier of the interlace, where

$$\mathrm{j}=\begin{cases}2\times \mathrm{i}, & \text{if the slot has a scrambler seed index of 3}\\ 2\times \mathrm{i}+1, & \text{if the slot has a scrambler seed index of 4}\end{cases}$$

5.2.2.10.1.4.7 OFDM Common Operation

The modulated TDM Pilot 2 Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

The TDM Pilot 2 channel OFDM symbol includes a post-fix interval in addition to the flat guard interval and windowed guard interval (see Table 5.2.2.10.1.4.7-1). The post-fix interval is used to ensure that the TDM Pilot 2 Channel includes two identical periods. The duration of the flat guard interval and the post-fix interval shall be as specified in Table 5.2.2.10.1.4.7-1.

Table 5.2.2.10.1.4.7-1 TDM Pilot 2 Channel: OFDM Symbol Parameters

FFT Size	Flat Guard Interval (Chips)	Post-fix Interval (Chips)	OFDM symbol Interval (Chips)
1024	256	1024	2321
2048	512	2048	4625
4096	512	0	4625
8192	1024	8192	17425

5.2.2.10.1.5 Transition Pilot Channel (TPC)

The Transition Pilot Channel consists of 2 sub-channels: the Wide-area Transition Pilot Channel (WTPC) and the Local-area Transition Pilot Channel (LTPC). The TPC flanking the Wide-area OIS and the Wide-area Data Channel is called the WTPC. The TPC flanking the Local-area OIS and the Local-area Data Channel is called the LTPC. For the 1K, 2K and 4K FFT sizes, the WTPC spans 1 MAC time unit on either side of every Wide-area channel transmission[50] (the Wide-area Data and the Wide-area OIS Channel) in a superframe. For the 8K FFT size, the WTPC spans 2 MAC time units on either side of every Wide-area channel transmission in a superframe. For the 1K, 2K and 4K FFT sizes, the LTPC spans 1 MAC time unit on either side of every Local-area Channel transmission[51] (the Local-area Data and the Local-area OIS Channel). For the 8K FFT size, the LTPC spans 2 MAC time units on either side of every Local-area channel transmission in a superframe. The purpose of the TPC MAC time unit(s) is two-fold: to allow channel estimation at the boundary between the Local-area and the Wide-area channels and to facilitate timing synchronization.

The number of TPC MAC time units in a superframe is equally divided between the WTPC and the LTPC as illustrated in Figure 5.2.2.3-2. There are nine instances where the LTPC and the WTPC transmissions occur right next to each other. These are the beginning and end of each of the four frames, and between the Wide-area OIS and the Local-area OIS channels. There are two instances where only one of these channels is transmitted. Only the WTPC is transmitted after the TDM Pilot 2 Channel, and only the LTPC is transmitted prior to either the Positioning Pilot Channel (PPC) or the Signaling Paramter Channel (SPC).

The exact MAC time indices for the TPC can be specified in terms of the following three parameters. Let

W be the number of MAC time units associated with the Wide-area Data Channel in a frame.

L be the number of MAC time units associated with the Local-area Data Channel in a frame.

F be the number of MAC time units in a frame, including the WTPC at the beginning of the frame and the LTPC at the end of the frame. The value of F is related to the number of data OFDM symbols per frame (D) as

$$F = \begin{cases} \left(\dfrac{N_{FFT}}{4096}\right) \times D + 4, & \text{1K/2K/4K FFT sizes} \\ 2 \times D + 8, & \text{8K FFT size} \end{cases}$$

The value of D depends on the FFT size (N_{FFT}), chip rate (B), the flat guard interval (T_{FGI}) and whether the PPC is present or absent. For each combination, it is specified in 6.1.

The MAC time indices for the TPC in a superframe shall be as specified in Table 5.2.2.10.1.5-1.

---

[50] With the exception of the WIC.

[51] With the exception of the LIC.

Table 5.2.2.10.1.5-1 TPC MAC Time Indices in a Superframe

Transition Pilot Channel	**WTPC MAC time index (1K/2K/4K)**	**LTPC MAC time index (1K/2K/4K)**	**WTPC MAC time index (8K)**	**LTPC MAC time index (8K)**
TDM Pilot 2 Channel→Wide-area OIS Channel	4	---	4, 5	---
Wide-area OIS Channel→Local-area OIS Channel	10	11	12, 13	14, 15
Local-area OIS Channel→Wide-area Data Channel	18	17	24, 25	22, 23
Wide-area Data Channel→Local-area Data Channel	$19+W+F\times i,$ $\{i=0,1,2,3\}$	$20+W+F\times i,$ $\{i=0,1,2,3\}$	$26+W+F\times i$ $27+W+F\times i$ $i=\{0,1,2,3\}$	$28+W+F\times i$ $29+W+F\times i$ $i=\{0,1,2,3\}$
Local-area Data Channel →Wide-area Data Channel	$18+F\times i,$ $\{i=1,2,3\}$	$17+F\times i,$ $\{i=1,2,3\}$	$24+F\times i$ $25+F\times i$ $i=\{1,2,3\}$	$22+F\times i$ $23+F\times i$ $i=\{1,2,3\}$
Local-area Data Channel → PPC or SPC	---	$17+F\times 4$	---	$22+F\times 4$ $23+F\times 4$

All slots in the TPC MAC time units use as input one of two 1000-bit fixed patterns (see 5.2.2.10.1.5.2). These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1.

5.2.2.10.1.5.1 Slot Allocation

Each TPC MAC time unit shall be allocated all 8 slots with indices 0 through 7.

5.2.2.10.1.5.2 Filling of Slot Buffer

The buffer for the slot with index 0 shall be completely filled with a fixed pattern consisting of 1000 bits, with each bit set to '0'.

The buffer for the slots with indices 1, 2,..., 7, shall be completely filled with a fixed pattern generated by using a 11-tap linear feedback shift register (LFSR) with generator sequence $h(D)=D^{11}+D^{9}+1$ and initial state '11000011111'. The LFSR structure shall be as specified in Figure 5.2.2.10.1.5.2-1. The fixed pattern shall correspond to the first 1000 output bits. The first 23-bits of the fixed pattern shall be '11111100110011001011010', with '111' appearing first.

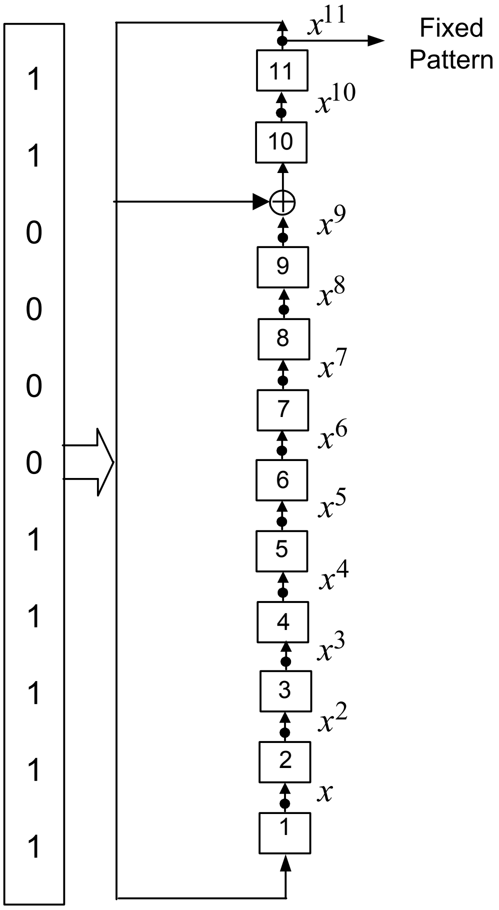


Figure 5.2.2.10.1.5.2-1 LFSR for Generating Alternate Fixed Pattern Input.

5.2.2.10.1.5.3 Slot Scrambling

The bits of each allocated TPC slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.5.4 Modulation Symbol Mapping

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 0, 1, 2,..., 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1 respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1, with D = $\frac{1}{\sqrt{2}}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.5.5 Slot to Interlace Mapping

The mapping of slots to interlaces for the TPC MAC time unit shall be as specified in 5.2.2.11. Each slot maps to 4, 2, 1 and ½ interlaces for the 1K, 2K, 4K and 8K FFT sizes, respectively (see Table 5.2.2.8-1). When a slot is mapped to multiple interlaces, these interlaces belong to consecutive OFDM symbols.

5.2.2.10.1.5.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot are sequentially assigned to interlace sub-carriers. When a slot is mapped to multiple interlaces over consecutive OFDM symbols, the interlaces are filled in the order of the OFDM symbol index.

For the 1K FFT size, let $[I_0(s), I_1(s), I_2(s), I_3(s)]$ denote the interlaces in four consecutive OFDM symbols mapped to slot s. Then the ith complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the jth sub-carrier of interlace $I_k(s)$, where

$$j = i \bmod 125, \quad k = \left\lfloor \frac{i}{125} \right\rfloor .$$

If j = 124 and $I_k(s) = 0$ (the last sub-carrier in interlace 0), the modulation symbol shall not be transmitted.

For the 2K FFT size, let $[I_0(s), I_1(s)]$ denote the interlaces in two consecutive OFDM symbols that are mapped to slot s. Then the ith complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the jth sub-carrier of interlace $I_k(s)$, where

$$j = i \bmod 250, \quad k = \left\lfloor \frac{i}{250} \right\rfloor .$$

For the 4K FFT size, the ith complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the ith sub-carrier of the mapped interlace.

For the 8K FFT size, the ith complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the jth sub-carrier of the interlace, where

$$j = \begin{cases} 2 \times i, & \text{if the slot belongs to an even MAC time unit} \\ 2 \times i + 1, & \text{if the slot belongs to an odd MAC time unit} \end{cases}$$

5.2.2.10.1.5.7 OFDM Common Operation

The modulated TPC sub-carriers shall undergo common operations as specified in 5.2.2.12.

The last LTPC OFDM symbol includes a post-fix interval in addition to the flat guard interval and windowed guard interval (see Figure 5.2.2.3-1). When the positioning pilot channel (PPC) is present, the last LTPC OFDM symbol immediately precedes the first OFDM symbol of the PPC (see Figure 5.2.2.3-2). When the PPC is absent, the last LTPC OFDM symbol immediately precedes the first OFDM symbol of the SPC.

The post-fix interval of the last LTPC OFDM symbol is used to accommodate chips left over after an integer number of MAC time units and an integer number of data channel OFDM symbols have been accommodated in each frame. For each combination of FFT size (N_{FFT}), chip rate (B), flat guard interval (T_{FGI}) and presence/absence of PPC, the post-fix interval (T_{PFI}) shall be as specified in 6.1.

If the post-fix interval exceeds the useful duration, then it shall consist of one or more consecutive segments of the useful duration followed possibly by a fractional part of the useful duration. For an illustration of the post-fix interval when it exceeds the useful duration, see Figure 6.1-1.

5.2.2.10.1.6 Positioning Pilot Channel

The Positioning Pilot Channel (PPC), when present, will appear near the end of a superframe, between the last LTPC OFDM symbol and the SPC. The presence or absence of the PPC is signaled over the OIS Channel. When present, the PPC can be used by the Forward Link Only receiver to estimate the received power levels and channel estimates from individual Forward Link Only transmitters. Each transmitter is assigned a unique 18 bit identifier (TxID) that is conveyed in the PPC. Each transmitter can also convey its geographical location and/or its timing offset in the PPC. The TxID can be used by the receiver to map the power levels and channel estimates to the geographical location of the transmitter. Channel estimates from multiple transmitters can be used for determining the geographical position of the Forward Link Only receiver. In future applications, the PPC can also be used to convey additional information from each transmitter to the Forward Link Only receiver.

When the PPC is present, it follows the last LTPC OFDM symbol at the end of Frame 4. For the 1K, 2K and 4K FFT sizes, the PPC spans 8 PPC MAC time units. For the 8K FFT size, the PPC spans 16 PPC MAC time units. Each PPC MAC time unit contains 8 slots and has the duration of 4, 2, 1 and 1/2 of a PPC OFDM symbol for the 1K, 2K, 4K and 8K FFT sizes, respectively. The number of PPC MAC time units and PPC OFDM symbols shall be as specified in Table 5.2.2.10.1.5.7-1.

Since the PPC uses a longer flat guard interval ($FGI_{Fraction}$ is equal to 1/2), the PPC MAC time unit is longer in duration than the MAC time unit in the TPC/Data/OIS channels. In addition, the PPC MAC time units are indexed separately. The PPC MAC time index ranges from 0 to 7 for the 1K, 2K and 4K FFT sizes, and from 0 to 15 for the 8K FFT size.

Table 5.2.2.10.1.5.7-1 Positioning Pilot Channel Duration

FFT Size	Number of PPC MAC time units	Number of PPC OFDM symbols	OFDM symbol duration (chips)	PPC duration (Chips)
1024	8	32	1553	49696
2048	8	16	3089	49424
4096	8	8	6161	49288
8192	16	8	12305	98440

During each PPC MAC time unit, a transmitter may be in one of three states: Inactive, Identification and Reserved. For the 8K FFT size, PPC MAC time units are assigned to transmitters in consecutive pairs, since each pair corresponds to one PPC OFDM symbol. Hence, during each pair of PPC MAC time units, a transmitter may be in the Inactive, Identification or Reserved state.

For each transmitter, the PPC MAC time units in the Reserved state follow immediately after PPC MAC time units in the Identification state. The number of PPC MAC time units in the Reserved state is conveyed during Identification.

When a transmitter is in the Identification or Reserved state, neighboring transmitters should be in the Inactive state.

5.2.2.10.1.6.1 Positioning Pilot Channel (PPC) for Inactive State

5.2.2.10.1.6.1.1 Slot Allocation

For all FFT sizes, the PPC MAC time unit shall be allocated only one slot. The slot index shall be 7. For the 8K FFT size, slot 7 is allocated in both PPC MAC time units that correspond to the PPC OFDM symbol.

5.2.2.10.1.6.1.2 Filling of Slot Buffer

The buffer for slot 7, shall be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2.

The buffers for the un-allocated slots shall be left empty.

5.2.2.10.1.6.1.3 Slot Scrambling

The bits of the allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.6.1.4 Modulation Symbol Mapping

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i,2k) and SB(i,2k + 1), i = 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1, with D = 2. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.6.1.5 Slot to Interlace Mapping

The mapping of slots to interlaces shall be an identity mapping. Therefore, Slot 7 shall be mapped to Interlace 7. The identity mapping shall be used even when the slot is mapped to multiple interlaces for the 1K and 2K FFT sizes. For the 8K FFT size, the two slots with index 7 for each PPC OFDM symbol shall be mapped to Interlace 7.

5.2.2.10.1.6.1.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub carriers

The 500 modulation symbols in each allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.1.6.1.7 OFDM Common Operation

The modulated interlace sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.1.6.2 Positioning Pilot Channel (PPC) for Identification

5.2.2.10.1.6.2.1 Slot Allocation

For the 1K, 2K and 4K FFT sizes, the slots 0, 1, 2, 3, 4 and 6 shall be allocated. Slot 1 is used to convey the WID assigned to the transmitter, and Slot 3 is used to convey the TxID as well as the number of succeeding PPC MAC time units that are allocated to the transmitter. Slots 0, 2, 4, 6 can be used by the Forward Link Only receiver to determine the LID and the channel estimate from the transmitter.

For the 8K FFT size, slots 1 and 3 are allocated only in the first PPC MAC time unit. Therefore, the allocated slots shall be 0, 1, 2, 3, 4, 6 in the first PPC MAC time unit and 0, 2, 4, 6 in the second PPC MAC time unit.

5.2.2.10.1.6.2.2 Filling of Slot Buffers for Slots 0, 1, 2, 4 and 6

The buffers for slots 0, 1, 2, 4 and 6 shall each be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2.

The buffers for the un-allocated slots shall be left empty.

5.2.2.10.1.6.2.3 Filling of Slot Buffer for Slot 3

5.2.2.10.1.6.2.3.1 Overview

Slot 3 is used to convey 49 bits of information to the Forward Link Only receiver. The processing of these bits is as shown in

Figure
5.2.2.10.1.6.2.3-1

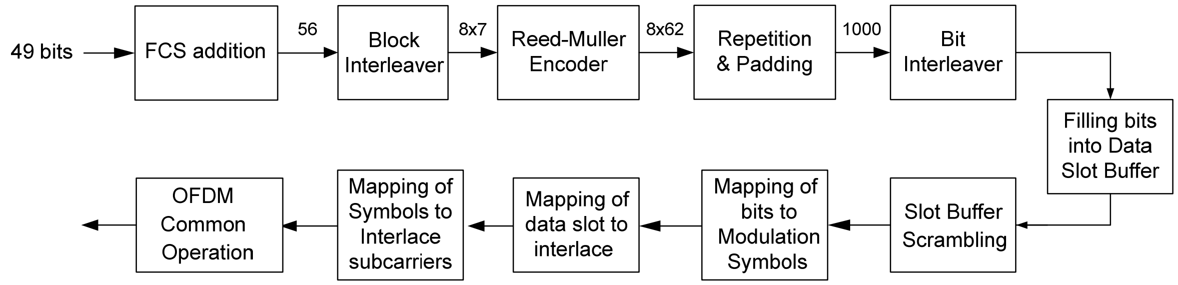


Figure 5.2.2.10.1.6.2.3-1 Processing for Slot 3

5.2.2.10.1.6.2.3.2 PPC Packet format

The PPC Packet shall use the following format:

Field	Length (bits)
Packet type	4
TxID	18
Tx parameter	24
Tx allocation	3
FCS	7

Packet type	-	Indicates which parameter is conveyed in addition to the TxID
TxID	-	Identifier assigned to the transmitter
Tx allocation	-	Number of succeeding PPC MAC time units that are allocated to the transmitter
Tx parameter	-	Additional parameter conveyed by the transmitter (see Table 5.2.2.10.1.6.2-1)
FCS	-	Frame check sequence (see 5.2.2.10.1.6.2.3.3)

Figure 5.2.2.10.1.6.2.3-2 illustrates the format of the PPC Packet.

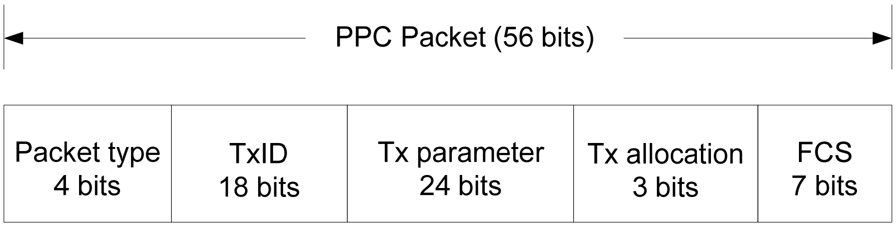


Figure 5.2.2.10.1.6.2.3-2 PPC Packet format

The packet type is used to identify the Tx parameter conveyed in the PPC packet. The Tx parameters for the first five packet types shall be as defined in Table 5.2.2.10.1.6.2-1. The remaining packet types from ‘0101’ to ‘1111’ are reserved for future use.

When the length of a parameter is less than 24 bits, the parameter shall use the least significant bits of the 24 bit Tx parameter field and the remaining most significant bits shall be set to ‘0’. The length (in bits) of the Latitude, Longitude and Altitude in Table 5.2.2.10.1.6.2-1 are the same as in [4].[52]

Table 5.2.2.10.1.6.2-1 PPC packet types

Packet type	**Tx parameter conveyed**	**Tx parameter length (bits)**
0000	None	0
0001	Latitude	24
0010	Longitude	24
0011	Altitude	15
0100	Tx offset	21
0101 - 1111	Reserved for future use	Not defined

The packet type to be sent during a particular PPC MAC time unit is assigned to the transmitter. The transmitter shall support the packet type ‘0000’ and should support the remaining packet types. When supported by the transmitter, the parameters for the packet types ‘0001’ to ‘0100’ shall be set as follows.

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[52] See also [5], which has similar definitions of the Latitude, Longitude and Altitude of the transmitter, but at a lower resolution.

Latitude	The transmitter shall set this field to its latitude with respect to the WGS 84 reference ellipsoid. The value shall be expressed as a two's complement signed number with positive numbers signifying north latitudes. For a latitude L in degrees, $-90 \le L < 90$, the transmitter shall set this field[53] to $\left\lfloor \frac{L \times 2^{24}}{180} \right\rfloor$.
Longitude	The transmitter shall set this field to its longitude with respect to the WGS 84 reference ellipsoid. The value shall be expressed as a two's complement signed number with positive numbers signifying east longitudes. For a longitude L in degrees, $-180 \le L < 180$, the transmitter shall set this field to $\left\lfloor \frac{L \times 2^{24}}{360} \right\rfloor$.
Altitude	The transmitter shall set this field to its altitude with respect to the WGS 84 reference ellipsoid. The value shall be expressed as a two's complement signed number with positive numbers signifying altitude above the reference ellipsoid. For an altitude A in meters, $-16384 \le A < 16384$, the transmitter shall set this field to $\lfloor A \rfloor$.
Tx offset	The transmitter shall set this field to the offset of the start of its superframe from the Forward Link Only system time. The value shall be expressed as a two's complement signed number with positive numbers signifying that the start of the superframe is after the FLO system time reference. For an offset D in nano-seconds[54], $-1048576 \le D < 1048576$, the transmitter shall set this field to $\lfloor D \rfloor$.

5.2.2.10.1.6.2.3.3 Computation of the FCS bits

The FCS shall be a CRC calculated using the generator polynomial:

$$g(x)=x^7+x^6+x^4+1$$

- The FCS shall be equal to the value computed according to the following procedure as shown in Figure 5.2.2.10.1.6.2.3-3 :

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[53] For negative numbers, the "floor" function, $\lfloor\ \rfloor$, yields the negative integer away from zero.

[54] While the Tx offset is specified with a resolution of 1 nano-second and a range of +/-1048576 nano-seconds, the transmitter may support a lower resolution and range. The actual requirements for the resolution and range of the Tx offset shall be as specified in [2] (see also 5.2.3).

- All shift-register elements shall be initialized to ‘1’s[55].
- The switches shall be set in the up position.
- The register shall be clocked once for each of the 49 information bits, from the MSB to LSB.
- The switches shall be set in the down position so that the output is a modulo-2 addition with a ‘0’ and the successive shift-register inputs are ‘0’s.
- The register shall be clocked an additional 7 times for the 7 FCS bits.
- The output bits constitute the PPC Packet.

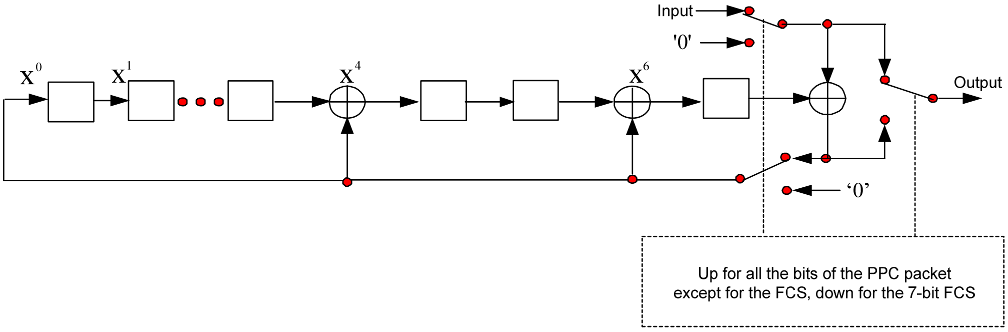
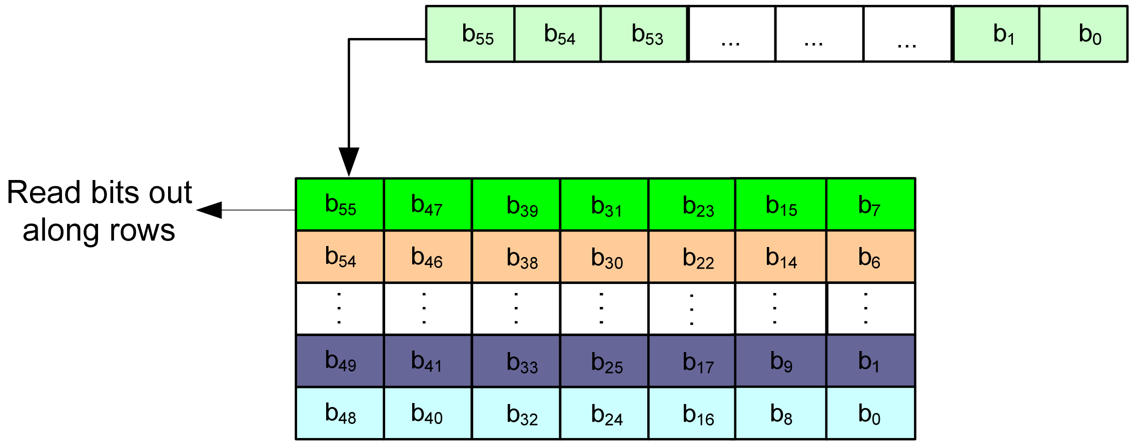


Figure 5.2.2.10.1.6.2.3-3 FCS Computation for the PPC Packet

5.2.2.10.1.6.2.3.4 Bit interleaving

The 56 bits in the PPC packet are denoted by [$b_{55}b_{54}$ … b_0], where the last 7 bits, b_6…b_0, are the FCS bits. These bits are interleaved using a block interleaver of size 8 x 7. The bits are written into the columns of the block and read out along the rows. The bits are written into the block interleaver as shown in

Figure
5.2.2.10.1.6.2.3-4



b_{55}	b_{54}	b_{53}	…	…	…	b_1	b_0

b_{55}	b_{47}	b_{39}	b_{31}	b_{23}	b_{15}	b_7
b_{54}	b_{46}	b_{38}	b_{30}	b_{22}	b_{14}	b_6
⋮	⋮	⋮	⋮	⋮	⋮	⋮
b_{49}	b_{41}	b_{33}	b_{25}	b_{17}	b_9	b_1
b_{48}	b_{40}	b_{32}	b_{24}	b_{16}	b_8	b_0

Figure 5.2.2.10.1.6.2.3-4 Bit interleaving in the PPC packet

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[55] Initialization of the register to ones causes the CRC for all-zero data to be non-zero. This initialization shall be performed prior to starting the FCS computation.

Each row forms the input of length 7 bits to the Reed-Muller (RM) Encoder. Therefore, the input for generating the first RM codeword is [$b_{55}b_{47}b_{39}b_{31}b_{23}b_{15}b_7$].

5.2.2.10.1.6.2.3.5 Reed-Muller (RM) Encoding

Each 7 bit input to the RM Encoder is denoted by [$m_6m_5m_4m_3m_2m_1m_0$]. The 7 bit input is encoded using a (62,7) RM code[56] to result in 62 coded bits [$c_{61}c_{60} \dots c_0$].

For each value of [$m_6m_5m_4m_3m_2m_1m_0$], the encoding procedure shall generate the same 62 coded bits as generated by the following procedure (see Figure 5.2.2.10.1.6.2.3-5.)

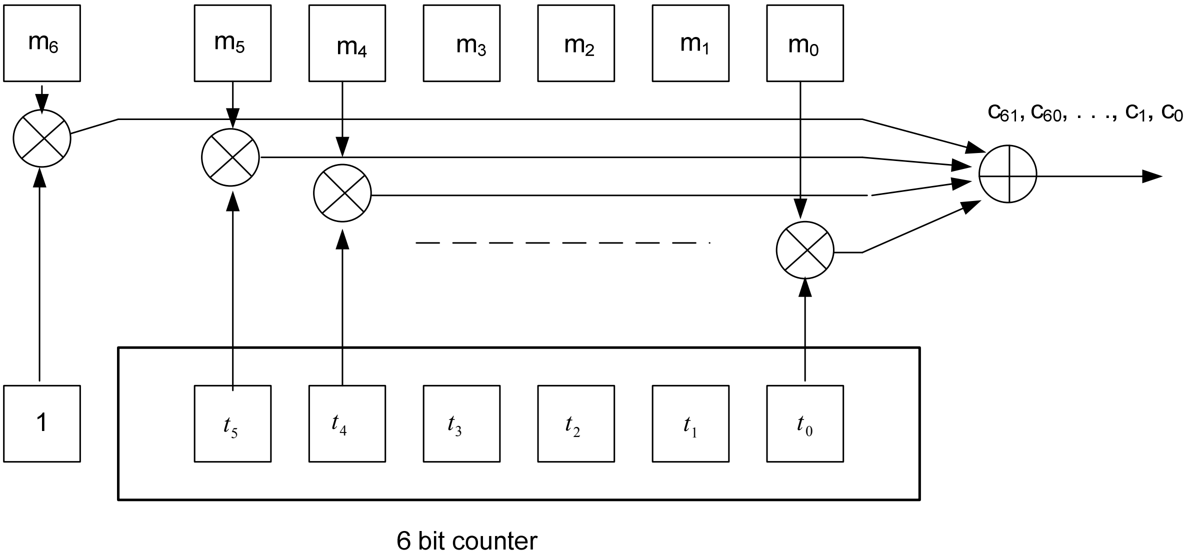

Figure 5.2.2.10.1.6.2.3-5 (62,7) Reed-Muller (RM) encoder

1. Initialize a six bit counter, denoted by [$t_5t_4t_3t_2t_1t_0$], to ‘000000’.
2. For k = 0 to 61
    a. $c_k = m_6 + \sum_{j=0}^{5} t_j m_j \pmod{2}$
    b. Increment counter by 1

Here, the additions and multiplications are over the binary Galois Field, GF(2).

For each PPC packet, the encoding procedure shall be performed eight times to result in eight codewords.

5.2.2.10.1.6.2.3.6 Repetition and Padding

The output bits of the eight codewords are denoted by $c_k(i)$, where k=0,...,61 is the bit index and i = 0,...,7 is the codeword index. Thus, the output bits of the first codeword correspond to an input of [$b_{55}b_{47}b_{39}b_{31}b_{23}b_{15}b_7$] (see Figure 5.2.2.10.1.6.2.3-5) and are denoted as $c_k(0)$, k = 0,...,61.

---

[56] The (62,7) RM code is obtained by puncturing two bits from the output of a (64,7) first order RM code.

The output bits from the eight codewords shall be repeated as shown in Figure 5.2.2.10.1.6.2.3-6. The bits from the eight codewords are concatenated to form 496 bits and repeated once.

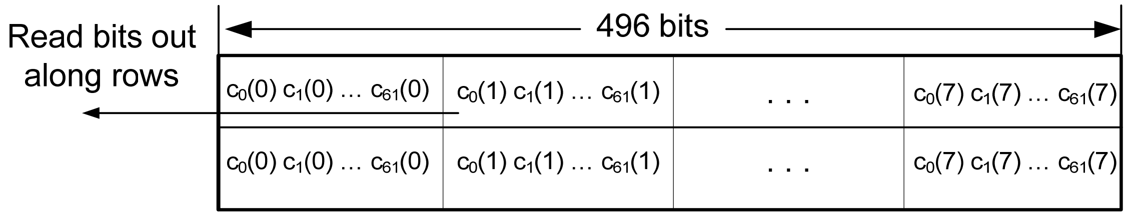

Figure 5.2.2.10.1.6.2.3-6 Repetition order of Reed-Muller codewords

The bits shall be read out along the rows of the 2 x 496 block to result in a bit sequence of length 992. An eight bit field of zeros ‘00000000’ shall be appended to the 992 bits to result in 1000 bits.

5.2.2.10.1.6.2.3.7 Bit interleaving

The 1000 bits resulting from the repetition and padding shall be interleaved using the procedure specified in 5.2.2.10.2.2, where the value of N is 1000 and the bit interleaver matrix consists of 250 rows and 4 columns.

The bit interleaver output constitutes the 1000 bits that fill the buffer for Slot 3.

5.2.2.10.1.6.2.4 Slot Scrambling

For slots 0, 1, 2, 3, 4 and 6, the bits of the allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.6.2.5 Modulation Symbol Mapping

Each group of two consecutive bits from the i^{th} scrambled slot buffer, SB(i,2k) and SB(i,2k + 1), i = 0, 1, 2, 3, 4, 6 and k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

The value of D shall be as shown in Table 5.2.2.10.1.6.2.5-1 .

Table 5.2.2.10.1.6.2.5-1 QPSK constellation factor (D) for PPC slots

FFT Size	Slot index	D
1K/2K/4K	0, 1, 2, 4, 6	$2/3$
1K/2K/4K	3	$4/3$
8K	0, 2, 4, 6	$2/3$
8K	1	$2\sqrt{2}/3$
8K	3	$4\sqrt{2}/3$

5.2.2.10.1.6.2.6 Slot to Interlace Mapping

The mapping of slots to interlaces shall be an identity mapping. Therefore, Slots 0, 1, 2, 3, 4 and 6 shall be mapped to interlaces 0, 1, 2, 3, 4 and 6 respectively. The identity mapping shall be used even when the slot is mapped to multiple interlaces for the 1K and 2K FFT sizes. For the 8K FFT size, the two slots with index k in each PPC OFDM symbol are mapped to interlace k.

5.2.2.10.1.6.2.7 Mapping of Slot Buffer Modulation Symbols to Interlace Sub carriers

For slots 0, 1, 2, 4 and 6, the 500 modulation symbols in each slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

For slot 3, the 500 modulation symbols shall be assigned to interlace sub-carriers as specified in 5.2.2.10.2.8.

5.2.2.10.1.6.2.8 OFDM Common Operation

The modulated interlace sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.1.6.3 Positioning Pilot Channel (PPC) for Reserved State

5.2.2.10.1.6.3.1 Slot Allocation

The Reserved PPC MAC time unit shall be allocated all 8 slots with indices 0 through 7.

5.2.2.10.1.6.3.2 Filling of Slot Buffer

The buffer for each of the 8 slots shall be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2.

5.2.2.10.1.6.3.3 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.1.6.3.4 Modulation Symbol Mapping

Each group of two consecutive bits from the i^{th} scrambled slot buffer, SB(i,2k) and SB(i,2k + 1), i = 0, 1, 2,..., 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.6.3.5 Slot to Interlace Mapping

The mapping of slots to interlaces shall be an identity mapping. Therefore, slot k shall be mapped to interlace k, k=0, 1, 2, ..., 7. The identity mapping shall be used even when the slot is mapped to multiple interlaces for the 1K and 2K FFT sizes. For the 8K FFT size, the two slots with index k for each PPC OFDM symbol are mapped to interlace k.

5.2.2.10.1.6.3.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.1.6.3.7 OFDM Common Operation

The modulated OFDM symbol sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.1.7 Signaling Parameter Channel (SPC)

The Signaling Parameter Channel (SPC) shall span two OFDM symbols, each of length 4625 chips, for all FFT sizes. These two OFDM symbols precede the TDM Pilot 1 Channel and, hence, occur at the end of the superframe. This is an overhead channel that is used to convey the FFT size, the Flat guard interval fraction ($FGI_{Fraction}$) and the slot-to-interlace mapping in the TPC, Data/FDM Pilot and OIS/FDM Pilot channels. Each SPC OFDM symbol can convey 8 bits of information using two allocated slots. The 16 bit payload over the two SPC OFDM symbols is denoted as $[p_{15}p_{14}p_{13} \ldots p_3p_2p_1p_0]$, with $[p_7p_6p_5p_4p_3p_2p_1p_0]$ transmitted in the first SPC OFDM symbol and $[p_{15}p_{14}p_{13}p_{12}p_{11}p_{10}p_9p_8]$ transmitted in the second SPC OFDM symbol.

For a fixed value of the payload, the SPC OFDM symbols are identical across the FFT sizes. The structure of each SPC OFDM symbol is described below as a 4K OFDM symbol with a flat guard interval of 512 chips.[57]

5.2.2.10.1.7.1 Slot Allocation

Each SPC OFDM symbol shall be allocated two slots with indicies 0 and 4. The allocated and un-allocated slots in the SPC OFDM symbol are illustrated in Figure 5.2.2.10.1.7.1-1.

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[57] However, the SPC OFDM symbol can also be generated using other FFT sizes of 1K, 2K or 8K, since it has only 1000 non-zero sub-carriers.

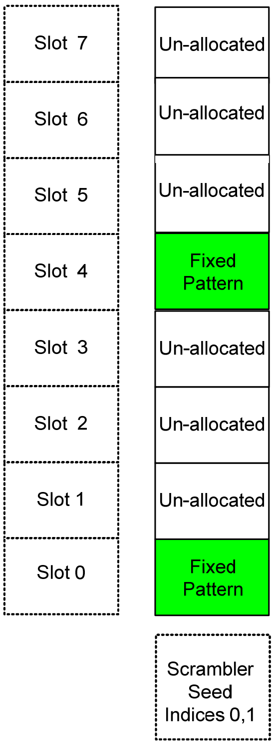

Figure 5.2.2.10.1.7.1-1 SPC Slot Allocation

5.2.2.10.1.7.2 Filling of Slot Buffer

The buffers for slots 0 and 4 shall each be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2. The buffers for the un-allocated slots shall be left empty.

5.2.2.10.1.7.3 Slot Scrambling

The bits of the slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The 20 bit initial state of the LFSR is denoted by $[d_3d_2d_1d_0c_3c_2c_1c_0b_0a_{10}a_9a_8a_7a_6a_5a_4a_3a_2a_1a_0]$ and the least significant 16 bits $(c_3c_2 \ldots a_1a_0)$ shall be set as specified in 5.2.2.10.1.2.3. The 4 most significant bits, $d_3d_2d_1d_0$ shall be mapped to the SPC payload as follows.

For the first SPC OFDM symbol,

$$d_3d_2d_1d_0 = \begin{cases} p_7p_6p_5p_4 & \text{for slot 4} \\ p_3p_2p_1p_0 & \text{for slot 0} \end{cases}$$

For the second SPC OFDM symbol,

$$d_3d_2d_1d_0 = \begin{cases} p_{15}p_{14}p_{13}p_{12} & \text{for slot 4} \\ p_{11}p_{10}p_9p_8 & \text{for slot 0} \end{cases}$$

The parameters conveyed by the 16 bits in the two SPC OFDM symbols are summarized in Table 5.2.2.10.1.6.3.7-1.

Table 5.2.2.10.1.6.3.7-1 Parameters conveyed by SPC

Bits	**OFDM Symbol Parameter**
$[p_{15}p_{14}p_{13}p_{12}]$	Reserved for future use
$[p_{11}p_{10}]$	PPC Status
$[p_9p_8]$	PHY Type
$[p_7p_6p_5]$	FFT Size (N_{FFT})
$[p_4p_3]$	Slot to Interlace mapping
$[p_2p_1p_0]$	$FGI_{Fraction}$

4 out of 8 (p15 through p12) bits conveyed by the second SPC OFDM symbol are reserved for future use and shall be set to '0'. The Forward Link Only receiver shall ignore these 4 bits. The 8 bits conveyed by the first SPC symbol shall be mapped to the FFT Size, FGI fraction and the Slot to Interlace Mapping as shown in Table 5.2.2.10.1.7.3-2. The 4 bits conveyed in the second SPC symbol shall be mapped to the PHY Type used by the Data Channel and the status of PPC symbols (present/absent) in the superframe as shown in

Table 5.2.2.10.1.7.3-3

Table 5.2.2.10.1.7.3-2 Bit definitions for SPC symbol 1

Bits $[p_7p_6p_5]$	**FFT Size**
000	1024
001	2048
010	4096
011	8192
100–111	Reserved for future use

Bits $[p_4p_3]$	**Slot to Interlace mapping**
00	Mapping1 (See 5.2.2.11.1)
01	Mapping 2 (See 5.2.2.11.2)
10-11	Reserved for future use

Bits $[p_2p_1p_0]$	**FGI Fraction**
000	1/16
001	1/8
010	3/16
011	1/4
100–111	Reserved for future use

Table 5.2.2.10.1.7.3-3 Bit definitions for SPC symbol 2

Bits $[p_{11}p_{10}]$	**PPC Status**
00	Unknown
01	PPC Present
10	PPC absent
11	Reserved for future use

Bits $[p_9p_8]$	**PHY Type**
00	PHY Type 1
01	PHY Type 2
10	PHY Type 1 and PHY Type 2
11	Reserved for future use

After each of slots 0 and 4 are scrambled using the seed based on the signaling parameters, the slot buffer is denoted by SB.

5.2.2.10.1.7.4 Modulation Symbol Mapping

Each group of two consecutive bits from the i^{th} scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 0, 4 and k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with D = $\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.1.7.5 Slot to Interlace Mapping

The mapping of slots to interlaces for the SPC shall be an identity mapping. Therefore, slots 0 and 4 are mapped to 4K interlaces with indices 0 and 4, respectively.

5.2.2.10.1.7.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in the allocated slot shall be sequentially assigned to 500 interlace sub-carriers as follows: the i^{th} complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the i^{th} sub-carrier of that interlace.

5.2.2.10.1.7.7 OFDM Common Operation

The modulated SPC sub-carriers shall undergo common operations as specified in 5.2.2.12, with $N_{FFT} = 4096$.

5.2.2.10.2 Wide-area OIS Channel

This channel is used to convey overhead information about the active MLC's associated with the Wide-area Data Channel, such as their scheduled transmission times and slot allocations, in the current superframe. For the 1K, 2K and 4K FFT sizes, the Wide-area OIS Channel spans 5 MAC time units in each superframe, which corresponds to 20, 10 and 5 OFDM symbols, respectively. For the 8K FFT size, the Wide-area OIS Channel spans 6 MAC time units, which corresponds to 3 OFDM symbols.

The Physical layer packet for the Wide-area OIS Channel shall be processed according to the steps illustrated in Figure 5.2.2.10.2-1.

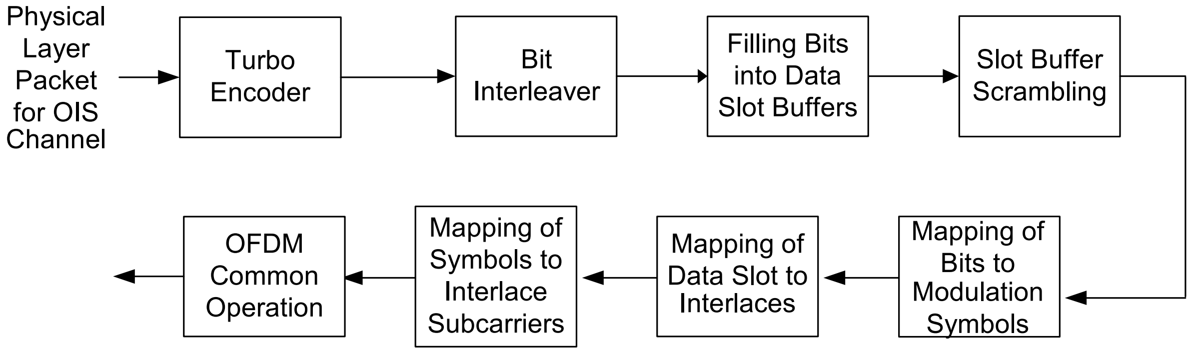

Figure 5.2.2.10.2-1 OIS Physical Layer Packet Processing in the Transmitter

5.2.2.10.2.1 Encoding

The Wide-area OIS Channel Physical layer packets shall be encoded with code rate R = 1/5. The encoder shall discard the 6-bit TAIL field of the incoming Physical layer packet and encode the remaining bits with a parallel turbo encoder as specified in 5.2.2.10.2.1.1. The turbo encoder shall add an internally generated tail of 6/R (=30) output code bits, so that the total number of turbo encoded bits at the output is 1/R times the number of bits in the input Physical layer packet.

Figure 5.2.2.10.2.1-1 illustrates the encoding scheme for the Wide-area OIS Channel. The Wide-area OIS Channel encoder parameters shall be as specified in Table 5.2.2.10.2.1-1.

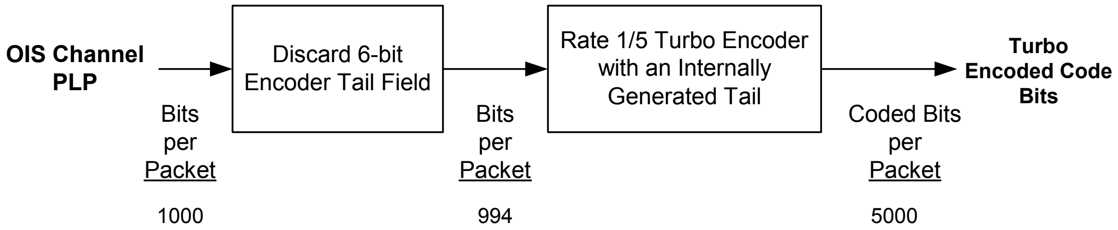

Figure 5.2.2.10.2.1-1 Wide-area/Local-area OIS Channel Encoder

Table 5.2.2.10.2.1-1 Parameters of the Wide-area/Local-area OIS Channel Encoder

Bits	**Turbo Encoder Input Bits** **N_{turbo}**	**Code Rate**	**Turbo Encoder Output bits**
1000	994	1/5	5000

5.2.2.10.2.1.1 Turbo Encoder

The turbo encoder employs two systematic, recursive, convolutional encoders connected in parallel, with an interleaver, the turbo interleaver, preceding the second recursive convolutional encoder. The two recursive convolutional codes are called the constituent codes of the turbo code. The outputs of the constituent encoders are punctured and repeated to achieve the desired number of turbo encoded output bits.

A common constituent code shall be used for turbo codes of rates 1/5, 2/7, 1/3, 4/11, 2/5, 1/2, and 2/3. The transfer function for the constituent code shall be

$$G(D) = \begin{bmatrix} 1 & \frac{n_0(D)}{d(D)} & \frac{n_1(D)}{d(D)} \end{bmatrix}$$

where $d(D) = 1 + D^2 + D^3$, $n_0(D) = 1 + D + D^3$, and $n_1(D) = 1 + D + D^2 + D^3$.

The turbo encoder shall generate an output symbol sequence that is identical to the one generated by the encoder shown in Figure 5.2.2.10.2.1.1-1. Initially, the states of the constituent encoders' registers in this figure are set to zero. Then, the constituent encoders are clocked with the switches in the position noted.

The encoded data output bits are generated by clocking the constituent encoders N_{turbo} times with the switches in the up positions and puncturing the output as specified in Table 5.2.2.10.2.1.1-1. Within a puncturing pattern, a '0' means that the bit shall be deleted and a '1' means that the bit shall be passed. The constituent encoder outputs for each bit period shall be passed in the sequence X, Y_0, Y_1, X', Y'_0, Y'_1 with the X output first. Bit repetition is not used in generating the encoded data output bits.

The constituent encoder output symbol puncturing for the tail period shall be as specified in Table 5.2.2.10.2.1.1-2. Within a puncturing pattern, a '0' means that the symbol shall be deleted and a '1' means that a symbol shall be passed.

For rate 1/5 turbo codes, the tail output code bits for each of the first three tail periods shall be punctured and repeated to achieve the sequence $XXY_0Y_1Y_1$, and the tail output code bits for each of the last three tail bit periods shall be punctured and repeated to achieve the sequence $X'X'Y'_0Y'_1Y'_1$.

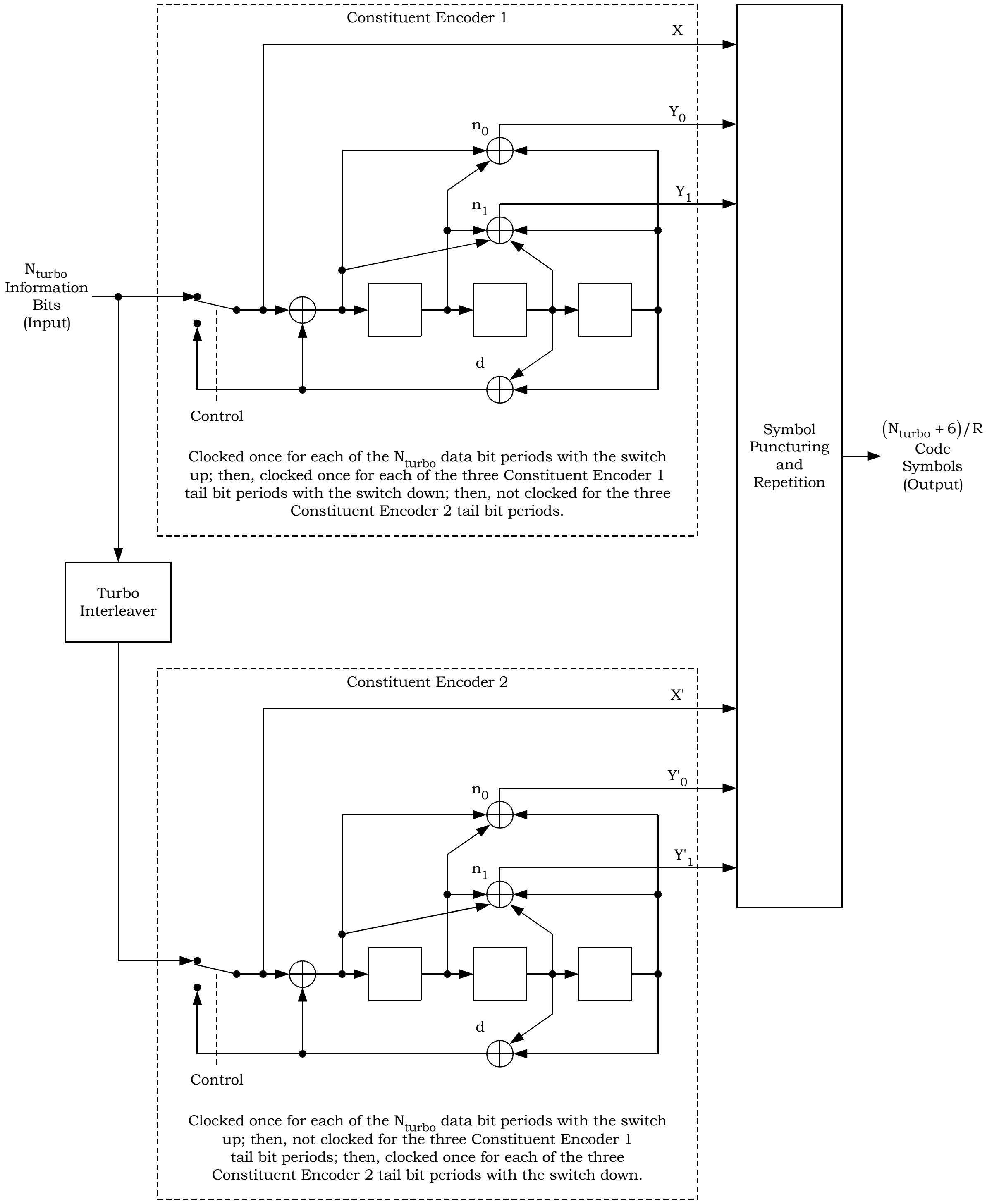

Figure 5.2.2.10.2.1.1-1 Turbo Encoder

Table 5.2.2.10.2.1.1-1 Puncturing Patterns for the Data Bit Periods for the OIS Channel

	Code Rate
Output	**1/5**
X	1
Y_0	1
Y_1	1
X′	0
Y'_0	1
Y'_1	1

Note: The puncturing table is to be read from top to bottom.

Table 5.2.2.10.2.1.1-2 Puncturing Patterns for the Tail Bit Periods for the OIS Channel

	Code Rate
Output	**1/5**
X	111 000
Y_0	111 000
Y_1	111 000
X′	000 111
Y'_0	000 111
Y'_1	000 111

Note: For rate-1/5 turbo codes, the puncturing table is to be read first from top to bottom repeating X, X′, Y_1, and Y'_1 and then from left to right.

5.2.2.10.2.1.2 Turbo Interleaver

The turbo interleaver, which is part of the turbo encoder, shall block interleave the turbo encoder input data that is fed to the Constituent Encoder 2.

The turbo interleaver shall be functionally equivalent to an approach where the entire sequence of turbo interleaver input bits are written sequentially into an array at a sequence of addresses and then the entire sequence is read out from a sequence of addresses that are defined by the procedure described below.

Let the sequence of input addresses be from 0 to $N_{turbo} - 1$. Then, the sequence of interleaver output addresses shall be equivalent to those generated by the procedure illustrated in Figure 5.2.2.10.2.1.2-1 and described below.[58]

1. Determine the turbo interleaver parameter, n, where n is the smallest integer such that $N_{turbo} \le 2^{n+5}$. Table 5.2.2.10.2.1.2-1 gives this parameter for the 1000-bit and 16000-bit Turbo input packet. The Turbo input packet size shall be 1000 bits for Data Channel for PHY Type 1 and 16000 bits for Data Channel for PHY Type 2 respectively. The Turbo input packet size shall be 1000 bits for OIS channel.
2. Initialize an (n + 5)-bit counter to 0.
3. Extract the n most significant bits (MSBs) from the counter and add one to form a new value. Then, discard all except the n least significant bits (LSBs) of this value.
4. Obtain the n-bit output of the table lookup defined in Table 5.2.2.10.2.1.2-2 with a read address equal to the five LSBs of the counter. Note that this table depends on the value of n.
5. Multiply the values obtained in Steps 3 and 4, and discard all except the n LSBs.
6. Bit-reverse the five LSBs of the counter.
7. Form a tentative output address that has its MSBs equal to the value obtained in Step 6 and its LSBs equal to the value obtained in Step 5.
8. Accept the tentative output address as an output address if it is less than N_{turbo}; otherwise, discard it.
9. Increment the counter and repeat Steps 3 through 8 until all N_{turbo} interleaver output addresses are obtained.

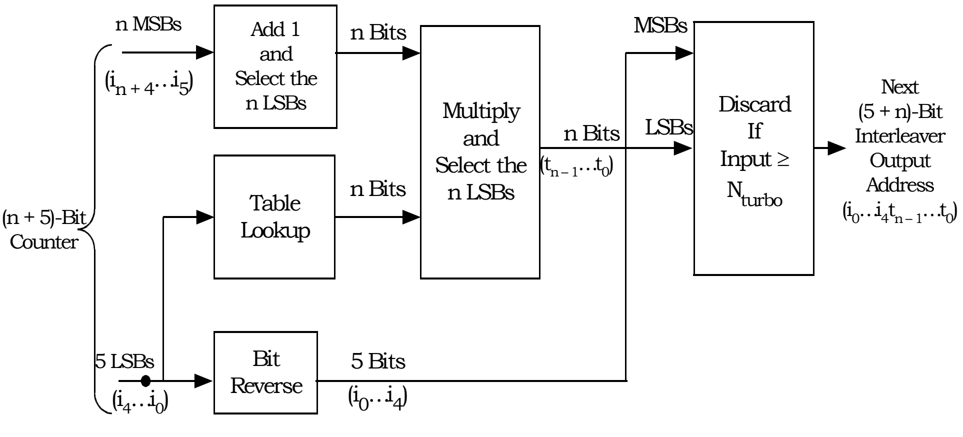

Figure 5.2.2.10.2.1.2-1 Turbo Interleaver Output Address Calculation Procedure

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[58] This procedure is equivalent to one where the counter values are written into a 2^5-row by 2^n-column array by rows, the rows are shuffled according to a bit-reversal rule, the elements within each row are permuted according to a row-specific linear congruential sequence, and tentative output addresses are read out by column. The linear congruential sequence rule is $x(i + 1) = (x(i) + c) \bmod 2^n$, where $x(0) = c$ and c is a row-specific value from a table lookup.

Table 5.2.2.10.2.1.2-1 Turbo Interleaver Parameter

PHY Type	Turbo Input Packet Size	Turbo Interleaver Block Size N_{turbo}	Turbo Interleaver Parameter n
1	1,000	994	5
2	16,000	15,994	9

Table 5.2.2.10.2.1.2-2 Turbo Interleaver Lookup Table Definition

Table Index	n = 5 Entries	n = 9 Entries	Table Index	n = 5 Entries	n=9 Entries
0	27	13	16	21	509
1	3	335	17	19	215
2	1	87	18	1	47
3	15	15	19	3	425
4	13	15	20	29	295
5	17	1	21	17	229
6	23	333	22	25	427
7	13	11	23	29	83
8	9	13	24	9	409
9	3	1	25	13	387
10	15	121	26	23	193
11	3	155	27	13	57
12	13	1	28	13	501
13	1	175	29	1	313
14	13	421	30	13	489
15	29	5	31	13	391

5.2.2.10.2.2 Bit Interleaving

For the OIS Channel, the bit interleaving is a form of block interleaving. The code bits of a turbo encoded packet are interleaved in such a pattern that adjacent code bits are mapped into different constellation symbols.

The Bit Interleaver shall reorder the turbo encoded bits as per the following procedure:

a. For N bits to be interleaved, the bit interleaver matrix M shall be a 4 columns by N/4 rows block interleaver. The N input bits shall be written into the interleaving array column-by-column sequentially. Label the rows of the matrix M by index j, where j = 0 through N/4 –1 and row 0 is the first row.

b. For every row j, with even index (j mod 2 =0), the elements in the 2nd and the 3rd column shall be interchanged.

c. For every row with odd index (j mod 2 !=0), the elements in the 1st and the 4th column shall be interchanged.

d. Denote the resulting matrix by $\overline{M}$. The contents of $\overline{M}$ shall be read out row-wise, from left to right.

Figure 5.2.2.10.2.2-1 illustrates the output of the bit-interleaver[59] for the hypothetical case of N = 20.

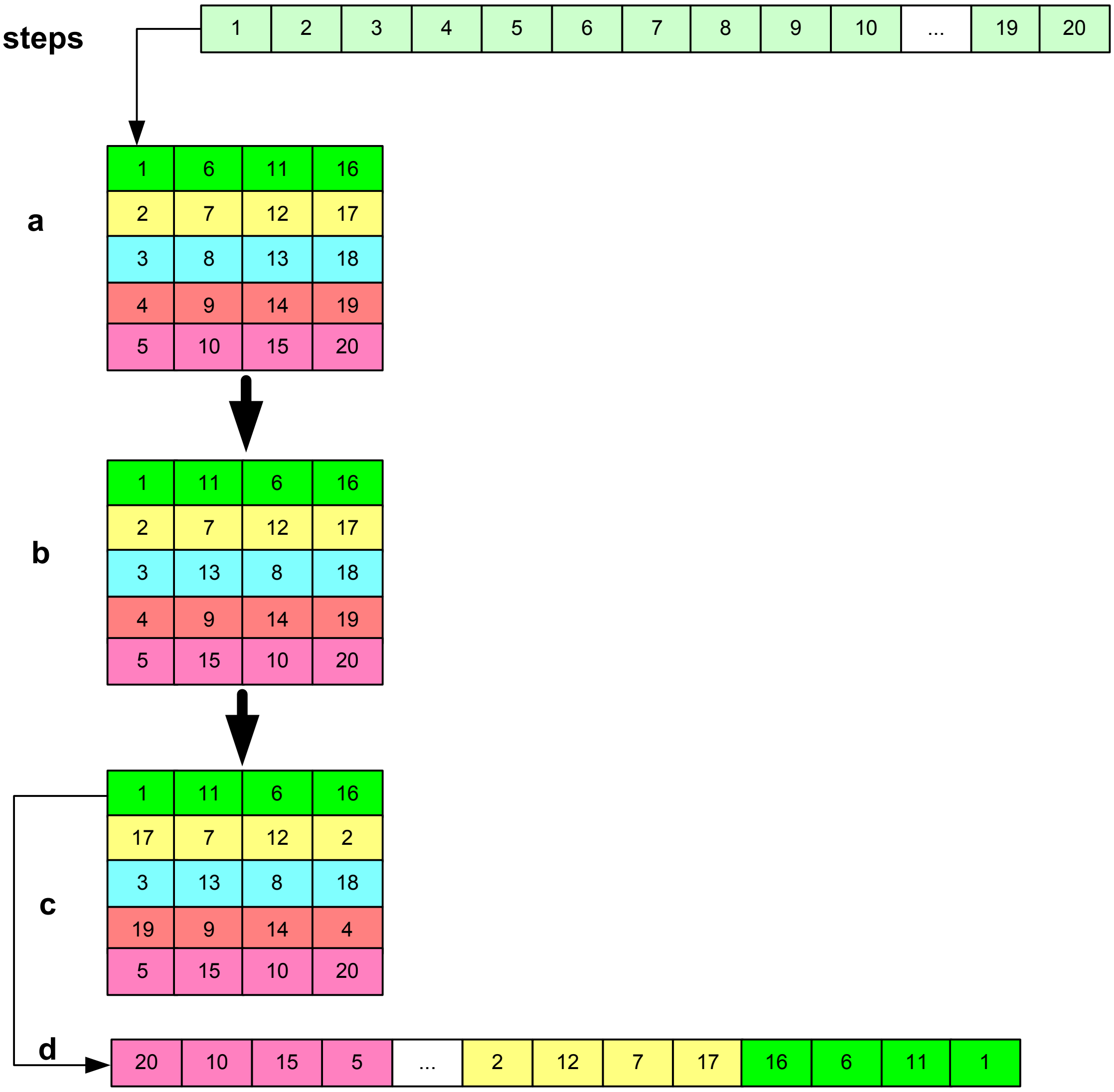

Figure 5.2.2.10.2.2-1 Bit Interleaver Operation Example for N = 20

5.2.2.10.2.3 Data Slot Allocation

For the Wide-area OIS Channel, 7 data slots shall be allocated per MAC time unit for the transmission of OIS Channel turbo encoded packets. The Wide-area OIS Channel shall use transmit mode 5. Therefore, it requires 5 data slots to accommodate the content of a single turbo encoded packet. Some Wide-area OIS Channel turbo encoded packets may span two consecutive MAC time units. For the 1K, 2K and 4K FFT sizes, 7 turbo encoded packets are

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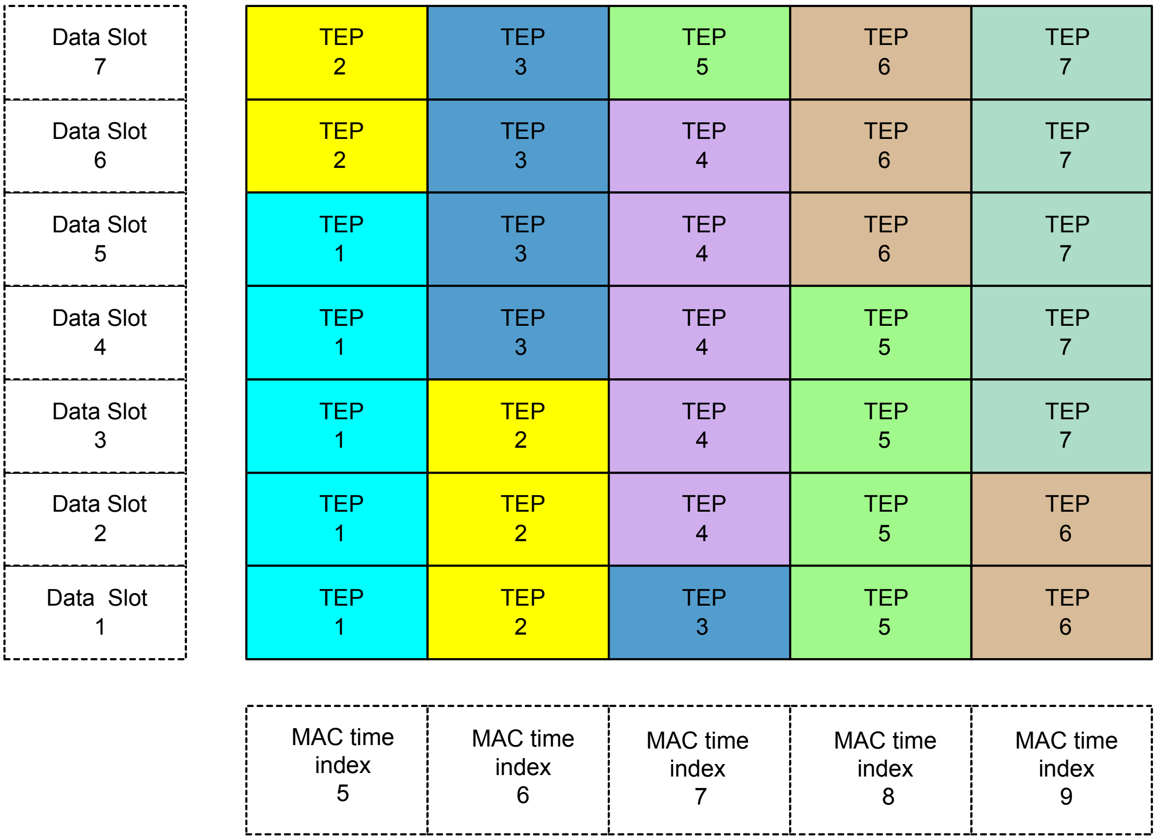
[59] In Figure 5.2.2.10.2.2-1, the label '1' denotes the first bit that is output by the turbo encoder and the label '20' denotes that last (hypothetical) output bit from the encoder.

transmitted over 5 MAC time units and all data slots are allocated. For the 8K FFT size, a sixth MAC time unit with un-allocated slots is appended to result in an integer number (3) of OFDM symbols for the Wide-area OIS.

5.2.2.10.2.4 Filling of Data Slot Buffer

The bit-interleaved code bits of a Wide-area OIS Channel turbo encoded packet shall be written sequentially into 5 consecutive data slot buffers in either one or two consecutive MAC time units as illustrated in Figure 5.2.2.10.2.4-1. These data slot buffers correspond to slot indices 1 through 7. The data slot buffer size shall be 1000 bits[60].

For the 1K, 2K and 4K FFT sizes, the 7 Wide-area OIS Channel turbo encoded packets (TEP) shall occupy consecutive slots over 5 consecutive MAC time units in the Wide-area OIS Channel (see Figure 5.2.2.10.2.4-1).



Data Slot 7	TEP 2	TEP 3	TEP 5	TEP 6	TEP 7
Data Slot 6	TEP 2	TEP 3	TEP 4	TEP 6	TEP 7
Data Slot 5	TEP 1	TEP 3	TEP 4	TEP 6	TEP 7
Data Slot 4	TEP 1	TEP 3	TEP 4	TEP 5	TEP 7
Data Slot 3	TEP 1	TEP 2	TEP 4	TEP 5	TEP 7
Data Slot 2	TEP 1	TEP 2	TEP 4	TEP 5	TEP 6
Data Slot 1	TEP 1	TEP 2	TEP 3	TEP 5	TEP 6
	MAC time index 5	MAC time index 6	MAC time index 7	MAC time index 8	MAC time index 9

Figure 5.2.2.10.2.4-1 Wide-area OIS Channel Turbo Encoded Packet Mapping to Data Slot Buffers: 1K/2K/4K FFT sizes

For the 8K FFT size, the 7 Wide-area OIS Channel turbo encoded packets (TEP) shall occupy consecutive slots over 5 consecutive MAC time units in the Wide-area OIS Channel (See Figure 5.2.2.10.2.4-2). All 7 data slots in the sixth MAC time unit shall be un-allocated. The processing of un-allocated slots shall be as described in 5.2.2.10.6.3.

The processing of the allocated slots shall be as described below.

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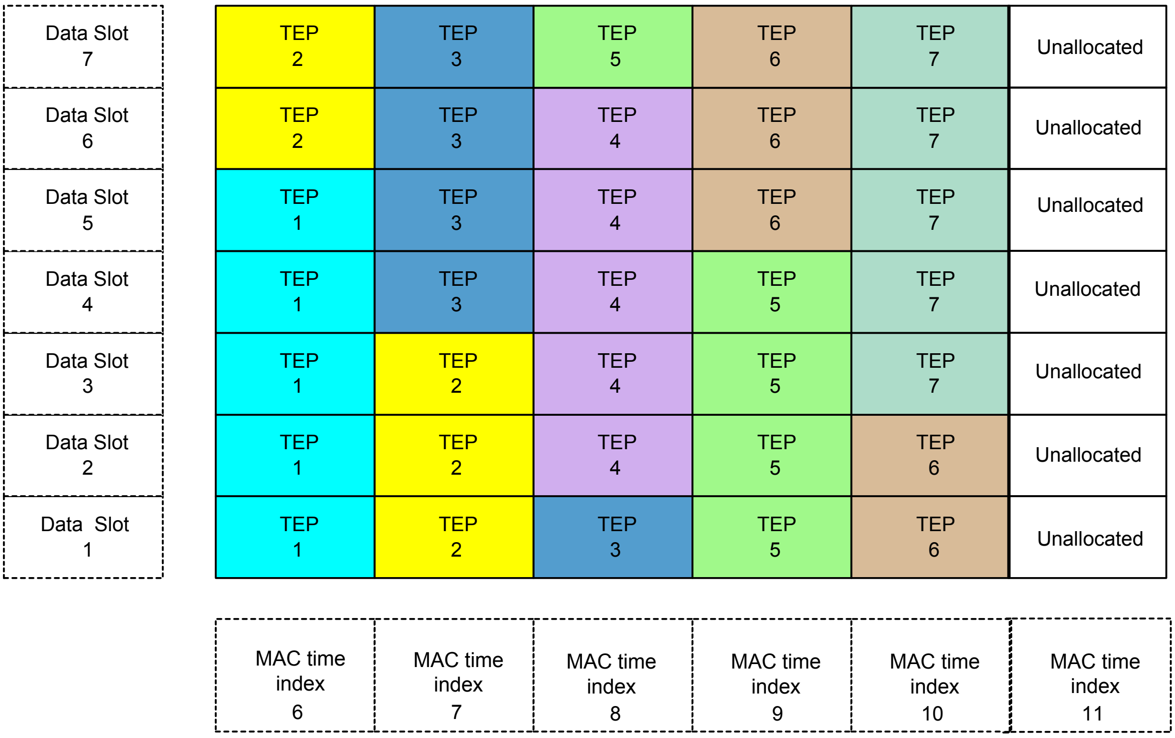
[60] The data slot buffer size is 1000 bits for QPSK and 2000 bits for 16-QAM and layered modulation.



	MAC time index 6	MAC time index 7	MAC time index 8	MAC time index 9	MAC time index 10	MAC time index 11
Data Slot 7	TEP 2	TEP 3	TEP 5	TEP 6	TEP 7	Unallocated
Data Slot 6	TEP 2	TEP 3	TEP 4	TEP 6	TEP 7	Unallocated
Data Slot 5	TEP 1	TEP 3	TEP 4	TEP 6	TEP 7	Unallocated
Data Slot 4	TEP 1	TEP 3	TEP 4	TEP 5	TEP 7	Unallocated
Data Slot 3	TEP 1	TEP 2	TEP 4	TEP 5	TEP 7	Unallocated
Data Slot 2	TEP 1	TEP 2	TEP 4	TEP 5	TEP 6	Unallocated
Data Slot 1	TEP 1	TEP 2	TEP 3	TEP 5	TEP 6	Unallocated

Figure 5.2.2.10.2.4-2 Wide-area OIS Channel Turbo Encoded Packet Mapping to Data Slot Buffers: 8K FFT size

5.2.2.10.2.5 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.2.6 Mapping of Bits to Modulation Symbols

Each group of two consecutive bits from the i^{th} scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 1, 2,..., 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.2.7 Slot to Interlace Mapping

The mapping of slots to interlaces for the Wide-area OIS Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.2.8 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be sequentially assigned to 500 interlace sub-carriers using a Sub-carrier Index Vector (SCIV) of length 500. The Sub-carrier Index Vector is formed as per the following procedure[61]:

a. Create an empty Sub-carrier Index Vector (SCIV).

b. Let i be an index variable in the range ($i \in \{0, 1, \ldots, 511\}$). Initialize i to 0.

---

[61] SCIV needs to be computed only once and can be used for all data slots.

c. Represent i by its 9-bit value i_b.

d. Bit reverse i_b and denote the resulting value as i_{br}. If $i_{br} < 500$, then append i_{br} to the SCIV.

e. If $i < 511$, then increment i by 1 and go to step c.

The modulation symbols in a data slot are then mapped to an interlace sub-carrier as per the following procedure:

- For the 1K FFT size, let $[I_0(s), I_1(s), I_2(s), I_3(s)]$ denote the interlaces in four consecutive OFDM symbols mapped to slot s. The i^th^ complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the j^th^ sub-carrier of interlace $I_k(s)$, where

$$j = \left\lfloor \frac{\mathrm{SCIV[i]}}{4} \right\rfloor, \quad k = \mathrm{BR}_2\left(\mathrm{SCIV[i]} \bmod 4\right)$$

  where $\mathrm{BR}_2(.)$ is the bit reversal operation[62] for two bits, i.e., $\mathrm{BR}_2(0) = 0$, $\mathrm{BR}_2(1) = 2$, $\mathrm{BR}_2(2) = 1$, $\mathrm{BR}_2(3) = 3$. If $j = 124$ and $I_k(s) = 0$ (the last sub-carrier in interlace 0), the modulation symbol shall not be transmitted.

- For the 2K FFT size, let $[I_0(s), I_1(s)]$ denote the interlaces in two consecutive OFDM symbols that are mapped to slot s. Then the i^th^ complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the j^th^ sub-carrier of interlace $I_k(s)$, where[63]

$$j = \left\lfloor \frac{\mathrm{SCIV[i]}}{2} \right\rfloor, \quad k = \mathrm{SCIV[i]} \bmod 2\,.$$

- For the 4K FFT size, the i^th^ complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the interlace sub-carrier with index SCIV[i].

For the 8K FFT size, the i^th^ complex modulation symbol (where $i \in \{0, 1, \ldots, 499\}$) shall be mapped to the j^th^ sub-carrier of the interlace, where

$$j = \begin{cases} 2 \times \mathrm{SCIV[i]}, & \text{if the slot belongs to an even MAC time unit} \\ 2 \times \mathrm{SCIV[i]} + 1, & \text{if the slot belongs to an odd MAC time unit} \end{cases}$$

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[62] The two bit reversal operation makes the mapping equivalent to the one generated by the following algorithm: 1) Divide each slot into four equal groups, with the first group consisting of the first 125 modulation symbols, the second group with the next 125 modulation symbols, and so on. 2) Map the modulation symbols in group k (where k = 0, 1, 2, 3) to sub-carriers in interlace $I_k(s)$ using a sub-carrier interlace vector (SCIV) of length 125, generated using a punctured 7 bit reversal instead of a punctured 9 bit reversal.

[63] This mapping can be equivalently generated by the following algorithm: 1) Divide each slot into two equal groups, with the first group consisting of the first 250 modulation symbols, the second group with the next 250 modulation symbols. 2) Map the modulation symbols in group k (where k = 0, 1) to sub-carriers in interlace $I_k(s)$ using a sub-carrier interlace vector (SCIV) of length 250, generated using a punctured 8 bit reversal instead of a punctured 9 bit reversal.

5.2.2.10.2.9 OFDM Common Operation

The modulated Wide-area OIS Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.3 Local-area OIS Channel

This channel is used to convey overhead information about the active MLCs associated with the Local-area Data Channel, such as their scheduled transmission times and slot allocations, in the current superframe. For the 1K, 2K and 4K FFT sizes, the Local-area OIS Channel spans 5 MAC time units in each superframe, which corresponds to 20, 10 and 5 OFDM symbols, respectively. For the 8K FFT size, the Local-area OIS Channel spans 6 MAC time units, which corresponds to 3 OFDM symbols.

The Physical layer packet for the Local-area OIS Channel shall be processed according to the steps illustrated in Figure 5.2.2.10.2-1.

5.2.2.10.3.1 Encoding

The Local-area OIS Channel Physical layer packets shall be encoded with code rate R = 1/5. The encoding procedure shall be identical to that for the Wide-area OIS Channel Physical layer packets as specified in 5.2.2.10.2.1.

5.2.2.10.3.2 Bit Interleaving

The Local-area OIS Channel turbo encoded packet shall be bit interleaved as specified in 5.2.2.10.2.2.

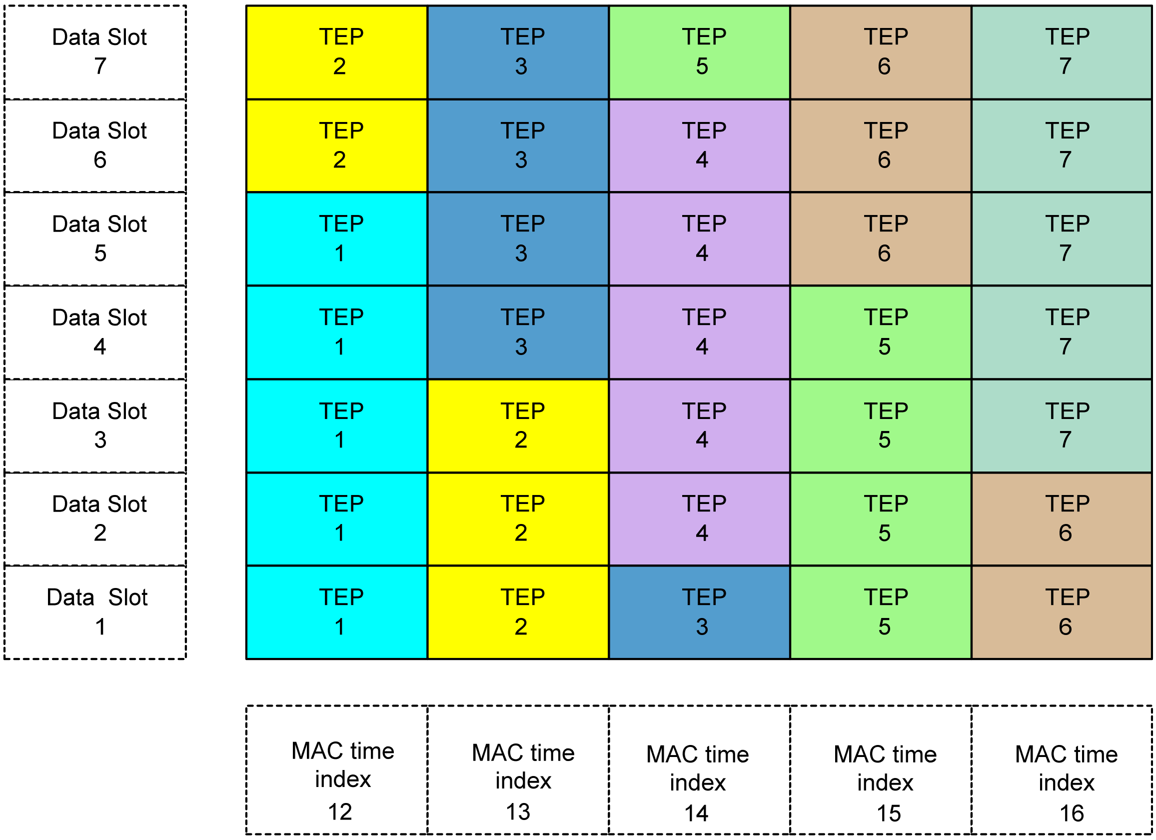
5.2.2.10.3.3 Data Slot Allocation

For the Local-area OIS Channel, 7 data slots shall be allocated per MAC time unit for the transmission of turbo encoded packets. The Local-area OIS Channel shall use transmit mode 5. Therefore, it requires 5 data slots to accommodate the content of a single turbo encoded packet. Some Local-area OIS turbo-packets may span two consecutive MAC time units. The data slot allocations are made at the MAC layer (see 4.8). For the 1K, 2K and 4K FFT sizes, 7 turbo encoded packets are transmitted over 5 MAC time units and all data slots are allocated. For the 8K FFT size, a sixth MAC time unit with un-allocated slots is appended to result in an integer number (3) of OFDM symbols for the Local-area OIS.

5.2.2.10.3.4 Filling of Data Slot Buffers

The bit-interleaved code bits of a Local-area OIS Channel turbo encoded packet shall be written sequentially into 5 consecutive data slot buffers in either one or two consecutive MAC time units as illustrated in Figure 5.2.2.10.3.4-1. These data slot buffers correspond to slot indices 1 through 7. The data slot buffer size shall be 1000 bits.

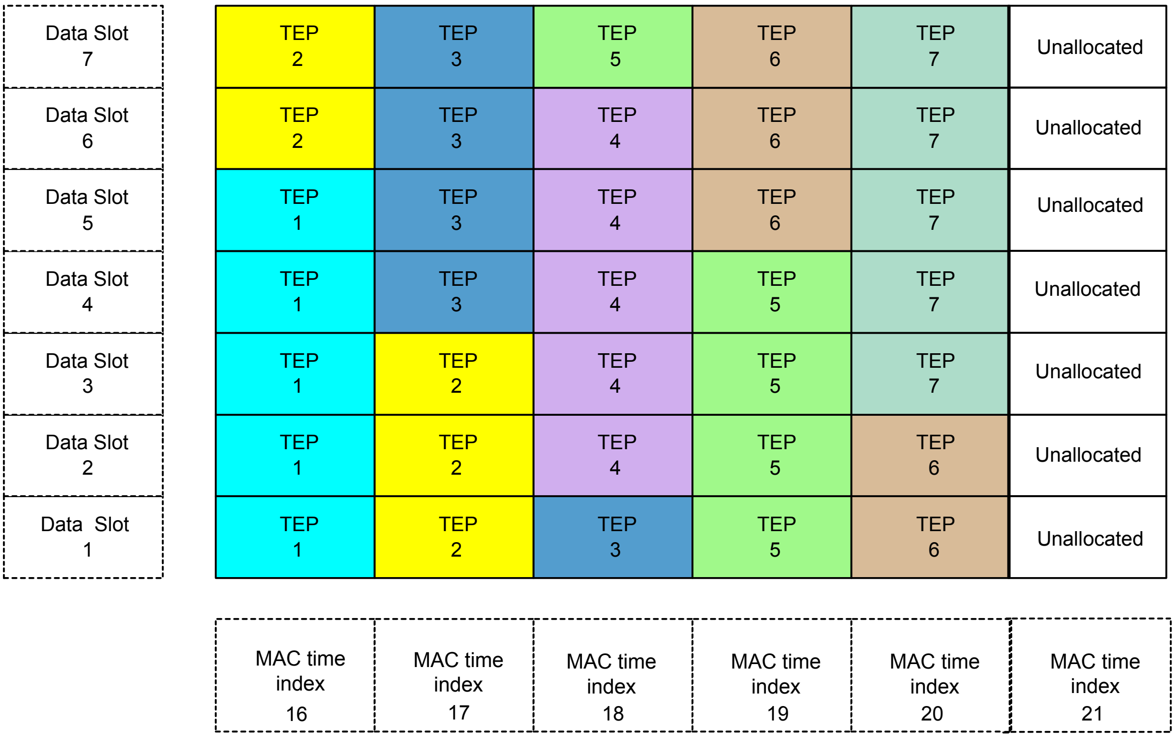
For the 1K, 2K and 4K FFT sizes, the 7 Local-area OIS Channel turbo encoded packets (TEP) shall occupy consecutive slots over 5 consecutive MAC time units in the Local-area OIS Channel (see Figure 5.2.2.10.3.4-1).



	MAC time index 12	MAC time index 13	MAC time index 14	MAC time index 15	MAC time index 16
Data Slot 7	TEP 2	TEP 3	TEP 5	TEP 6	TEP 7
Data Slot 6	TEP 2	TEP 3	TEP 4	TEP 6	TEP 7
Data Slot 5	TEP 1	TEP 3	TEP 4	TEP 6	TEP 7
Data Slot 4	TEP 1	TEP 3	TEP 4	TEP 5	TEP 7
Data Slot 3	TEP 1	TEP 2	TEP 4	TEP 5	TEP 7
Data Slot 2	TEP 1	TEP 2	TEP 4	TEP 5	TEP 6
Data Slot 1	TEP 1	TEP 2	TEP 3	TEP 5	TEP 6

Figure 5.2.2.10.3.4-1 Local-area OIS Turbo Encoded Packet Mapping to Data Slot Buffers: 1K/2K/4K FFT sizes

For the 8K FFT size, the 7 Local-area OIS Channel turbo encoded packets (TEP) shall occupy consecutive slots over 5 consecutive MAC time units in the Local-area OIS Channel (See Figure 5.2.2.10.3.4-2). All 7 data slots in the sixth MAC time unit shall be un-allocated. The processing of un-allocated slots shall be as described in 5.2.2.10.7.2.



	MAC time index 16	MAC time index 17	MAC time index 18	MAC time index 19	MAC time index 20	MAC time index 21
Data Slot 7	TEP 2	TEP 3	TEP 5	TEP 6	TEP 7	Unallocated
Data Slot 6	TEP 2	TEP 3	TEP 4	TEP 6	TEP 7	Unallocated
Data Slot 5	TEP 1	TEP 3	TEP 4	TEP 6	TEP 7	Unallocated
Data Slot 4	TEP 1	TEP 3	TEP 4	TEP 5	TEP 7	Unallocated
Data Slot 3	TEP 1	TEP 2	TEP 4	TEP 5	TEP 7	Unallocated
Data Slot 2	TEP 1	TEP 2	TEP 4	TEP 5	TEP 6	Unallocated
Data Slot 1	TEP 1	TEP 2	TEP 3	TEP 5	TEP 6	Unallocated

Figure 5.2.2.10.3.4-2 Local-area OIS Channel Turbo Encoded Packet Mapping to Data Slot Buffers: 8K FFT size

5.2.2.10.3.5 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.3.6 Mapping of bits to Modulation Symbols

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i, 2k) and SB(i, 2k + 1), i = 1, 2,…, 7, k = 0, 1,…, 499, which are labeled as s_0 and s_1 respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.3.7 Slot to Interlace Mapping

The mapping of slots to interlaces for the Local-area OIS Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.3.8 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

This procedure shall be identical to that for the Wide-area OIS Channel as specified in 5.2.2.10.2.8.

5.2.2.10.3.9 OFDM Common Operation

The modulated Local-area OIS Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.4 Wide-area FDM Pilot Channel

The Wide-area FDM Pilot Channel is transmitted in conjunction with the Wide-area Data Channel or the Wide-area OIS Channel. The Wide-area FDM Pilot Channel carries a fixed bit pattern that may be used for Wide-area Channel estimation and other functions by the Forward Link Only device.

For the Wide-area FDM Pilot Channel a single slot shall be allocated during every MAC time unit that carries either the Wide-area Data Channel or the Wide-area OIS Channel.

The allocated slot shall use a 1000-bit fixed pattern as input. These bits shall be set to zero. These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1.

5.2.2.10.4.1 Slot Allocation

The Wide-area FDM Pilot Channel shall be allocated the slot with index 0 during every MAC time unit that carries either the Wide-area Data Channel or the Wide-area OIS Channel.

5.2.2.10.4.2 Filling of Slot Buffer

The buffer for the slot allocated to the Wide-area FDM Pilot Channel shall be completely filled with a fixed pattern consisting of 1000-bits, with each bit set to ‘0’.

5.2.2.10.4.3 Slot Scrambling

The bits of the Wide-area FDM Pilot Channel slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.4.4 Modulation Symbol Mapping

Each group of two consecutive bits of the i^{th} scrambled slot buffer, SB(i ,2k) and SB(i,2k+1), $i = 0$, $k = 0, 1, \ldots, 499$, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.4.5 Slot to Interlace Mapping

The mapping of the Wide-area FDM Pilot Channel slots to interlaces shall be as specified in 5.2.2.11.

5.2.2.10.4.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in the allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.4.7 OFDM Common Operation

The modulated Wide-area FDM Pilot Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.5 Local-area FDM Pilot Channel

The Local-area FDM Pilot Channel is transmitted in conjunction with the Local-area Data Channel or the Local-area OIS Channel. The Local-area FDM Pilot Channel carries a fixed bit pattern that may be used for Local-area channel estimation and other functions by the Forward Link Only device.

For the Local-area FDM Pilot Channel a single slot shall be allocated during every MAC time unit that carries either the Local-area Data Channel or the Local-area OIS Channel.

The allocated slot shall use a 1000-bit fixed pattern as input. These bits shall be set to zero. These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1.

5.2.2.10.5.1 Slot Allocation

The Local-area FDM Pilot Channel shall be allocated the slot with index 0 during every MAC time unit that carries either the Local-area Data Channel or the Local-area OIS Channel.

5.2.2.10.5.2 Filling of Pilot Slot Buffer

The buffer for the slot allocated to the Local-area FDM Pilot Channel shall be completely filled with a fixed pattern consisting of 1000-bits with each bit set to '0'.

5.2.2.10.5.3 Slot Buffer Scrambling

The bits of the Local-area FDM Pilot slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambler seed index shall be equal to the MAC time index. The scrambled slot buffer is denoted by SB.

5.2.2.10.5.4 Modulation Symbol Mapping

Each group of two consecutive bits of the i^{th} scrambled slot buffer, SB(i,2k) and SB(i, 2k+1), $i = 0$, $k = 0, 1,\ldots, 499$ which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.5.5 Slot to Interlace Mapping

The mapping of the Local-area FDM Pilot Channel slots to interlaces shall be as specified in 5.2.2.11.

5.2.2.10.5.6 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in the allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.5.7 OFDM Common Operation

The modulated Local-area FDM Pilot Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.6 Wide-area Data Channel

The Wide-area Data Channel is used to carry Physical layer packets meant for Wide-area multicast. The Physical layer packets for the Wide-area Data Channel can be associated with any one of the active MLCs transmitted in the Wide-area. The processing of Physical layer packets for the Wide-area Data Channel depends on the Physical layer option as described below.

5.2.2.10.6.1 Wide-area Data Channel Processing for Allocated Slots for PHY Type 1

The Physical layer packet for the Wide-area Data Channel for PHY Type 1 shall be processed according to the steps illustrated in Figure 5.2.2.10.6.1-1.

For regular modulation (QPSK and 16-QAM), the Physical layer packet is turbo-encoded and bit interleaved before being stored in the Data slot buffer(s). For layered modulation, the base component Physical layer packet and the enhancement component Physical layer packet are turbo-encoded and bit interleaved independently before being multiplexed into the Data slot buffer(s).

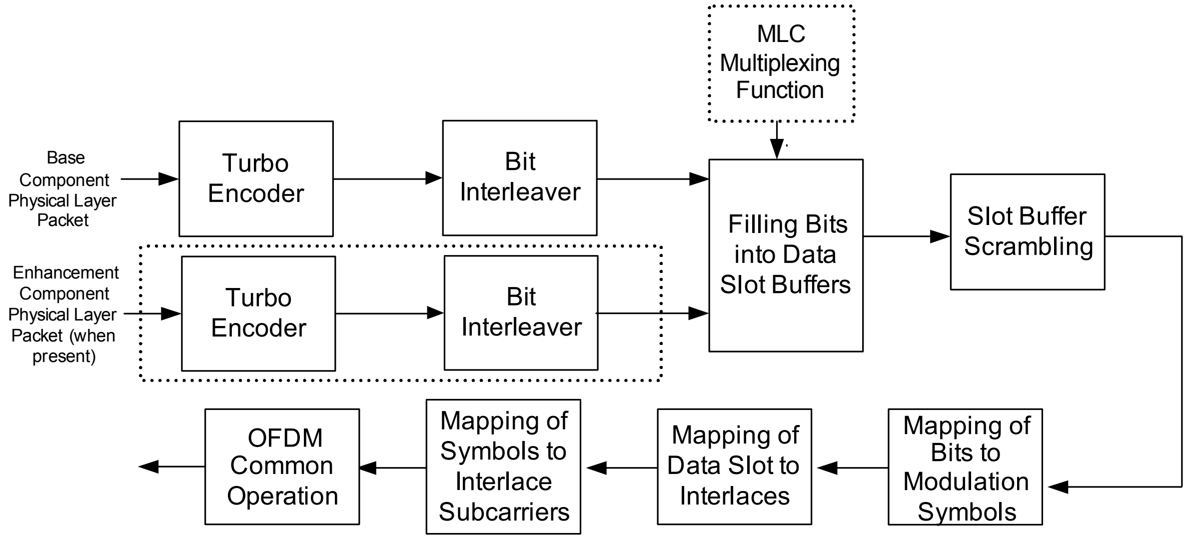


Figure 5.2.2.10.6.1-1 Data Channel Physical Layer Packet Processing in the Transmitter

5.2.2.10.6.1.1 Encoding

The Wide-area Data Channel Physical layer packets shall be encoded with code rate R = 1/2, 1/3, or 2/3. The encoder shall discard the 6-bit TAIL field of the incoming Physical layer packet and encode the remaining bits with a parallel turbo encoder as specified in 5.2.2.10.2.1.1. The turbo encoder shall add an internally generated tail of 6/R (= 12, 18 or 9) output code bits, so that the total number of turbo encoded bits at the output is 1/R times the number of bits in the input Physical layer packet.

Figure 5.2.2.10.6.1.1-1 illustrates the encoding scheme for the Wide-area Data Channel. The Wide-area Data Channel encoder parameters shall be as specified in Table 5.2.2.10.6.1.1-1.

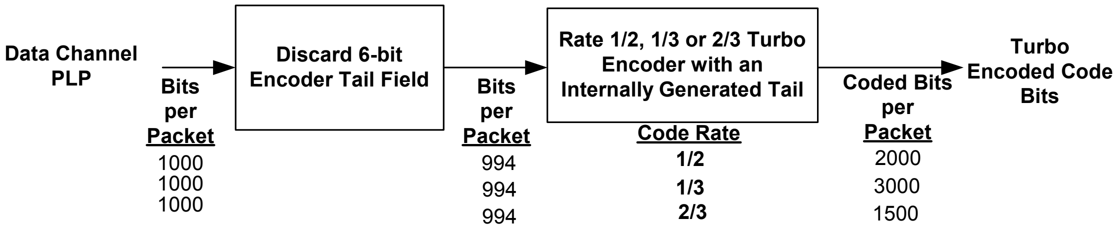


Figure 5.2.2.10.6.1.1-1 Data Channel Encoder

Table 5.2.2.10.6.1.1-1 Parameters of the Data Channel Encoder for PHY Type 1

Bits	Turbo Encoder Input Bits N_{turbo}	Code Rate	Turbo Encoder Output bits
1000	994	1/2	2000
1000	994	1/3	3000
1000	994	2/3	1500

5.2.2.10.6.1.1.1 Turbo Encoder

The turbo encoder used for Wide-area Data Channel Physical layer packets shall be as specified in 5.2.2.10.2.1.1.

The encoded data output bits are generated by clocking the constituent encoders N_{turbo} times with the switches in the up positions and puncturing the output as specified in Table 5.2.2.10.6.1.1.1-1. Within a puncturing pattern, a ‘0’ means that the bit shall be deleted and a ‘1’ means that the bit shall be passed. The constituent encoder outputs for each bit period shall be passed in the sequence X, Y_0, Y_1, X′, Y'_0, Y'_1 with the X output first. Bit repetition is not used in generating the encoded data output symbols.

The constituent encoder output symbol puncturing for the tail period shall be as specified in Table 5.2.2.10.6.1.1.1-2. Within a puncturing pattern, a ‘0’ means that the symbol shall be deleted and a ‘1’ means that a symbol shall be passed.

For rate 1/2 turbo codes, the tail output code bits for each of the first three tail bit periods shall be XY_0, and the tail output code bits for each of the last three tail bit periods shall be $X'Y'_0$.

For rate 1/3 turbo codes, the tail output code bits for each of the first three tail bit periods shall be XXY_0, and the tail output code bits for each of the last three tail bit periods shall be $X' X'Y'_0$.

For rate 2/3 turbo codes, the tail output code bits for the first three tail bit periods shall be XY_0, X and XY_0 respectively. The tail output code bits for the last three tail bit periods shall be X′, $X'Y'_0$ and X′, respectively.

Table 5.2.2.10.6.1.1.1-1 Puncturing Patterns for the Data Bit Periods for PHY Type 1

	Code Rate		
Output	**1/2**	**1/3**	**2/3**
X	11	11	1111
Y_0	10	11	1000
Y_1	00	00	0000
X'	00	00	0000
Y'_0	01	11	0001
Y'_1	00	00	0000

Note: The puncturing table is to be read from top to bottom.

Table 5.2.2.10.6.1.1.1-2 Puncturing Patterns for the Tail Bit Periods for PHY Type 1

	Code Rate		
Output	**1/2**	**1/3**	**2/3**
X	111 000	111 000	111 000
Y_0	111 000	111 000	101 000
Y_1	000 000	000 000	000 000
X'	000 111	000 111	000 111
Y'_0	000 111	000 111	000 010
Y'_1	000 000	000 000	000 000

Note: For rate-1/2 turbo codes, the puncturing table is to be read first from top to bottom and then from left to right. For Rate 1/3 turbo code, the puncturing table is to be read from top to bottom repeating X and X’, and then from left to right. For rate-2/3 turbo codes, the puncturing table is to be read first from top to bottom and then from left to right.

5.2.2.10.6.1.1.2 Turbo Interleaver

The turbo interleaver for the Wide-area Data Channel shall be as specified in 5.2.2.10.2.1.2.

5.2.2.10.6.1.2 Bit Interleaving

The Wide-area Data Channel turbo encoded packets shall be bit interleaved as specified in 5.2.2.10.2.2.

5.2.2.10.6.1.3 Data Slot Allocation

For the Wide-area Data Channel, up to 7 data slots may be allocated per MAC time unit for the transmission of multiple turbo encoded packets associated with one or more MLCs. For certain modes (2, 4, 8 and 11, see Table 5.2.2.9-1) a turbo encoded packet occupies a fraction of a slot. However, slots are allocated to MLCs in a manner that avoids multiple MLCs sharing slots within the same MAC time unit.

5.2.2.10.6.1.4 Filling of Data Slot Buffers

The bit-interleaved code bits of a Wide-area Data Channel turbo encoded packet shall be written into one or more data slot buffers. These data slot buffers correspond to slot indices 1 through 7.

The data slot buffer size shall be 1000 bits for QPSK and 2000 bits for 16-QAM and layered modulation.

For QPSK and 16-QAM modulation, the bit-interleaved code bits shall be sequentially written into the slot buffer(s).

For layered modulation, the bit-interleaved code bits corresponding to the base and the enhancement components shall be interleaved as illustrated in Figure 5.2.2.10.6.1.4-1, prior to filling the slot buffer(s).

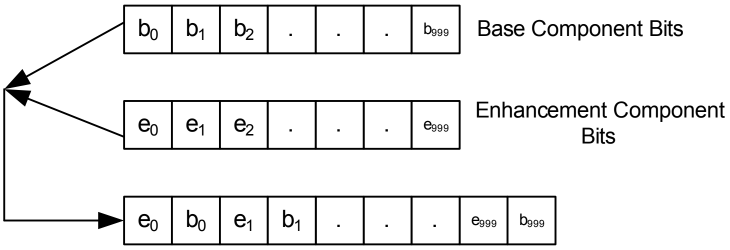


Figure 5.2.2.10.6.1.4-1 Interleaving of Base and Enhancement Component Bits for Filling the Slot Buffer for Layered Modulation

Figure 5.2.2.10.6.1.4-2 illustrates the case where a single turbo encoded packet spans three data slot buffers.

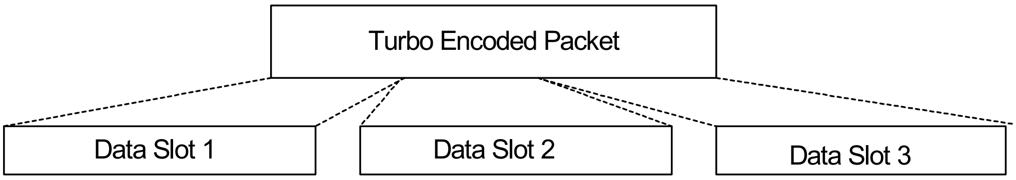


Figure 5.2.2.10.6.1.4-2 A Data Channel Turbo Encoded Packet Occupying Three Data Slot Buffers

Figure 5.2.2.10.6.1.4-3 illustrates the case where a base component turbo encoded packet with code rate 1/3 is multiplexed with an enhancement component turbo packet (with the same code rate) to occupy 3 data slot buffers.

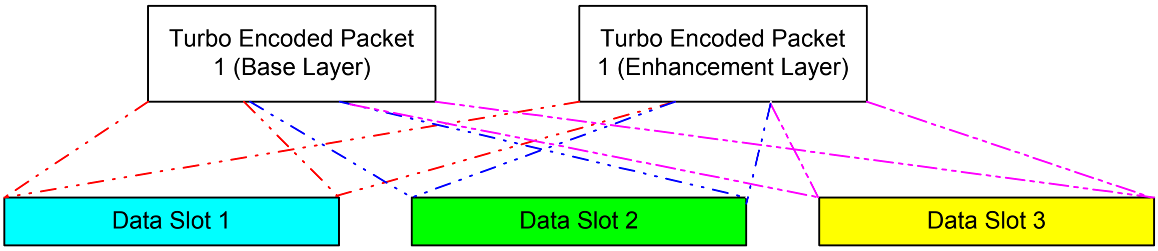


Figure 5.2.2.10.6.1.4-3 Multiplexing of Base and Enhancement Component Turbo Encoded Packets Occupying Three Data Slot Buffers

Figure 5.2.2.10.6.1.4-4 illustrates the case where a Data Channel turbo encoded packet occupies a fraction of a data slot and four turbo encoded packets are required to fill up an integer number of data slots.

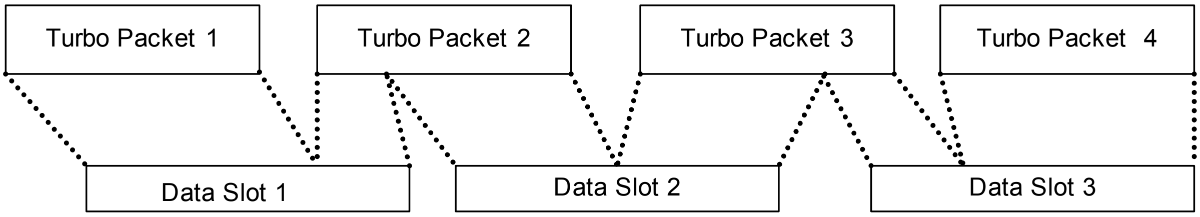


Figure 5.2.2.10.6.1.4-4 Data Channel Turbo Encoded Packet Occupying 3 Data Slot Buffers

The three slots in the figure may span one MAC time unit or multiple consecutive MAC time units. In either case, the data slot allocation over a MAC time unit for an MLC shall have consecutive slot indices.

Figure 5.2.2.10.6.1.4-5 illustrates a snapshot of slot allocations to five different MLCs over three consecutive MAC time units in a frame. In the figure, *TEP n,m* denotes n^{th} turbo encoded packet for the m^{th} MLC. In that figure,

- MLC 1 uses transmit mode 0 and requires three slots for each turbo encoded packet. It uses 3 consecutive MAC time units to send one turbo encoded packet.
- MLC 2 uses transmit mode 1 and utilizes 2 slots to transmit a single turbo encoded packet. It uses MAC time units n and n+1, to send two turbo encoded packets.
- MLC 3 uses transmit mode 2 and requires 1.5 slots for transmitting one turbo encoded packet. It uses three consecutive MAC time units to transmit 6 turbo encoded packets.
- MLC 4 uses transmit mode 1 and requires 2 slots to transmit a single turbo encoded packet. It uses 2 consecutive MAC time units to send two turbo encoded packets.
- MLC 5 uses transmit mode 3 and requires 1 slot to transmit a turbo encoded packet. It uses one MAC time unit to send a turbo encoded packet.

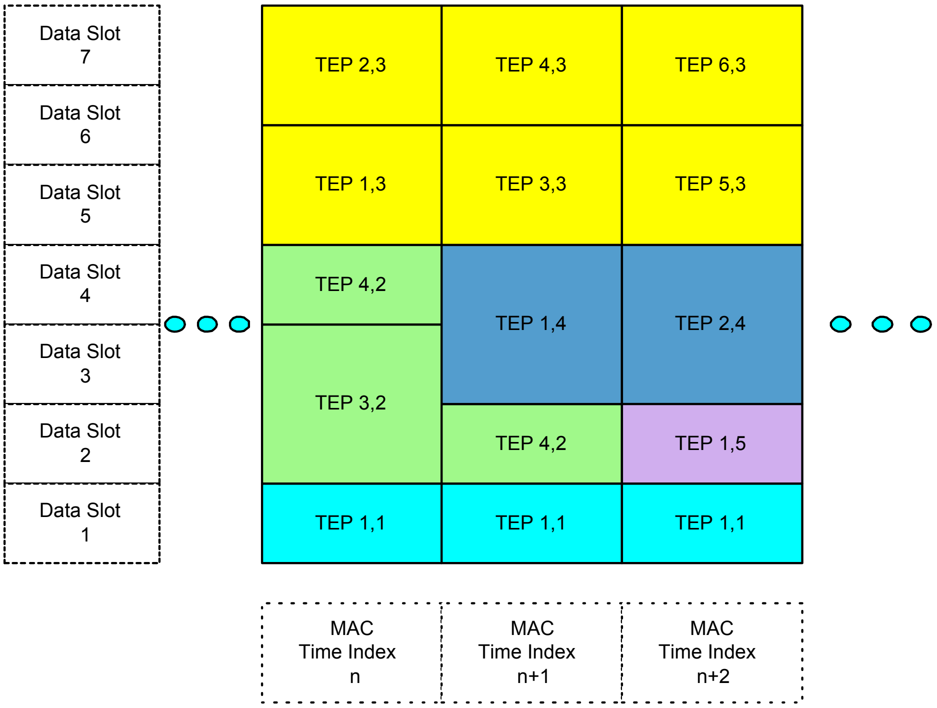


Figure 5.2.2.10.6.1.4-5 Example Slot Allocation to Multiple MLCs over 3 consecutive MAC time units in a Frame

5.2.2.10.6.1.5 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.6.1.6 Mapping of Bits to Modulation Symbols

QPSK, 16-QAM or Layered Modulation may be used for the Wide-area Data Channel depending on the transmit mode.

5.2.2.10.6.1.6.1 QPSK Modulation

Each group of two consecutive bits from the ith scrambled slot buffer, SB(i,2k) and SB(i,2k + 1), i =1, 2,..., 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.6.1.6.2 16-QAM Modulation

Each group of four consecutive bits from the ith scrambled data slot buffer, SB(i,4k), SB(i,4k+1), SB(i, 4k+2) and SB(i,4k+3), i = 1, 2,..., 7, k = 0, 1,..., 499 shall be grouped and mapped to a 16-QAM complex modulation symbol S(k)= (m_I(k), m_Q(k)), k = 0, 1,..., 499 as specified in Table 5.2.2.10.6.1.6.2-1 with $A = 1/\sqrt{10}$. Figure 5.2.2.10.6.1.6.2-1 shows the signal constellation of the 16-QAM modulator, where s_0=SB(i,4k), s_1=SB(i,4k+1), s_2=SB(i,4k+2), and s_3 = SB(i,4k + 3).

Table 5.2.2.10.6.1.6.2-1 16-QAM Modulation Table

Interleaved Bits				**Modulation Symbols**	
s_3 SB(i,4k + 3)	**s_2 SB(i,4k + 2)**	**s_1 SB(i,4k + 1)**	**s_0 SB(i,4k)**	**$m_Q(k)$**	**$m_I(k)$**
0	0	0	0	3A	3A
0	0	0	1	3A	A
0	0	1	1	3A	–A
0	0	1	0	3A	–3A
0	1	0	0	A	3A
0	1	0	1	A	A
0	1	1	1	A	–A
0	1	1	0	A	–3A
1	1	0	0	–A	3A
1	1	0	1	–A	A
1	1	1	1	–A	–A
1	1	1	0	–A	–3A
1	0	0	0	–3A	3A
1	0	0	1	–3A	A
1	0	1	1	–3A	–A
1	0	1	0	–3A	–3A

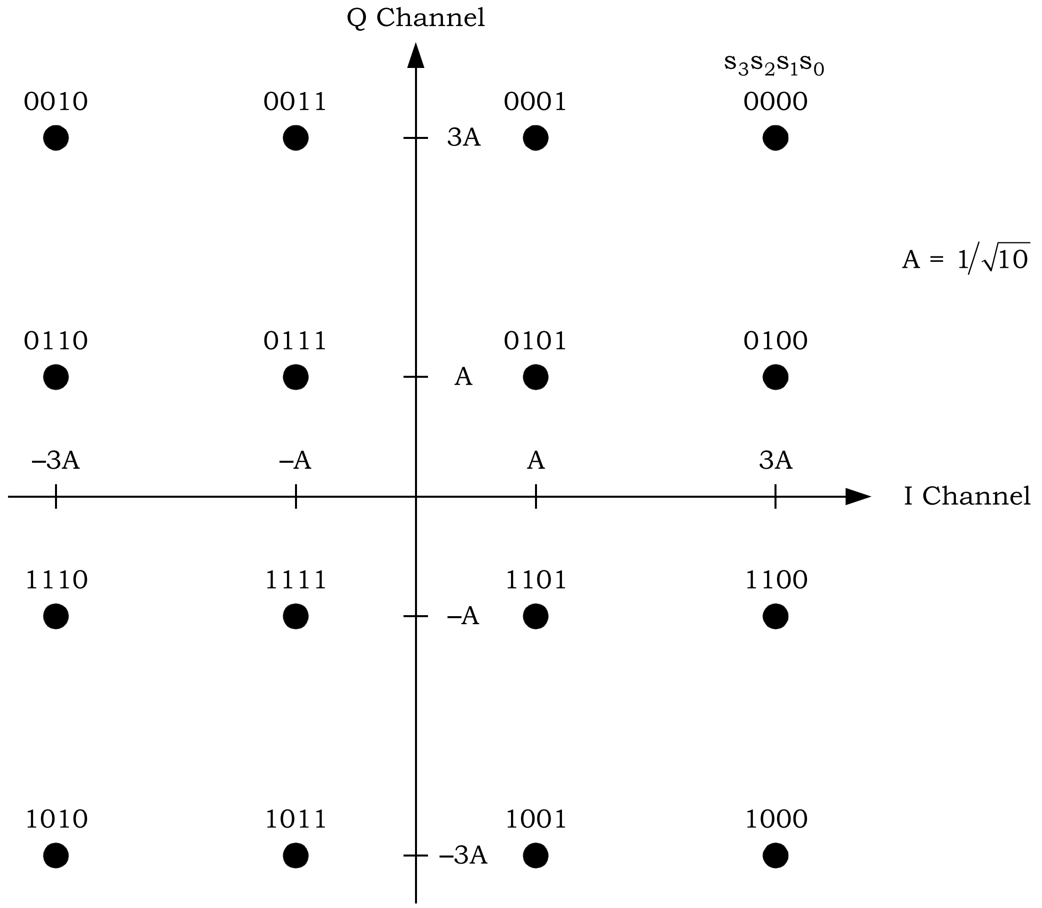


Figure 5.2.2.10.6.1.6.2-1 Signal Constellation for 16-QAM Modulation

5.2.2.10.6.1.6.3 Layered Modulation with Base and Enhancement Components

Each group of four consecutive bits from the ith scrambled data slot buffer, SB(i,4k), SB(i,4k+1), SB(i,4k+2) and SB(i,4k+3), i = 1, 2,..., 7, k = 0, 1,..., 499 shall be grouped and mapped to a layered modulation complex symbol S(k)= (m_I(k), m_Q(k)), k = 0, 1,..., 499 as specified in Table 5.2.2.10.6.1.6.3-1. If r denotes the energy ratio between the base component and the enhancement component, then α and β shall be given by: $\alpha = \sqrt{\frac{r}{2(1+r)}}$ and $\beta = \sqrt{\frac{1}{2(1+r)}}$ (see Figure 5.2.2.10.6.1.6.3-1).

Figure 5.2.2.10.6.1.6.3-1 shows the signal constellation for the layered modulation, where s_0=SB(i,4k), s_1=SB(i,4k+1), s_2=SB(i,4k+2), and s_3 = SB(i,4k + 3). It should be noted that the procedure for filling the slot buffer(s) ensures (see Figure 5.2.2.10.6.1.4-1) that bits s_0 and s_2 correspond to the enhancement component and bits s_1 and s_3 correspond to the base component.

Table 5.2.2.10.6.1.6.3-1 Layered Modulation Table

Interleaved Bits				Modulation Symbols	
s_3 SB(i,4k + 3)	s_2 SB(i,4k + 2)	s_1 SB(i,4k + 1)	s_0 SB(i,4k)	$m_Q(k)$	$m_I(k)$
0	0	0	0	$\alpha+\beta$	$\alpha+\beta$
0	0	0	1	$\alpha+\beta$	$\alpha-\beta$
0	0	1	1	$\alpha+\beta$	$-\alpha+\beta$
0	0	1	0	$\alpha+\beta$	$-\alpha-\beta$
0	1	0	0	$\alpha-\beta$	$\alpha+\beta$
0	1	0	1	$\alpha-\beta$	$\alpha-\beta$
0	1	1	1	$\alpha-\beta$	$-\alpha+\beta$
0	1	1	0	$\alpha-\beta$	$-\alpha-\beta$
1	1	0	0	$-\alpha+\beta$	$\alpha+\beta$
1	1	0	1	$-\alpha+\beta$	$\alpha-\beta$
1	1	1	1	$-\alpha+\beta$	$-\alpha+\beta$
1	1	1	0	$-\alpha+\beta$	$-\alpha-\beta$
1	0	0	0	$-\alpha-\beta$	$\alpha+\beta$
1	0	0	1	$-\alpha-\beta$	$\alpha-\beta$
1	0	1	1	$-\alpha-\beta$	$-\alpha+\beta$
1	0	1	0	$-\alpha-\beta$	$-\alpha-\beta$

Note: $\alpha = \sqrt{\dfrac{r}{2(1+r)}}$, $\beta = \sqrt{\dfrac{1}{2(1+r)}}$, where r is the ratio of the base component energy to the enhancement component energy.

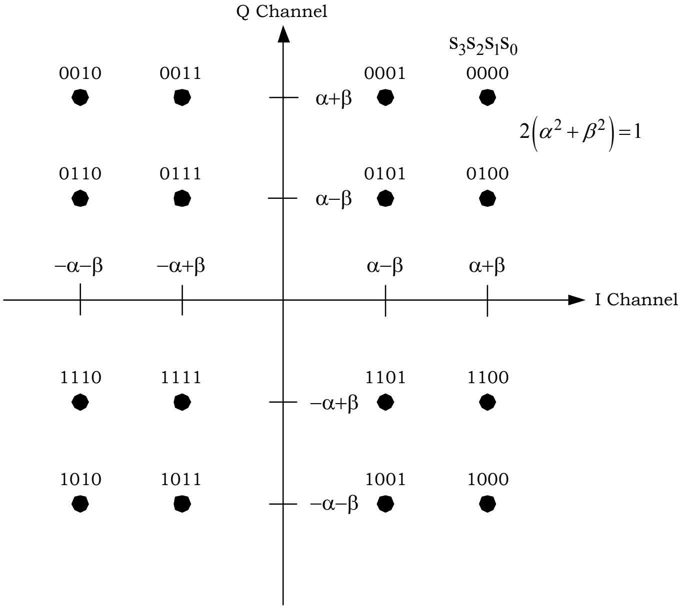


Figure 5.2.2.10.6.1.6.3-1 Signal Constellation for Layered Modulation

5.2.2.10.6.1.6.4 Layered Modulation with Base Component Only

The 2nd and 4th bits from each group of four consecutive bits from the ith scrambled slot buffer, SB(i, 4k+1) and SB(i, 4k + 3), i = 1, 2,…, 7, k = 0, 1,…, 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.6.1.7 Slot to Interlace Mapping

The mapping of slots to interlaces for the Wide-area Data Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.6.1.7.1 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be sequentially assigned to 500 interlace sub-carriers using the procedure specified in 5.2.2.10.2.8.

5.2.2.10.6.1.7.2 OFDM Common Operation

The modulated Wide-area Data Channel sub-carriers shall undergo common operation specified in 5.2.2.11.2.

5.2.2.10.6.2 Wide-area Data Channel Processing for Allocated Slots for PHY Type 2

The Physical layer packets for the Wide-area Data Channel for PHY Type 2 are first grouped corresponding to each of the active MLCs in the superframe and shall be processed according to the steps illustrated in Figure 5.2.2.10.6.2-1.

For regular modulation (QPSK and 16-QAM), all the Physical layer packets in the superframe corresponding to an MLC are grouped to form Turbo input packets which are turbo-encoded, bit interleaved and sub-packet interleaved before being stored in the data slot buffers. For layered modulation, the Turbo input packets corresponding to the base component Physical layer packets and the enhancement component Physical layer packets are turbo-encoded, bit interleaved and sub-packet interleaved independently before being multiplexed into the data slot buffers.

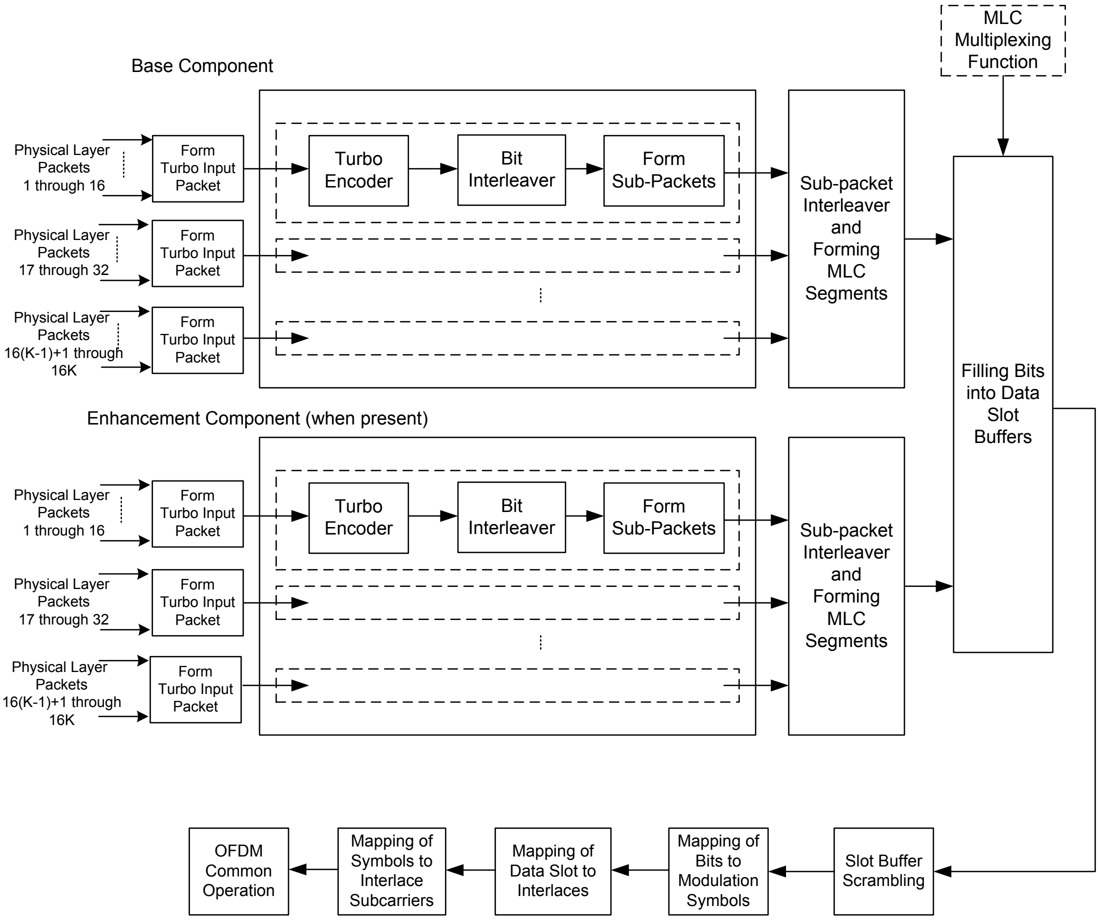


Figure 5.2.2.10.6.2-1 Data Channel Physical Layer Packet Processing in the Transmitter for PHY Type 2

5.2.2.10.6.2.1 Turbo Input Packet

The Physical layer packets in a superframe for the Wide-area Data Channel that belong to a particular active MLC are combined in groups of 16, along with the addition of Reserved bits, frame check sequence, and an encoder tail bit field to result in Turbo input packet to facilitate further processing in PHY Type 2.

5.2.2.10.6.2.1.1 Forming Turbo Input Packets

The Turbo input packet for PHY Type 2 is constructed from 16 consecutive Physical layer packets. The 16 Physical layer packets used to form the Turbo input packet for PHY Type 2 shall belong to the same MLC. If an MLC has more than 16 Physical layer packets in the superframe, groups of sixteen consecutive Physical layer packets shall be used to form multiple Turbo input packets that correspond to the same MLC. If an MLC has both base and enhancement components, Turbo input packets shall be formed separately for the base and enhancement components.

The Turbo input packet for PHY Type 2 has a length of 16000 bits. The 2 bit Reserved field and 6 bit TAIL field in each of the incoming Physical layer packets (see 5.1.2 for Physical layer packet format) shall be discarded before assembling the Turbo input packet.

The format of the first Turbo input packet of an MLC shall be as follows:

Table 5.2.2.10.6.2.1.1-1 Format of the Turbo Input Packet for PHY Type 2

Field	Length (bits)
Physical Layer Packet 1 after discarding Reserved and TAIL fields	992
Physical Layer Packet 2 after discarding Reserved and TAIL fields	992
Physical Layer Packet 3 after discarding Reserved and TAIL fields	992
Physical Layer Packet 4 after discarding Reserved and TAIL fields	992
Physical Layer Packet 5 after discarding Reserved and TAIL fields	992
Physical Layer Packet 6 after discarding Reserved and TAIL fields	992
Physical Layer Packet 7 after discarding Reserved and TAIL fields	992
Physical Layer Packet 8 after discarding Reserved and TAIL fields	992
Physical Layer Packet 9 after discarding Reserved and TAIL fields	992
Physical Layer Packet 10 after discarding Reserved and TAIL fields	992
Physical Layer Packet 11 after discarding Reserved and TAIL fields	992
Physical Layer Packet 12 after discarding Reserved and TAIL fields	992
Physical Layer Packet 13 after discarding Reserved and TAIL fields	992
Physical Layer Packet 14 after discarding Reserved and TAIL fields	992
Physical Layer Packet 15 after discarding Reserved and TAIL fields	992
Physical Layer Packet 16 after discarding Reserved and TAIL fields	992
Reserved	98
FCS	24
TAIL	6

Physical Layer Packet - Physical layer packet formed from the MAC layer packet from the Data or Control Channel MAC protocol

Reserved - This field shall be set to all ‘0’s. This field may be used to convey useful information in future versions of this specification.

FCS - Frame Check Sequence (see 5.2.2.10.6.2.1.2).

TAIL - Encoder tail bits. This field shall be set to all ‘0’s.

If an MLC has more than 16 Physical layer packets in the superframe, then further Turbo input packets shall be formed from successive groups of 16 consecutive Physical layer packets following the format of the Turbo input packet shown in Table 5.2.2.10.6.2.1.1-1.

5.2.2.10.6.2.1.2 Computation of the FCS Bits for Turbo Input Packet

The FCS computation described here shall be used for the computation of the FCS field in the Turbo input packet for PHY Type 2.

The FCS shall be a 24-bit CRC calculated using the standard CRC-CCITT generator polynomial:

$$g(x) = x^{24} + x^{23} + x^{6} + x^{5} + x + 1.$$

The FCS shall be equal to the value computed according to the following procedure as shown in:

- All shift-register elements shall be initialized to '1's[64].
- The switches shall be set in the up position.
- The register shall be clocked once for each bit of the Turbo input packet except for the FCS and TAIL bits. The turbo input packet shall be read from the MSB to LSB.
- The switches shall be set in the down position so that the output is a modulo-2 addition with a '0' and the successive shift-register inputs are '0's.
- The register shall be clocked an additional 24 times for the 24 FCS bits.

The output bits constitute all fields of the Turbo input packet for PHY Type 2 except the TAIL field.

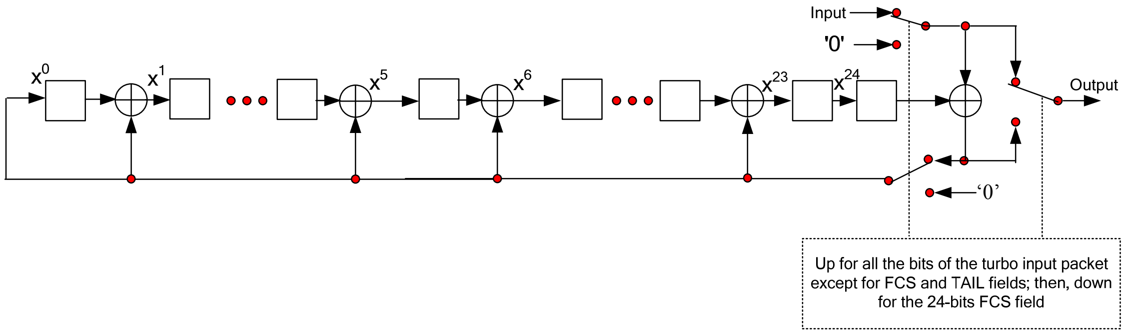


Figure 5.2.2.10.6.2.1.2-1 FCS Computation for the Turbo Input Packet for PHY Type 2

5.2.2.10.6.2.2 Encoding

The Wide-area Data Channel Turbo input packets shall be encoded with code rate R = 2/7, 1/3, 4/11, 2/5, 1/2 or 2/3. The encoder shall discard the 6-bit TAIL field of the incoming Turbo input packet and encode the remaining bits with a parallel turbo encoder as specified in 5.2.2.10.2.1.1. The turbo encoder shall add an internally generated tail of 6/R (= 21, 18, 15, 12, 9) output code bits for R=2/7, 1/3, 2/5, 1/2 and 2/3 respectively, so that the total number of turbo encoded bits at the output is 1/R times the number of bits in the Turbo input packet. For R=4/11, the turbo encoder shall add an internally generated tail of 17 bits, so that the total number of turbo encoded bits at the output is 1/R times the number of bits in the Turbo input packet.

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[64] Initialization of the register to ones causes the CRC for all-zero data to be non-zero. This initialization shall be performed prior to starting the FCS computation for each Turbo input packet.

Figure 5.2.2.10.6.2.2-1 illustrates the encoding scheme for the Wide-area Data Channel for PHY Type 2. The Wide-area Data Channel encoder parameters shall be as specified in Table 5.2.2.10.6.2.2-1.

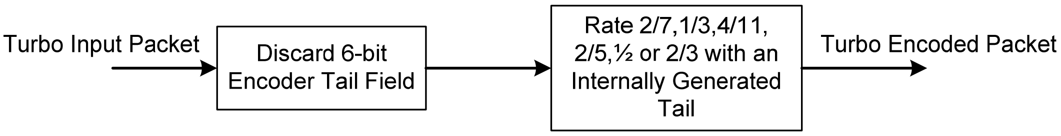

Figure 5.2.2.10.6.2.2-1 Data Channel Encoder for PHY Type 2

Table 5.2.2.10.6.2.2-1 Parameters of the Data Channel Encoder for PHY Type 2

Turbo Input Packet Length	**Turbo Encoder Input Bits N_{turbo}**	**Code Rate**	**Turbo Encoder Output bits N**
16000	15994	2/7	56000
16000	15994	1/3	48000
16000	15994	4/11	44000
16000	15994	2/5	40000
16000	15994	1/2	32000
16000	15994	2/3	24000

5.2.2.10.6.2.2.1 Turbo Encoder

The turbo encoder used for Wide-area Data Channel Turbo input packets shall be as specified in 5.2.2.10.2.1.1.

The encoded data output bits are generated by clocking the constituent encoders N_{turbo} times with the switches in the up positions and puncturing the output as specified in Table 5.2.2.10.6.2.2.1-1. Within a puncturing pattern, a '0' means that the bit shall be deleted and a '1' means that the bit shall be passed. The constituent encoder outputs for each bit period shall be passed in the sequence X, Y_0, Y_1, X′, Y'_0, Y'_1 with the X output first. Bit repetition is not used in generating the encoded data output symbols.

The constituent encoder output symbol puncturing for the tail period shall be as specified in Table 5.2.2.10.6.2.2.1-2. Within a puncturing pattern, a '0' means that the symbol shall be deleted and a '1' means that a symbol shall be passed.

For rate 2/7 turbo code, the tail output code bits for the first three tail bit periods shall be XXY_0Y_1, XXY_1 and XXY_0Y_1 respectively while the tail output code bits for the last three tail bit periods shall be $X'X'Y'_1$, $X'X'Y'_0Y'_1$ and $X'X'Y'_1$ respectively.

For rate 1/3 turbo code, the tail output code bits for each of the first three tail bit periods shall be XXY_0 respectively and the tail output code bits for each of the last three tail bit periods shall be $X'X'Y'_0$ respectively.

For rate 4/11 turbo code, the tail output code bits for the first three tail bit periods shall be XY_0Y_1. The tail output code bits for the fourth tail bit period shall be $X'Y'_1$. The tail output code bits for the fifth and sixth tail bit periods shall be $X'Y'_0Y'_1$.

For rate 2/5 turbo code, the tail output code bits for the first three tail bit periods shall be XY_0Y_1, XY_1 and XY_0Y_1 respectively, and the tail output code bits for each of the last three tail bit periods shall be $X'Y'_1$, $X'Y'_0Y'_1$ and $X'Y'_1$ respectively.

For rate 1/2 turbo code, the tail output code bits for each of the first three tail bit periods shall be XY_0, and the tail output code bits for each of the last three tail bit periods shall be $X'Y'_0$.

For rate 2/3 turbo code, the tail output code bits for the first three tail bit periods shall be XY_0, X and XY_0 respectively. The tail output code bits for the last three tail bit periods shall be X', $X'Y'_0$ and X', respectively.

Table 5.2.2.10.6.2.2.1-1 Puncturing Patterns for the Data Bit Periods for PHY Type 2

	Code Rate					
Output	**2/7**	**1/3**	**4/11**	**2/5**	**1/2**	**2/3**
X	1111	11	11111111	1111	11	1111
Y_0	0001	11	00000000	0000	10	1000
Y_1	1111	00	01111111	1110	00	0000
X'	0000	00	00000000	0000	00	0000
Y'_0	0100	11	00000000	0000	01	0001
Y'_1	1111	00	11110111	1011	00	0000

Note: The puncturing table is to be read from top to bottom.

Table 5.2.2.10.6.2.2.1-2 Puncturing Patterns for the Tail Bit Periods for PHY Type 2

	Code Rate					
Output	**2/7**	**1/3**	**4/11**	**2/5**	**1/2**	**2/3**
X	111 000	111 000	111 000	111 000	111 000	111 000
Y_0	101 000	111 000	111 000	101 000	111 000	101 000
Y_1	111 000	000 000	111 000	111 000	000 000	000 000
X'	000 111	000 111	000 111	000 111	000 111	000 111
Y'_0	000 010	000 111	000 011	000 010	000 111	000 010
Y'_1	000 111	000 000	000 111	000 111	000 000	000 000

Note: For rate 2/7 turbo code, the puncturing table is to be read first from top to bottom repeating X and X', and then from left to right. For rate 1/3 turbo code, the puncturing table is to be read from top to bottom repeating X and X', and then from left to right. For rate 4/11 turbo code, the puncturing table is to be read from top to bottom, and then from left to right. For rate 2/5 turbo code, the puncturing table is to be read first from top to bottom and then from left to right. For rate-1/2 turbo code, the puncturing table is to be read first from top to bottom and then from left to right. For rate-2/3 turbo code, the puncturing table is to be read first from top to bottom and then from left to right.

5.2.2.10.6.2.2.2 Turbo Interleaver

The Turbo Interleaver for the Wide-area Data Channel for PHY Type 2 shall be as specified in 5.2.2.10.2.1.2 where the value of n is 9.

5.2.2.10.6.2.3 Bit Interleaving

The code bits of a turbo encoded packet for PHY Type 2 are interleaved by a Bit Interleaver which is a Reduced-Set M-Sequence Interleaver derived from a 15-tap or 16-tap linear feedback shift register (LFSR) depending on the length of the turbo encoded output bits.

The Bit Interleaver shall be functionally equivalent to an approach where the entire sequence of turbo encoded bits are written sequentially into an array at a sequence of addresses and then the entire sequence is read out from a sequence of addresses that are defined by the procedure described below.

Let the sequence of input addresses be from 0 to N-1 where N is given by the turbo code rate as shown in Table 5.2.2.10.6.2.2-1. Then the sequence of output addresses shall be equivalent to those generated by the procedure described below.

a. Determine the Bit Interleaver register length L, where L is the smallest integer such that $N \le 2^L$. Table 5.2.2.10.6.2.3-1 gives the value of L as a function of N.

b. If the value of L from Table 5.2.2.10.6.2.3-1 corresponds to 15, then use the 15-tap LFSR with generator sequence $h(D)=D^{15}+D^{14}+1$ and initial state '000000000000001' as shown in Figure 5.2.2.10.6.2.3-1. If the value of L from Table 5.2.2.10.6.2.3-1 corresponds to 16, then use the 16-tap LFSR with generator sequence $h(D)=D^{16}+D^{15}+D^{13}+D^4+1$ and initial state '0000000000000001' as shown in Figure 5.2.2.10.6.2.3-2.

c. Form a tentative output address whose bits are given by the value in the LFSR register. For the 15-tap LFSR, the tentative output address is given by $s_{15}s_{14}s_{13}s_{12}s_{11}s_{10}s_9s_8s_7s_6s_5s_4s_3s_2s_1$. For the 16-tap LFSR, the tentative output address is given by $s_{16}s_{15}s_{14}s_{13}s_{12}s_{11}s_{10}s_9s_8s_7s_6s_5s_4s_3s_2s_1$.

d. Accept the tentative output address if it is less than N+1, otherwise discard it. If the tentative output address is equal to N, set the output address to zero.

e. Clock the LFSR to obtain the next state and repeat Steps (c) and (d) until all N Bit Interleaver output addresses are obtained.

Table 5.2.2.10.6.2.3-1 Bit Interleaver Register Length

Turbo Encoder Output bits N	Bit Interleaver Register Length L
56000	16
48000	16
44000	16
40000	16
32000	15
24000	15

The first 20 states generated by the 15-tap LFSR shall be 0x1, 0x2, 0x4, 0x8, 0x10, 0x20, 0x40, 0x80, 0x100, 0x200, 0x400, 0x800, 0x1000, 0x2000, 0x4000, 0x4001, 0x4003, 0x4007, 0x400f, 0x401f.

The first 20 states generated by the 16-tap LFSR shall be 0x1, 0x2, 0x4, 0x8, 0x10, 0x20, 0x40, 0x80, 0x100, 0x200, 0x400, 0x800, 0x1000, 0x2000, 0x4000, 0x8000, 0xa011, 0xe033, 0x6077, 0xc0ee.

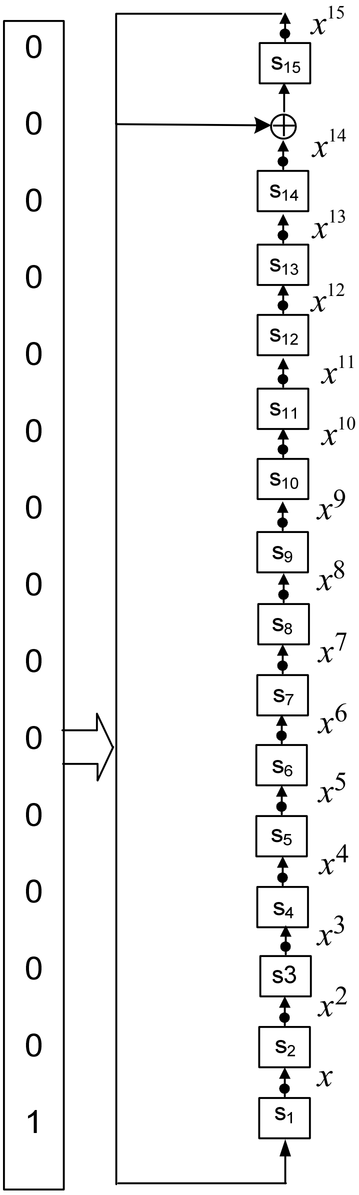

Figure 5.2.2.10.6.2.3-1 15-tap LFSR used by Bit Interleaver

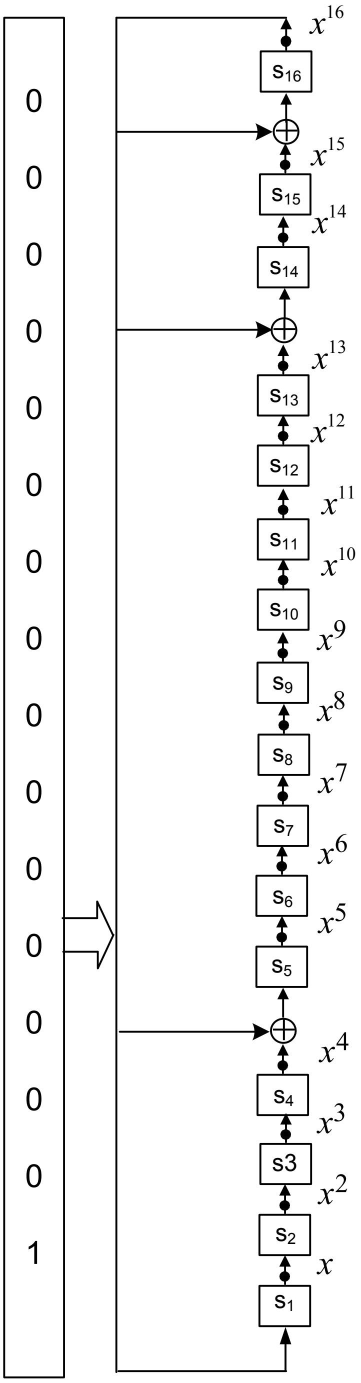

Figure 5.2.2.10.6.2.3-2 16-tap LFSR used by Bit Interleaver

5.2.2.10.6.2.4 Sub-packet Formation

The bit interleaved turbo encoded packets are further interleaved at the granularity of multiple bits called sub-packets.

Table 5.2.2.10.6.2.4-1 Sub-packet Length

Turbo Encoder Output bits N	Sub-packet Length
56000	700
48000	600
44000	550
40000	500
32000	400
24000	300

The bit interleaved turbo encoded packet shall be divided into 80 sub-packets. Each sub-packet shall be formed using N/80 consecutive bits from the bit interleaved turbo encoded packet as shown in Figure 5.2.2.10.6.2.4-1, where N is the length of the turbo encoded packet. The length of the sub-packet depends on the turbo encoded packet length as shown in Table 5.2.2.10.6.2.4-1.

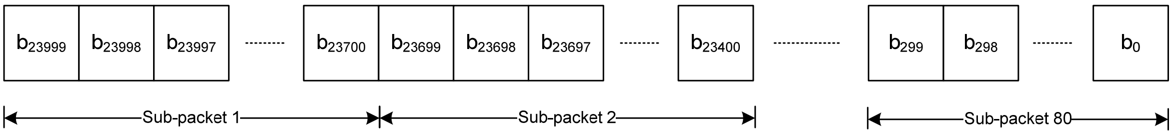

Figure 5.2.2.10.6.2.4-1 Forming Sub-packets from Bit Interleaved Turbo Encoded Packet for N=24000

5.2.2.10.6.2.5 Sub-packet Interleaver

The sub-packets from all the turbo encoded packets that belong to a particular component (base or enhancement) of an MLC in the superframe shall be interleaved by the Sub-packet Interleaver. The Sub-packet Interleaver is a block interleaver, where the number of rows is 80 (number of sub-packets per turbo encoded packet) and the number of columns is given by the number of turbo encoded packets for the MLC (or each component of the MLC if both base and enhancement components are present) in the superframe.

Let the number of turbo encoded packets to be sub-packet interleaved be K. Let the sub-packets be indexed by (m,n), where m corresponds to the turbo encoded packet and n corresponds to the sub-packet within the turbo encoded coded packet. With K turbo encoded packets for the MLC, m ranges from 1 to K, while n always ranges from 1 to 80. The Sub-packet Interleaver shall reorder the sub-packets of the MLC using a block interleaver M with 80 rows and K columns for the sub-packet indices. The indices of the interleaved sub-packets shall be obtained by writing the original sequence of sub-packet indices along the rows of M and reading out interleaved sub-packet indices along the columns of M.

K is set to 3 as an example in Figure 5.2.2.10.6.2.5-1. The sequence of sub-packets before sub-packet interleaving is given by $SP_{1,1}$, $SP_{1,2}$, $SP_{1,3}$, …, $SP_{1,80}$, $SP_{2,1}$, $SP_{2,2}$, $SP_{2,3}$, …, $SP_{2,80}$, SP$_{3,1}$, SP$_{3,2}$, SP$_{3,3}$, …, SP$_{3,80}$. After the sub-packet interleaving, the sequence of packets corresponds to SP$_{1,1}$, SP$_{2,1}$, SP$_{3,1}$, SP$_{1,2}$, SP$_{2,2}$, SP$_{3,2}$, SP$_{1,3}$, SP$_{2,3}$, SP$_{3,3}$, … SP$_{1,80}$, SP$_{2,80}$, SP$_{3,80}$.

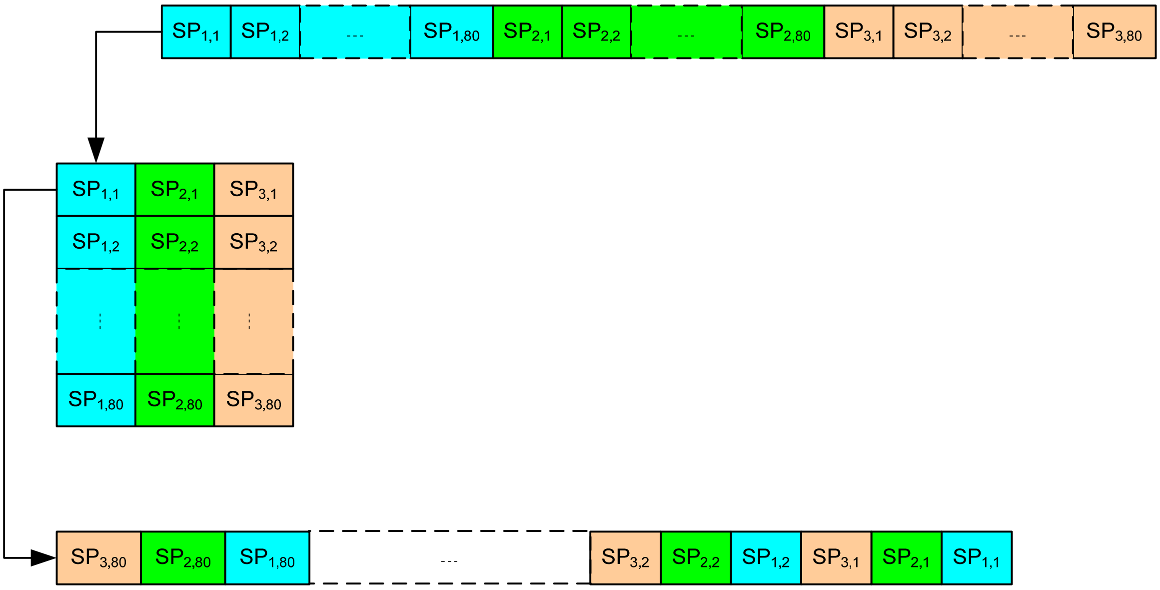

Figure 5.2.2.10.6.2.5-1 Sub-packet Interleaver Operation example for K=3

5.2.2.10.6.2.6 Formation of MLC Segments

After sub-packet interleaving, all the sub-packet interleaved bits corresponding to an MLC are divided into four equal portions called MLC Segments for facilitating further processing. If the MLC has multiple components (base and enhancement), then the sub-packet interleaved bits corresponding to each component are divided into four MLC Segments respectively. Each MLC Segment (of each component, if multiple components are present) corresponds to 4000×K/R consecutive bits of the MLC after sub-packet interleaving, where K is the number of turbo encoded packets (of each component, if multiple components are present) for the MLC in the superframe and R is the turbo code rate.

Each MLC Segment is transmitted in a unique frame in the superframe. In Figure 5.2.2.10.6.2.6-1 which shows an MLC with 2 turbo encoded packets, MLC Segments 1 through 4 are transmitted in Frames 1 through 4 respectively.

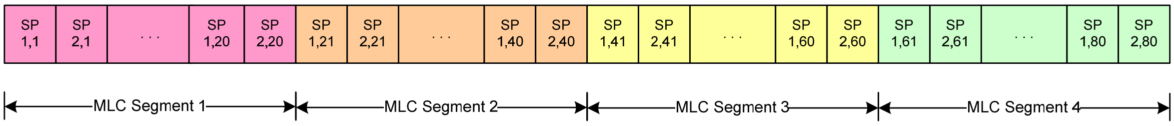

Figure 5.2.2.10.6.2.6-1 Forming MLC Segments for one MLC component for K=2

5.2.2.10.6.2.7 Data Slot Allocation

For the Wide-area Data Channel, up to 7 data slots may be allocated per MAC time unit for the transmission of one or more MLCs. Slots are allocated to MLCs in a manner that avoids multiple MLCs sharing slots within the same MAC time unit.

5.2.2.10.6.2.8 Filling of Data Slot Buffers

The sub-packet interleaved bits forming the MLC Segment of a Wide-area Data Channel MLC shall be written into multiple data slot buffers. These data slot buffers correspond to slot indices 1 through 7.

The data slot buffer size shall be 1000 bits for QPSK and 2000 bits for 16-QAM and layered modulation.

For QPSK and 16-QAM modulation, sub-packet interleaved bits corresponding to an MLC Segment shall be sequentially written into the slot buffers.

For layered modulation, the sub-packet interleaved code bits corresponding to the base and the enhancement component MLC Segments shall be interleaved as illustrated in Figure 5.2.2.10.6.2.8-1, prior to filling the slot buffers.

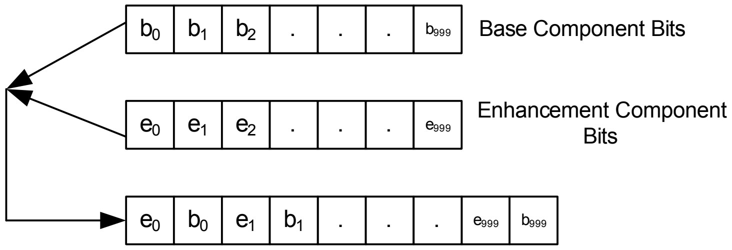

Figure 5.2.2.10.6.2.8-1 Interleaving of Base and Enhancement Component Bits from the MLC Segments for Filling the Slot Buffer for Layered Modulation

Figure 5.2.2.10.6.2.8-2 illustrates the case where a single MLC Segment spans three data slot buffers.

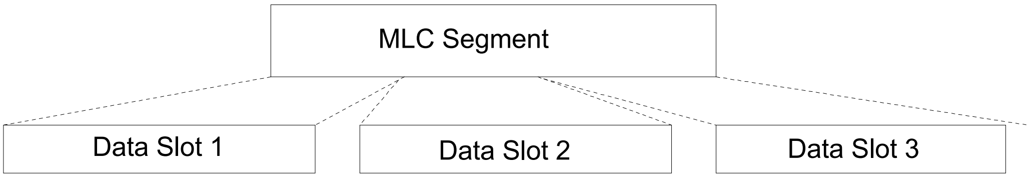

Figure 5.2.2.10.6.2.8-2 A Data Channel MLC Segment Occupying Three Data Slot Buffers

Figure 5.2.2.10.6.2.8-3 illustrates the case where a base component MLC Segment is multiplexed with an enhancement component MLC Segment to occupy 3 data slot buffers.

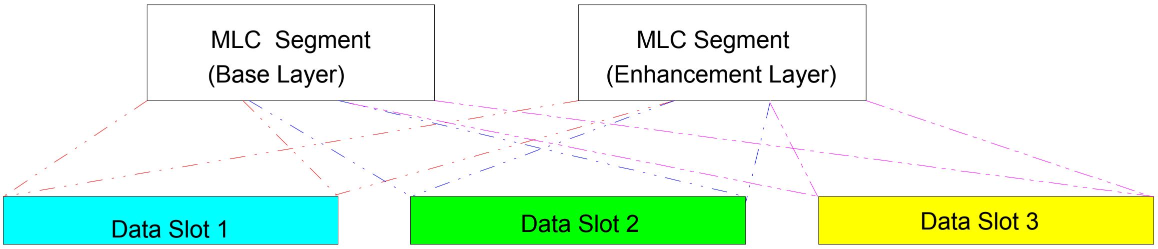

Figure 5.2.2.10.6.2.8-3 Multiplexing of Base and Enhancement Component MLC Segments Occupying Three Data Slot Buffers

5.2.2.10.6.2.9 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.6.2.10 Mapping of Bits to Modulation Symbols

QPSK, 16-QAM or Layered Modulation may be used for the Wide-area Data Channel depending on the transmit mode.

5.2.2.10.6.2.10.1 QPSK Modulation

Each group of two consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.1.6.1.

5.2.2.10.6.2.10.2 16-QAM Modulation

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a 16-QAM modulation symbol as specified in 5.2.2.10.6.1.6.2.

5.2.2.10.6.2.10.3 Layered Modulation with Base and Enhancement Components

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a layered modulation symbol as specified in 5.2.2.10.6.1.6.3 .

5.2.2.10.6.2.10.4 Layered Modulation with Base Component Only

The 2nd and 4th bits from each group of four consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.1.6.4.

5.2.2.10.6.2.11 Slot to Interlace Mapping

The mapping of slots to interlaces for the Wide-area Data Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.6.2.11.1 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be sequentially assigned to 500 interlace sub-carriers using the procedure specified in 5.2.2.10.2.8.

5.2.2.10.6.2.11.2 OFDM Common Operation

The modulated Wide-area Data Channel sub-carriers shall undergo common operation specified in 5.2.2.11.2.

5.2.2.10.6.3 Wide-area Data Channel Processing for Un-allocated Slots

The Wide-area Data Channel processing for un-allocated slots shall be identical for PHY Type 1 and PHY Type 2. The un-allocated slots in the Wide-area Data Channel use as input a 1000-bit fixed pattern, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2. These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1.

5.2.2.10.6.3.1 Filling of Slot Buffer

The buffer for each un-allocated slot of the Wide-area Data Channel shall be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2.

5.2.2.10.6.3.2 Slot Scrambling

The bits of each un-allocated slot buffer in the Wide-area Data Channel shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.6.3.3 Modulation Symbol Mapping

Each group of two consecutive bits from the i^{th} scrambled slot buffer, SB(i,2k) and SB(i,2k + 1), i = 1, 2,..., 7, k = 0, 1,..., 499, which are labeled as s_0 and s_1, respectively, shall be mapped into a complex modulation symbol MS = (m_I, m_Q) as specified in Table 5.2.2.10.1.1.3-1 with $D = 1/\sqrt{2}$. Figure 5.2.2.10.1.1.3-1 shows the signal constellation for the QPSK modulation.

5.2.2.10.6.3.4 Slot to Interlace Mapping

The mapping of slots to interlaces for the un-allocated slots in the Wide-area Data Channel OFDM symbol shall be as specified in 5.2.2.11

5.2.2.10.6.3.5 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each un-allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.6.3.6 OFDM Common Operation

This modulated Wide-area Data Channel OFDM symbol sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.7 Local-area Data Channel

The Local-area Data Channel is used to carry Physical layer packets meant for Local-area multicast. The Physical layer packets for the Local-area Data Channel can be associated with any one of the active MLCs transmitted in the Local-area. The processing of the Physical layer packets for Local-area Data Channel depends on the Physical Layer option as described below.

5.2.2.10.7.1 Local-area Data Channel Processing for Allocated Slots for PHY Type 1

The Physical layer packet for the Local-area Data Channel for PHY Type 1 shall be processed according to the steps illustrated in Figure 5.2.2.10.6.1-1.

For regular modulation (QPSK and 16-QAM), the Physical layer packet is turbo-encoded and bit interleaved before being stored in the Data slot buffer(s). For layered modulation, the base component Physical layer packet and the enhancement component Physical layer packet are turbo-encoded and bit interleaved independently before being multiplexed into the Data slot buffer(s).

5.2.2.10.7.1.1 Encoding

The Local-area Data Channel Physical layer packets shall be encoded with code rates R = 1/3, ½, or 2/3. The encoding procedure shall be identical to that for the Wide-area Data Channel as specified in 5.2.2.10.6.1.1.

5.2.2.10.7.1.2 Bit Interleaving

The Local-area Data Channel turbo encoded packet shall be bit interleaved as specified in 5.2.2.10.2.2.

5.2.2.10.7.1.3 Data Slot Allocation

For the Local-area Data Channel, the slot allocation shall be as specified in 5.2.2.10.6.1.3.

5.2.2.10.7.1.4 Filling of Data Slot Buffers

The procedure for filling the slot buffer for the Local-area Data Channel shall be as specified in 5.2.2.10.6.1.4.

5.2.2.10.7.1.5 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.7.1.6 Mapping of Slot Bits to Modulation Symbols

QPSK, 16-QAM or Layered Modulation may be used for the Local-area Data Channel depending on the transmit mode.

5.2.2.10.7.1.6.1 QPSK Modulation

Each group of two consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.1.6.1.

5.2.2.10.7.1.6.2 16-QAM Modulation

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a 16-QAM modulation symbol as specified in 5.2.2.10.6.1.6.2.

5.2.2.10.7.1.6.3 Layered Modulation with Base and Enhancement Components

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a layered modulation symbol as specified in 5.2.2.10.6.1.6.3 .

5.2.2.10.7.1.6.4 Layered Modulation with Base Component Only

The 2nd and 4th bits from each group of four consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.1.6.4.

5.2.2.10.7.1.7 Slot to Interlace Mapping

The mapping of slots to interlaces for Local-area Data Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.7.1.8 Mapping of Slot Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be sequentially assigned to 500 interlace sub-carriers using the procedure specified in 5.2.2.10.2.8.

5.2.2.10.7.1.9 OFDM Common Operation

The modulated Local-area Data Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.7.2 Local-area Data Channel Processing for Allocated Slots for PHY Type 2

The Physical layer packet for the Local-area Data Channel for PHY Type 2 shall be processed according to the steps illustrated in Figure 5.2.2.10.6.2-1.

For regular modulation (QPSK and 16-QAM), all the Physical layer packets in the superframe corresponding to an MLC are used to form Turbo input packet(s) which are turbo-encoded, bit interleaved and sub-packet interleaved before being stored in the Data slot buffers. For layered modulation, the Turbo input packet(s) corresponding to the base component Physical layer packets and the enhancement component Physical layer packets are turbo-encoded, bit interleaved and sub-packet interleaved independently before being multiplexed into the Data slot buffer.

5.2.2.10.7.2.1 Turbo Input Packet

The Local-area Data Channel Physical layer packets in the superframe that belong to a particular MLC are combined to form Turbo input packet(s) as specified in 5.2.2.10.6.2.1.

5.2.2.10.7.2.2 Encoding

The Turbo input packets corresponding to Local-area Data Channel Physical layer packets shall be encoded with code rates R = 2/7, 1/3, 4/11, 2/5, 1/2 or 2/3. The encoding procedure shall be identical to that for the Wide-area Data Channel for PHY Type 2 as specified in 5.2.2.10.6.2.2.

5.2.2.10.7.2.3 Bit Interleaving

The Local-area Data Channel turbo encoded packet shall be bit interleaved as specified in 5.2.2.10.6.2.3.

5.2.2.10.7.2.4 Sub-packet Formation

The bit interleaved turbo packet is divided into sub-packets for further processing as specified in 5.2.2.10.6.2.4.

5.2.2.10.7.2.5 Sub-packet Interleaver

The sub-packets from all the turbo encoded packets that belong to a particular component (base or enhancement) of an MLC in the superframe shall be interleaved by the Sub-packet Interleaver as specified in 5.2.2.10.6.2.5.

5.2.2.10.7.2.6 Formation of MLC Segments

After sub-packet interleaving, all the sub-packet interleaved bits corresponding to a particular component of an MLC are divided into four equal portions called MLC Segments for facilitating further processing as specified in 5.2.2.10.6.2.6

5.2.2.10.7.2.7 Data Slot Allocation

For the Local-area Data Channel, the slot allocation shall be as specified in 5.2.2.10.6.2.7.

5.2.2.10.7.2.8 Filling of Data Slot Buffers

The procedure for filling the slot buffer for the Local-area Data Channel shall be as specified in 5.2.2.10.6.2.8.

5.2.2.10.7.2.9 Slot Scrambling

The bits of each allocated slot buffer shall be scrambled as specified in 5.2.2.10.6.2.9. The scrambled slot buffer is denoted by SB.

5.2.2.10.7.2.10 Mapping of Slot Bits to Modulation Symbols

QPSK, 16-QAM or Layered Modulation may be used for the Local-area Data Channel depending on the transmit mode.

5.2.2.10.7.2.10.1 QPSK Modulation

Each group of two consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.2.10.1.

5.2.2.10.7.2.10.2 16-QAM Modulation

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a 16-QAM modulation symbol as specified in 5.2.2.10.6.2.10.2.

5.2.2.10.7.2.10.3 Layered Modulation with Base and Enhancement Components

Each group of four consecutive bits from the scrambled slot buffer shall be mapped into a layered modulation symbol as specified in 5.2.2.10.6.2.10.3.

5.2.2.10.7.2.10.4 Layered Modulation with Base Component Only

The 2nd and 4th bits from each group of four consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.2.10.4.

5.2.2.10.7.2.11 Slot to Interlace Mapping

The mapping of slots to interlaces for Local-area Data Channel OFDM symbols shall be as specified in 5.2.2.11.

5.2.2.10.7.2.12 Mapping of Slot Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each allocated slot shall be sequentially assigned to 500 interlace sub-carriers using the procedure specified in 5.2.2.10.2.8.

5.2.2.10.7.2.13 OFDM Common Operation

The modulated Local-area Data Channel sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.10.7.3 Local-area Data Channel Processing for Un-allocated Slots

The Local-area Data Channel Processing for Un-allocated Slots shall be identical for PHY Type 1 and PHY Type 2. The un-allocated slots in the Local-area Data Channel use as input a 1000-bit fixed pattern, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2. These bits shall be processed according to the steps illustrated in Figure 5.2.2.10.1.2-1.

5.2.2.10.7.3.1 Filling of Slot Buffers

The buffer for each un-allocated slot of the Local-area Data Channel shall be completely filled with a fixed pattern consisting of 1000 bits, generated by using the LFSR and initial state specified in 5.2.2.10.1.5.2.

5.2.2.10.7.3.2 Slot Scrambling

The bits of each un-allocated slot buffer in the Local-area Data Channel shall be scrambled as specified in 5.2.2.10.1.2.3. The scrambled slot buffer is denoted by SB.

5.2.2.10.7.3.3 Modulation Symbol Mapping

Each group of two consecutive bits from the scrambled slot buffer shall be mapped into a QPSK modulation symbol as specified in 5.2.2.10.6.3.3.

5.2.2.10.7.3.4 Slot to Interlace Mapping

The mapping of slots to interlaces for the un-allocated slots in the Local-area Data Channel OFDM symbol shall be as specified in 5.2.2.11

5.2.2.10.7.3.5 Mapping of Slot Buffer Modulation Symbols to Interlace Sub-carriers

The 500 modulation symbols in each un-allocated slot shall be assigned to interlace sub-carriers as specified in 5.2.2.10.1.5.6.

5.2.2.10.7.3.6 OFDM Common Operation

This modulated Local-area Data Channel OFDM symbol sub-carriers shall undergo common operations as specified in 5.2.2.12.

5.2.2.11 Mapping of Slots to Interlaces

The slot to interlace mapping varies from one OFDM symbol to the next as specified in this section. The slot to interlace mapping is based on the OFDM symbol index in a superframe. For all FFT sizes, the OFDM symbol index is equal to 1, 2 and 3 for WIC, LIC and TDM Pilot 2 channels, respectively.[65] For the remaining OFDM symbols, starting from the first WTPC OFDM symbol, the OFDM symbol index shall be related to the MAC time index as shown in Table 5.2.2.11-1.

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[65] The TDM Pilot 1 Channel marks the start of the superframe and has the implicit OFDM symbol index of 0.

Table 5.2.2.11-1 Relationship between OFDM symbol index and MAC time index

FFT Size	**OFDM symbol indices for MAC time index m** (m = 4, 5,...)
1024	$4m - 12, 4m - 11,$ $4m - 10, 4m - 9$
2048	$2m - 4, 2m - 3$
4096	m
8192	$\left\lfloor \frac{m+4}{2} \right\rfloor$

For the 1K and 2K FFT sizes, each slot maps to multiple interlaces across consecutive OFDM symbols (see

Table 5.2.2.7-1 and Table 5.2.2.8-1). The interlace index for each slot varies across these consecutive OFDM symbols. For the 8K FFT size, each OFDM symbol contains two MAC time units. Therefore, each OFDM symbol contains pairs of slots with the same slot index. The slot to interlace mapping shall assign each pair of slots with the same slot index to one interlace in a 8K OFDM symbol.

There are two options for the slot to interlace mapping, as outlined in this section. The Forward Link Only Network and Forward Link Only receiver shall support at least one of the specified mappings. The mapping used shall be signaled in the Signaling Parameter Channel (SPC), as specified in Table 5.2.2.10.1.7.3-2. Each mapping is uniquely identified by the periodic interlace pattern of the FDM Pilot Channel.

For all FFT sizes, the FDM Pilot Channel shall utilize slot 0. The interlaces occupied by the FDM pilot channel across OFDM symbols follows a periodic pattern. Two pilot patterns and the corresponding slot to interlace mappings are specified in 5.2.2.11.1and 5.2.2.11.2. The pilot patterns are referred to as Pilot pattern 1 and Pilot pattern 2, and the slot to interlace mappings are referred to as Mapping 1 and Mapping 2, respectively.

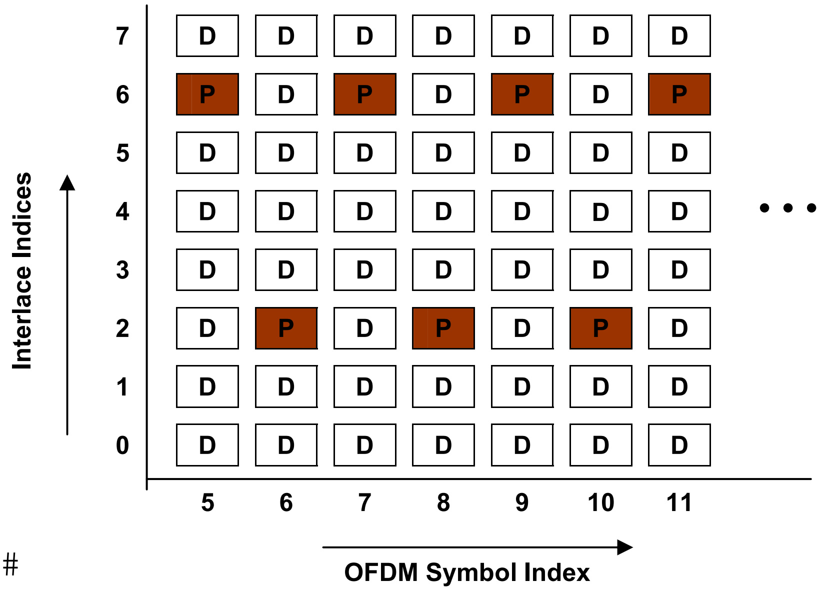
5.2.2.11.1 Slot to interlace mapping for Pilot pattern 1

Slot 0 shall be assigned interlace $I_p[j]$ for OFDM symbol index j in a superframe as follows:

- if (j mod 2 = 0), then $I_p[j] = 2$.
- Otherwise, $I_p[j] = 6$

The interlace assignment procedure for slot 0 ensures that the FDM Pilot Channel is assigned interlace 2 and 6 for even and odd OFDM symbol indices respectively. The remaining 7 interlaces in each OFDM symbol are assigned to slots 1 through 7. This is illustrated in Figure 5.2.2.11.1-1, where P and D denote the interlaces assigned to the slots occupied by the FDM Pilot Channel and the Data Channel, respectively.

Figure 5.2.2.11.1-1 Interlace Allocations to FDM Pilots: Pilot pattern 1



	5	6	7	8	9	10	11
7	D	D	D	D	D	D	D
6	P	D	P	D	P	D	P
5	D	D	D	D	D	D	D
4	D	D	D	D	D	D	D
3	D	D	D	D	D	D	D
2	D	P	D	P	D	P	D
1	D	D	D	D	D	D	D
0	D	D	D	D	D	D	D

#

The slot to interlace mapping for slots 1 through 7 shall be as follows:

1. Let i be the 3-bit value of the interlace index i ($i \in \{0, 1, \ldots, 7\}$). Denote the bit-reversed value of i as i_{br}.
2. Let I_k denote the k^{th} interlace as defined in 5.2.2.2.4. Permute the interlace sequence $\{I_0\, I_1\, I_2\, I_3\, I_4\, I_5\, I_6\, I_7\}$ by replacing the index i ($i \in \{0, 1, \ldots, 7\}$) in I_i with i_{br} to generate the permuted sequence, PS= $\{I_0\, I_4\, I_2\, I_6\, I_1\, I_5\, I_3\, I_7\}$.
3. Club interlaces[66] I_2 and I_6 in the PS to generate shortened interlace sequence, SIS = $\{ I_0\, I_4\, I_2/I_6\, I_1\, I_5\, I_3\, I_7\}$.
4. For the OFDM symbol with index j ($j \in \{1, 2, 3, \ldots\}$)[67] in a superframe, perform a right hand cyclic shift[68] on SIS in step 3, by a value equal to $(2 \times j) \bmod 7$ to generate the permuted shortened interlace sequence PSIS(j).
5. If ($j \bmod 2 = 0$), then choose interlace I_6 in the PSIS(j). Otherwise, choose I_2 in the PSIS[j].
6. For the j^{th} OFDM symbol interval in a superframe, the k^{th} data slot (for $k \in \{1, 2, \ldots, 7\}$) #shall be assigned the interlace PSIS(j)[k-1].

Figure 5.2.2.11.1-2 illustrates the interlace assignment to all 8 slots over 15 consecutive OFDM symbol intervals. The mapping pattern from slots to interlaces repeats after 14 consecutive OFDM symbol intervals[69].

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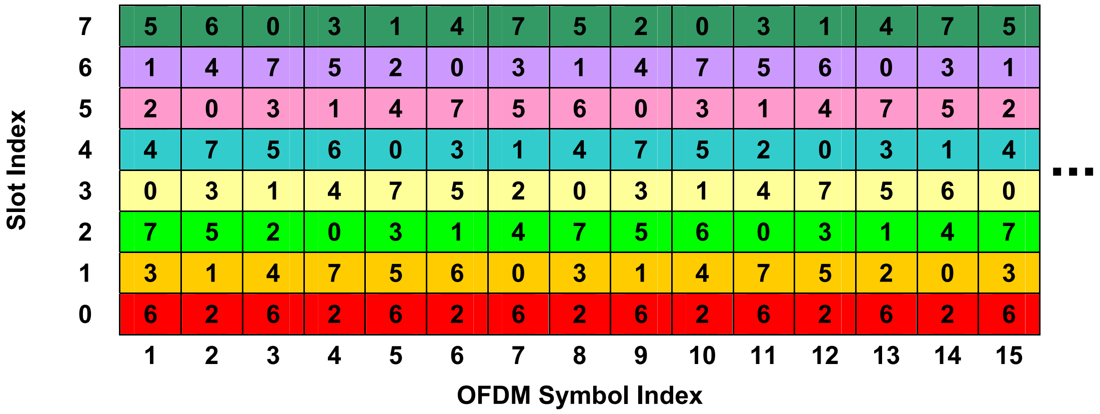
[66] Since interlaces 2 and interlace 6 are used alternatively for the pilot, the remaining seven interlaces are used for assignment to data slots.

[67] As described in Annex A, the number of OFDM symbols in a superframe depends on the FFT size, the bandwidth, the Flat Guard interval and whether the PPC is present or absent.

[68] Right hand cyclic shift of the sequence s = {1 2 3 4 5} by 2 yields the sequence s(2) = { 4 5 1 2 3}.



Slot Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	5	6	0	3	1	4	7	5	2	0	3	1	4	7	5
6	1	4	7	5	2	0	3	1	4	7	5	6	0	3	1
5	2	0	3	1	4	7	5	6	0	3	1	4	7	5	2
4	4	7	5	6	0	3	1	4	7	5	2	0	3	1	4
3	0	3	1	4	7	5	2	0	3	1	4	7	5	6	0
2	7	5	2	0	3	1	4	7	5	6	0	3	1	4	7
1	3	1	4	7	5	6	0	3	1	4	7	5	2	0	3
0	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6

Figure 5.2.2.11.1-2 Interlace Allocations to Slots: Mapping 1

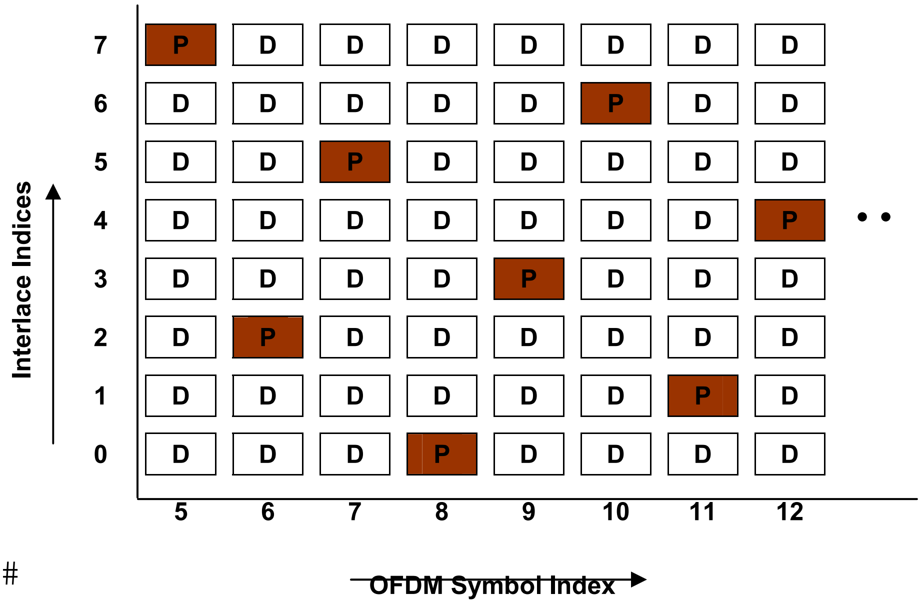
5.2.2.11.2 Slot to interlace mapping for Pilot pattern 2

Slot 0 shall be assigned interlace $I_p[j]$ for OFDM symbol index *j* in a superframe as follows:

$$I_p[j] = PS[j \bmod 8]$$

where PS[0] = 0, PS[1] = 3, PS[2] = 6, PS[3] = 1, PS[4] = 4, PS[5] = 7, PS[6] = 2, PS[7]= 5.

The interlace assignment procedure for slot 0 ensures that the FDM Pilot Channel is assigned all 8 interlaces over 8 consecutive OFDM symbols. The remaining 7 interlaces in each OFDM symbol are assigned to slots 1 through 7. This is illustrated in Figure 5.2.2.11.2-1 where P and D denote the interlaces assigned to the slots occupied by the FDM Pilot Channel and the Data Channel, respectively.



Interlace Indices	5	6	7	8	9	10	11	12
7	P	D	D	D	D	D	D	D
6	D	D	D	D	D	P	D	D
5	D	D	P	D	D	D	D	D
4	D	D	D	D	D	D	D	P
3	D	D	D	D	P	D	D	D
2	D	P	D	D	D	D	D	D
1	D	D	D	D	D	D	P	D
0	D	D	D	P	D	D	D	D

#

Figure 5.2.2.11.2-1 Interlace Allocations to FDM Pilots: Pilot pattern 2

The slot to interlace mapping for slots 1 through 7 shall be as follows:

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[69] The figure shows that all data slots get assigned to interlaces next to the Pilot interlace about the same fraction of time, and the channel estimation performance for all data slots is about the same.

1. For the jth OFDM symbol interval in a superframe, define the rotation factor

$$R[j] = (2 \times j) \bmod 7$$

2. Define a distance vector D of length 7 as

$$D=\left[7,2,4,6,1,5,3\right]$$

   where D[0] = 7, D[1] = 2,..., D[6] = 3.

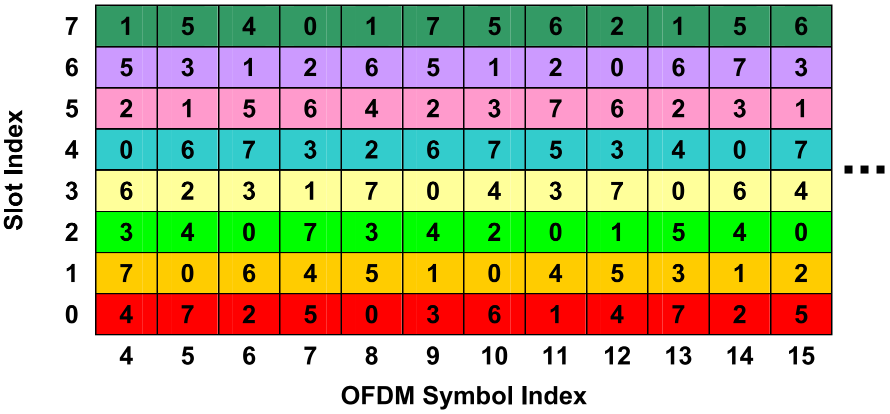
3. For the j^{th} OFDM symbol interval in a superframe, form the rotated distance vector, $D_{R[j]}$ through a right cyclic shift of the distance vector by the rotation factor:

$$D_{R[j]}[m]=D\left[\left(m\text{-}R[j]\right)\ \bmod\ 7\right],\quad m=0,1,\ldots,6$$

4. For the jth OFDM symbol interval in a superframe, the kth data slot (for k $\in\{1, 2,..., 7\}$) #shall be assigned the interlace

$$\left(I_p[j]+D_{R[j]}\left[k-1\right]\right)\ \bmod\ 8\,\#$$

Figure 5.2.2.11.2-2 illustrates the interlace assignment to all 8 slots over 12 consecutive OFDM symbol intervals. Since OFDM symbols with indices 1, 2 and 3 always use Mapping 1, Figure 5.2.2.11.2-2 shows the mapping starting from OFDM symbol index 4. The mapping from slots to interlaces repeats after 56 consecutive OFDM symbol intervals.



Slot Index												
7	1	5	4	0	1	7	5	6	2	1	5	6
6	5	3	1	2	6	5	1	2	0	6	7	3
5	2	1	5	6	4	2	3	7	6	2	3	1
4	0	6	7	3	2	6	7	5	3	4	0	7
3	6	2	3	1	7	0	4	3	7	0	6	4
2	3	4	0	7	3	4	2	0	1	5	4	0
1	7	0	6	4	5	1	0	4	5	3	1	2
0	4	7	2	5	0	3	6	1	4	7	2	5
	4	5	6	7	8	9	10	11	12	13	14	15

Figure 5.2.2.11.2-2 Interlace Allocations to Slots: Mapping 2

5.2.2.12 OFDM Common Operation

This block transforms the complex modulation symbols $X_{k,m}$, associated with sub-carrier index k for OFDM symbol interval m , into the RF transmitted signal. The operations are illustrated in Figure 5.2.2.12-1.

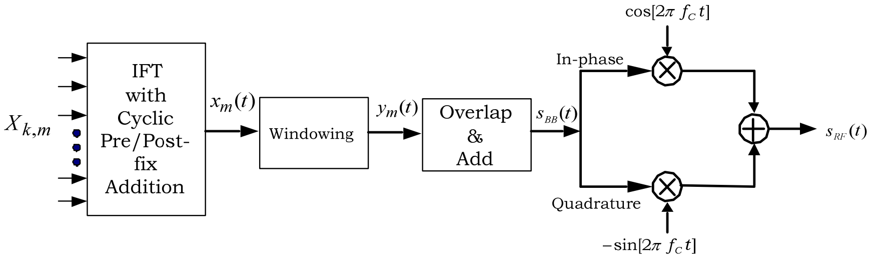


Figure 5.2.2.12-1 OFDM Common Operation

5.2.2.12.1 IFT Operation

The complex modulation symbols $X_{k,m}$, $k = 0, 1, \ldots, \mathrm{N}_{\mathrm{FFT}} - 1$, associated with the m^{th} OFDM symbol shall be related to the continuous-time signal $x_m(t)$ by the inverse Fourier Transform (IFT) equation. Specifically,

$$x_m(t)=\frac{1}{\sqrt{N_{FFT}}}\sum_{k=0}^{N_{FFT}-1} X_{k,m}\, e^{j2\pi(\Delta f)_{SC}\left(k-\frac{N_{FFT}}{2}\right)(t-T_{WGI}-T_{FGI})}, \ \mathit{for}\ 0\le t\le T_S'$$

In the above equation, $(\Delta f)_{SC}$ is the sub-carrier spacing (see 5.2.2.2.2), while $\mathrm{T}_{\mathrm{WGI}}$, $\mathrm{T}_{\mathrm{FGI}}$ and T_{s}' are defined in 5.2.2.3.

5.2.2.12.2 Windowing

The signal $x_m(t)$ shall be multiplied by the window function $w(t)$, where

$$w(t)=\begin{cases} 0.5+0.5\cos(\pi+\pi\ t/\mathrm{T}_{\mathrm{WGI}}) & 0\le \mathrm{t}\le \mathrm{T}_{\mathrm{WGI}} \\ 1 & \mathrm{T}_{\mathrm{WGI}}<t<\mathrm{T}_{\mathrm{s}}'-\mathrm{T}_{\mathrm{WGI}}\,. \\ 0.5+0.5\cos(\pi+\pi\ (\mathrm{T}_{\mathrm{s}}'\text{-}t)/\mathrm{T}_{\mathrm{WGI}}) & \mathrm{T}_{\mathrm{s}}'-\mathrm{T}_{\mathrm{WGI}}\le \mathrm{t}\le \mathrm{T}_{\mathrm{s}}' \end{cases}$$

The windowed signal is denoted by $y_m(t)$, where

$$y_m(t)=x_m(t)\ w(t).$$

In the above, $\mathrm{T}_{\mathrm{WGI}}$ and T_{s}' are as defined in 5.2.2.3.

5.2.2.12.3 Overlap and Add

The base-band signal $s_{BB}(t)$ shall be generated by overlapping the windowed, continuous-time signals from successive OFDM symbols by $\mathrm{T}_{\mathrm{WGI}}$. This is illustrated in Figure 5.2.2.12.3-1. Specifically, $s_{BB}(t)$ is given by

$$s_{BB}(t)=\sum_{m=-\infty}^{0} y_m\left(t+\sum_{k=m}^{-1}\mathrm{T}_{\mathrm{s,k}}\right)+\sum_{m=1}^{\infty} y_m\left(t-\sum_{k=0}^{m-1}\mathrm{T}_{\mathrm{s,k}}\right)$$

where $\mathrm{T}_{\mathrm{s,k}}$ is the OFDM symbol interval of the kth OFDM symbol.

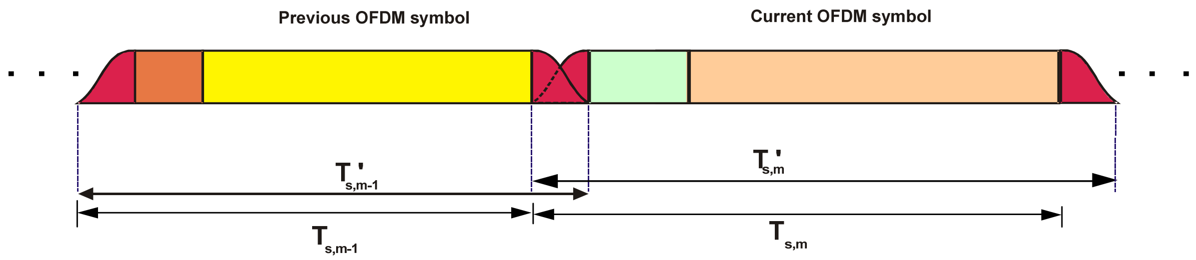


Figure 5.2.2.12.3-1 Overlap of Windowed OFDM Symbols

5.2.2.12.4 Carrier Modulation

The in-phase and quadrature base-band signals shall be up-converted to RF frequency and summed to generate the RF waveform $s_{RF}(t)$. In Figure 5.2.2.12-1, f_c is the centre frequency of the Forward Link Only RF channel.

5.2.3 Synchronization and Timing

Each transmitter shall use a time base from which all time-critical transmissions shall be derived. The time base reference shall be time-aligned to the Forward Link Only system time in 1.7. The transmitter shall provide for a programmable offset between the start of a superframe and the Forward Link Only system time. For carrier center frequencies between 470 and 862 MHz, the requirements for the range and permissible error of the offset shall be as specified in [2]. For other carrier center frequencies, the requirements for the range and allowable error of the offset will be specified in future revisions of [2]

No text.

6 ANNEX A – NORMATIVE

6.1 System Parameters for different FFT sizes, Bandwidths and Guard intervals

The Physical layer for the Forward Link Only air interface, as described in Section 5, was parameterized in terms of the FFT size (N_{FFT}), chip rate (B) and the flat guard Interval (T_{FGI}), see Table 5.2.2.3-1. There are four possible values for each of the parameters. In addition, the PPC can be present or absent. Hence, there are a total of 128 different options for the OFDM symbol and superframe numerology. In this section, the numerology is summarized for all the options in terms of the number of Data Channel OFDM symbols per frame and the post-fix interval of the last LTPC OFDM symbol.

These two parameters can be derived for each option as follows.

1. The superframe duration is fixed at 1 second, and the chip rate is fixed at 0.925 times the bandwidth. For example, at 6 MHz bandwidth, the chip rate is 5.55 MHz and there are 5550000 chips in a superframe.
2. The superframe starts with three TDM pilots (TDM Pilot 1, WIC, LIC) and each of these channels has a fixed duration of 4625 chips.
3. The superframe ends with the Signal Parameter channel (SPC), which has a fixed duration of 9250 chips.
4. The TDM Pilot 2 channel follows the LIC and its duration ranges from 2321 chips to 17425 chips for the different FFT sizes, as summarized in Table 5.2.2.10.1.4.7-1.
5. When the PPC is present, it immediately precedes the SPC. The duration of the PPC for the different FFT sizes is as summarized in Table 5.2.2.10.1.5.7-1.
6. The remaining portion of the superframe consists of the TPC, the OIS and the four data frames. The Flat Guard Interval Fraction is the same for all the OFDM symbols in these channels. For example, with $FGI_{Fraction} = 1/8$, the OFDM symbol duration for the 1K, 2K, 4K and 8K FFT sizes is 1169, 2321, 4625 and 9233 chips, respectively.
7. For the 1K, 2K and 4K FFT sizes, the number of TPC MAC time units is 20 while the number of OIS MAC time units is 10. For the 8K FFT size, the number of TPC MAC time units is 40 while the number of OIS MAC time units is 12. The number of OFDM symbols per MAC time unit is 4, 2, 1 and ½ for FFT sizes of 1K, 2K, 4K and 8K respectively. The span of the TPC and OIS channels can be calculated from the number of OFDM symbols and the duration of each OFDM symbol (as obtained in Step 6).
8. The remaining chips are allocated equally among an integer number of OFDM symbols in each of the four data frames. Any residual chips are placed in the post-fix interval of the last LTPC OFDM symbol.
9. For the 1K and 2K FFT sizes, the following additional constraints are imposed:
    - For the 1K FFT size, the number of OFDM symbols per frame in the Data Channel shall be a multiple of 4.
    - For the 2K FFT size, the number of OFDM symbols per frame in the Data Channel shall be a multiple of 2.

These constraints ensure that there are an integer number of MAC time units per frame in the 1K and 2K FFT sizes.

If the number of 2K OFDM symbols (as obtained in Step 8) per frame is odd, it shall be further reduced by one and the chips corresponding to the four additional OFDM symbols shall be included in the post-fix interval in the last LTPC OFDM symbol.

If the number of 1K OFDM symbols per frame (as obtained in step 8) is not a multiple of 4, then it shall be reduced to become a multiple of 4 and the chips corresponding to the additional OFDM symbols shall be included in the post-fix interval in last LTPC OFDM symbol.

For illustration, consider the 2K FFT size with PPC present, 1/16 FGI fraction and 5 MHz Bandwidth. The calculation would proceed as follows:

1. Total number of chips in a superframe = 4625000
2. Chips for TDM Pilot1, WIC, LIC = 13875
3. Chips for SPC = 9250
4. Chips for TDM Pilot 2 = 4625
5. Chips for PPC = 8 x 2 x 3089 = 49424
6. OFDM symbol duration for TPC/OIS/Data
   = 2048+128+17 = 2193
7. Chips for TPC (40) and OIS (20) = 131580
8. Remaining chips in superframe = 4416246
9. Possible data OFDM symbols per frame
   = 4416246/(4x2193) = 503.448...
10. Data OFDM symbols per frame
    (with even OFDM symbol constraint) = 502
11. Post-fix interval for the last LTPC (chips)
    = (503.448...-502)x4x2193 = 12702

Hence, the post-fix interval consists of 6 repetitions of the useful duration, followed by a copy of the first 414 chips of the useful duration. This is shown in Figure 6.1-1, where R1 to R6 denote the 6 complete repetitions of the useful duration and are followed by a partial repetition. The partial repetition consists of the first 414 chips from the left most end of the useful duration in Figure 6.1-1

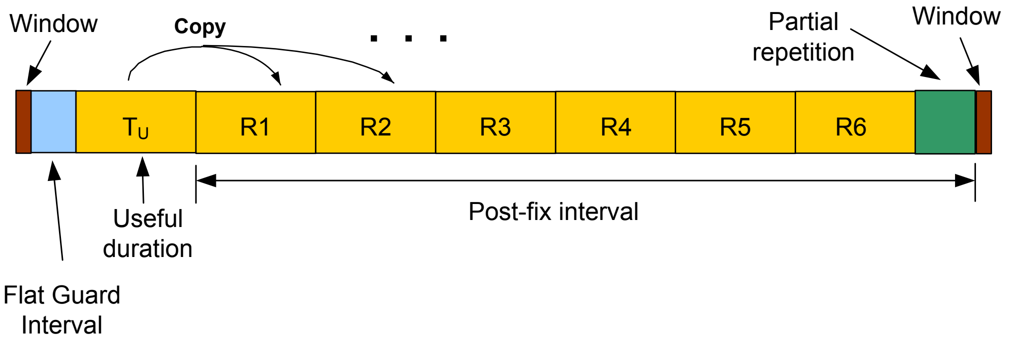


Figure 6.1-1 Post-fix generation for 2K FFT size with FGIFraction= 1/16, 5 MHz Bandwidth and PPC present

For each choice of FFT size, bandwidth, Flat Guard interval and presence/absence of PPC, the number of data OFDM symbols per frame and the post-fix interval for the last LTPC OFDM symbol shall be as specified in Table 6.1-1 to Table 6.1-8.

Table 6.1-1 1K FFT size, PPC Present

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	940	14138
	6	1140	3938
	7	1336	12442
	8	1536	2242
1/16	5	996	14938
	6	1208	2898
	7	1416	8538
	8	1624	14178
3/16	5	892	2554
	6	1080	338
	7	1264	17850
	8	1452	15634
1/4	5	844	15546
	6	1024	6706
	7	1200	18618
	8	1380	9778

Table 6.1-2 1K FFT size, PPC Absent

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	952	7722
	6	1148	16226
	7	1348	6026
	8	1544	14530
1/16	5	1008	11594
	6	1216	17234
	7	1428	5194
	8	1636	10834
3/16	5	900	12794
	6	1088	10578
	7	1276	8362
	8	1464	6146
1/4	5	856	2986
	6	1032	14898
	7	1212	6058
	8	1388	17970

Table 6.1-3 2K FFT size, PPC Present

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	474	7950
	6	574	4550
	7	674	1150
	8	772	16318
1/16	5	502	12702
	6	608	7870
	7	714	3038
	8	818	15750
3/16	5	448	12278
	6	542	16454
	7	638	1038
	8	732	5214
1/4	5	426	1998
	6	514	19894
	7	604	17174
	8	694	14454

Table 6.1-4 2K FFT size, PPC Absent

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	480	1670
	6	578	16838
	7	678	13438
	8	778	10038
1/16	5	508	9494
	6	614	4662
	7	718	17374
	8	824	12542
3/16	5	454	2926
	6	548	7102
	7	642	11278
	8	736	15454
1/4	5	430	10190
	6	520	7470
	7	610	4750
	8	700	2030

Table 6.1-5 4K FFT size, PPC Present

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	238	6212
	6	288	6212
	7	338	6212
	8	388	6212
1/16	5	252	12940
	6	305	11712
	7	358	10484
	8	411	9256
3/16	5	225	8632
	6	272	16004
	7	320	3852
	8	367	11224
1/4	5	213	17128
	6	258	17468
	7	303	17808
	8	348	18148

Table 6.1-6 4K FFT Size, PPC Absent

$FGI_{Fraction}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	241	0
	6	291	0
	7	341	0
	8	391	0
1/16	5	255	9800
	6	308	8572
	7	361	7344
	8	414	6116
3/16	5	227	18872
	6	275	6720
	7	322	14092
	8	370	1940
1/4	5	216	4772
	6	261	5112
	7	306	5452
	8	351	5792

Table 6.1-7 8K FFT size, PPC Present

$\mathrm{FGI}_{\mathrm{Fraction}}$	**RF Channel Bandwidth (W (MHz))**	**Data OFDM symbols per frame (D)**	**T_{PFI} for last LTPC OFDM symbol (chips)**
1/8	5	114	35704
	6	140	472
	7	165	2172
	8	190	3872
1/16	5	122	3416
	6	148	21432
	7	175	4564
	8	201	22580
3/16	5	108	22800
	6	132	12280
	7	156	1760
	8	179	30220
1/4	5	102	34472
	6	125	15828
	7	147	38212
	8	170	19568

Table 6.1-8 8K FFT size, PPC Absent

$\text{FGI}_{\text{Fraction}}$	RF Channel Bandwidth (W (MHz))	Data OFDM symbols per frame (D)	T_{PFI} for last LTPC OFDM symbol (chips)
1/8	5	117	23348
	6	142	25048
	7	167	26748
	8	192	28448
1/16	5	124	32088
	6	151	15220
	7	177	33236
	8	204	16368
3/16	5	111	4300
	6	134	32760
	7	158	22240
	8	182	11720
1/4	5	105	9828
	6	127	32212
	7	150	13568
	8	172	35952

6.2 Physical Layer Data Rates for 5, 6, 7 and 8 MHz RF Channel Bandwidths

The Physical layer data rate during the Data Channel can be calculated from the OFDM symbol interval and the transmit mode. Since there are 3500 data sub-carriers per 4K OFDM symbol, the data rate is given by

$$\text{Data rate (Mbps)} = \frac{3500}{4096} \times \frac{N_{FFT}}{T_s} \times (\text{bits per symbol of FLO transmit mode})$$

where the OFDM symbol interval (T_s) is

$$T_s = \frac{N_{FFT}(1 + FGI_{Fraction}) + 17}{B}$$

The number of bits per symbol of a transmit mode is the product of the bits per modulation symbol and the turbo code rate, and these values are as specified in Table 5.2.2.6-1 and Table 5.2.2.6-3.

Table 6.2-1a lists the Physical layer Data rates for all the Forward Link Only Data Channel transmit modes for PHY Type 1 for 5, 6, 7, and 8 MHz RF channel bandwidths. Table 6.2-2 lists the Physical layer Data Rates for all the Forward Link Only Data Channel transmit modes for PHY Type 2 for 5, 6, 7 and 8 MHz RF channel bandwidths. These data rates correspond to an FGIFraction of 1/8, and data rates for other options can be derived in a similar manner.

Table 6.2-1 Data Channel Physical Layer Data Rates for PHY Type 1 for Different RF Channel Bandwidths

Transmit Mode	5 MHz Physical Layer Data Rate (Mbps)	6 MHz Physical Layer Data Rate (Mbps)	7 MHz Physical Layer Data Rate (Mbps)	8 MHz Physical Layer Data Rate (Mbps)
0	2.33	2.8	3.27	3.73
1	3.5	4.2	4.9	5.6
2	4.67	5.6	6.53	7.47
3	7.0	8.4	9.8	11.2
4	9.33	11.2	13.07	14.93
5	N/A[70]			
6	4.67	5.6	6.53	7.47
7	7.0	8.4	9.8	11.2
8	9.33	11.2	13.07	14.93
9	4.67	5.6	6.53	7.47
10	7.0	8.4	9.8	11.2
11	9.33	11.2	13.07	14.93

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[70] Transmit Mode 5 is only available for use for OIS Channel.

Table 6.2-2 Data Channel Physical Layer Data Rates for PHY Type 2 for Different RF Channel Bandwidths

Transmit Mode	5 MHz Physical Layer Data Rate (Mbps)	6 MHz Physical Layer Data Rate (Mbps)	7 MHz Physical Layer Data Rate (Mbps)	8 MHz Physical Layer Data Rate (Mbps)
64	2.33	2.80	3.27	3.73
65	2.55	3.05	3.56	4.07
66	2.80	3.36	3.92	4.48
67	3.50	4.20	4.90	5.60
68	4.00	4.80	5.60	6.40
69	4.67	5.60	6.53	7.47
70	5.60	6.72	7.84	8.96
71	7.00	8.40	9.80	11.20
72	9.33	11.20	13.07	14.93
80	4.00	4.80	5.60	6.40
81	4.67	5.60	6.53	7.47
82	5.09	6.11	7.13	8.15
83	5.60	6.72	7.84	8.96
84	7.00	8.40	9.80	11.20
85	9.33	11.20	13.07	14.93
86	4.00	4.80	5.60	6.40
87	4.67	5.60	6.53	7.47
88	5.09	6.11	7.13	8.15
89	5.60	6.72	7.84	8.96
90	7.00	8.40	9.80	11.20
91	9.33	11.20	13.07	14.93

No text.

7 ANNEX B – FREQUENCY UTILIZATION REQUIREMENTS (NORMATIVE)

7.1 Frequency Coverage

The frequency from 207.5 to 222 MHz shall be applicable.

7.2 Occupied Bandwidth

The occupied bandwidth (OBW) is defined as the frequency range, whereby the power of emissions averaged over the frequency above and under the edge frequency is 0.5 % each of the total radiation power of a modulated carrier. The occupied bandwidth shall not exceed the value specified the table below.

RF Bandwidth [MHz]	Occupied Bandwidth [MHz]
5	4.625
6	5.55
7	6.475
8	7.4

7.3 Frequency Tolerance

Frequency tolerance is the ability of a transmitter to transmit at an assigned center frequency. The frequency difference between the mean actual transmit carrier frequency and the specified transmit frequency shall be less than the limits specified in the table below. The difference shall be less than 500Hz in areas under coverage from a single isolated transmitter.

	Transmitter	Repeater
Frequency Tolerance [Hz]	$B \times 1000/N_{FFT}$	$B \times 10000/N_{FFT}$

Where

B = 4.625, 5.55, 6.475 or 7.4 MHz

N_{FFT} = 1024, 2048, 4096 or 8192.

7.4 Spectrum Emission Mask

The spectrum emission mask is defined as a mask, relative to the in-band power, for out-of-band emissions. The out-of-band emissions shall not exceed the value specified in the table below.

Distance from carrier frequency [MHz]	**Attenuation from the mean output power [dB/10kHz]**	**Type of stipulation**
±(3×13/14×B/5.55+0.25/126)	-10log(5550×8000/8192/10×B/5.55)	Upper limit
±(3×13/14×B/5.55+0.25/126+1/14)	-(20+10log(5550×8000/8192/10×B/5.55))	Upper limit
±(3×13/14×B/5.55+0.25/126+3/14)	-(27+10log(5550×8000/8192/10×B/5.55))	Upper limit
±(3×13/14×B/5.55+0.25/126+22/14)	-(50+10log(5550×8000/8192/10×B/5.55))*	Upper limit

*If the output power is more than 0.025×B/5.55W and equal to or less than 2.5×B/5.55W, then -(73.4+10logP) dB/10kHz shall be applied. If the output power is equal to or less than 0.025×B/5.55W, then -57.4dB/10kHz shall be applied.

Note 1: For the adjacent channels of radio equipment that amplifies multiple waves together, an attenuation of -10log(5550×8000/8192/10×B/5.55) dB/10kHz can be used as the upper limit regardless of the above table.

Note 2: B shall be 4.625, 5.55, 6.475 or 7.4 (in units of MHz).

Note 3: The out-of-band emissions shall be applied to the frequency range of ±2.5×B MHz.

Note 4: For the frequencies lower than 202.5MHz, the output power shall not exceed the limits specified the table below regardless of the above table.

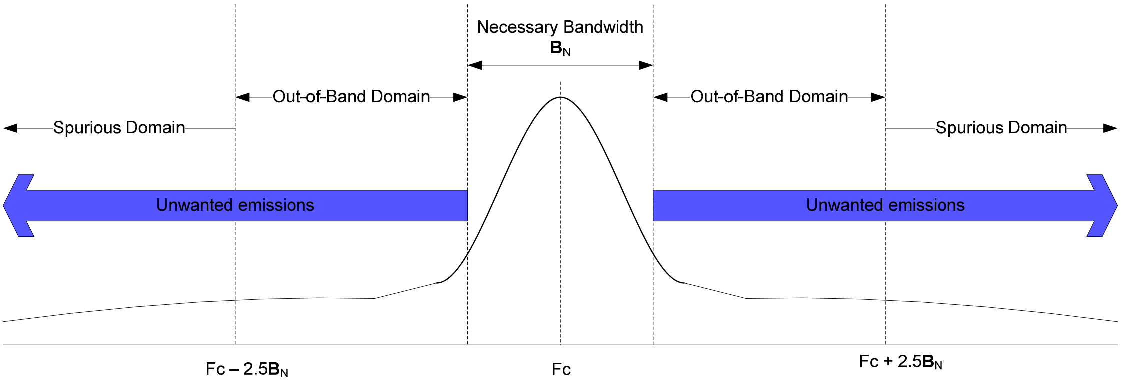
Output Power [W/MHz]	**Output Power Upper Limit at 202.5MHz [dBW/10kHz]**
P> 1000/6	-62.4
1000/6 ≥ P > 100/6	10log(P)-20-65
100/6 ≥ P	-72.4

7.5 Spurious or Unwanted Emissions Limit

The spurious or unwanted emissions are the emissions at frequencies in the out-of-band domain and spurious domain. CW tone is used for the spurious emissions measurement in the out-of-band domain while modulated signal is used for the unwanted emissions measurement in the spurious domain. The spurious or unwanted emissions shall be less than all the limits specified in the table below.

Output Power	**Spurious Emissions Limit in the out-of-band domain**	**Unwanted Emissions Limit in the spurious domain**
P > 42W	Less or equal to 1mW and -60dBc	Less or equal to 1mW and -60dBc
1.68W < P ≤ 42W		Less or equal to 25μW
P ≤ 1.68W	Less or equal to 100μW	

The boundary of out-of-band and spurious domain is shown in the figure below.



The necessary bandwidth is the width of the frequency band which is just sufficient to ensure the transmission of information at the rate with the quality required under specified condition. The necessary bandwidth shall be equal to the occupied bandwidth. Fc is the carrier center frequency.

Change History List of Standard Ver.1.1

No.	Item No.	Description	Page	Reason
1	Scope	This standard applies to the multimedia broadcasting defined in Section 2 of Chapter ~~3-2~~4, Ordinance No.~~26~~87 of the Ministry of Internal Affairs and Communications, ~~2003~~2011.		Modifications in line with the amendment of Ordinance and Notification.
2	Annexed Table	Industrial Property Rights for Ver.1.0 (Selection of Option 2)		Updated with the IPR declarations received.
3	Reference	Industrial Property Rights for Ver.1.0 (Not applied in Japan)		Updated with the IPR declarations received.
4	NORMATIVE REFERENCES	[8] Ordinance No.~~26~~87 of the Ministry of Internal Affairs and Communications, ~~2003~~2011. [9] Notification No.~~88~~299 of the Ministry of Internal Affairs and Communications, ~~2009~~2011.	vii	Modifications in line with the amendment of Ordinance and Notification.

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