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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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This Technical Specification establishes a Normative Reference to the Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast published by the Telecommunications Industry Association (TIA) as Standard TIA-1099.

These TIA published standards were based on input technical contributions from the FLO Forum. Founded in 2005, the FLO Forum is an international consortium of public and private sector organizations in the Mobile TV industry. Its aim is to promote the global standardization of Forward Link Only Mobile TV technology, to promote the availability of Forward Link Only Mobile TV technology-based product certification and testing, and to promote the availability of spectrum for advanced wireless services on a technology neutral basis in support of the Mobile TV industry. Now comprising over 90 organizations from more than a dozen countries around the world, the FLO Forum fosters a contribution-driven environment for the advancement of Forward Link Only technology and the Mobile TV industry.

Introduction

An introduction to the Forward Link Only air interface can be found in Informative annex A. Additional details on the derivation of the baseline parameters for 8 MHz, 7 MHz, 6MHz and 5 MHz RF channel bandwidths is provided in annex B.

1 Scope

The present document specifies the Forward Link Only air interface by referencing TIA Terrestrial Mobile Multimedia Multicast standards and by their use.

2 References

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

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

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

2.1 Normative references

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

[1] TIA 1099 (March 2007): "Forward Link Only Air Interface for Terrestrial Mobile Multimedia Multicast".

NOTE: Available at http://www.tiaonline.org/standards/technology/tm3/.

2.2 Informative references

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

Not applicable.

3 Definitions, symbols and abbreviations

For the purposes of the present document, the terms, definitions, symbols and abbreviations given in [1] apply.

4 System definition

Forward Link Only technology is a terrestrial mobile multimedia multicast system for datagrams. These datagrams support a multiplicity of multimedia services, including, but not limited to real-time streaming audio and video, file-based audio and video, general file downloading services and the conveyance of IP datagrams.

4.1 General

The objective of the Forward Link Only air interface is to provide a spectrally-efficient means for delivering multimedia datagrams over digital terrestrial broadcasting networks to mobile devices, including, but not limited to handheld terminals.

The Forward Link Only air interface encompasses details of the:

- Physical layer.
- Medium Access Control (MAC) layer.
- Control/Stream layer.

4.2 Physical Layer

The Forward Link Only air interface Physical layer shall follow TIA 1099 [1] except for the second sentence in clause 5.2.1.1.3 that begins with, "For operations in the U.S. …".

4.3 MAC Layer

The Forward Link Only air interface MAC layer shall follow TIA 1099 [1].

4.4 Control/Stream Layer

The Forward Link Only air interface Control/Stream layer shall follow TIA 1099 [1].

Annex A (informative): Forward Link Only Air Interface Specification Overview

Overview

The scope of the Forward Link Only air interface specification includes the following: a Physical layer, a MAC layer, a Control/Stream layer and a Transport layer. The different layers are depicted in figure A.1.

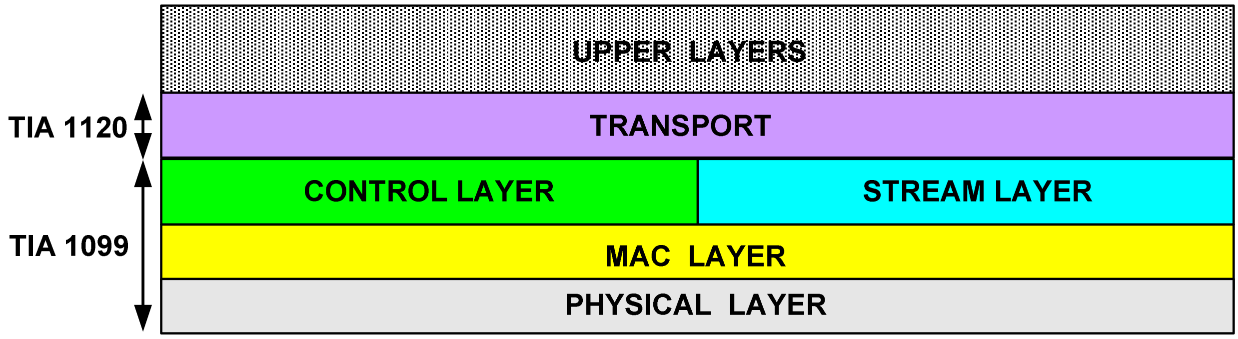

Figure A.1: Forward Link Only Air Interface Layering Architecture

Physical Layer

The Forward Link Only Physical layer provides the channel structure, frequency, power output, modulation and encoding specification for Forward Link Only radio networks. The Forward Link Only Physical layer uses Orthogonal Frequency Division Multiplexing (OFDM) as the modulation technique. In addition, it incorporates forward error correction techniques involving the concatenation of a parallel concatenated convolutional code (PCCC), i.e. Turbo code and a Reed-Solomon erasure correcting code.

In the Forward Link Only Physical layer, transmission and reception are based on using 4 096 (4 K) subcarriers. The QAM modulation symbols are chosen from a QPSK or 16-QAM alphabet. The Forward Link Only Physical layer transmission parameters are outlined in table A.1.

Table A.1: Forward Link Only Transmission Parameters

	Parameters	Values
1	Channel bandwidths (see note 1)	a. 5 MHz b. 6 MHz c. 7 MHz d. 8 MHz
2	Used bandwidth	a. *4,52 MHz (see note 2)* b. *5,42 MHz* c. *6,32 MHz* d. *7,23 MHz*
3	Number of subcarriers or segments	4 000 (out of 4 096) - 4 K
4	Subcarrier spacing	a. *1,1292 KHz* b. *1,355 KHz* c. *1,5808 KHz* d. *1,8066 KHz*
5	Active Symbol or segment duration	a. *885,6216 µs* b. *738,018 µs* c. *632,587 µs* d. *553,5135 µs*
6	Guard interval or Cyclic Prefix duration - 1/8th of useful OFDM symbol	a. *110,7027 µs* b. *92,2523 µs* c. *79,0734 µs* d. *69,1892 µs* (see note 3)
7	Transmission unit (frame) duration - Superframe - exactly 1 second in duration. Values in OFDM symbols - each superframe consists of 4 frames of equal duration (approx 1/4 second in duration)	a. 1 000 b. 1 200 c. 1 400 d. 1 600
8	Time/frequency synchronization	Time-division multiplex (TDM) and frequency-division multiplex (FDM) pilot channels
9	Modulation methods	QPSK, 16-QAM, layered modulation
10	Coding and error correction methods	Inner code: Parallel concatenated convolutional code (PCCC), rates 1/3, 1/2 and 2/3 for data and 1/5 for overhead information Outer code: RS with rates 1/2, 3/4, 7/8 and 1.
11	Net data rates (see note 4)	a. *2,3 Mbps to 9,3 Mbps* b. *2,8 Mbps to 11,2 Mbps* c. *3,2 Mbps to 13 Mbps* d. *3,7 Mbps to 14,9 Mbps*
NOTE 1: All parameters that may vary depending on selected channel bandwidth are listed in the order of corresponding channel bandwidths as shown in row 1 using sub-references a, b, c and d, as applicable. NOTE 2: Values in italics are approximate values. NOTE 3: The placement of the pilot sub-carriers in consecutive Forward Link Only OFDM symbols enables estimation of channels with delay spread up to two times the guard interval duration. NOTE 4: Data rates do not include the overhead due to use of RS coding.		

In each Forward Link Only OFDM symbol, there are 4 000 active subcarriers. These active subcarriers are further equally divided into eight disjoint groups called interlaces. An interlace consists of 500 subcarriers that are evenly spaced across the Forward Link Only signal bandwidth. In each OFDM symbol, either interlace 2 or 6 is assigned to the FDM Pilot and is used for channel estimation. The interlace structure supports:

- The frequency-division multiplexing of Forward Link Only logical channels, referred to as Multicast Logical Channels (MLCs), within each OFDM symbol, without the loss of frequency diversity. The minimum frequency allocation to an MLC, within a single OFDM symbol, is an interlace. Hence, at most 7 MLCs can be multiplexed within a single OFDM symbol. Frequency diversity is achieved as the subcarriers within an interlace span the total FLO signal bandwidth.

- The transmission of MLCs with fine granularity. For transmission at high spectral efficiency, tens of kbits can potentially be transmitted within a single OFDM symbol. The ability to allocate a fraction of the subcarriers to MLCs supports low data rate MLCs without incurring a large overhead expense.

- The FFT block in the receiver can be designed such that only the required subset of interlaces, corresponding to the desired MLCs, are demodulated. Hence, when combined with the frequency multiplexing of MLCs, the receiver need not always perform a 4 096-point FFT, thereby reducing power consumption.

Each Forward Link Only service is carried over one or more logical channels (i.e. MLC). An MLC has the attribute that it contains one or more decodable subcomponents of a service that is of independent (user-level) reception interest. MLCs are distinguishable at the Physical layer. For example, the video and audio components of a given service can be sent over two different MLCs. A device that is solely interested in the audio component can receive the corresponding MLC without receiving the MLC for the video component, thereby saving on battery resources.

The data rates required by multimedia services are expected to vary over a wide range, depending on their content. While low to moderate data rates, i.e. tens of kbps, may be sufficient for data and audio streams, video streams may require instantaneous rates ranging from a few kbps to a few Mbps even though the average rate is in the range of 200 kbps to 300 kbps. Statistical multiplexing of different services, or MLCs, is achieved by varying *only* the MLC time and frequency allocations over prescribed time intervals to match the variability in the MLC's source rates. The possibility of varying the constellation and code rate assigned to an MLC is excluded in order to *maintain a constant coverage area* for each MLC. Specifically, MLCs are transmitted over a certain number of OFDM symbols to achieve Time-Division Multiplexing (TDM) and a subset of the interlaces in these OFDM symbols to achieve Frequency-Division Multiplexing (FDM). The implementation of statistical multiplexing in FLO enables the receiver to demodulate and decode *only* the MLC(s) of interest.

In the case of layered modulation, a video or audio stream can be sent in two layers, i.e. a *base* (B) layer that enables reception over a certain coverage area and an *enhancement* (E) layer that improves the audio-visual experience provided by the base layer over a subset of that coverage area. The base and enhancement layers of a given service are sent within a *single* MLC. The choice of constellation and code rate for each MLC is based on various factors, including the service (wide-area/local-area) area, the content (video/audio/data), coverage requirements and whether layered modulation is used.

The Forward Link Only air interface provides several choices for constellation and code rate that allow a service provider to trade-off spectral efficiency against coverage. The Forward Link Only air interface design is based on the use of a concatenated coding scheme, consisting of an outer Reed-Solomon (RS) code and an inner Parallel Concatenated Convolutional Code (PCCC), i.e. turbo code. More specifically, the outer code consists of an (N, K) Reed-Solomon code over the Galois Field with 256 elements, $GF(256)$, and is intended for erasure-correction. The value of N is fixed at 16, while the value of K can be chosen from the set {8, 12, 14, 16}. The case of $K = 16$ corresponds to the case when no RS encoding is actually performed. For MLCs containing a base and enhancement layer, the encoding is done independently for each layer.

MAC and Control/Stream Layers

The MAC layer performs multiplexing of packets belonging to different media streams. The Stream layer provides for binding upper layer data flows to Forward Link Only streams. The Control layer, which is at the same level as the Stream layer in Forward Link Only air interface architecture, is used by the network to disseminate information to facilitate device operation in Forward Link Only systems.

The Forward Link Only superframe has a duration of exactly 1 second, and consists of 4 frames of equal duration, each roughly 1/4th of second. These packets are first RS-encoded and then Turbo-encoded. They are referred to as MAC layer packets. During the Reed-Solomon encoding process, $N - K$ parity packets are generated for every K information packets. CRC bits are generated for each of the N packets. The packets with data and CRC bits are Turbo encoded and transmitted. Thus, the minimum number of information packets of an MLC that can be transmitted in a superframe is K. The collection of K information packets and $N - K$ parity packets is referred to as an RS, or outer, code block. Finally, MLC transmissions in each superframe are always in integer multiples of outer code blocks. During transmission, each RS code block is split into 4 equal sub-blocks, with each sub-block sent in an unique frame within a super-frame. The main purpose of utilizing RS-coding is to exploit the time diversity of the packets within a superframe. The time span of the packets of an RS code block is at least 0,75 seconds. Such a time span supports decorrelation of packets even at low vehicle or walking speeds.

The MAC information or parity packets are Turbo-coded. In Forward Link Only networks, the code rates used are 1/5, for transmitting critical overhead information, and {1/3, 1/2, 2/3} for transmitting MLCs. The higher code rates are obtained from the base code rate using puncturing. The inner code exploits the frequency-diversity inherent in the channel.

The Forward Link Only air interface supports the transmission of both wide-area and local-area services. The waveforms corresponding to the two types of services are time-division multiplexed (TDM), because a wide-area may consist of multiple local-areas where there is the possibility of interference between transmissions received at the boundary between neighbouring local-areas. This enables the independent optimization of the transmit waveforms intended for the different coverage areas. The TDM is achieved by subdividing each frame into two parts.

The first part is referred to as the Wide-area Data Channel and is dedicated to the transmission of wide-area services, and the second part is referred to as the Local-area Data Channel and is used solely for the transmission of local-area services. Correspondingly, each superframe header contains the Overhead Information Symbols (OIS) that carry overhead information regarding the wide and local data channels. Specifically, they contain the time-frequency allocation for each MLC in the *current* superframe, which is subdivided into two equal parts, as described above.

The percentage of capacity allocated to wide-area (or local-area) data channel can vary from 0 % to 100 %. Although the percentage can be set in every superframe, it is expected to vary infrequently. The available time-frequency (channel) resources are allocated once for both the wide-area and the local-area MLCs in each superframe.

Transport Layer

In a Forward Link Only system, the uppermost service layer applications deliver multimedia data packets via media transport protocols (beyond the scope of the Forward Link Only air interface specification) to the Forward Link Only Transport Layer. Within the Forward Link Only Transport Layer, these variable-sized service packets are concatenated, fragmented and recombined into a sequence of Frames. The core function of the Forward Link Only Transport Layer is to deliver a set of fixed-size Frames to the Forward Link Only Stream layer. In addition, the Transport Layer provides an optional encryption/decryption facility and a cyclic redundancy check (CRC) to support data integrity processing.

The sequence of data packets for a service component constitutes a Flow. The Stream layer organizes an MLC into three Streams. The Stream Layer does not interpret the bitstream transported in the Stream. The sequence of bits transmitted in each Stream over the base layer or the enhancement layer in a superframe constitutes a Stream Packet.

One of the Streams, Stream 0, is reserved for transporting time-critical control information related to the other two streams, such as Entitlement Control Messages (ECMs) in support of conditional access systems. The other two streams may be used to transport Flows. The Transport Layer causes each Flow to be transported over a Stream in an MLC. The mapping of MLCs and Streams to Flows is signalled in the Control layer. The Transport Layer also specifies the general format of messages transported in Stream 0.

The Transport Layer fragments the sequence of input data packets for each Flow, and for Stream 0, into a set of Frames which are usually 122 bytes long. The Transport Layer can be configured to add a CRC to each data packet before fragmentation. Each Frame consists of a sequence set of Fragments of the input data packets. Each Fragment is preceded by a Fragment header giving the length of the Fragment and stating whether it is the last Fragment of an input packet. Fragments of consecutive input packets are concatenated without the insertion of intervening padding. Each Flow may be configured to permit a data packet to straddle a superframe boundary, or to require that each superframe contains an integral number of data packets. In the second case, the last Fragment of the last data packet in the Stream Packet may be followed by padding.

The Stream Packet so formed is optionally subject to AES-128 encryption in CTR mode by the Transport Layer in Streams 1 and 2.

Annex B (informative): Support for 8 MHz, 7 MHz and 5 MHz RF Channel Bandwidths in Forward Link Only Air Interface Specification

Note

All figures and numerical values shown below are derived solely and directly from [1].

Overview

The Forward Link Only Air Interface specification supports operation in multiple RF channel bandwidths, including 5 MHz, 6 MHz, 7 MHz and 8 MHz. The baseline parameters of the OFDM waveform are introduced in [1] for the case of 6 MHz RF bandwidth. The normative annex in [1] addresses the changes in the baseline OFDM parameters for alternate RF channel bandwidths. While the description in [1] completely specifies the Forward Link Only waveform for all RF channel bandwidths, this annex provides additional details on the derivation of the baseline parameters for the 8 MHz, 7 MHz and 5 MHz RF bandwidths.

OFDM Parameters

In the Forward Link Only system, the number of sub-carriers is fixed at 4 096, or 4K. The frequency spanned by these 4 096 sub-carriers is referred to as the *chip rate*. The chip rate for the 6 MHz RF channel bandwidth is 5,55 MHz, and is scaled proportionately for other RF bandwidths. Hence, for 8 MHz, the chip rate is:

$$\frac{5{,}55 \times 8}{6} = 7{,}4 \text{ MHz.}$$

For 7 MHz, the chip rate is:

$$\frac{5{,}55 \times 7}{6} = 6{,}475 \text{ MHz.}$$

Similarly, for 5 MHz, the chip rate is:

$$\frac{5{,}55 \times 5}{6} = 4{,}625 \text{ MHz.}$$

The inverse of the chip rate is referred to as the *chip duration*, which is the fundamental time unit for the base-band waveform. The chip duration for the different RF channel bandwidths are listed in table B.1.

The sub-carrier spacing is the chip rate divided by the total number of sub-carriers, i.e. 4 096. Hence, for 8 MHz, the sub-carrier spacing is:

$$\frac{7{,}4 \times 10^6}{4\,096} = 1{,}80664\ldots \text{ kHz.}$$

For 7 MHz, the sub-carrier spacing is:

$$\frac{6{,}475 \times 10^6}{4\,096} = 1{,}5808\ldots \text{ kHz.}$$

Similarly, for 5 MHz, the sub-carrier spacing is:

$$\frac{4{,}625 \times 10^6}{4\,096} = 1{,}1292\ldots \text{ kHz.}$$

Of the 4 096 sub-carriers, 96 are guard sub-carriers in which no energy is transmitted. The remaining 4 000 active sub-carriers occupy a *used* bandwidth of 7,23 MHz, 6,32 MHz, and 4,52 MHz for the 8 MHz, 7 MHz and 5 MHz RF bandwidths cases, respectively.

In the time domain, an OFDM symbol is comprised of four parts: a useful part with duration T_U, a flat guard interval with duration T_{FGI}, and two windowed intervals of duration T_{WGI} on the two sides. The duration (in units of chips) of these intervals is fixed across all RF bandwidths at $T_U = 4\,096$ chips, $T_{FGI} = 512$ chips, and $T_{WGI} = 17$ chips. Hence, the duration of an individual OFDM symbol is given by $T_S^{'} = T_U + T_{FGI} + 2 \times T_{WGI} = 4\,642$ chips. The chip duration is listed in table B.1 for the different RF channel bandwidths. The different parts of an individual OFDM symbol are illustrated in figure B.1.

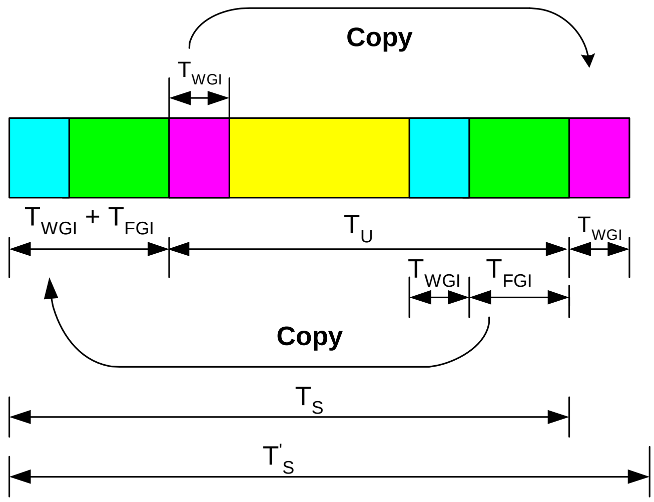

Figure B.1: OFDM Symbol Duration

However, since the windowed intervals of two consecutive OFDM symbols overlap [1], the effective duration of an OFDM symbol is $T_S = T_U + T_{FGI} + T_{WGI} = 4\,625$ chips. The overlap of two consecutive OFDM symbols is illustrated in figure B.2.

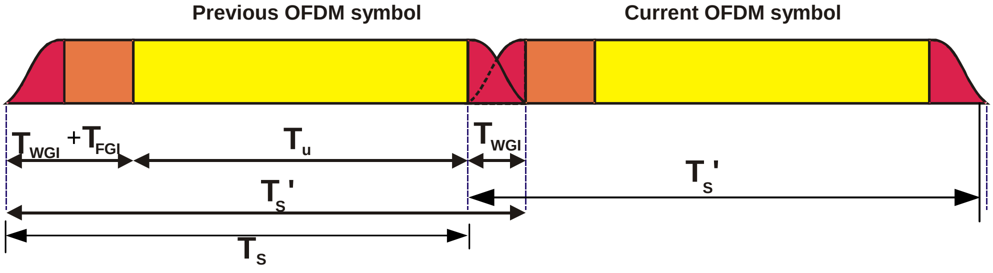

Figure B.2: Overlap of Windowed OFDM Symbols

Since the chip duration, in seconds, varies as a function of the RF channel bandwidth, the duration of these intervals is as given below for the different RF bandwidths.

For the case of 8 MHz RF bandwidth:

$$\begin{cases} T_U = 4\,096 \text{ chips} = \dfrac{4\,096}{7.4\times 10^6} = 553{,}513...\ \mu\text{s} \\ T_{FGI} = 512 \text{ chips} = \dfrac{512}{7.4\times 10^6} = 69{,}189...\ \mu\text{s} \\ T_{WGI} = 17 \text{ chips} = \dfrac{17}{7.4\times 10^6} = 2{,}297...\ \mu\text{s} \end{cases}$$

As a result, $T_s^{'} = 627{,}297...\mu\text{s}$, while $T_S = 625\ \mu\text{s}$.

For the case of 7 MHz RF bandwidth:

$$\begin{cases} T_U = 4\,096 \text{ chips} = \dfrac{4\,096}{6.475\times 10^6} = 632{,}586872...\ \mu\text{s} \\ T_{FGI} = 512 \text{ chips} = \dfrac{512}{6.475\times 10^6} = 79{,}073359...\ \mu\text{s} \\ T_{WGI} = 17 \text{ chips} = \dfrac{17}{6.475\times 10^6} = 2{,}625482...\ \mu\text{s} \end{cases}$$

As a result, $T_S^{'} = 716{,}911196...\mu\text{s}$, while $T_S = 714{,}285714\ \mu\text{s}$.

Similarly, for the case of 5 MHz RF bandwidth:

$$\begin{cases} T_U = 4\,096 \text{ chips} = \dfrac{4\,096}{4.625\times 10^6} = 885{,}6...\ \mu\text{s} \\ T_{FGI} = 512 \text{ chips} = \dfrac{512}{6.475\times 10^6} = 110{,}7...\ \mu\text{s} \\ T_{WGI} = 17 \text{ chips} = \dfrac{17}{6.475\times 10^6} = 3{,}7...\ \mu\text{s} \end{cases}$$

As a result, $T_S^{'} = 1\,003{,}7...\mu\text{s}$, while $T_S = 1\,000\ \mu\text{s}$.

In the following, the effective OFDM symbol duration is referred to as the OFDM symbol duration. Table B.1 summarizes the main OFDM symbol parameters for the 8 MHz, 7 MHz, and 5 MHz RF channel bandwidths. For comparison purposes, the values for 6 MHz bandwidth are also listed in table B.1.

Table B.1: OFDM Symbol Parameters for 8 MHz, 7 MHz, 6 MHz and 5 MHz RF Channel Bandwidths

Parameters	8 MHz RF Channel Bandwidth	7 MHz RF Channel Bandwidth	6 MHz RF Channel Bandwidth	5 MHz RF Channel Bandwidth
Chip Rate (MHz)	7,4	6,475	5,55	4,625
Chip Duration (ηs)	*135,14*	*154,44*	*180,18*	*216,22*
Sub-carrier spacing (kHz)	*1,81*	*1,58*	*1,355*	*1,1292*
Active duration (μs)	*553,51*	*632,59*	*738,02*	*885,6*
Flat Guard Interval (μs)	*69,19*	*79,07*	*92,25*	*110,7*
Window interval (μs)	*2,29*	*2,62*	*3,03*	*3,7*
OFDM symbol duration (μs)	625	*714,29*	*833,33*	1 000

Duration of Physical Layer Sub-channels in Superframe

The duration of a superframe is fixed, regardless of RF bandwidth, at 1 second. From the OFDM symbol duration, the number of OFDM symbols in a superframe is easily computed. Hence, the number of OFDM symbols in each superframe is given by $(1/T_s)$.

For 8 MHz, there are 1 600 OFDM symbols in a superframe. For 7 MHz, there are 1 400 OFDM symbols, while, for 5 MHz, there are 1 000 OFDM symbols in a superframe.

In the Forward Link Only system, each superframe consists of four Physical layer sub-channels:

(a) TDM Pilot channel;

(b) FDM Pilot channel;

(c) Overhead Information Symbols (OIS) channel; and

(d) Data channel.

The TDM Pilot, OIS, and Data channels are time-division multiplexed within the superframe. The FDM Pilot channel is frequency-division multiplexed with the OIS and Data channels.

The TDM Pilot channel consists of the following 6 sub-channels:

(a) TDM Pilot 1 channel;

(b) Wide-area Identification channel (WIC);

(c) Local-area Identification channel (LIC);

(d) TDM Pilot 2 channel;

(e) Transition Pilot channel (TPC); and

(f) Positioning Pilot Channel (PPC)/Reserved OFDM symbols.

The durations of each sub-channel within the TDM Pilot channel is as follows: The TDM Pilot 1 channel, the WIC, the LIC, and the TDM Pilot 2 channel each consists of a single OFDM symbol. There are 20 OFDM symbols in the TPC, while the PPC/Reserved OFDM symbols field has duration of either 2 OFDM, 6 OFDM, 10 OFDM or 14 OFDM symbols. Note that the durations of the TDM Pilot sub-channels, in units of OFDM symbols, does not vary with RF channel bandwidth. Hence, the total duration of the TDM Pilot channel is either 26 OFDM, 30 OFDM, 34 OFDM or 38 OFDM symbols.

Next, the OIS channel duration is fixed at 10 OFDM symbols, regardless of RF bandwidth. Of these OFDM symbols, the first 5 OFDM symbols convey the wide-area OIS, while the latter 5 OFDM symbols convey the local-area OIS.

Based on the above, the combined duration of the TDM Pilot channel and the OIS channel is either 36, 40, 44 or 48 OFDM symbols.

The duration of the Data channel can be obtained by subtracting the combined duration of the TDM Pilot and OIS channels from the total number of OFDM symbols in a superframe. Hence, the duration of the Data Channel is a function of RF bandwidth. For 8 MHz, the Data channel consists of either 1 564, 1 560, 1 556 or 1 552 OFDM symbols, while, for 7 MHz, the Data channel consists of either 1 364, 1 360, 1 356, or 1 352 OFDM symbols. Finally, for 5 MHz, the Data channel consists of either 964, 960, 956 or 952 OFDM symbols.

Finally, a superframe consists mainly of four frames of equal duration. Each frame contains 1/4th of the OFDM symbols in the Data channel in addition to 4 TPC OFDM symbols. Hence, for 8 MHz, a frame consists of either 395, 394, 393 or 392 OFDM symbols, while, for 7 MHz, a frame consists of either 345, 344, 343 or 342 OFDM symbols. Finally, for 5 MHz, a frame consists of either 245, 244, 243 or 242 OFDM symbols.

The frame duration, in units of OFDM symbols and ms, for different durations of the PPC/Reserved OFDM symbols field is summarized in tables B.2, B.3, B.4 and B.5, for the 8 MHz, 7 MHz, 6MHz, and 5 MHz RF channel bandwidths, respectively.

Table B.2: Frame Duration for Different Number of OFDM Symbols in PPC/Reserved OFDM Symbols for 8 MHz RF Bandwidth

Number of OFDM Symbols in PPC/Reserved OFDM symbols	Frame Duration in units of OFDM symbols	Frame Duration in ms
2	395	246,875
6	394	246,25
10	393	245,625
14	392	245

Table B.3: Frame Duration for Different Number of OFDM Symbols in PPC/Reserved OFDM Symbols for 7 MHz RF Bandwidth

Number of OFDM Symbols in PPC/Reserved OFDM symbols	Frame Duration in units of OFDM symbols	Frame Duration in ms
2	345	246,43
6	344	245,71
10	343	245
14	342	244,29

Table B.4: Frame Duration for Different Number of OFDM Symbols in PPC/Reserved OFDM Symbols for 6 MHz RF Bandwidth

Number of OFDM Symbols in PPC/Reserved OFDM symbols	Frame Duration in units of OFDM symbols	Frame Duration in ms
2	295	245,83
6	294	245
10	293	244,17
14	292	243,33

Table B.5: Frame Duration for Different Number of OFDM Symbols in PPC/Reserved OFDM Symbols for 5 MHz RF Bandwidth

Number of OFDM Symbols in PPC/Reserved OFDM symbols	Frame Duration in units of OFDM symbols	Frame Duration in ms
2	245	245
6	244	244
10	243	243
14	242	242

Physical Layer Data Rates

As indicated in annex A, the Forward Link Only system supports multiple combinations of constellation and inner code rate, referred to as transmit modes. The different transmit modes are listed in table B.6.

For a specific transmit mode, the data rate (see note) supported by the Physical layer is given by:

$$R = \frac{3\,500 \times b \times r_{inner}}{T_s},$$

where b is the number of bits per constellation symbol, r_{inner} is the inner code rate, and T_s is the OFDM symbol duration. Note that, of the 4 000 active sub-carriers, 500 sub-carriers are used to transmit the FDM Pilot Channel, which is primarily used for channel estimation at the receiver. Hence, the number of sub-carriers available for MLC transmission is 3 500.

NOTE: This computation does not include the overhead due to the TDM Pilot and OIS channels, and the outer Reed-Solomon code.

The data rates for the different transmit modes are listed in table B.6 for the 8 MHz, 7 MHz and 5 MHz RF bandwidths. For comparison purposes, the data rates for the 6 MHz RF bandwidth are also provided in table B.6.

Table B.6: Physical Layer Data Rates for 8 MHz, 7 MHz, 6 MHz and 5 MHz RF Channel Bandwidths

Mode Number	Constellation	Inner Code Rate	8 MHz Physical Layer Data Rate (Mbps)	7 MHz Physical Layer Data Rate (Mbps)	6 MHz Physical Layer Data Rate (Mbps)	5 MHz Physical Layer Data Rate (Mbps)
0	QPSK	1/3	*3,73*	*3,27*	2,8	*2,33*
1	QPSK	1/2	5,6	4,9	4,2	3,5
2	16-QAM	1/3	*7,47*	*6,53*	5,6	*4,67*
3	16-QAM	1/2	11,2	9,8	8,4	7
4	16-QAM	2/3	*14,93*	*13,07*	11,2	*9,33*
5 (see note)	QPSK	1/5	*2,24*	*1,96*	*1,68*	1,4
6	Layered Modulation with energy ratio 4	1/3	*7,47*	*6,53*	5,6	*4,67*
7	Layered Modulation with energy ratio 4	1/2	11,2	9,8	8,4	7
8	Layered Modulation with energy ratio 4	2/3	*14,93*	*13,07*	11,2	*9,33*
9	Layered Modulation with energy ratio 6.25	1/3	*7,47*	*6,53*	5,6	*4,67*
10	Layered Modulation with energy ratio 6.25	1/2	11,2	9,8	8,4	7
11	Layered Modulation with energy ratio 6.25	2/3	*14,93*	*13,07*	11,2	*9,33*
NOTE: This transmit mode is used only for the OIS channel.						

For the layered modes, the data rates listed in table B.6 is the sum total of the rates in the base and enhancement layers.

History

Document history		
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