ARIB STD-B46
Version 1.3-E1

ENGLISH TRANSLATION

TRANSMISSION SYSTEM FOR TERRESTRIAL MOBILE MULTIMEDIA BROADCASTING BASED ON CONNECTED SEGMENT TRANSMISSION

ARIB STANDARD

ARIB STD-B46 Version 1.3

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Association of Radio Industries and Businesses

General Notes to the English Translation of ARIB Standards and Technical Reports

1. Notes on Copyright

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Foreword

The Association of Radio Industries and Businesses (ARIB) investigates and summarizes the basic technical requirements for various radio systems in the form of “ARIB Standards”. These standards are developed with the participation of and through discussions amongst radio equipment manufacturers, telecommunication operators, broadcasting equipment manufacturers, broadcasters and users, etc.

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This ARIB Standard is developed for transmission system for terrestrial mobile multimedia broadcasting based on connected segment transmission. In order to ensure fairness and transparency in the defining stage, the standard was set by consensus at the ARIB Standard Assembly with the participation of both domestic and foreign interested parties from radio equipment manufacturers, telecommunication operators, broadcasting equipment manufacturers, broadcasters, and users, etc.

ARIB sincerely hopes that this ARIB Standard will be widely used by radio equipment manufacturers, telecommunication operators, broadcasting equipment manufacturers, broadcasters, and users etc.

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Annexed Table

Patent Applicant/ Holder	Name of Patent	Registration No./ Application No.	Remarks
Japan Broadcasting Corporation (NHK)	直交周波数分割多重ディジタル信号送信装置および受信装置	特許第 2904986 号	Japan, United States, United Kingdom, Germany, France
	符号化変調装置および復調装置	特許第 2883238 号	Japan
	直交周波数分割多重変調信号伝送方式	特許第 3110244 号	Japan
	ディジタル信号伝送方法及び受信機	特許第 3457482 号	Japan
	デジタル信号伝送方法、デジタル信号送信装置およびデジタル信号受信装置	特許第 3795183 号	Japan
	デジタル信号伝送装置	特許第 3133958 号	Japan
	OFDM 波伝送装置	特許第 3133960 号	Japan
	デジタル信号送信装置、およびデジタル信号受信装置	特許第 3691211 号	Japan
	送信装置および受信装置	特許第 3884869 号	Japan
Japan Broadcasting Corporation (NHK) Advanced Digital Television Broadcasting Laboratory	デジタル信号受信装置	特許第 2975932 号	Japan
Japan Broadcasting Corporation (NHK) NHK Engineering Services Inc.	地上デジタルテレビジョン放送における緊急速報を受信する受信機	特許第 4555360 号	Japan
	地上デジタルテレビジョン放送における緊急速報の受信機	特許第 4555393 号	Japan
	地上デジタルテレビジョン放送における緊急速報を受信する受信機、及び緊急速報を送信する送信装置、並びに伝送システム	特許第 4510925 号	Japan
	地上デジタルテレビジョン放送における緊急速報を受信する受信機	特許第 4555391 号	Japan
Sony Corporation Japan Broadcasting Corporation (NHK)	ディジタル放送装置	特許第 3940541 号	Japan, Australia, Brazil, China, United States, Hong Kong
Sony Corporation	OFDM 送信装置及び方法	特許第 3799951 号	Japan, Australia, Brazil, China , United States

Patent Applicant/ Holder	Name of Patent	Registration No./ Application No.	Remarks
JVC KENWOOD Holdings	Submitted comprehensive confirmation of patents for ARIB STD-B46 Ver1.0		
QUALCOMM Incorporated	Submitted comprehensive confirmation of patents for ARIB STD-B46 Ver1.0		
	Submitted comprehensive confirmation of patents for ARIB STD-B46 Ver1.1*1		
Panasonic Corporation	Submitted comprehensive confirmation of patents for ARIB STD-B46 Ver1.0*2		
Advanced Digital Television Broadcasting Laboratory Matsushita Electric Industrial Co., Ltd. Japan Broadcasting Corporation (NHK)	直交周波数分割多重伝送方式とその送信装置及び受信装置*2	特許第 3083159 号	Japan, China, Korea, Taiwan
	直交周波数分割多重伝送方式及びその送受信装置*2	特許第 3046960 号	Japan
Panasonic Corporation Japan Broadcasting Corporation (NHK)	送信方法、受信方法、送信装置、受信装置*2	特許第 4197568 号	Japan
	送信方法、受信方法、送信装置、受信装置*2	特許第 4197690 号	Japan
Matsushita Electric Industrial Co., Ltd. Japan Broadcasting Corporation (NHK)	送信方法、受信方法、送信装置、受信装置*2	特許第 4057603 号	Japan
QUALCOMM Incorporated	Broadcast and multicast services in wireless communication systems*3	JP2010-502124	US20080056387, US, CN, EP, HK, IN, KR, TW

*1: Valid for the revised part of ARIB STD-B46 Ver 1.1 (received on March 18, 2011)
*2: Valid for ARIB STD-B46 Ver 1.0 (received on March 15, 2011)
*3: Valid for ARIB STD-B46 Ver 1.0 (received on May 10, 2011)

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for Terrestrial Mobile Multimedia Broadcasting
Based on Connected Segment Transmission

Transmission System for Terrestrial Mobile Multimedia Broadcasting Based on Connected Segment Transmission

Contents

Chapter 1: General Terms

1.1 Objective

This standard is meant to define the transmission system used by a connected segment transmission scheme from among several schemes of terrestrial multimedia broadcasting for mobile and portable terminals.

This system is adopted in our country's technical standards for the terrestrial multimedia broadcasting based on the connected segment transmission scheme (hereinafter referred to as "terrestrial multimedia broadcasting based on ISDB-Tmm") conducted by broadcasting stations using radio waves with a frequency above 207.5 MHz and below 222 MHz (VHF-high band).

1.2 Scope

This standard applies to terrestrial multimedia broadcasting based on ISDB-Tmm. Note that for the standards such as the source coding scheme, multiplexing scheme, and others from among the standards associated with terrestrial multimedia broadcasting based on ISDB-Tmm, the relevant standards shall be referred to.

1.3 References

1.3.1 Normative References

The following documents are those from which excerpts included in this standard were taken:

- "Ministerial ordinance for amending the entire standard transmission system for digital broadcasting among standard television broadcasting and the like (Ordinance No. 87 of the Ministry of Internal Affairs and Communications, 2011)" (hereinafter referred to as "Ordinance")
- "The definition of the arrangement of TMCC symbol and AC symbol and the configuration of time interleave and frequency interleave (relevant to Section 11 and Section 12 of Ordinance)" (Notification No. 303 of the Ministry of Internal Affairs and Communications, 2011)" (hereinafter referred to as "Notification No. 303")
- "The definition of the configuration of TMCC information (relevant to Section 13 of Ordinance)" (Notification No. 304 of the Ministry of Internal Affairs and Communications, 2011)" (hereinafter referred to as "Notification No. 304")
- "The definition of the configuration of seismic motion warning information (relevant to the Annexed Table 18 of Ordinance)" (Notification No. 306 of the Ministry of Internal Affairs and Communications, 2011)" (hereinafter referred to as "Notification No. 306")
- "Radio Equipment Regulations (Radio Regulatory Commission Rules No.18, 1950)" (Ministerial Ordinance of the Ministry of Internal Affairs and Communications)
- "Transmission equipment of terrestrial basic broadcasting stations conducting multimedia broadcasting and their technical requirements" (Notification No. 174 of the Ministry of Internal Affairs and Communications, 2010)" (hereinafter referred to as "Notification No. 174")

1.3.2 Informative References

The following are the standards and other documents related to the transmission of digital terrestrial television broadcasting based on this standard:

- ARIB STD-B10, "Service Information for Digital Broadcasting System" ARIB Standard

- ARIB STD-B24, "Data Coding and Transmission Specification for Digital Broadcasting" ARIB Standard
- ARIB STD-B25, "Access Control System Specifications for Digital Broadcasting" ARIB Standard
- ARIB STD-B29, "Transmission System for Digital Terrestrial Sound Broadcasting" ARIB Standard
- ARIB STD-B31, "Transmission System for Digital Terrestrial Television Broadcasting" ARIB Standard
- ARIB STD-B32, "Video Coding, Audio Coding, and Multiplexing Specifications for Digital Broadcasting" ARIB Standard
- ARIB STD-B53, "Receiver for Terrestrial Mobile Multimedia Broadcasting based on Connected Segment Transmission" ARIB Standard (desirable specifications)
- ARIB STD-B55, "Transmission System for Area Broadcasting" ARIB Standard

1.4 Terminology

1.4.1 Definitions

Terrestrial multimedia broadcasting (multimedia broadcasting)	Multimedia broadcasting carried out with terrestrial basic broadcasting stations as defined in Chapter 4, Ordinance
Terrestrial mobile multimedia broadcasting based on connected segment transmission	Multimedia broadcasting as defined in Section 1 of Chapter 4, Ordinance
Digital terrestrial broadcasting	Digital broadcasting and high-definition television broadcasting from among the various standard television broadcasting systems using the terrestrial basic broadcasting stations stipulated in Chapter 3, Ordinance
Digital terrestrial sound broadcasting	Digital broadcasting among various types of ultra-high-frequency-wave broadcasting carried out with terrestrial basic broadcasting stations as defined in Chapter 2, Ordinance
Data segment	Data group that corresponds to the effective carrier. This is an elementary block for channel coding.
OFDM segment	Basic band (1/14 of television-channel bandwidth) for transmission signals, generated by adding control-signal carriers to data carriers. OFDM segment also means signal processed to make up a frame.
Type-A super segment	The 13-segment format OFDM segment based on the "Transmission System for Digital Terrestrial Television Broadcasting" (ARIB STD-B31)
Type-B super segment	The concatenation of 14 or less one-segment format OFDM segments based on "Transmission System for Digital Terrestrial Sound Broadcasting" (ARIB STD-B29)
Super segment	Type-A super segment or type-B super segment
Reference channel	A channel used to transmit a super segment, having the same bandwidth as digital terrestrial television broadcasting (One super segment is transmitted within the bandwidth of one reference channel. However, it is possible to allocate the one segment at the edge of the bandwidth of the type-B super segment over multiple reference channels. In addition, reference channels can be defined with some part of the bandwidths

	overlapping each other.)
Mode	Identification of transmission mode based on the spacings between OFDM carrier frequencies
IFFT sampling frequency	IFFT sampling frequency for OFDM modulation on the transmission side
FFT sampling frequency	FFT sampling frequency for model receivers used to form multiple frame patterns
ISDB-T	Digital terrestrial television broadcasting system in which transmission bands consist of 13 OFDM segments
ISDB-T_{SB}	Digital terrestrial sound broadcasting system in which transmission bands consist of one or three OFDM segments
ISDB-Tmm	Broadcasting system for terrestrial multimedia broadcasting for mobile and portable terminals in which the transmission bands consist of one or 13 OFDM segments
Partial reception	Reception of only one OFDM segment at the center of a group of signals consisting of three or 13 OFDM segments; note that, as the configuration of three OFDM segments is not stipulated in ISDB-Tmm, this only applies to the configuration of 13 OFDM segments.
OFDM symbol	Transmission symbol for the OFDM transmission signal
OFDM frame	Transmission frame consisting of 204 OFDM symbols
Multiplex frame	Frame that is provided for signal-processing purposes and is used to re-multiplex MPEG-2 TSs to create a single TS. This frame is identical to an OFDM frame in terms of duration.
Model receiver	Virtual receiver used to arrange transmission TSPs on a multiplex frame
Carrier symbol	A symbol per OFDM carrier
Segment number	Number used to identify 13 OFDM segments and their corresponding data segments
Sub-channel number	Number assigned to the bandwidth of the reference channel for each virtual bandwidth (1/3 of OFDM segment bandwidth), corresponding to ISDB-T_{SB}, ISDB-Tmm tuning step
Unit transmission-wave	Transmission signal of one-segment-type or 13-segment-type OFDM segment
Connected signal transmission	A type of transmission of ISDB-T_{SB} or ISDB-Tmm signals arranged without a guard band
Constraint length	Number obtained by adding 1 to the number of delay elements in a convolutional coder
Hierarchical transmission	Simultaneous transmission of multiple OFDM segments that are channel-coded differently
Hierarchical layer information	Channel-coding parameter information on each layer in hierarchical transmission
Control information	Information other than MPEG-2 TS that assists the receiver in demodulation and decoding operations
Additional information	Information that is transmitted using part of the control information carrier
Seismic motion warning information	The information regarding seismic motion warning conducted based on the regulation of Clause 1 of Article 13, the *Meteorological Service Act* (Act No. 165 of 1952) Although seismic motion warning is generally called “Earthquake Early Warning,” this standard uses the term “Seismic Motion Warning,” as is the case with the Ordinance and Notifications referred to.

Transmission TSP	204-byte packet formed by adding 16-byte parity to 188-byte MPEG-2 TSP
Spurious emission	Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.
Out-of-band emission	Emission on a frequency or frequencies immediately outside the necessary bandwidth resulting from the modulation process, but excluding spurious emissions.
Unwanted emissions	Consist of spurious emission and out-of-band emissions.
Spurious domain	The frequency range beyond the out-of-band domain in which spurious emissions generally predominate.
Out-of-band domain	The frequency range in which out-of-band emission generally predominates. In the case of terrestrial multimedia broadcasting based on ISDB-Tmm systems outside the necessary bandwidth, the frequency bands from the center frequency (the frequency of the center of the necessary frequency bandwidth) up to the frequency band within ± (2.5 * (6 / 14 * n + 38.48 / 1000)) [MHz] (n is the number of segments.) (However, the frequencies in the boundary of the out-of-band domain and spurious domain are included in the spurious domain.)
Necessary bandwidth	A frequency band of 6/14 * n + 38.48/1000 [MHz] (n is the number of segments) in the case of terrestrial multimedia broadcasting based on the ISDB-Tmm system
Broadcasting TS	TS signal having the multiplex frame structure of a terrestrial multimedia broadcasting signal based on the ISDB-Tmm system, which complies with MPEG-2 systems
Connected and combined TS	A TS signal in which the broadcasting TS for every unit transmission-wave is time-division multiplexed.

1.4.2 Abbreviations

AC	Auxiliary Channel
CIP	Connected transmission Information Packet
CP	Continual Pilot
CRC	Cyclic Redundancy Check
DBPSK	Differential Binary Phase Shift Keying
DQPSK	Differential Quaternary Phase Shift Keying
FFT	Fast Fourier Transform
IF	Intermediate frequency
IFFT	Inverse Fast Fourier Transform
IIP	ISDB-Tmm Information Packet
ISDB	Integrated Services Digital Broadcasting
ISDB-T	ISDB for Terrestrial Television Broadcasting
ISDB-T_{SB}	ISDB for Terrestrial Sound Broadcasting
ISDB-Tmm	ISDB for Terrestrial Multi-Media Broadcasting
MPEG	Moving Picture Experts Group
NSI	Network Synchronization Information
OCT	Octal notation
OFDM	Orthogonal Frequency Division Multiplexing
PRBS	Pseudo-Random Binary Sequence

QAM	Quadrature Amplitude Modulation
QPSK	Quaternary Phase Shift Keying
RF	Radio frequency
RS	Reed-Solomon
SP	Scattered Pilot
SFN	Single Frequency Network
TMCC	Transmission Multiplexing Configuration Control
TS	Transport Stream
TSP	Transport Stream Packet

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Chapter 2: ISDB-Tmm System Overview

ISDB-Tmm is a transmission system for terrestrial multimedia broadcasting using the connected segment transmission scheme on the basis of a transmission system similar to that for digital terrestrial television broadcasting (hereinafter referred to as "ISDB-T") and that for digital terrestrial sound broadcasting (hereinafter referred to as "ISDB-T_{SB}"). This system is stipulated in our country's technical standards as one of the transmission systems for terrestrial multimedia broadcasting conducted by broadcasting stations using radio waves with frequencies between 207.5 MHz and 222 MHz (VHF-high band).

The terrestrial multimedia broadcasting system based on ISDB-Tmm realizes a storage-type broadcasting service that enables us to view the broadcasting at any time after storing it once in the terminal, in addition to a real-time-based broadcasting service that makes it possible to view the broadcasting on a real-time basis using terminals anywhere while moving or away from home.

As is the case with ISDB-T and ISDB-T_{SB}, the signal with a bandwidth equal to one 14^{th} of a single-channel bandwidth of terrestrial television broadcasting is specified as an OFDM block (hereinafter referred to as an "OFDM segment") for an ISDB-Tmm transmission signal. With this block as a unit, the ISDB-Tmm transmission signal is formed by respectively connecting the arbitrary number of 13-segment-type OFDM segments similar to ISDB-T and one-segment-type OFDM segments similar to ISDB-T_{SB}. Structuring OFDM segment carrier configuration in a way that makes segment connection possible enables inter-operability with ISDB-T and ISDB-T_{SB} and the sharing of hardware and software resources with these, in addition to dealing with the bandwidth and transmission characteristics suited to the service in a flexible manner.

2.1 OFDM segment configuration

The following super segments are connected to form OFDM segments (hereinafter referred to as a "connected OFDM segment") for ISDB-Tmm.

- 13-segment-type OFDM segment that complies with the transmission system for digital terrestrial television broadcasting (ARIB STD-B31) (type-A super segment)
- 14 or less 1-segment-type OFDM segments connected segment that complies with the transmission system for digital terrestrial sound broadcasting (ARIB STD-B29) (type-B super segment)

The use of these connected OFDM segments make it feasible to share circuits, software, and others with one-segment terminals and digital terrestrial television broadcasting receivers, and it is possible to form a spectrum with arbitrary width on an OFDM-segment basis, which allows for the effective utilization of frequency bandwidth available for the terrestrial multimedia broadcasting for mobile and portable terminals.

2.2 Positions of reference channels and super segments

As ISDB-Tmm is based on ISDB-T and ISDB-T_{SB}, there is a necessity to assume the use of the channel (reference channel) with a bandwidth similar to that for terrestrial television broadcasting in the frequency band allocated for terrestrial multimedia broadcasting. An ISDB-Tmm transmission signal is generated by connecting the aforementioned type-A and type-B super segments, and in this occasion, the transmission spectrum of each super segment is arranged in either one of reference channels (out of the one-segment-type OFDM segments, however, those with sub-channel numbers 0, 1, and 41 are arranged such that they overlap reference channels [see Section 3.13.1.2] Note that there is a possibility that the frequency positions of reference channels are defined with part of the bands overlapped. In this case, the frequency bandwidth of the overlapped part becomes an integral multiple of the OFDM segment bandwidth.

When the frequency allocated for terrestrial multimedia broadcasting is 207.5 MHz to 222 MHz (bandwidth: 14.5 MHz) and when the reference channel bandwidth is 6 MHz, the maximum segment number of the connected OFDM segments is estimated at 33. In this case, the following arrangement is likely to be selected for reference channels and super segments.

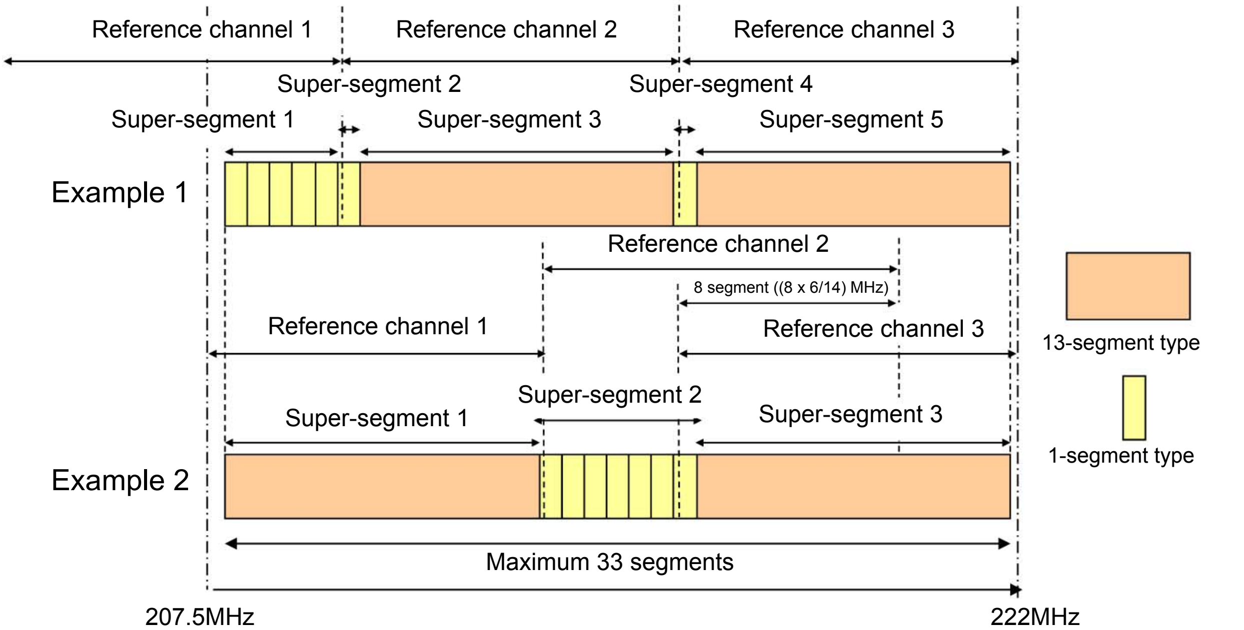


Fig. 2-1: Configuration of a Connected OFDM Segment

2.3 Model receiver

Receivers demodulate 13-segment-type or one-segment-type ISDB-Tmm signals in a selective manner.

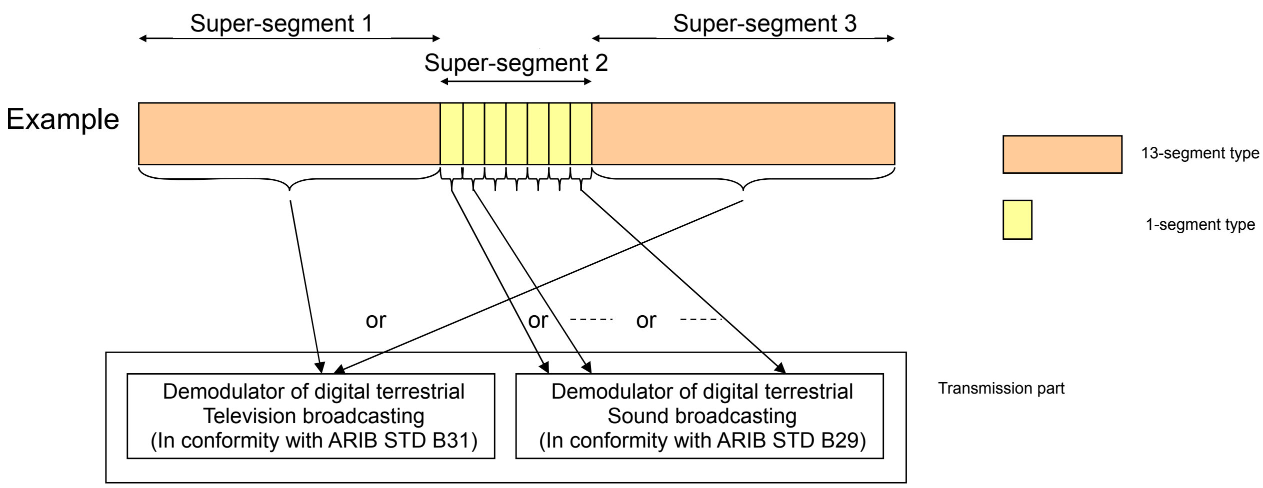


Fig. 2-2: Model Receiver

2.4 Model transmitter

An ISDB-Tmm signal is generated by the connected OFDM segments subjected to the IFFT/guard interval-added processing in a collective manner. Now, a 13-segment-type portion is divided into a maximum of three hierarchical layers (out of which partial reception at one segment is possible), as is the case with ISDB-T, thus making it possible independently to set up modulation, coding rate, and so forth on a hierarchical-layer basis (in conformity with digital terrestrial television broadcasting [ARIB STD-B31]). It is also possible for one-segment-type portions to set up modulation, coding rate, and so on for every segment (in conformity with digital terrestrial sound broadcasting [ARIB STD-B29]). Accordingly, the ISDB-Tmm model transmitter compatible with the super-segment configuration for Example 2 shown in Fig. 2-1 is capable of implementing channel-coding processing for nine systems in parallel.

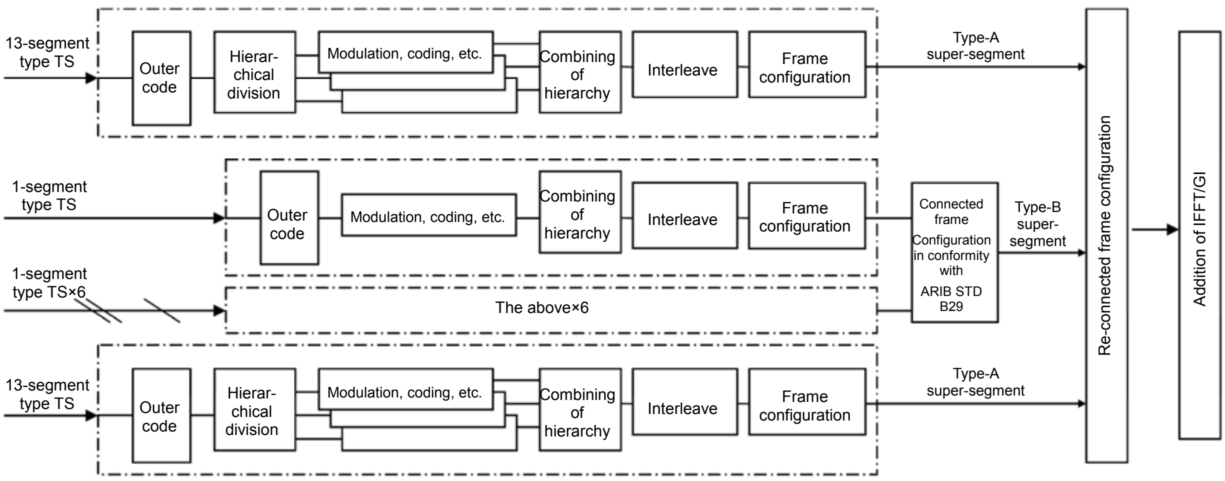


Fig. 2-3: Model Transmitter Configuration

2.5 Transmission signal parameters and information bit rates

Table 2-1 and Table 2-2 show one-segment-type transmission signal parameters and 13-segment-type transmission parameters, respectively. Also shown in Table 2-3 and Table 2-4 are one-segment-type information bit rates and 13-segment-type information bit rates, respectively. Note that the above-mentioned show the examples with the reference bandwidth of 6 MHz in all cases.

Note also that the effective symbol length and guard interval ratio are stipulated by Article 28-3 and Article 28-4 of Ordinance, along with the information bit rate by Annexed Table 9 of Ordinance.

Table 2-1: One-segment-type Transmission Signal Parameters

Mode		Mode 1	Mode 2	Mode 3
Segment bandwidth (Bws)		6000/14 = 428.571…kHz		
Bandwidth (Bw)		Bws + Cs = 432.5…kHz	Bws + Cs = 430.5…kHz	Bws + Cs = 429.5…kHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s (n_s+n_d=1)		
Spacings between carrier frequencies (Cs)		Bws/108 = 3.968…kHz	Bws/216 = 1.984…kHz	Bws/432 = 0.992…kHz
Number of carriers	Total count	108 + 1 = 109	216 + 1 = 217	432 + 1 = 433
	Data	96	192	384
	SP	9×n_s	18×n_s	36×n_s
	CP*1	n_d + 1	n_d + 1	n_d + 1
	TMCC*2	n_s + 5×n_d	2×n_s + 10×n_d	4×n_s + 20×n_d
	AC1*3	2	4	8
	AC2*3	4×n_d	9×n_d	19×n_d
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbol)		204		
Effective symbol length		252 μs	504 μs	1008 μs
Guard interval length		63 μs (1/4), 31.5 μs (1/8), 15.75 μs (1/16), 7.875 μs (1/32)	126 μs (1/4), 63 μs (1/8), 31.5 μs (1/16), 15.75 μs (1/32)	252 μs (1/4), 126 μs (1/8), 63 μs (1/16), 31.5 μs (1/32)
Frame length		64.26 ms (1/4), 57.834 ms (1/8), 54.621 ms (1/16), 53.0145 ms (1/32)	128.52 ms (1/4), 115.668 ms (1/8), 109.242 ms (1/16), 106.029 ms (1/32)	257.04 ms (1/4), 231.336 ms (1/8), 218.484 ms (1/16), 212.058 ms (1/32)
FFT sampling frequency		64/63 = 1.015873… MHz		
Interleave	Frequency	Intra-segment frequency interleave		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional-byte interleave per 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4: The inner code is taken as a convolutional code in which the mother-code with a constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table 2-2: 13-segment-type Transmission Signal Parameters

Mode		Mode 1	Mode 2	Mode 3
Number of OFDM segments (N_s)		13 segments		
Bandwidth (Bw)		Bws × N_s + Cs = 5.575…MHz	Bws × N_s + Cs = 5.573…MHz	Bws × N_s + Cs = 5.572…MHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s (n_s+n_d=N_s)		
Spacings between carrier frequencies (Cs)		Bws/108 = 3.968…kHz	Bws/216 = 1.984…kHz	Bws/432 = 0.992…kHz
Number of carriers	Total count	108×N_s + 1 = 1405	216×N_s + 1 = 2809	432×N_s + 1 = 5617
	Data	96×N_s = 1248	192×N_s = 2496	384×N_s = 4992
	SP	9×n_s	18×n_s	36×n_s
	CP*1	n_d + 1	n_d + 1	n_d + 1
	TMCC*2	n_s + 5×n_d	2×n_s + 10×n_d	4×n_s + 20×n_d
	AC1*3	2×N_s= 26	4×N_s= 52	8×N_s= 104
	AC2*3	4×n_d	9×n_d	19×n_d
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbol)		204		
Effective symbol length		252 μs	504 μs	1008 μs
Guard interval		63 μs (1/4), 31.5 μs (1/8), 15.75 μs (1/16), 7.875 μs (1/32)	126 μs (1/4), 63 μs (1/8), 31.5 μs (1/16), 15.75 μs (1/32)	252 μs (1/4), 126 μs (1/8), 63 μs (1/16), 31.5 μs (1/32)
Frame length		64.26 ms (1/4), 57.834 ms (1/8), 54.621 ms (1/16), 53.0145 ms (1/32)	128.52 ms (1/4), 115.668 ms (1/8), 109.242 ms (1/16), 106.029 ms (1/32)	257.04 ms (1/4), 231.336 ms (1/8), 218.484 ms (1/16), 212.058 ms (1/32)
FFT sampling frequency		2048/252 = 8.126984… MHz		
Interleave	Frequency	Inter-segment and intra-segment frequency interleave		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional-byte interleave per 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4: The inner code is taken as a convolutional code in which the mother-code with a constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table 2-3: One-segment-type Information Bit Rates

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information bit rate (kbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	12 / 24 / 48	280.85	312.06	330.42	340.43
	2/3	16 / 32 / 64	374.47	416.08	440.56	453.91
	3/4	18 / 36 / 72	421.28	468.09	495.63	510.65
	5/6	20 / 40 / 80	468.09	520.10	550.70	567.39
	7/8	21 / 42 / 84	491.50	546.11	578.23	595.76
16QAM	1/2	24 / 48 / 96	561.71	624.13	660.84	680.87
	2/3	32 / 64 / 128	748.95	832.17	881.12	907.82
	3/4	36 / 72 / 144	842.57	936.19	991.26	1021.30
	5/6	40 / 80 / 160	936.19	1040.21	1101.40	1134.78
	7/8	42 / 84 / 168	983.00	1092.22	1156.47	1191.52
64QAM	1/2	36 / 72 / 144	842.57	936.19	991.26	1021.30
	2/3	48 / 96 / 192	1123.43	1248.26	1321.68	1361.74
	3/4	54 / 108 / 216	1263.86	1404.29	1486.90	1531.95
	5/6	60 / 120 / 240	1404.29	1560.32	1652.11	1702.17
	7/8	63 / 126 / 252	1474.50	1638.34	1734.71	1787.28

Table 2-4: 13-segment-type Information Bit Rates*2

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information bit rate (Mbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	156/ 312 / 624	3.651	4.056	4.295	4.425
	2/3	208 / 416 / 832	4.868	5.409	5.727	5.900
	3/4	234 / 468 / 936	5.476	6.085	6.443	6.638
	5/6	260 / 520 / 1040	6.085	6.761	7.159	7.376
	7/8	273 / 546 / 1092	6.389	7.099	7.517	7.744
16QAM	1/2	312 / 624 / 1248	7.302	8.113	8.590	8.851
	2/3	416/ 832 / 1664	9.736	10.818	11.454	11.801
	3/4	468 / 936 / 1872	10.953	12.170	12.886	13.276
	5/6	520/ 1040 / 2080	12.170	13.522	14.318	14.752
	7/8	546/ 1092 / 2184	12.779	14.198	15.034	15.489
64QAM	1/2	468 / 936 / 1872	10.953	12.170	12.886	13.276
	2/3	624 / 1248 / 2496	14.604	16.227	17.181	17.702
	3/4	702 / 1404 / 2808	16.430	18.255	19.329	19.915
	5/6	780 / 1560 / 3120	18.255	20.284	21.477	22.128
	7/8	819 / 1638 / 3276	19.168	21.298	22.551	23.234

*1: Represents the number of TSPs transmitted per frame

*2: The information bit rates are an example because the hierarchical transmission is possible with the coding rates of modulation and convolutional codes set as variables.

Chapter 3: Channel-Coding Scheme

3.1 Basic configuration of channel-coding

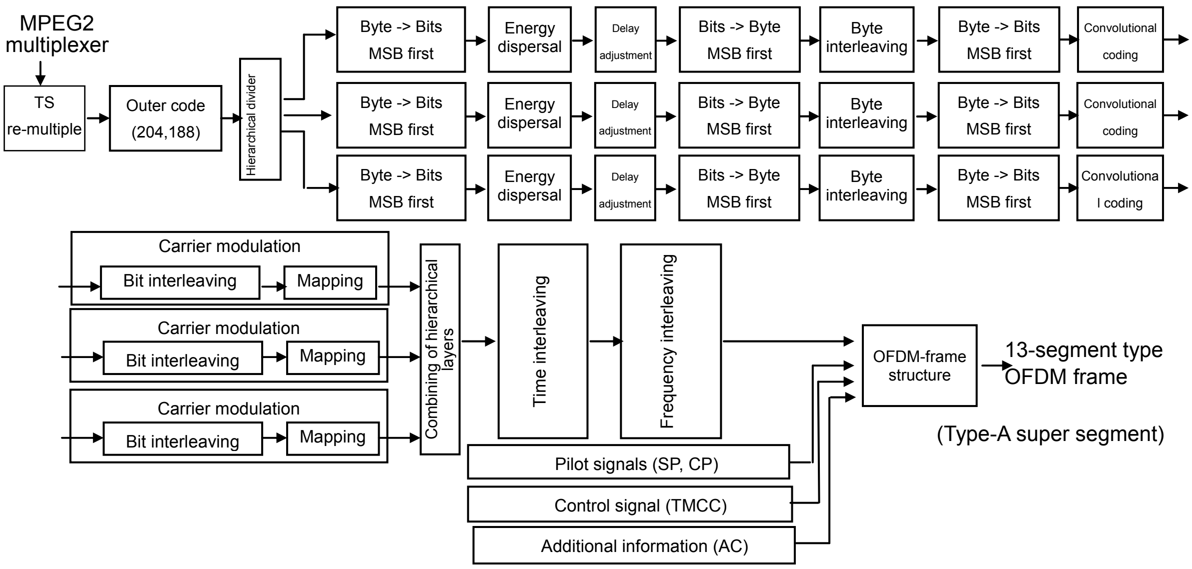
The outputs of MPEG-2 multiplexer are converted through the TS re-multiplexer into the 13-segment-type or one-segment-type transmission TSPs stipulated in Section 3.2. The 13-segment-type transmission TSPs refer to the transmission TSPs stipulated by ARIB STD-B31 and undergo the channel-coding process compatible with this stipulation, which then leads to the generation of the 13-segment-type OFDM frame. The same applies to the one-segment-type transmission TSPs that are the transmission TSPs stipulated by ARIB STD-B29. Namely, with the channel-coding processing compatible with this stipulation and a maximum of 14 segment-connected processing, a maximum of 14 one-segment-type segment-connected OFDM frames are formed. As mentioned previously, the former is referred to as a type-A super segment and the latter as a type-B super segment, for the sake of convenience.

ISDB-Tmm OFDM signals are generated by connecting further multiple super segments thus generated and carrying out an IFFT operation.

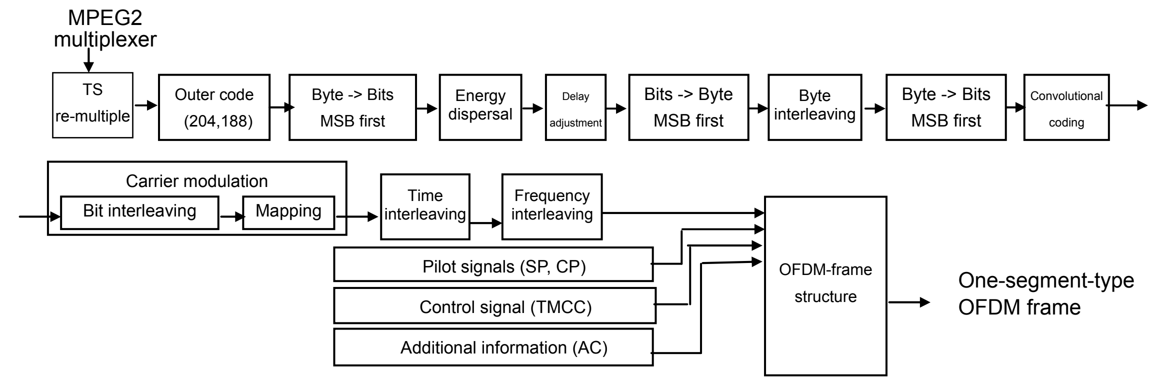
Fig. 3-1 shows the basic configuration of the channel-coding portion.

This section stipulates the 13-segment-type and one-segment-type channel-coding. The connected transmission is stipulated in the next section.

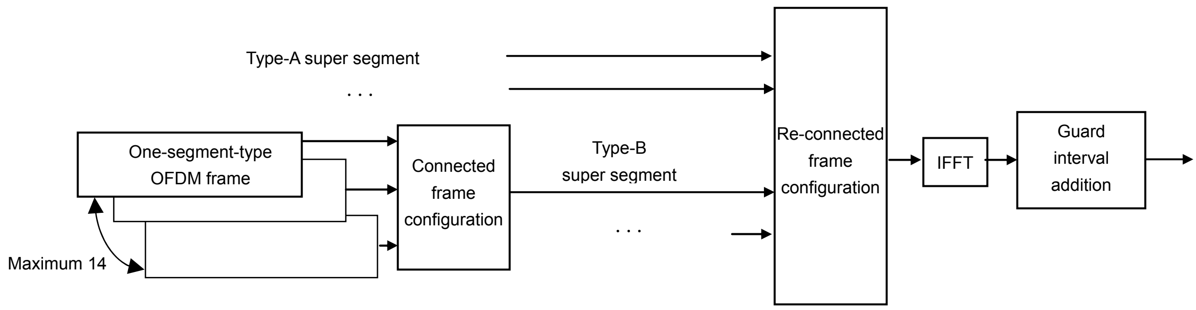
Note that the basic configuration and others of the transmission signals are stipulated in Article 28-1, Article 29, Article 11-2, Article 11-6, Article 12-2, Article 15, and so on of Ordinance.



(a) 13-segment-type channel-coding system



(b) One-segment-type channel-coding system



(c) Connected frame configuration, IFFT, guard interval adding processing system

Fig. 3-1: Blocks Available in the Channel Coding

3.2 TS re-multiplexing

3.2.1 Multiplex-frame configuration

A re-multiplexed transport stream (TS) is formed by multiplex frames as elementary units, each of which consists of n pieces of transport-stream packets (TSPs). Table 3-1 shows the numbers of TSPs used for different transmission modes and guard-interval ratios.

Each of the TSPs comprising a multiplex frame is 204 bytes in length, consisting of 188-byte program data with 16-byte null data added. This TSP is referred to as “transmission TSP.” In the case of one-segment-type OFDM frames, the multiplex-frame length matches that of the OFDM frame when the clock rate for sending the transmission TSP is increased to two times 1.0158… MHz (one-segment-type FFT sampling frequency). While, in the case of 13-segment-type OFDM frame, the multiplex-frame length matches that of the OFDM frame when the clock rate for sending the transmission TSP is increased to four times 8.12698… MHz (13-segment-type FFT sampling frequency). Note that the clock rates indicated here for sending the transmission TSP for one-segment-type and 13-segment-type OFDM frames are examples for a reference channel bandwidth of 6 MHz.

As shown in Fig. 3-2, each of the transmission TSPs within a multiplex frame belong to either (TSPx) transmitted by hierarchical layer X of an OFDM signal (layer X designates either layer of A, B, or C hierarchical layer) or a null packet (TSP_{null}) that is not transmitted ultimately as an OFDM signal. The arrangement of transmission TSPs within a multiplex frame is determined in advance to ensure that it is identical to that of the TSs that will be reproduced by the model receiver shown in Fig. 3-3.

Because the number of transport-stream packets that can be transmitted per unit time varies substantially depending on the parameters specified for each hierarchical layer, it is generally not possible to achieve consistency between TSs input to the re-multiplexer and a single TS output from it. However, the addition of an appropriate number of null packets allows interfacing between the re-multiplexer and modulator during transmission of transport streams at a constant clock rate, regardless of which transmission parameters are specified.

Because multiplex-frame length is the same as OFDM-frame length, the receiver can reproduce transport-stream synchronization based on OFDM-signal synchronization, thus ensuring improved synchronization performance.

Correlating TSP arrangement within a multiplex-frame with “division of TS into multiple hierarchical layers and combining of these layers” allows the receiving side to select the same single TS as the one transmitted from among multiple signals of different layers, and to reproduce that TS.

For this reason, we define the model receiver operation on the transmitting side to indirectly stipulate TSP arrangement. The receiving side can reproduce TS without any TSP position information when it operates in the same manner as the model receiver.

Fig. 3-2 shows an example of a re-multiplexed transport stream.

Table 3-1: Multiplex-Frame Configuration

Mode		Number of transmission TSPs included in one multiplex-frame			
		Guard-interval ratio 1/4	Guard-interval ratio 1/8	Guard-interval ratio 1/16	Guard-interval ratio 1/32
One-segment type	Mode 1	80	72	68	66
	Mode 2	160	144	136	132
	Mode 3	320	288	272	264
13-segment type	Mode 1	1280	1152	1088	1056
	Mode 2	2560	2304	2176	2112
	Mode 3	5120	4608	4352	4224

(Ordinance Annexed Table 15, Item 1)

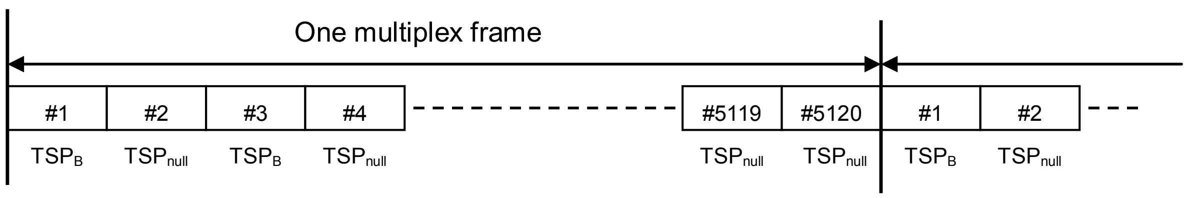


Fig. 3-2: Example of a Re-Multiplexed Transport Stream

(13-segment type, Mode 3, guard-interval ratio 1/4,
for two hierarchical layer transmissions [QPSK 1/2, use of one segment, 16QAM 1/2, use of 12 segments])

3.2.2 Model receiver for forming multiplex frame patterns

TSPs are arranged on a multiplex frame in accordance with the configuration of TS reproduced by the model receiver shown in Fig. 3-3.

Note that a clock written in this section means an FFT sampling clock.

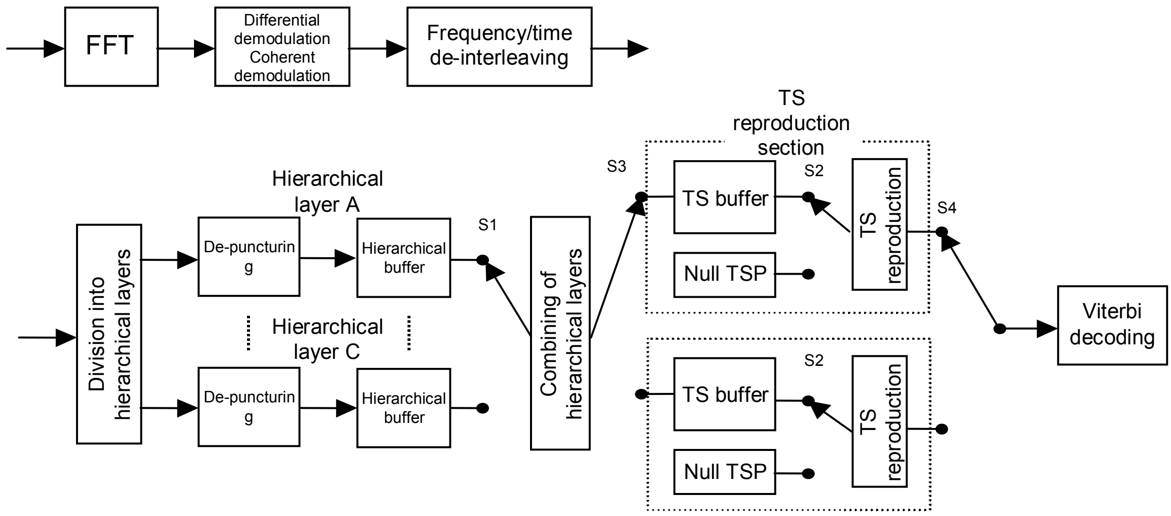


Fig. 3-3: Model Receiver for Forming Multiplex Frame Patterns

3.2.2.1 Input signals to the hierarchical divider

Upon completion of processing such as carrier demodulation and de-interleaving, input signals to the hierarchical divider are arranged in ascending order of segment number, and also in ascending order of the carrier frequency of information symbol within a segment (obtained by excluding the carriers of control symbol). Fig. 3-4 shows an example for two hierarchical layers (QPSK 1/2, the use of one segment, and 16QAM 1/2, the use of 12 segments) with Mode3 and guard-interval ratio 1/4.

During the period of one OFDM symbol, data the size of 384 (384 × 1) carriers is input to hierarchical layer A, followed by the input of data the size of 4,608 (384 ×12) carriers to hierarchical layer B and a null signal the size of 5,248 carriers.

The null signal corresponds to the sum of samplings which are equivalent to pilot signals inserted by the OFDM framing section, FFT sampling in excess of the net signal band, and equivalent to guard-interval duration. This operation is repeated as many times as 204 symbols for the duration of one OFDM frame.

Note that delays are adjusted such that the periods of time required for differential or coherent demodulation become the same.

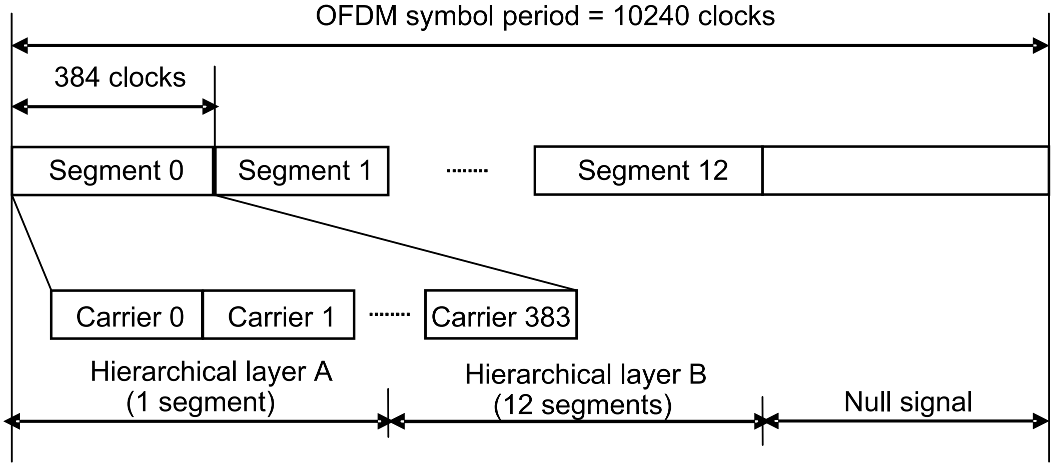


Fig. 3-4: Time Arrangement for Input Signals to Hierarchical Layers

3.2.2.2 Operation of the model receiver from the hierarchical divider to the Viterbi decoding input

Signal, divided into multiple hierarchical layers, is then subjected to de-puncturing before being stored in the hierarchical buffer. In this case, we assume that the processing delay time is the same for all layers, and that there is no delay time for the model receiver.

At this time, the number of bits $B_{X,k}$ that are input to and stored in the hierarchical buffer upon input of the kth datum to hierarchical layer X in a single multiplex frame can be determined by the following formula:

$$B_{X,k} = 2 \times ([k \times S_x \times R_x] - [(k-1) \times S_x \times R_x])$$

where [ ] indicates that all digits to the right of the decimal point are discarded. Note that R_X represents the convolutional-code coding rate at hierarchical layer X. Note also that S_X takes one of the values given in Table 3-2, depending on the modulation scheme selected for hierarchical layer X.

Table 3-2: Sx Value

Modulation scheme	S_X
DQPSK/QPSK	2
16QAM	4
64QAM	6

Switch S1 is switched over to another hierarchical buffer when data the size of one TS packet (408 bytes*) is input to the hierarchical buffer. This data is transferred to the TS buffer provided in the TS reproduction section. In this case, we assume that data transfer is instantaneous.

* Convolutional coding of a single TS packet (204 bytes) of data produces 408 bytes, as the coding rate of the mother code of the convolutional code is 1/2.

The TS reproduction section checks the TS buffer every TS packet period (816 clocks for one-segment types and 408 clocks for 13-segment types). If there is more data than the size of one TS packet, this section switches S2 over to the TS buffer position and reads out one TS packet of data. When there is no data in the TS buffer, the TS reproduction section switches S2 over to the null TSP position and transmits a null packet.

Switch S3 is used to alternately switch between two TS reproduction sections for inputting a hierarchical combiner output signal. In Mode 1, switching is performed at the beginning of an OFDM frame. Switch S4 is used to switch between TS reproduction-section signal outputs. This switch is switched over to the same position as S3 in three TS packet period (408×3 clocks) following the switching of S3, that is, at the beginning of an OFDM frame.

In Modes 2 and 3, switching of S3 and S4 is performed at 1/2 OFDM-frame intervals (102 OFDM-symbol intervals) and 1/4 OFDM-frame intervals (51 OFDM-symbol intervals), respectively.

3.3 Outer code

A shortened (204,188) Reed-Solomon code is used in every TSP as an outer code. The shortened (204,188) Reed-Solomon code is generated by adding 51-byte 00HEX at the beginning of the 188-byte input data bytes, processing with the (255,239) Reed-Solomon code, and then removing these 51 bytes.

The GF (2^8) element is used as the Reed-Solomon code element. The following primitive polynomial p (x) is used to define GF (2^8):

$$p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

Note also that the following polynomial g (x) is used to generate (204,188) shortened Reed-Solomon code:

$$g(x) = (x - \lambda^0)(x - \lambda^1)(x - \lambda^2) \cdots (x - \lambda^{15}) \qquad \text{provided that } \lambda = 02\ HEX$$

(Ordinance Annexed Table 12, Item 1)

This Reed-Solomon code (RS code) can correct up to 8 bytes in random error from among 204 bytes. Fig. 3-5 shows the MPEG2 TS packet and TS packet that is error-protected by RS code. Note that the TS packet among the latter packets that is transmitted by hierarchical layer A or hierarchical layer B of the OFDM signal is referred to as the "transmission TSP."

Synchronization byte (1 byte)	Data (187 bytes)

(a) MPEG2 TS Packet

Synchronization byte (1 byte)	Data (187 bytes)	Parity (16 bytes)

(b) TS Packet error-protected by RS code (transmission TSP)

Fig. 3-5: MPEG2 TS Packet and Transmission TSP

[Description]

Inner code error correction (convolutional coding / Viterbi decoding) results in burst errors when an error in decoding occurs. As a precaution against this, concatenated code, in which the error correction code is added further by way of interleave outside the convolutional coding / Viterbi decoding, is widely used. The Reed-Solomon code having high efficiency in burst errors is typically used as an outer code of the concatenated code.

The shortened Reed-Solomon code (204,188) is applied on a TSP basis as the outer code.

3.4 Division of TS into hierarchical layers

In the case of 13-segment-type channel-coding, the hierarchical divider divides re-multiplexed TS into multiple portions (transmission TSPs, each of which is 204 bytes in length, containing all bytes from the byte next to the TS synchronization byte to the next synchronization byte), and assigns each portion to the specified hierarchical layer. At the same time, the divider removes the null packet. The hierarchical layer to which each of the transmission TSPs belongs is specified by hierarchy information based on organization information. The maximum number of hierarchical layers must be three. Note also that OFDM-frame synchronization shifts by one byte, to the beginning of the information bytes.

Fig. 3-6 shows an example of the division of TS into two hierarchical layers.

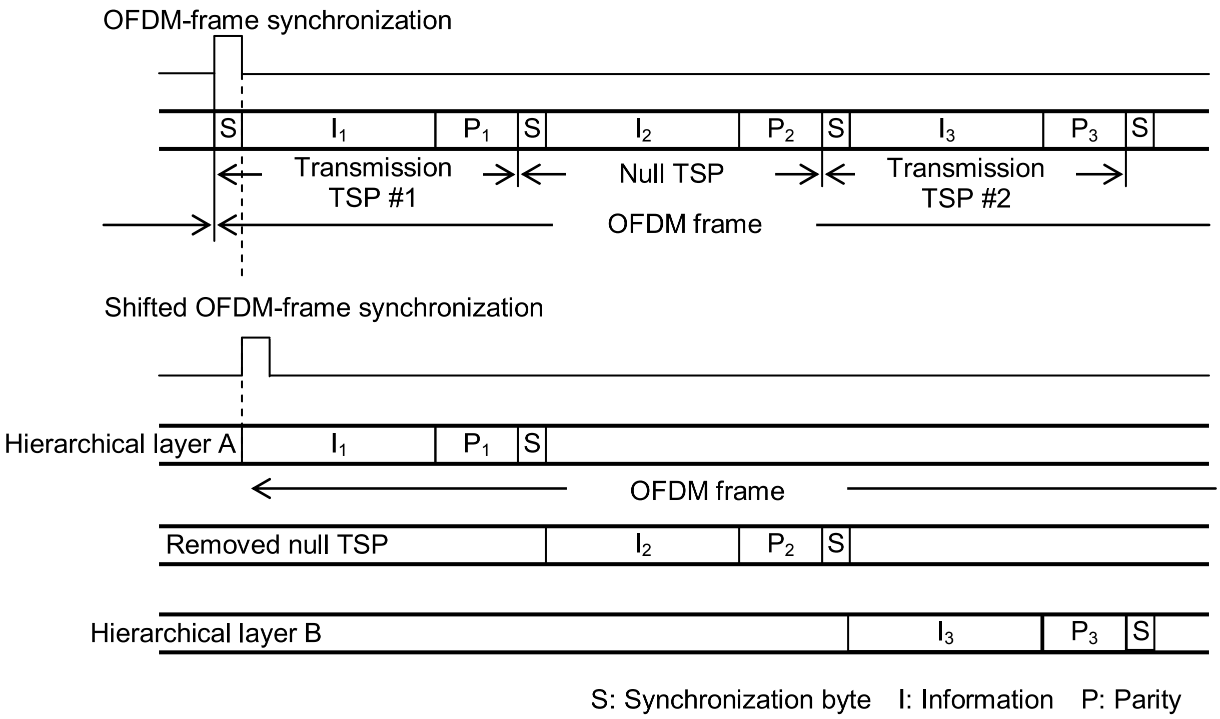


Fig. 3-6: An Example of Hierarchical Divider Operation

[Description]

For hierarchical layering purposes, the tolerance against the channel is changed on a layer basis for transmission by means of the combination of an inner code coding rate and a modulation scheme.

When the Viterbi decoding is conducted on the reception side, the synchronizing bytes are shifted by one byte for hierarchical layer division so that the synchronizing bytes can be used as the terminal codes for the Viterbi decoding.

3.5 Energy dispersal

The PRBS (pseudo-random binary sequence) generated by the circuit shown in Fig. 3-7 is EXCLUSIVE ORed at each hierarchical layer using signals excluding those with synchronizing bytes on a bit-by-bit basis.

The initial value of the register in the PRBS-generating circuit must be “100101010000000” (arranged in ascending order of bits, from left to right), and this value must be initialized every OFDM frame. At this time, the beginning of an OFDM frame must be the MSB of the byte next to the transmission TSP’s synchronization byte. Note also that the shift register must also perform shifting during the synchronization byte.

The PRBS-generating polynomial $g(x)$ shall be given as follows.

$$g(x) = X^{15} + X^{14} + 1$$

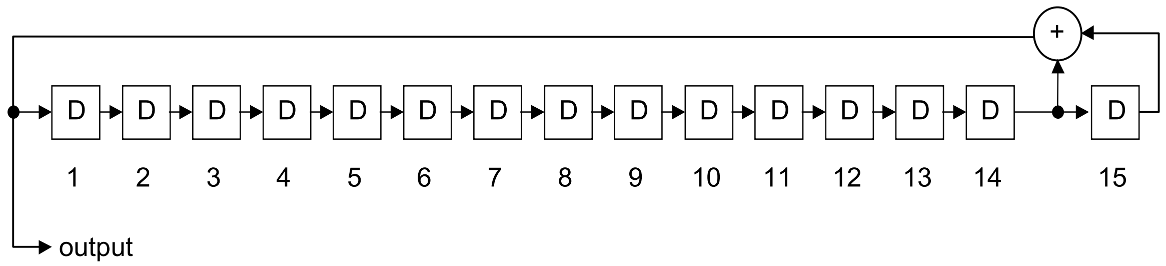


Fig. 3-7: PRBS-generating Circuit

(Ordinance Annexed Table 15, Annexed Statement 1)

[Description]
In order to ensure the consistency with digital satellite broadcasting and digital terrestrial television broadcasting, a dispersing signal of the 15th order M series $g(x)$ shown in the above generating polynomial is employed.

3.6 Delay adjustment

Delay adjustment associated with byte interleaving, intended to provide identical transmission and reception delay times for all hierarchical layers, is conducted on the transmitting side.

The delay adjustment value for each hierarchical layer is shown in Table 3-3. An appropriate value must be selected and specified for each hierarchical layer from among those (equivalent to the number of transmission TSPs) as shown in Table 3-3, such that all delays, including transmission and reception delays caused by byte interleaving (11 transmission TSPs), are one frame in length.

Table 3-3: Delay-Adjustment Values Required as a Result of Byte Interleaving

Carrier modulation	Convolutional code	Delay-adjustment value (number of transmission TSPs)		
		Mode 1	Mode 2	Mode 3
DQPSK QPSK	1/2	12 × N-11	24 × N-11	48 × N-11
	2/3	16 × N-11	32 × N-11	64 × N-11
	3/4	18 × N-11	36 × N-11	72 × N-11
	5/6	20 × N-11	40 × N-11	80 × N-11
	7/8	21 × N-11	42 × N-11	84 × N-11
16QAM	1/2	24 × N-11	48 × N-11	96 × N-11
	2/3	32 × N-11	64 × N-11	128 × N-11
	3/4	36 × N-11	72 × N-11	144 × N-11
	5/6	40 × N-11	80 × N-11	160 × N-11
	7/8	42 × N-11	84 × N-11	168 × N-11
64QAM	1/2	36 × N-11	72 × N-11	144 × N-11
	2/3	48 × N-11	96 × N-11	192 × N-11
	3/4	54 × N-11	108 × N-11	216 × N-11
	5/6	60 × N-11	120 × N-11	240 × N-11
	7/8	63 × N-11	126 × N-11	252 × N-11

N represents the number of segments used by that hierarchical layer.

(Ordinance Annexed Table 15, Annexed Statement 2, Item 2)

With hierarchical transmission, it is possible to specify different sets of transmission parameters (number of segments, inner-code coding rate, and modulation scheme) for different hierarchical layers. In this case, however, the transmission bit rate for one layer differs from that for another layer, resulting in different transmission capacities calculated as the time periods from coding of the inner code on the transmitting side to decoding on the receiving side.

Therefore, the amount of transmission TSP delay (11 TSPs) caused by byte interleaving (discussed later) for one layer differs from that for another layer when it is converted to delay time.

To compensate for this relative difference in delay time between hierarchical layers, delay adjustment is conducted at each layer prior to byte interleaving, in accordance with the transmission bit rate.

[Description]

When the bit rate is different from hierarchical layer to hierarchical layer (when the combination of the number of segments, the inner code coding rate, and the modulation scheme is different in each layer), this results in a different transmission speed from the coding of the inner code to inner code decoding on the reception side. For this reason, the amount of transmission TSP delay (11 transmission TSPs) caused by the byte interleaving discussed later varies from layer to layer when it is converted to delay time. To compensate for this, delay adjustment is conducted at each layer in accordance with the transmission bit rate.

3.7 Byte interleaving

The 204-byte transmission TSP, which is error-protected by means of RS code and energy-dispersed, undergoes convolutional byte interleaving. Interleaving must be 12 bytes in depth. Note, however, that the byte next to the synchronization byte must pass through a reference path that causes no delay.

Fig. 3-8 shows the byte interleaving circuit.

In the inter-code interleaving circuit, path 0 has no delay. The memory size for path 1 must be 17 bytes (as each path is selected every 12 bytes, the amount of delay for path 1 is estimated at 17 × 12 bytes), and that for path 2 must be 17 × 2 = 34 bytes (the amount of delay at 17 × 12 × 21 bytes), etc. Input and output must be switched over to a different path every byte, in a sequential and cyclic manner, in ascending order of path number (path 0 -> path 1 -> path 2 ---- path 11 -> path 0 -> path 1 -> path 2).

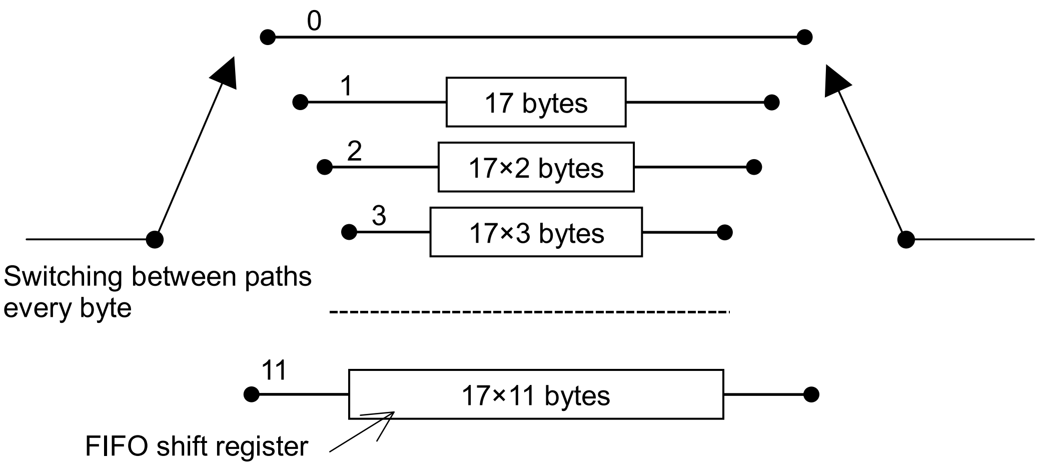


Fig. 3-8: Byte Interleaving Circuit

(Ordinance Annexed Table 15, Annexed Statement 2, Item 1)

The total sum of the delay in transmission and reception caused by the inter-code interleaving and deinterleaving is estimated at 17 × 11 × 12 bytes (equivalent to 11 transmission TSPs).

[Description]
In order to enable a concatenated code to fulfill its error-correction ability in an effective manner, a byte interleave circuit is provided between the outer code and inner code, thus dispersing more than one packet of the burst error in the decoding output of the inner code.

3.8 Inner code

The inner code is a punctured convolutional code with a mother code having a constraint length k of 7 and a coding rate of 1/2. The generating polynomial of the mother code must be G1 = 171_{OCT} and G2 = 133_{OCT}. Fig. 3-9 shows the coding circuit of the mother code with a constraint length k of 7 and a coding rate of 1/2.

Table 3-4 shows the selectable inner-code coding rates and transmission signal sequence that are punctured at that time. Note that the puncturing pattern must be reset by frame synchronization.

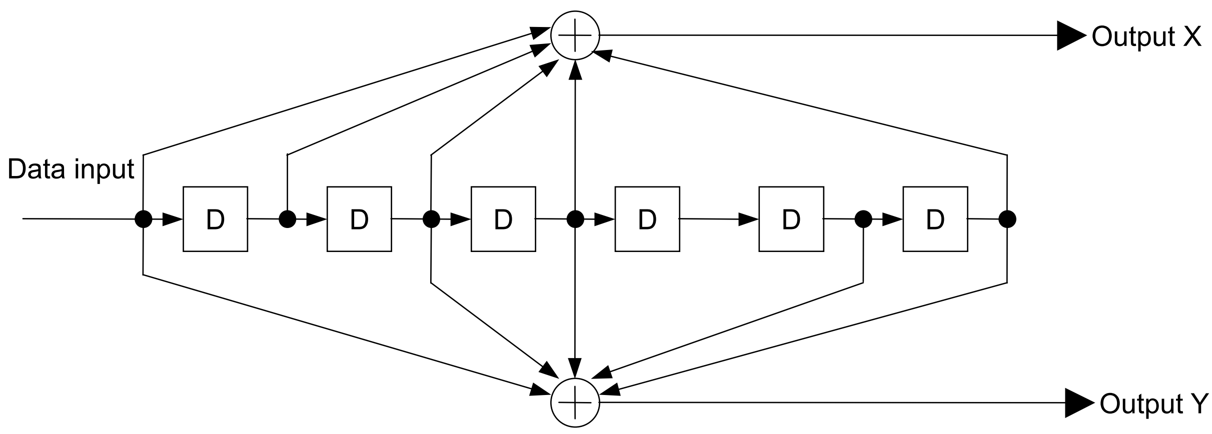


Fig. 3-9: Coding Circuit of a Convolutional Code with Constraint Length k of 7 and a Coding Rate of 1/2

Table 3-4: Inner-Code Coding Rates and Transmission-Signal Sequence

Coding rate	Puncturing pattern	Transmission-signal sequence
1/2	X : 1 Y : 1	X1, Y1
2/3	X : 1 0 Y : 1 1	X1, Y1, Y2
3/4	X : 1 0 1 Y : 1 1 0	X1, Y1, Y2, X3
5/6	X : 1 0 1 0 1 Y : 1 1 0 1 0	X1, Y1, Y2, X3 Y4, X5
7/8	X : 1 0 0 0 1 0 1 Y : 1 1 1 1 0 1 0	X1, Y1, Y2, Y3, Y4, X5, Y6, X7

(Ordinance Annexed Table 12, Item 3 and Item 4)

[Description]

Puncturing technology has made it possible to select multiple coding rates. Also, with the aim of ensuring consistency with digital satellite broadcasting and digital terrestrial television broadcasting, the convolutional code with a constraint length of 7 and a coding rate of 1/2 has been selected. Note that resetting by frame synchronization was employed, intending to ensure synchronization reliability of punctured patterns on the receiver side.

3.9 Carrier modulation

3.9.1 Configuration of carrier modulator

In the carrier modulation process, the input signal is bit-interleaved and mapped through the schemes specified for each hierarchical layer as shown in Fig. 3-10.

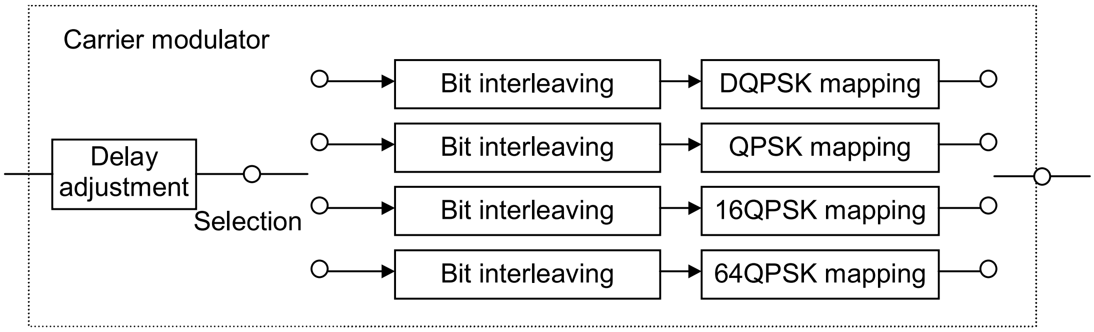


Fig. 3-10: Carrier-Modulator Configuration

[Description]

To avoid causing errors in modulation symbols in transmission channel that may result in burst errors in continual multiple bits, bit-interleaving is performed. Note that, as for the length of bit-interleaving, a maximum of 120 bits bit-interleaving was selected to ensure the consistency with digital terrestrial television broadcasting.

3.9.2 Delay adjustment

Transmission and reception delays equivalent to 120 carrier symbols occur as a result of bit interleaving, with the details shown in Section 3.9.3. This difference in delay is compensated on the transmission side through the addition of the appropriate delay-time adjustment value such that the transmission and reception delays are equal to two OFDM symbols.

Table 3-5: Delay-Adjustment Values Required as a Result of Bit Interleaving

Carrier modulation	Delay-adjustment value (number of bits)		
	Mode 1	Mode 2	Mode 3
DQPSK QPSK	384 × N-240	768 × N-240	1536 × N-240
16QAM	768 × N-480	1536 × N-480	3072 × N-480
64QAM	1152 × N-720	2304 × N-720	4608 × N-720

N represents the number of segments used by that hierarchical layer.

(Ordinance Annexed Table 10 Annexed Statement 1 Note 2)

[Description]

Delay adjustment is conducted intending to make clear the delay associated with bit interleaving and the OFDM symbols, thus regulating the delay such that the total transmission and reception delays are equal to just two OFDM symbols.

3.9.3 Bit interleaving and mapping

3.9.3.1 DQPSK

The input signal must be 2 bits per symbol and π/4-shift DQPSK-mapped to output multi-bit I- and Q-axes data.

Upon completion of serial-parallel conversion, the 120-bit delay element shown in Fig. 3-11 is inserted into the phase-calculator input for bit interleaving. Fig. 3-11, Table 3-6, and Fig. 3-12 show the system diagram, phase calculation, and constellation, respectively.

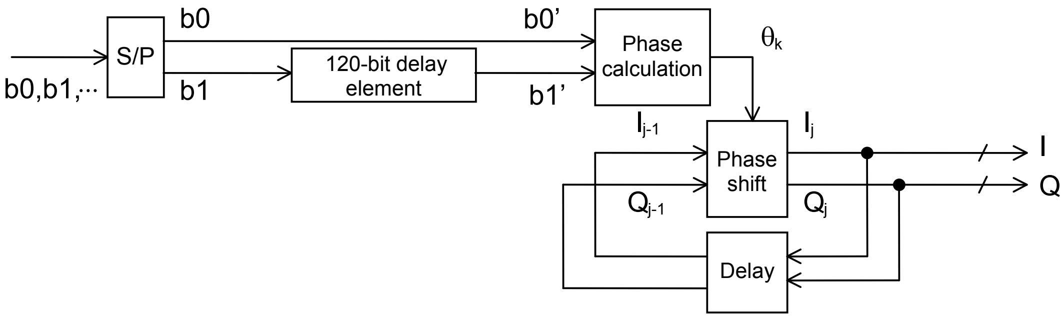


Fig. 3-11: π/4-Shift DQPSK Modulation System Diagram

Table 3-6: Phase Calculation

input b0' b1'	output θj
0 0	π/4
0 1	-π/4
1 0	3π/4
1 1	-3π/4

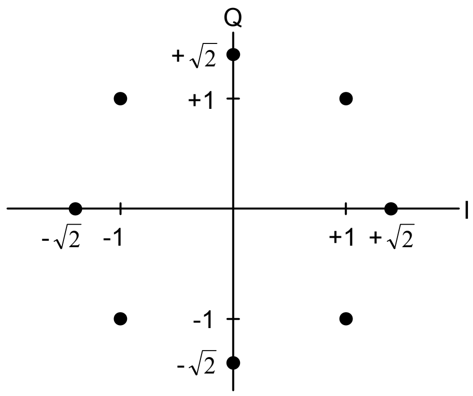


Fig. 3-12: π/4-Shift DQPSK Constellation

The following shows the phase shift:

$$\begin{pmatrix} I_j \\ Q_j \end{pmatrix} = \begin{pmatrix} \cos\theta_j & -\sin\theta_j \\ \sin\theta_j & \cos\theta_j \end{pmatrix} \begin{pmatrix} I_{j-1} \\ Q_{j-1} \end{pmatrix}$$

Provided that (I_j, Q_j) and (I_{j-1}, Q_{j-1}) represent the output symbol and the OFDM symbol immediately preceding the output symbol, respectively

(Ordinance Annexed Table 10, Annexed Statement 1, Item 1)

3.9.3.2 QPSK

The input signal must be 2 bits per symbol and QPSK-mapped to output multi-bit I- and Q-axes data. To conduct mapping, the 120-bit delay element shown in Fig. 3-13 is inserted into the mapping input for bit interleaving.

Figs. 3-13 and 3-14 show the system diagram and mapping constellation, respectively.

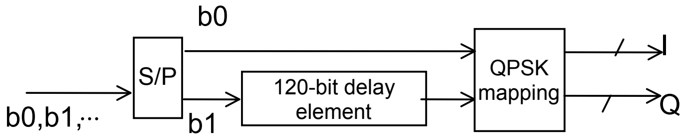


Fig. 3-13: QPSK Modulation System Diagram

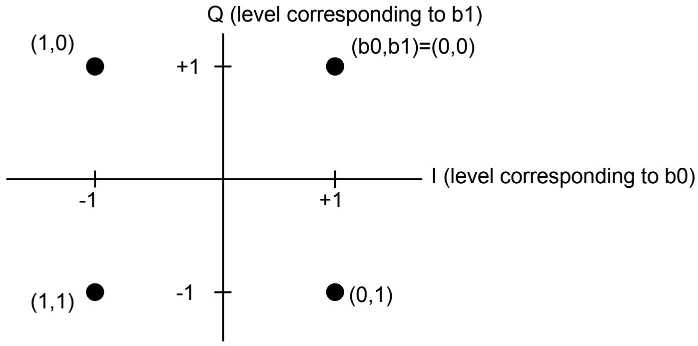


Fig. 3-14: QPSK Constellation

(Ordinance Annexed Table 10, Annexed Statement 1, Item 2)

3.9.3.3 16QAM

The input signal must be 4 bits per symbol and 16QAM-mapped to output multi-bit I- and Q-axes data.

To conduct mapping, the delay elements shown in Fig. 3-15 are inserted into b1 to b3 for bit interleaving.

Figs. 3-15 and 3-16 show the system diagram and mapping constellation, respectively.

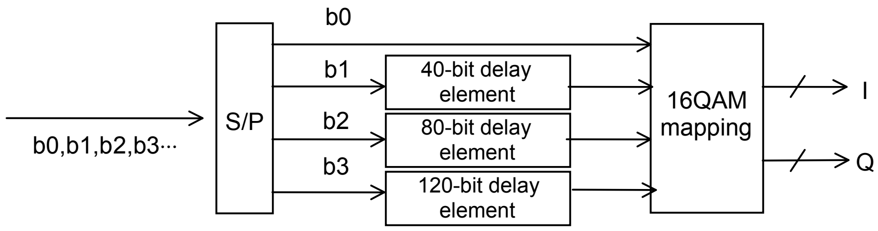


Fig. 3-15: 16QAM Modulation System Diagram

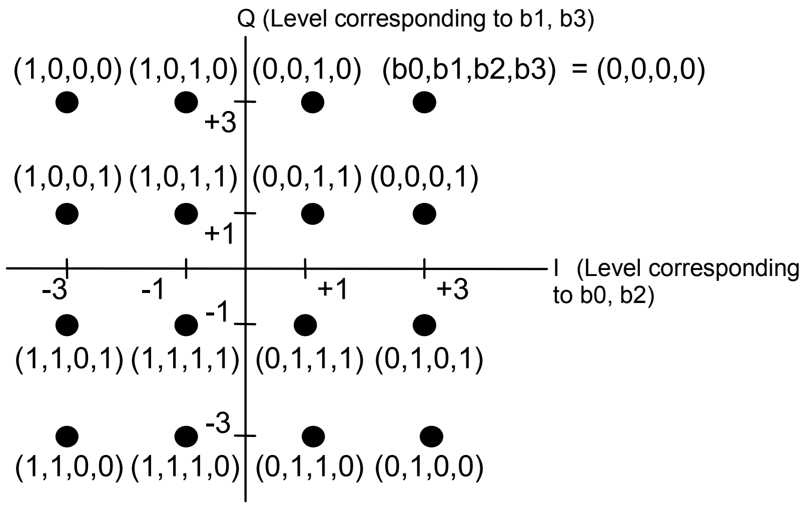


Fig. 3-16: 16QAM Constellation

(Ordinance Annexed Table 10, Annexed Statement 1, Item 3)

3.9.3.4 64QAM

The input signal must be 6 bits per symbol and 64QAM-mapped to output multi-bit I- and Q-axes data. To conduct mapping, the delay elements shown in Fig. 3-17 are inserted into b1 to b5 for bit interleaving.

Figs. 3-17 and 3-18 show the system diagram and mapping constellation, respectively.

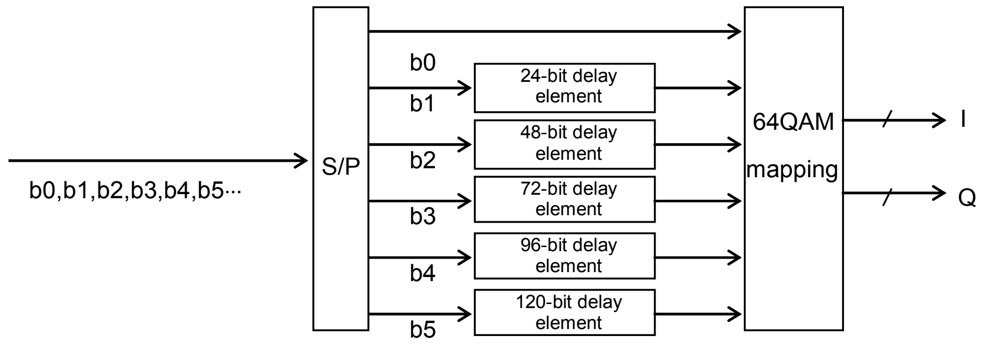


Fig. 3-17: 64QAM Modulation System Diagram

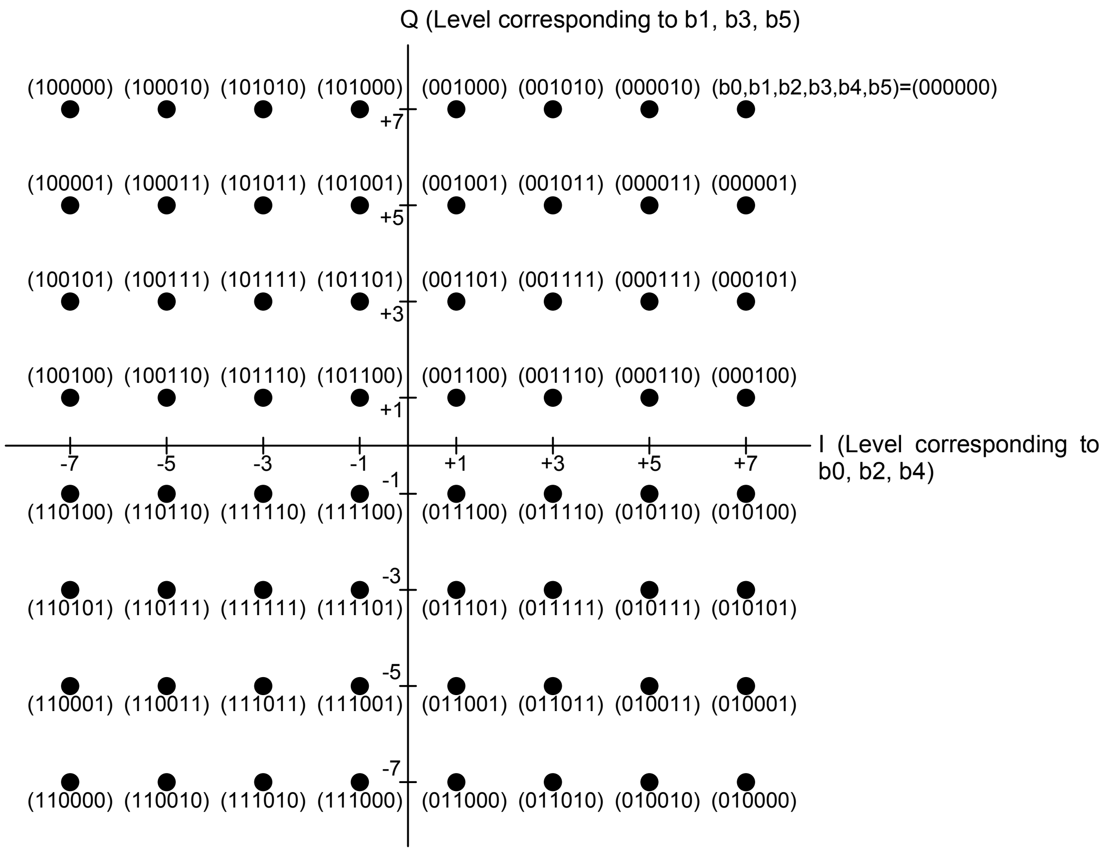


Fig. 3-18: 64QAM Constellation

(Ordinance Annexed Table 10, Annexed Statement 1, Item 4)

3.9.4 Modulation-level normalization

When we let the points in the constellations shown in Figs. 3-12, 3-14, 3-16, and 3-18 be expressed as Z (= I + jQ), the transmission-signal level must be normalized as shown in Table 3-7.

Table 3-7: Modulation Level Normalization

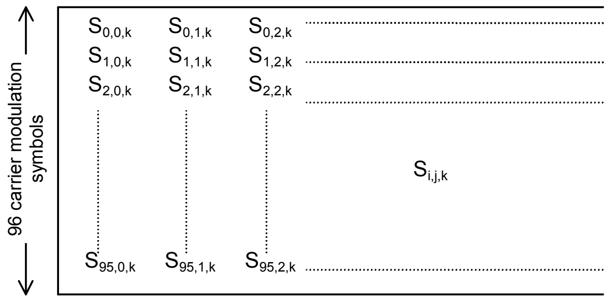
Carrier modulation scheme	Normalization factor
π/4-shift DQPSK	$Z/\sqrt{2}$
QPSK	$Z/\sqrt{2}$
16QAM	$Z/\sqrt{10}$
64QAM	$Z/\sqrt{42}$

(Ordinance Annexed Table 10, Annexed Statement 1, Note 4)

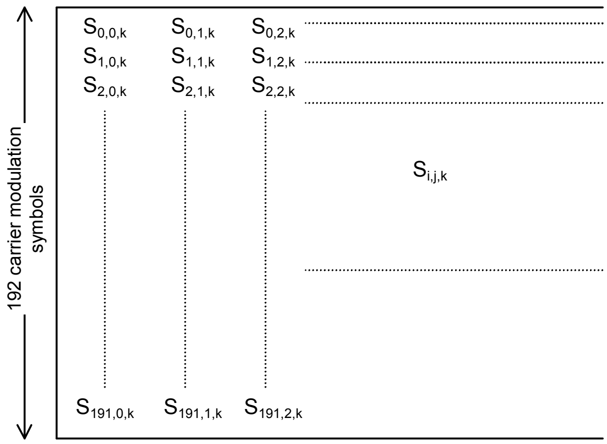
[Description]
This normalization is employed so that the average OFDM symbol power is kept constant regardless of which modulation scheme is used.

3.9.5 Data-segment configuration

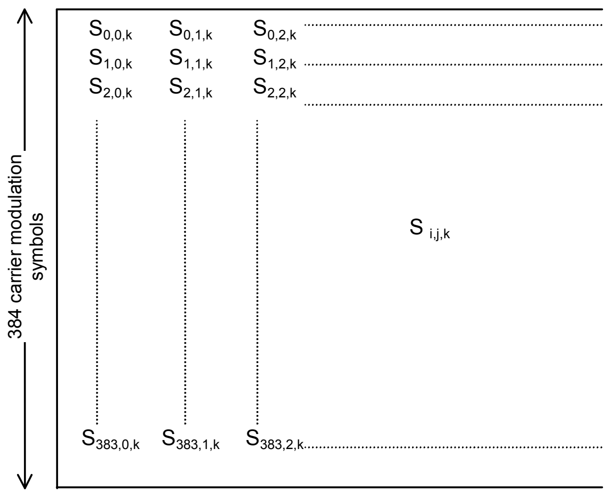
A data segment is equivalent to data part in an OFDM segment shown in Section 3.12. Data segments consist of 96, 192, and 384 carrier symbols in Modes 1, 2, and 3, respectively. Note that $S_{i,j,k}$ in the figure represents the kth segment carrier symbol. Note also that “i” must be equivalent to the carrier direction in the OFDM segment, while “j” must be equivalent to the symbol direction in the OFDM segment. Fig. 3-19 shows the data-segment configuration.



(a) Data-segment configuration in Mode 1



(b) Data-segment configuration in Mode 2



(c) Data-segment configuration in Mode 3

Fig. 3-19: Data-Segment Configurations

3.10 Combining hierarchical layers

Signals of different hierarchical layers, subjected to channel coding and carrier modulation by the specified parameters, must be combined and inserted into data segments and undergo speed conversion. Note that in the case of one-segment type, the signals undergo speed conversion only because they only consist of hierarchical layer A.

Fig. 3-20 shows the configuration of the hierarchical combiner.

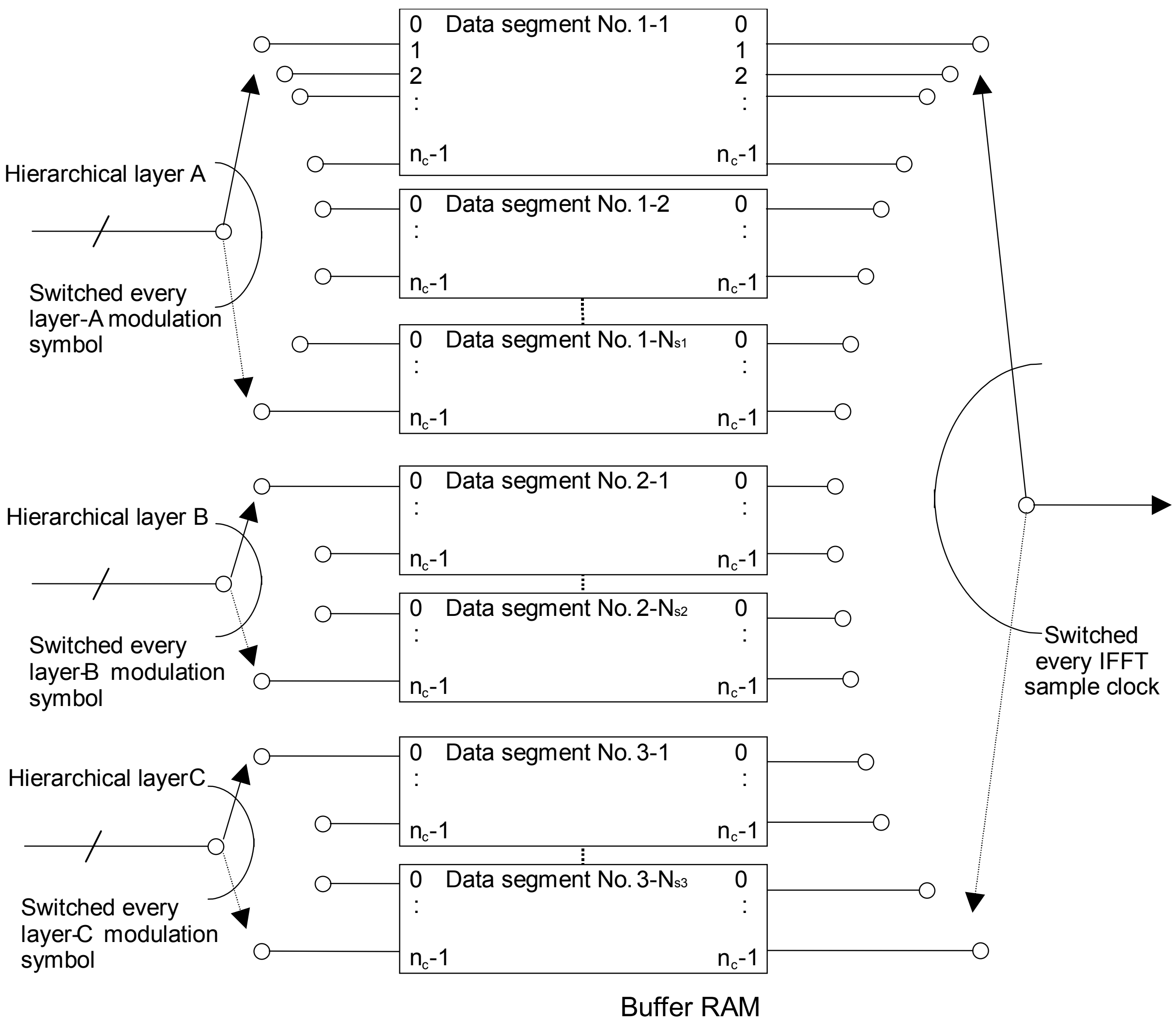


Fig. 3-20: Configuration of the Layer Combiner

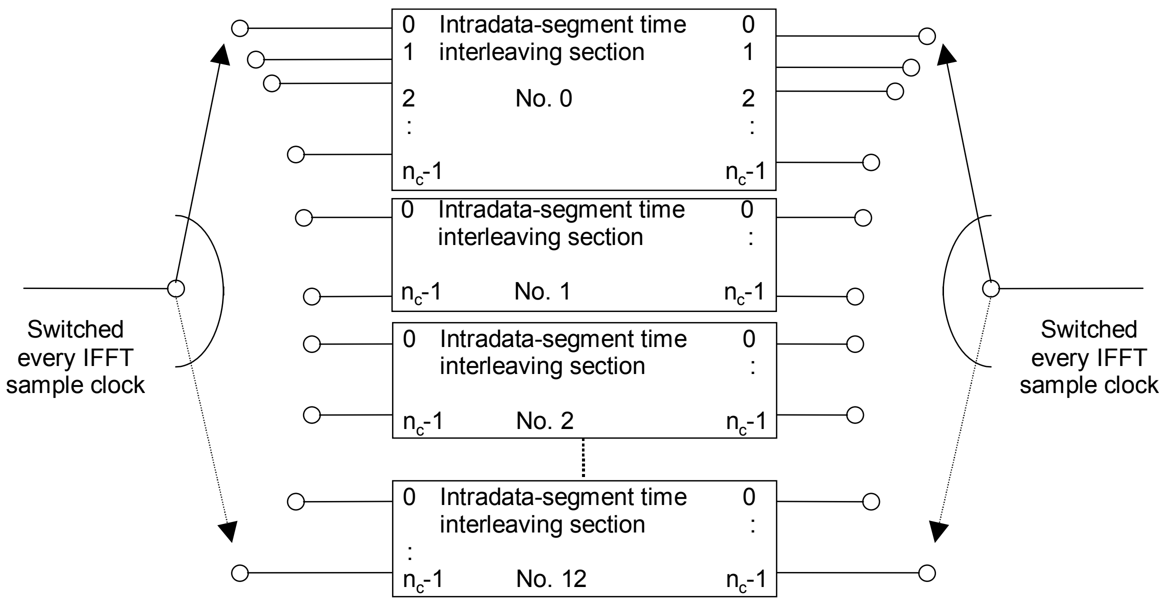
In the figure shown above, n_c is 96, 192, and 384 in Modes 1, 2, and 3, respectively. Note also that $N_{s1} + N_{s2} + N_{s3} = 13$.

(Ordinance Annexed Table 10, Annexed Statement 2)

3.11 Time and frequency interleaving

3.11.1 Time interleaving

Once signals of different hierarchical layers are combined, they must be time-interleaved in units of modulation symbols (for each of the I and Q axes), as shown in Fig. 3-21. Note that only segment No. 0 is time-interleaved in the case of a one-segment type.

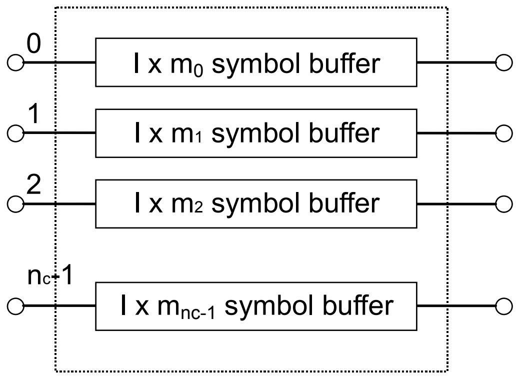


nc is 96, 192, and 384 in Modes 1, 2, and 3, respectively.

Fig. 3-21: Configuration of the Time Interleaving Section

(Notification No. 303, Annexed Table 2, Annexed Statement 1)

Fig. 3-22 shows the configuration of one of the intra-data segment time interleaving sections presented in Fig. 3-21. Note that "I" in the figure is a parameter related to interleaving length that can be specified for each hierarchical layer. This parameter is shown in Table 3-8.



Provided that m_i = (i × 5) mod 96, n_c is 96, 192, and 384 in Modes 1, 2, and 3, respectively.

Fig. 3-22: Configuration of the Intra-segment Time Interleaving Section

(Notification No. 303, Annexed Table 2, Annexed Statement 2)

The time interleaving length must be specified as I for each hierarchical layer, independently of other layers. The resulting difference in delay time must be corrected on the transmitting side using the number of symbols or the delay appropriate for each layer shown in Table 3-8, such that the total number of transmission and reception delays is a multiple of the number of frames.

Table 3-8: Time Interleaving Lengths and Delay Adjustment Values

Mode 1			Mode 2			Mode 3		
Length (I)	Number of delay-adjustment symbols	Number of delayed frames in transmission and reception	Length (I)	Number of delay-adjustment symbols	Number of delayed frames in transmission and reception	Length (I)	Number of delay-adjustment symbols	Number of delayed frames in transmission and reception
0	0	0	0	0	0	0	0	0
4	28	2	2	14	1	1	109	1
8	56	4	4	28	2	2	14	1
16	112	8	8	56	4	4	28	2

(Notification No. 303, Annexed Table 2, Annexed Statement 3(2))

Note that this delay adjustment must be conducted on signals prior to time interleaving.

[Description]

The number of transmission and reception delay frames that are time interleaved after delay adjustment is shown in Table 3-8 for each hierarchical layer. The same applies to a single hierarchical layer.

Time interleaving is conducted, intending to ensure improved capability against fading interference by dispersing the adjacent data after modulation in terms of time. This allows the improvement in mobile reception capability or in stationary reception capability under the flutter fading condition.

Furthermore, making the interleaving length addressable on a hierarchical layer basis enables one to specify the optimal interleaving length for each channel if each layer is intended for a different channel, namely, a form of reception that differs from that of other channels.

The purpose of using convolutional interleaving as the time interleaving method is to reduce the total transmission and reception delay time and to decrease the amount of memory taken up.

3.11.2 Frequency interleaving

Fig. 3-23 shows the configuration of the frequency interleaving section.

During segment division, data-segment numbers 0 to 12 are assigned sequentially to the partial-reception portion, differential modulations (segments for which DQPSK is specified for modulating carriers), and coherent modulation (segments for which QPSK, 16QAM, or 64QAM is specified for modulating carriers).

As for the relationship between the hierarchical configuration and data segments, data segments of the same hierarchical level must be successively arranged, and hierarchical layers must be named layer A, B, and C sequentially, in ascending order of data-segment number (that is, from smaller to larger segment numbers).

Inter-segment interleaving must be conducted on two or more data segments when they belong to the same type of modulated portion, even if their hierarchical levels differ.

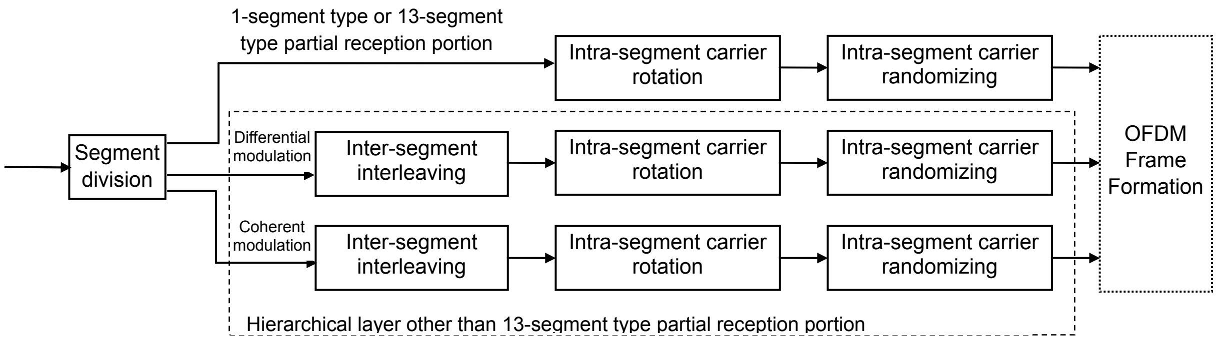


Fig. 3-23: Configuration of the Frequency Interleaving Section

(Notification No. 303, Annexed Table 2, Annexed Statement 4)

[Description]
Inter-segment interleaving is not conducted on the partial-reception portion, as it is assumed that the receiver designed to receive only that segment will be used.

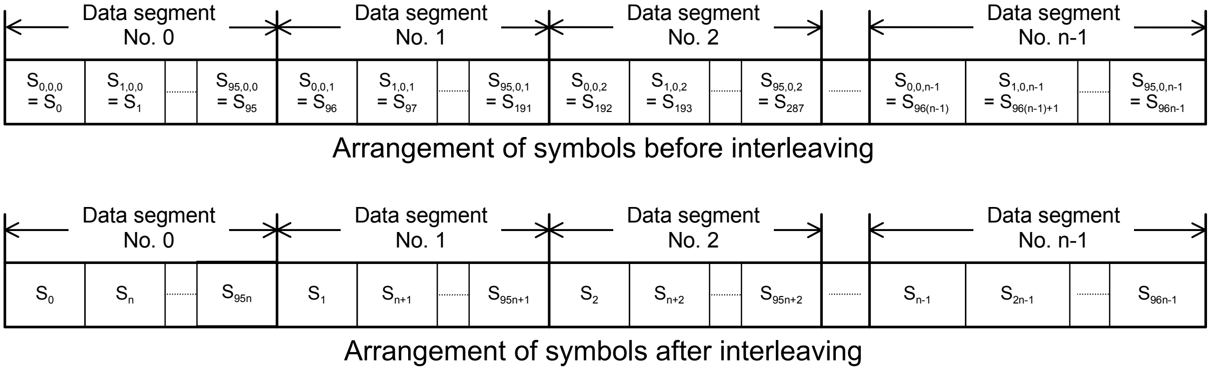
Note also that because the differential and coherent modulations differ in terms of frame structure, as shown in Section 3-12 ("Frame structure"), inter-segment interleaving is performed in each group.

Inter-segment interleaving conducted across layer boundaries is intended to maximize the frequency interleaving effect.

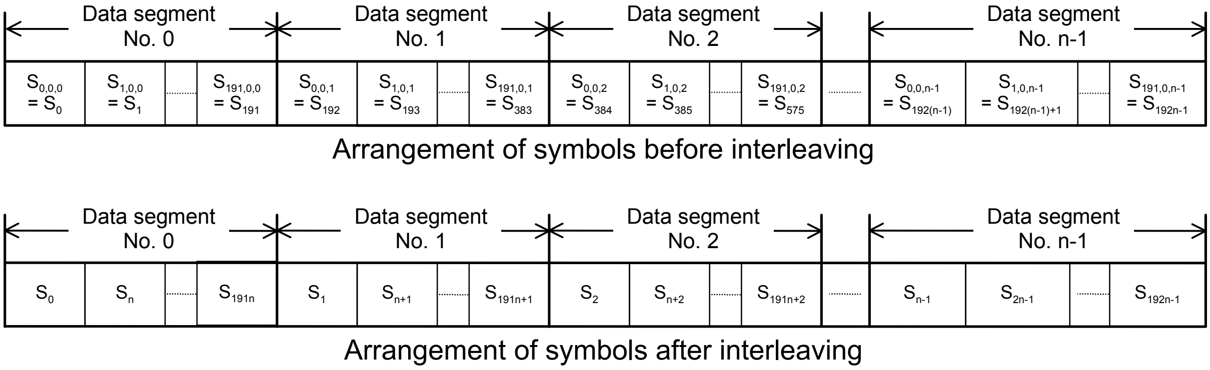
3.11.2.1 Inter-segment interleaving

In the case of 13-segment type, inter-segment interleaving must be conducted on each of the differential modulation (DQPSK) and coherent modulation (QPSK, 16QAM, 64QAM), as shown in Figs. 3-24 (a), 3-24 (b), and 3-24 (c).

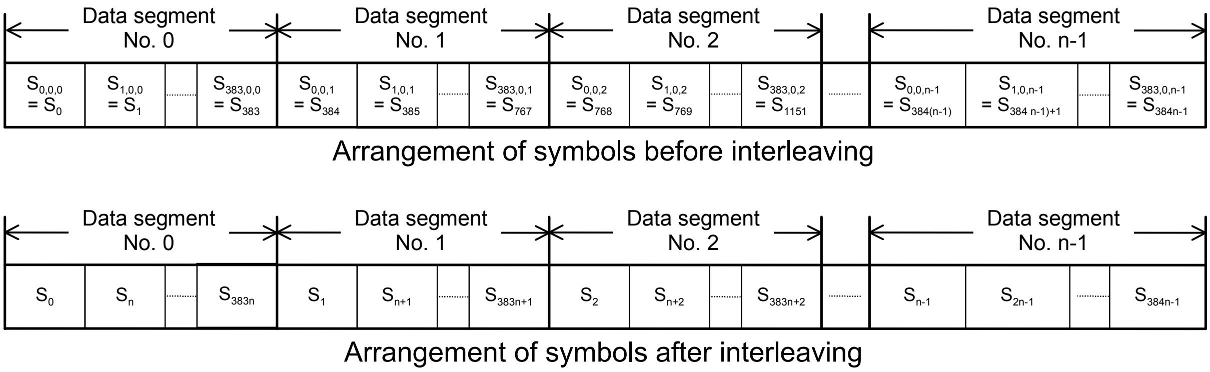
Note that Si,j,k, and n in the figures represent carrier symbols in the data-segment configuration (Fig. 3-19) and the number of segments assigned to the differential and coherent modulation, respectively.



(a) Mode 1



(b) Mode 2



(c) Mode 3

Fig. 3-24: Inter-segment Interleaving

(Notification No. 303, Annexed Table 2, Annexed Statement 5)

3.11.2.2 Intra-segment interleaving

Carrier rotation is conducted in obedience to the segment number for each segment as shown in Fig. 3-25 (a), (b), and (c), which is followed by carrier randomizing as shown in Table 3-9 (a), (b), and (c). Here, $S'_{i,j,k}$ represents the carrier symbol of the kth segment following inter-segment interleaving.

Note that no carrier rotation is needed for one-segment types because k = 0.

The number in the table represents the carrier number within the segment after carrier rotation. The data of the carrier with its value indicated in “before” of the table is available as the data of the carrier indicated in “after” as a result of the carrier randomizing within the segment.

S'0,0,k	S'1,0,k	S'2,0,k	···	S'95,0,k
		↓		
S'(k mod 96),0,k	S'(k+1 mod 96),0,k	S'(k+2 mod 96),0,k	···	S'(k+95 mod 96),0,k

(a) Mode 1

S'0,0,k	S'1,0,k	S'2,0,k	···	S'191,0,k
		↓		
S'(k mod 192),0,k	S'(k+1 mod 192),0,k	S'(k+2 mod 192),0,k	···	S'(k+191 mod 192),0,k

(b) Mode 2

S'0,0,k	S'1,0,k	S'2,0,k	···	S'383,0,k
		↓		
S'(k mod 384),0,k	S'(k+1 mod 384),0,k	S'(k+2 mod 384),0,k	···	S'(k+383 mod 384),0,k

(c) Mode 3

Fig. 3-25: Carrier Rotation

(Notification No. 303, Annexed Table 2, Annexed Statement 6)

Next, carrier randomizing in Mode 1, 2, and 3 is shown in Table 3-9 (a), (b), and (c), respectively.

These tables show which carriers are assigned, as a result of carrier randomizing, to carrier-rotated data arranged in ascending order of carrier number.

Table 3-9: Intra-Segment Carrier Randomizing

(a) Mode 1

Before	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
After	80	93	63	92	94	55	17	81	6	51	9	85	89	65	52	15	73	66	46	71	12	70	18	13

Before	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
After	95	34	1	38	78	59	91	64	0	28	11	4	45	35	16	7	48	22	23	77	56	19	8	36

Before	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
After	39	61	21	3	26	69	67	20	74	86	72	25	31	5	49	42	54	87	43	60	29	2	76	84

Before	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
After	83	40	14	79	27	57	44	37	30	68	47	88	75	41	90	10	33	32	62	50	58	82	53	24

(b) Mode 2

Before	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
After	98	35	67	116	135	17	5	93	73	168	54	143	43	74	165	48	37	69	154	150	107	76	176	79

Before	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
After	175	36	28	78	47	128	94	163	184	72	142	2	86	14	130	151	114	68	46	183	122	112	180	42

Before	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
After	105	97	33	134	177	84	170	45	187	38	167	10	189	51	117	156	161	25	89	125	139	24	19	57

Before	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
After	71	39	77	191	88	85	0	162	181	113	140	61	75	82	101	174	118	20	136	3	121	190	120	92

Before	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
After	160	52	153	127	65	60	133	147	131	87	22	58	100	111	141	83	49	132	12	155	146	102	164	66

Before	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
After	1	62	178	15	182	96	80	119	23	6	166	56	99	123	138	137	21	145	185	18	70	129	95	90

Before	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167
After	149	109	124	50	11	152	4	31	172	40	13	32	55	159	41	8	7	144	16	26	173	81	44	103

Before	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
After	64	9	30	157	126	179	148	63	188	171	106	104	158	115	34	186	29	108	53	91	169	110	27	59

(Notification No. 303, Annexed Table 2, Annexed Statement 7)

(c) Mode 3

Before	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
After	62	13	371	11	285	336	365	220	226	92	56	46	120	175	298	352	172	235	53	164	368	187	125	82

Before	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
After	5	45	173	258	135	182	141	273	126	264	286	88	233	61	249	367	310	179	155	57	123	208	14	227

Before	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
After	100	311	205	79	184	185	328	77	115	277	112	20	199	178	143	152	215	204	139	234	358	192	309	183

Before	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
After	81	129	256	314	101	43	97	324	142	157	90	214	102	29	303	363	261	31	22	52	305	301	293	177

Before	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
After	116	296	85	196	191	114	58	198	16	167	145	119	245	113	295	193	232	17	108	283	246	64	237	189

Before	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
After	128	373	302	320	239	335	356	39	347	351	73	158	276	243	99	38	287	3	330	153	315	117	289	213

Before	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167
After	210	149	383	337	339	151	241	321	217	30	334	161	322	49	176	359	12	346	60	28	229	265	288	225

Before	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
After	382	59	181	170	319	341	86	251	133	344	361	109	44	369	268	257	323	55	317	381	121	360	260	275

Before	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215
After	190	19	63	18	248	9	240	211	150	230	332	231	71	255	350	355	83	87	154	218	138	269	348	130

Before	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
After	160	278	377	216	236	308	223	254	25	98	300	201	137	219	36	325	124	66	353	169	21	35	107	50

Before	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263
After	106	333	326	262	252	271	263	372	136	0	366	206	159	122	188	6	284	96	26	200	197	186	345	340

Before	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287
After	349	103	84	228	212	2	67	318	1	74	342	166	194	33	68	267	111	118	140	195	105	202	291	259

Before	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311
After	23	171	65	281	24	165	8	94	222	331	34	238	364	376	266	89	80	253	163	280	247	4	362	379

Before	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335
After	290	279	54	78	180	72	316	282	131	207	343	370	306	221	132	7	148	299	168	224	48	47	357	313

Before	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359
After	75	104	70	147	40	110	374	69	146	37	375	354	174	41	32	304	307	312	15	272	134	242	203	209

Before	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383
After	380	162	297	327	10	93	42	250	156	338	292	144	378	294	329	127	270	76	95	91	244	274	27	51

(Notification No. 303, Annexed Table 2, Annexed Statement 7)

[Description]

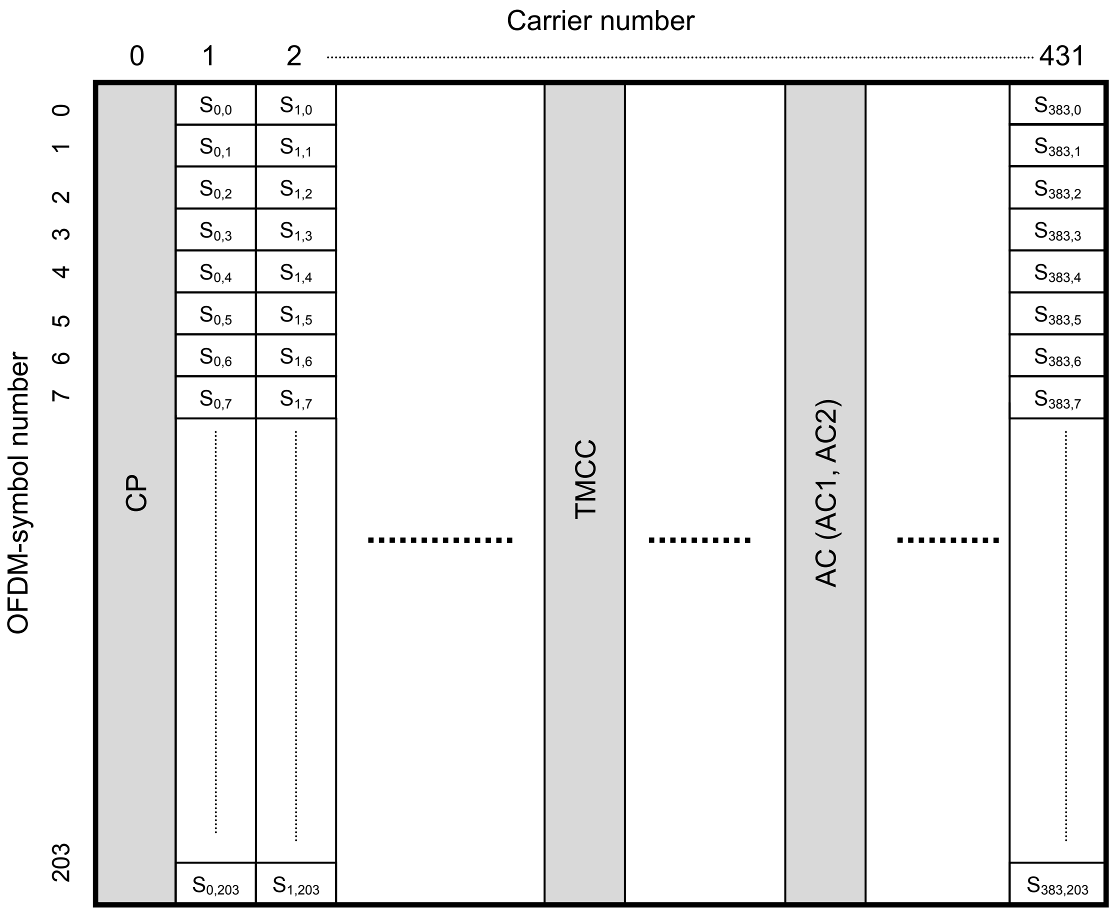
Carrier rotation and carrier randomizing are intended to eliminate periodicity in carrier arrangement. These operations make it possible to prevent burst errors of a specific segment's carrier, which may occur if the carrier arrangement period matches the frequency-selective fading after inter-segment interleaving.

3.12 Frame structure

All data-processing tasks in data segments required for channel coding are complete when the steps discussed up to Section 3.11 are performed. This section stipulates OFDM-frame structure achieved through the addition of various pilot signals to data segments.

3.12.1 OFDM-segment configuration for the differential modulation

Fig. 3-26 shows the OFDM-segment configuration for a differential modulation (DQPSK) (Mode 3).



(Ordinance Annexed Table 7, Item 1)

Fig. 3-26: OFDM-Segment Configuration for the Differential Modulation

Note, however, that $S_{i,j}$ represents carrier symbols within data segments following interleaving.

Note also that the CP (Continual Pilot), the TMCC (Transmission and Multiplexing Configuration Control), and the AC (Auxiliary Channel) are the continuous carrier, the signal for conveying control information, and the extension signal for conveying additional information, respectively.

In Mode 1, carrier numbers 0 to 107 are available, while in Modes 2 and 3, carrier numbers 0 to 215 and 0 to 431 are assigned, respectively.

The arrangement of various control signals (represented by carrier numbers) that are added by the OFDM-frame structure section in each mode is shown in Tables 3-10 (a), (b), and (c). Note that in the case of one-segment types, the segment number is 0.

Table 3-10: Arrangement of the CP, TMCC, and AC Carriers for the Differential Modulation

(a) Arrangement of the CP, AC, and TMCC Carriers in Mode 1

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
CP	0	0	0	0	0	0	0	0	0	0	0	0	0
AC1_ 1	10	53	61	11	20	74	35	76	4	40	8	7	98
AC1_ 2	28	83	100	101	40	100	79	97	89	89	64	89	101
AC2_ 1	3	3	29	28	23	30	3	5	13	72	36	25	10
AC2_ 2	45	15	41	45	63	81	72	18	93	95	48	30	30
AC2_ 3	59	40	84	81	85	92	85	57	98	100	52	42	55
AC2_ 4	77	58	93	91	105	103	89	92	102	105	74	104	81
TMCC 1	13	25	4	36	10	7	49	31	16	5	78	34	23
TMCC 2	50	63	7	48	28	25	61	39	30	10	82	48	37
TMCC 3	70	73	17	55	44	47	96	47	37	21	85	54	51
TMCC 4	83	80	51	59	47	60	99	65	74	44	98	70	68
TMCC 5	87	93	71	86	54	87	104	72	83	61	102	101	105

Segment numbers are arranged in ascending order of frequency along the frequency axis (see Section 3.14).

(Notification No. 303, Annexed Table 1, Annexed Statement 1)

(b) Arrangement of the CP, AC, and TMCC Carriers in Mode 2

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
CP	0	0	0	0	0	0	0	0	0	0	0	0	0
AC1_ 1	10	61	20	35	4	8	98	53	11	74	76	40	7
AC1_ 2	28	100	40	79	89	64	101	83	101	100	97	89	89
AC1_ 3	161	119	182	184	148	115	118	169	128	143	112	116	206
AC1_ 4	191	209	208	205	197	197	136	208	148	187	197	172	209
AC2_ 1	3	29	23	3	13	36	10	3	28	30	5	72	25
AC2_ 2	45	41	63	72	93	48	30	15	45	81	18	95	30
AC2_ 3	59	84	85	85	98	52	55	40	81	92	57	100	42
AC2_ 4	77	93	105	89	102	74	81	58	91	103	92	105	104
AC2_ 5	108	108	108	108	108	108	108	108	108	108	108	108	108
AC2_ 6	111	136	138	113	180	133	111	137	131	111	121	144	118
AC2_ 7	123	153	189	126	203	138	153	149	171	180	201	156	138
AC2_ 8	148	189	200	165	208	150	167	192	193	193	206	160	163
AC2_ 9	166	199	211	200	213	212	185	201	213	197	210	182	189
TMCC 1	13	4	10	49	16	78	23	25	36	7	31	5	34
TMCC 2	50	7	28	61	30	82	37	63	48	25	39	10	48
TMCC 3	70	17	44	96	37	85	51	73	55	47	47	21	54
TMCC 4	83	51	47	99	74	98	68	80	59	60	65	44	70
TMCC 5	87	71	54	104	83	102	105	93	86	87	72	61	101
TMCC 6	133	144	115	139	113	142	121	112	118	157	124	186	131
TMCC 7	171	156	133	147	118	156	158	115	136	169	138	190	145
TMCC 8	181	163	155	155	129	162	178	125	152	204	145	193	159
TMCC 9	188	167	168	173	152	178	191	159	155	207	182	206	176
TMCC 10	201	194	195	180	169	209	195	179	162	212	191	210	213

(Notification No. 303, Annexed Table 1, Annexed Statement 2)

(c) Arrangement of the CP, AC, and TMCC Carriers in Mode 3

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
CP	0	0	0	0	0	0	0	0	0	0	0	0	0
AC1_ 1	10	20	4	98	11	76	7	61	35	8	53	74	40
AC1_ 2	28	40	89	101	101	97	89	100	79	64	83	100	89
AC1_ 3	161	182	148	118	128	112	206	119	184	115	169	143	116
AC1_ 4	191	208	197	136	148	197	209	209	205	197	208	187	172
AC1_ 5	277	251	224	269	290	256	226	236	220	314	227	292	223
AC1_ 6	316	295	280	299	316	305	244	256	305	317	317	313	305
AC1_ 7	335	400	331	385	359	332	377	398	364	334	344	328	422
AC1_ 8	425	421	413	424	403	388	407	424	413	352	364	413	425
AC2_ 1	3	23	13	10	28	5	25	29	3	36	3	30	72
AC2_ 2	45	63	93	30	45	18	30	41	72	48	15	81	95
AC2_ 3	59	85	98	55	81	57	42	84	85	52	40	92	100
AC2_ 4	77	105	102	81	91	92	104	93	89	74	58	103	105
AC2_ 5	108	108	108	108	108	108	108	108	108	108	108	108	108
AC2_ 6	111	138	180	111	131	121	118	136	113	133	137	111	144
AC2_ 7	123	189	203	153	171	201	138	153	126	138	149	180	156
AC2_ 8	148	200	208	167	193	206	163	189	165	150	192	193	160
AC2_ 9	166	211	213	185	213	210	189	199	200	212	201	197	182
AC2_ 10	216	216	216	216	216	216	216	216	216	216	216	216	216
AC2_ 11	245	219	252	219	246	288	219	239	229	226	244	221	241
AC2_ 12	257	288	264	231	297	311	261	279	309	246	261	234	246
AC2_ 13	300	301	268	256	308	316	275	301	314	271	297	273	258
AC2_ 14	309	305	290	274	319	321	293	321	318	297	307	308	320
AC2_ 15	324	324	324	324	324	324	324	324	324	324	324	324	324
AC2_ 16	352	329	349	353	327	360	327	354	396	327	347	337	334
AC2_ 17	369	342	354	365	396	372	339	405	419	369	387	417	354
AC2_ 18	405	381	366	408	409	376	364	416	424	383	409	422	379
AC2_ 19	415	416	428	417	413	398	382	427	429	401	429	426	405
TMCC 1	13	10	16	23	36	31	34	4	49	78	25	7	5
TMCC 2	50	28	30	37	48	39	48	7	61	82	63	25	10
TMCC 3	70	44	37	51	55	47	54	17	96	85	73	47	21
TMCC 4	83	47	74	68	59	65	70	51	99	98	80	60	44
TMCC 5	87	54	83	105	86	72	101	71	104	102	93	87	61
TMCC 6	133	115	113	121	118	124	131	144	139	142	112	157	186
TMCC 7	171	133	118	158	136	138	145	156	147	156	115	169	190
TMCC 8	181	155	129	178	152	145	159	163	155	162	125	204	193
TMCC 9	188	168	152	191	155	182	176	167	173	178	159	207	206
TMCC 10	201	195	169	195	162	191	213	194	180	209	179	212	210
TMCC 11	220	265	294	241	223	221	229	226	232	239	252	247	250
TMCC 12	223	277	298	279	241	226	266	244	246	253	264	255	264
TMCC 13	233	312	301	289	263	237	286	260	253	267	271	263	270
TMCC 14	267	315	314	296	276	260	299	263	290	284	275	281	286
TMCC 15	287	320	318	309	303	277	303	270	299	321	302	288	317
TMCC 16	360	355	358	328	373	402	349	331	329	337	334	340	347
TMCC 17	372	363	372	331	385	406	387	349	334	374	352	354	361
TMCC 18	379	371	378	341	420	409	397	371	345	394	368	361	375
TMCC 19	383	389	394	375	423	422	404	384	368	407	371	398	392
TMCC 20	410	396	425	395	428	426	417	411	385	411	378	407	429

(Notification No. 303, Annexed Table 1, Annexed Statement 3)

The CP of a differential modulation's segment serves as the SP of a coherent modulation's segment when the differential modulation's segment at the lowermost frequency is adjacent to one of the coherent modulation's segments. The CP is thus provided at this low-frequency end. The receiver uses this CP as the high-frequency end SP for coherent detection in the coherent modulation's segment.

The TMCC and AC (AC1, AC2) carriers are arranged randomly with respect to the frequency in order to reduce the degradation caused by periodic dips on channel characteristics under multi-path environment.

Note that AC1 carriers for the differential modulation's segments are arranged at the same positions as those for the coherent modulation's segments.

3.12.2 OFDM-segment configuration for the coherent modulation

Fig. 3-27 shows an example of OFDM-segment configuration for a coherent modulation (QPSK, 16QAM, 64QAM) in Mode 3. $S_{i,j}$ represents carrier symbols within data segments following interleaving.

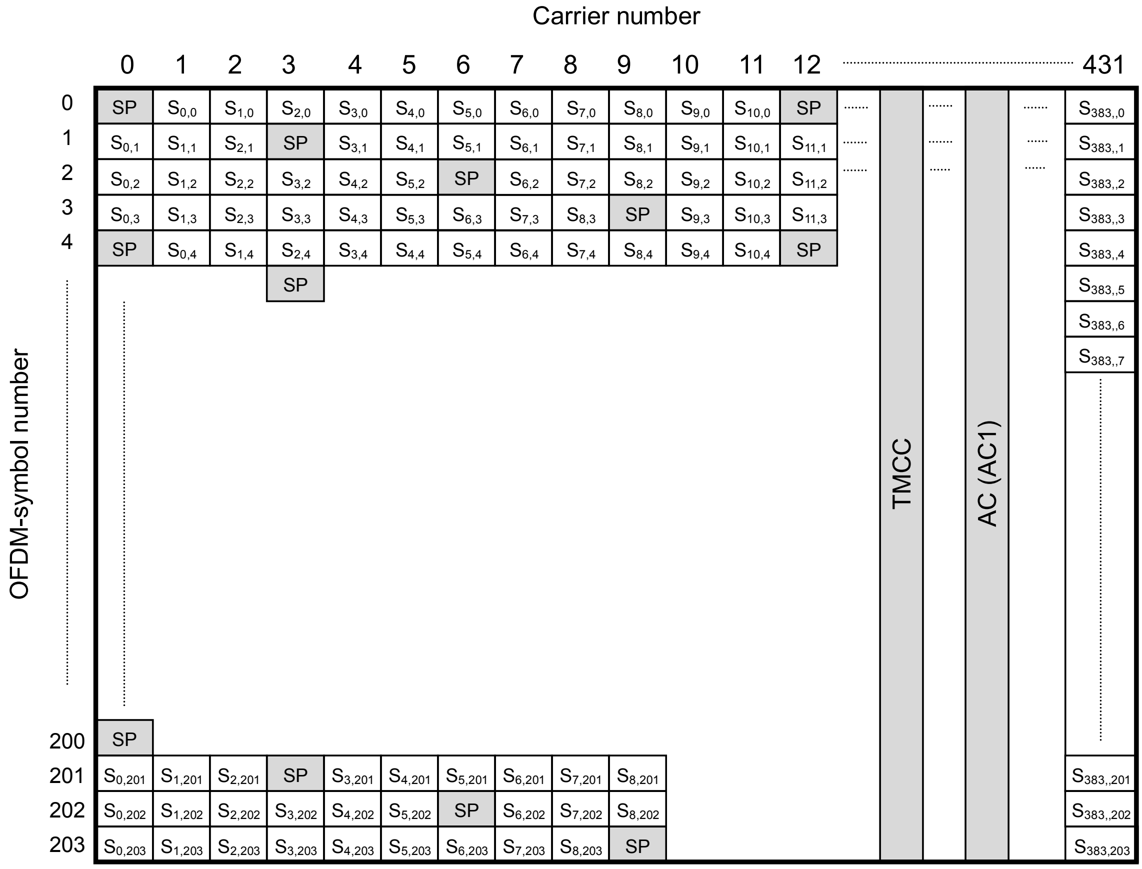


Fig. 3-27: OFDM-Segment Configuration for the Coherent Modulation

(Ordinance Annexed Table 7, Item 2)

The SP (Scattered Pilot) is inserted into a segment once every 12 carriers in the carrier direction, and once every 4 symbols in the symbol direction, as shown in the figure. Table 3-11 shows the AC and TMCC carrier arrangements. In the case of one-segment-type, AC and TMCC carrier arrangement of segment No.0 must be applied.

The AC1 carrier arrangement for the coherent modulation is the same as that for the differential modulation. Note that AC2 is available only for the differential modulation. Therefore, the coherent modulation does not have any AC2.

Table 3-11: AC and TMCC Carrier Arrangements for the Coherent modulation

(a) AC and TMCC Carrier Arrangements in Mode 1

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
AC1_ 1	10	53	61	11	20	74	35	76	4	40	8	7	98
AC1_ 2	28	83	100	101	40	100	79	97	89	89	64	89	101
TMCC 1	70	25	17	86	44	47	49	31	83	61	85	101	23

(b) AC and TMCC Carrier Arrangements in Mode 2

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
AC1_ 1	10	61	20	35	4	8	98	53	11	74	76	40	7
AC1_ 2	28	100	40	79	89	64	101	83	101	100	97	89	89
AC1_ 3	161	119	182	184	148	115	118	169	128	143	112	116	206
AC1_ 4	191	209	208	205	197	197	136	208	148	187	197	172	209
TMCC 1	70	17	44	49	83	85	23	25	86	47	31	61	101
TMCC 2	133	194	155	139	169	209	178	125	152	157	191	193	131

(c) AC and TMCC Carrier Arrangements in Mode 3

Segment No.	11	9	7	5	3	1	0	2	4	6	8	10	12
AC1_ 1	10	20	4	98	11	76	7	61	35	8	53	74	40
AC1_ 2	28	40	89	101	101	97	89	100	79	64	83	100	89
AC1_ 3	161	182	148	118	128	112	206	119	184	115	169	143	116
AC1_ 4	191	208	197	136	148	197	209	209	205	197	208	187	172
AC1_ 5	277	251	224	269	290	256	226	236	220	314	227	292	223
AC1_ 6	316	295	280	299	316	305	244	256	305	317	317	313	305
AC1_ 7	335	400	331	385	359	332	377	398	364	334	344	328	422
AC1_ 8	425	421	413	424	403	388	407	424	413	352	364	413	425
TMCC 1	70	44	83	23	86	31	101	17	49	85	25	47	61
TMCC 2	133	155	169	178	152	191	131	194	139	209	125	157	193
TMCC 3	233	265	301	241	263	277	286	260	299	239	302	247	317
TMCC 4	410	355	425	341	373	409	349	371	385	394	368	407	347

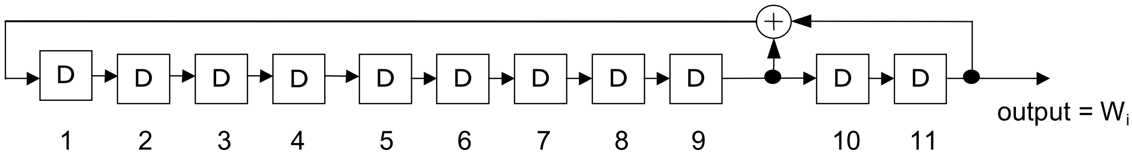
(Notification No. 303, Annexed Table 1, Annexed Statement 4, 5, and 6)

The TMCC and AC (AC1) carriers are arranged randomly with respect to the frequency direction in order to reduce the periodic impact of dip on channel characteristics caused by multipath. Note that AC1 carriers for the differential modulation's segments are arranged at the same positions as those for the coherent modulation's segments.

3.13 Pilot signal

3.13.1 Scattered pilot (SP)

Scattered pilot is a pilot symbol which have BPSK modulation constellation corresponding to the output bit W_i of PRBS (pseudo-random binary sequence) generated by Fig. 3-28, where the i of W_i corresponds to the carrier number i of the OFDM segment. The correspondence between W_i and the modulating signal is presented in Table 3-12.



$$g(x)=X^{11} + X^{9} + 1$$

Fig. 3-28: PRBS-Generating Circuit

Table 3-12: Modulating Signal and W_i

W_i value	Modulating-signal amplitude (I, Q)
1	(-4/3, 0)
0	(+4/3, 0)

(Ordinance Annexed Table 14, Item 1, 2)

3.13.1.1 Initial value of the PRBS-Generating circuit (13-Segment Type)

The initial value of the PRBS-generating circuit is defined on a segment basis. The initial values for 13-segment type are shown in Table 3-13.

Table 3-13: Initial Value of the PRBS-Generating Circuit
(Arranged in Ascending Order of Bits from Left to Right) (13-Segment Type)

Segment No.	Initial value in Mode 1	Initial value in Mode 2	Initial value in Mode 3
11	1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1
9	1 1 0 1 1 0 0 1 1 1 1	0 1 1 0 1 0 1 1 1 1 0	1 1 0 1 1 1 0 0 1 0 1
7	0 1 1 0 1 0 1 1 1 1 0	1 1 0 1 1 1 0 0 1 0 1	1 0 0 1 0 1 0 0 0 0 0
5	0 1 0 0 0 1 0 1 1 1 0	1 1 0 0 1 0 0 0 0 1 0	0 1 1 1 0 0 0 1 0 0 1
3	1 1 0 1 1 1 0 0 1 0 1	1 0 0 1 0 1 0 0 0 0 0	0 0 1 0 0 0 1 1 0 0 1
1	0 0 1 0 1 1 1 1 0 1 0	0 0 0 0 1 0 1 1 0 0 0	1 1 1 0 0 1 1 0 1 1 0
0	1 1 0 0 1 0 0 0 0 1 0	0 1 1 1 0 0 0 1 0 0 1	0 0 1 0 0 0 0 1 0 1 1
2	0 0 0 1 0 0 0 0 1 0 0	0 0 0 0 0 1 0 0 1 0 0	1 1 1 0 0 1 1 1 1 0 1
4	1 0 0 1 0 1 0 0 0 0 0	0 0 1 0 0 0 1 1 0 0 1	0 1 1 0 1 0 1 0 0 1 1
6	1 1 1 1 0 1 1 0 0 0 0	0 1 1 0 0 1 1 1 0 0 1	1 0 1 1 1 0 1 0 0 1 0
8	0 0 0 0 1 0 1 1 0 0 0	1 1 1 0 0 1 1 0 1 1 0	0 1 1 0 0 0 1 0 0 1 0
10	1 0 1 0 0 1 0 0 1 1 1	0 0 1 0 1 0 1 0 0 0 1	1 1 1 1 0 1 0 0 1 0 1
12	0 1 1 1 0 0 0 1 0 0 1	0 0 1 0 0 0 0 1 0 1 1	0 0 0 1 0 0 1 1 1 0 0

Note: Each of the initial values shown in Table 3-13 matches the value obtained by setting all bits to an initial value of "1"s and continuously generating all carriers, starting with the leftmost carrier (carrier 0 of segment 11) and ending with the rightmost carrier.

(Ordinance Annexed Table 14, Item 1, Note 1 (2))

3.13.1.2 Initial Value of the PRBS-Generating Circuit (One-segment Type)

The initial value of the register for a one-segment type is defined depending on what position of the sub-channel number, which is assigned to the reference channel bandwidth according to each tuning step (1/3 of OFDM segment bandwidth), the relevant segment center frequency corresponds to. Fig. 3-29 shows an example of the definition of the sub-channel number and the relation between the sub-channel number and segment position. This figure shows an imaginary channel with a reference channel bandwidth of 6 MHz and a sub-channel bandwidth of 1/7 MHz. The one-segment with the center sub-channel number 22 is shown in the figure as an example. Sub-channel 21, 22, and 23 form one segment. Table 3-14 shows the correspondence in the case of one-segment type between the center sub-channel number in units of segment and the initial value of the register generating the W_i of the segment.

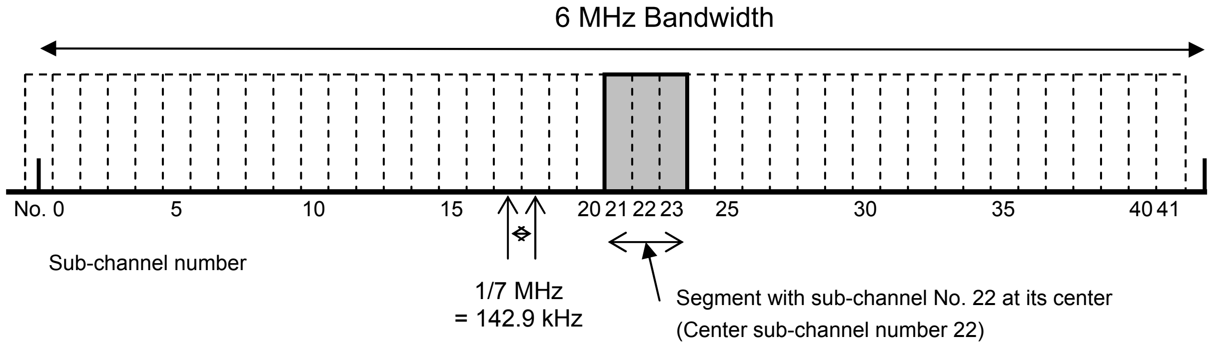


Fig. 3-29: Definition of Sub-channel Number and Relation Between Sub-channel Number and Segment

Table 3-14: Initial Value of PRBS Register (One-segment Type)

One-segment Center Sub-channel Number	Initial Value in Mode 1 D1 · · · · · · · · D11	Initial Value in Mode 2 D1 · · · · · · · · D11	Initial Value in Mode 3 D1 · · · · · · · · D11
41, 0, 1	1 1 1 0 0 1 0 0 1 0 1	0 0 0 1 1 0 1 1 1 1 0	1 1 1 0 0 0 1 1 1 0 1
2, 3, 4	1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1
5, 6, 7	1 1 0 1 1 0 0 1 1 1 1	0 1 1 0 1 0 1 1 1 1 0	1 1 0 1 1 1 0 0 1 0 1
8, 9, 10	0 1 1 0 1 0 1 1 1 1 0	1 1 0 1 1 1 0 0 1 0 1	1 0 0 1 0 1 0 0 0 0 0
11, 12, 13	0 1 0 0 0 1 0 1 1 1 0	1 1 0 0 1 0 0 0 0 1 0	0 1 1 1 0 0 0 1 0 0 1
14, 15, 16	1 1 0 1 1 1 0 0 1 0 1	1 0 0 1 0 1 0 0 0 0 0	0 0 1 0 0 0 1 1 0 0 1
17, 18, 19	0 0 1 0 1 1 1 1 0 1 0	0 0 0 0 1 0 1 1 0 0 0	1 1 1 0 0 1 1 0 1 1 0
20, 21, 22	1 1 0 0 1 0 0 0 0 1 0	0 1 1 1 0 0 0 1 0 0 1	0 0 1 0 0 0 0 1 0 1 1
23, 24, 25	0 0 0 1 0 0 0 0 1 0 0	0 0 0 0 0 1 0 0 1 0 0	1 1 1 0 0 1 1 1 1 0 1
26, 27, 28	1 0 0 1 0 1 0 0 0 0 0	0 0 1 0 0 0 1 1 0 0 1	0 1 1 0 1 0 1 0 0 1 1
29, 30, 31	1 1 1 1 0 1 1 0 0 0 0	0 1 1 0 0 1 1 1 0 0 1	1 0 1 1 1 0 1 0 0 1 0
32, 33, 34	0 0 0 0 1 0 1 1 0 0 0	1 1 1 0 0 1 1 0 1 1 0	0 1 1 0 0 0 1 0 0 1 0
35, 36, 37	1 0 1 0 0 1 0 0 1 1 1	0 0 1 0 1 0 1 0 0 0 1	1 1 1 1 0 1 0 0 1 0 1
38, 39, 40	0 1 1 1 0 0 0 1 0 0 1	0 0 1 0 0 0 0 1 0 1 1	0 0 0 1 0 0 1 1 1 0 0

(Ordinance Annexed Table 14, Item 1, Note 1 (1))

3.13.2 Continual pilot (CP)

As with the scattered pilot discussed in Section 3.13.1, continuous carrier is a BPSK signal modulated in accordance with the carrier position (carrier number within a segment) into which it is to be inserted, and also in accordance with the W_i value. The correspondence between W_i and the modulating signal is the same as that shown in Table 3-12. Note that the phase angle of CP determined with respect to carrier position is constant in every symbol.

3.13.3 TMCC

TMCC is transmitted by means of the DBPSK signal modulated in accordance with the information shown in Section 3.15. The reference for differential modulation B_0 is stipulated by Wi shown in Section 3.13.1. After differential coding, the TMCC modulating signal takes signal points (+4/3, 0) and (-4/3, 0) for information 0 and 1, respectively.

Information B'_0 to B'_{203} available following differential coding is stipulated in relation to information B_0 to B_{203} prior to differential coding, as follows:

$B'_0 = W_i$ (reference for differential modulation)

$B'_k = B'_{k-1} \oplus B_k$ (k = 1, 203, $\oplus$ represents EXCLUSIVE OR)

3.13.4 AC (Auxiliary Channel)

AC is a channel designed to convey additional information on broadcasting. The additional information on broadcasting refers to additional information on modulating signal-transmission control or information on seismic motion warning. AC is transmitted by means of modulating the pilot carrier of a type similar to CP through DBPSK, and its reference for differential modulation is provided at the top frame symbol, and takes the signal point with its value corresponding to W_i stipulated in Section 3.13.1.

The AC modulating signal takes signal points (+4/3, 0) and (-4/3, 0) for information 0 and 1, respectively, available following differential coding. If there is no additional information on broadcasting, information "1" is inserted as stuffing bits.

Two channels are available as ACs: AC1 channel with which the same carrier position is employed for all segments, regardless of which modulation scheme is used; and AC2 channel, which is provided in the differential modulation's segments.

Table 3-15 shows examples of the transmission capacity per segment. Note that the transmission capacity for all channels varies depending on the segment configuration.

Table 3-15: Examples of Transmission Capacities for AC Carriers
(Mode 3, Guard Interval Ratio of 1/4)

	Coherent modulation's segment		Differential modulation's segment	
Type	1 carrier	13 carriers	1 carrier	13 carriers
AC1	6.3 (kbps)	82.1 (kbps)	6.3 (kbps)	82.1 (kbps)
AC2	—	—	12.6 (kbps)	164.3 (kbps)

(without error-correction coding)

[Description]

It is intended that SP, CP, TMCC (reference for differential modulation), and AC (reference for differential modulation) randomize the carrier phase of each signal by means of modulating PRBS output bit sequence W_i through BPSK with the W_i corresponding to OFDM segment carrier number i.

AC (AC1) is also used for the effective utilization of pilot signals, that is, like TMCC, AC (AC1) is used for the transmission of additional information and seismic motion warning by modulation through DBPSK. AC has a feature of not causing delay due to time interleaving, thus ensuring extensibility so that it is available for new information transmission usage as a channel without delay.

Furthermore, the transmission of the segments in which the arrangement and phase pattern of SP, CP, etc., are equal at the time of connected transmission causes periodicity and an increase in peak level in OFDM signals, which lead to more stringent requirements for the interference of signals and the linearity of transmitters. In order to avoid this, reference signal carrier arrangements are intended to possess randomness in conformity to the system for digital terrestrial television broadcasting. As it is not known for receivers whether or not the transmission is connected one, Table 3-13 and Table 3-14 shall be followed for the relation between the segment number or sub-channel number and the initial values of W_i even in the event of 13-segment or one-segment independent transmission.

3.14 Transmission spectrum configuration

3.14.1 OFDM segment arrangement (13-segment type)

Fig. 3-30 stipulates the arrangement of OFDM segments for the 13-segment type. Segment No. 0 must be positioned at the center of the entire band, with successively numbered segments placed alternately above and below that segment. For hierarchical transmission, segments of the differential modulation must be assigned alternately above and below segment No. 0, in ascending order of segment number, with segments of the coherent modulation assigned alternately above and below segments of the differential modulation. ("Partial-reception portion," "Differential modulation portion," and "Coherent modulation portion" in the figure are merely examples of segment usage.) Note that, for hierarchical transmission, the segment position assigned to partial reception must be always No. 0.

Note also that, supposing that W_i is defined as the PRBS output bit (see Fig. 3-28) corresponding to the rightmost carrier of segment 12, the modulation signal of the uppermost continuous carrier is modulated through BPSK in accordance with the value of W_{r+1}. The modulating signal is shown in Table 3-12.

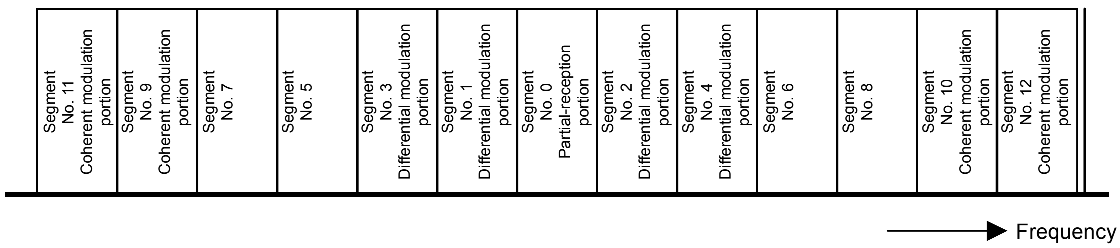


Fig. 3-30: OFDM-Segment Numbers on the Transmission Spectrum and Example of Usage (13-segment Type)

(Ordinance Annexed Table 25, Item 1)

The continuous carrier at the uppermost frequency of the bandwidth is the pilot carrier needed for demodulation when the adjacent segment is a coherent modulation, and this carrier is always provided with the system.

Table 3-16: Modulating Signal for the Rightmost Continuous Carrier

Mode	Modulating-signal amplitude (I, Q)
Mode 1	(-4/3, 0)
Mode 2	(+4/3, 0)
Mode 3	(+4/3, 0)

(Ordinance Annexed Table 14, Item 3)

3.14.2 OFDM segment arrangement (One-segment type)

Fig. 3-31 stipulates the arrangement of OFDM segments for one-segment type.

Supposing that W_r is defined as the PRBS output bit (refer to Fig. 3-28) corresponding to the rightmost carrier of segment 0 including the connected transmission, the modulating signal of the uppermost continuous carrier is modulated through BPSK in accordance with the value of $W_{r+1.}$ The modulating signal is shown in Table 3-12.

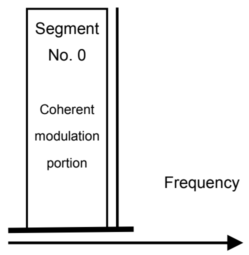


Fig. 3-31: OFDM Segment No. on Transmission Spectrum and Usage Example (One-segment Type)

3.14.3 Insertion of a guard interval

As shown in Fig. 3-32, a guard interval, the latter part of the IFFT data output for the specified duration equivalent to the length of guard interval, is added without any modification to the beginning of the effective symbol.

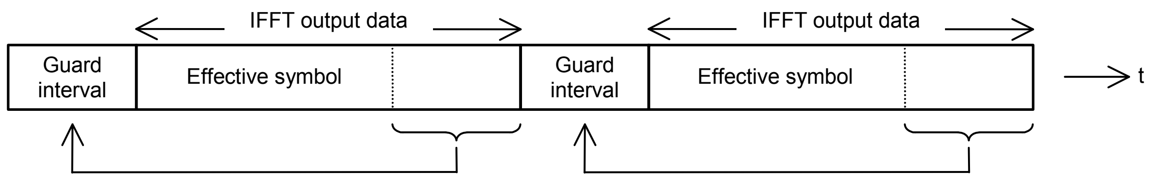


Fig. 3-32: Insertion of a Guard Interval

(Ordinance Annexed Table 5)

3.15 TMCC (Transmission and Multiplexing Configuration Control) signal

3.15.1 Bit assignment

Table 3-17 shows the assignment of 204 TMCC carrier bits B_0 to B_{203}.

Table 3-17: Bit Assignment

B_0	Reference signal for demodulation of TMCC Symbols
$B_1 – B_{16}$	Synchronizing signal (w0 = 0011010111101110, w1 = 1100101000010001)
$B_{17} – B_{19}$	Segment type identification (differential: 111;coherent: 000)
$B_{20} – B_{121}$	TMCC information (102 bits)
$B_{122} – B_{203}$	Parity bit

(Ordinance Annexed Table 11)

3.15.2 Reference signal for demodulation of TMCC symbols

The reference amplitude and phase of reference signal for demodulation of TMCC symbols is given by W_i in Section 3.13.1.

(Ordinance Annexed Table 11, Note 1)

3.15.3 Synchronizing signal

The synchronizing signal consists of a 16-bit word and takes one of two forms: one with w0 = $_{MSB}$0011010111101110$_{LSB}$ and the other with w1 = $_{MSB}$1100101000010001$_{LSB}$ obtained by inverting each bit of w0. One of w0 and w1 is transmitted alternately for each frame. The following Table 3-18 shows an example of synchronizing signal transmission:

Table 3-18: Example of Synchronizing Signal

Frame No.	Synchronizing signal
1	0011010111101110
2	1100101000010001
3	0011010111101110
4	1100101000010001
:	:

Note: Frame numbers are assigned for convenience of description.

(Ordinance Annexed Table 11, Note 2)

[Description]

A synchronizing signal is designed to indicate frame start and use for establishment of synchronization between transmission and reception of a TMCC signal and OFDM frame. A 16-bit pattern is used for the synchronizing signal, but the presence of the pattern in TMCC information identical to that of the synchronizing signal results in a false synchronization lock. To prevent this false synchronization lock, the synchronizing-signal polarity is inverted every frame. As TMCC information itself is not inverted every frame, it is possible to prevent false synchronization lock by means of protecting the synchronizing-signal for two frames.

3.15.4 Segment type identification

This signal is used to determine whether a segment is a differential or coherent modulation and consists of a 3-bit word. “111” and “000” are assigned to this signal for a differential and coherent modulation, respectively.

(Ordinance Annexed Table 11, Note 3)

3.15.5 TMCC information

The system identification, the indicator of transmission-parameter switching, the startup control signal (the start flag for emergency-alarm broadcasting), the current information, the next information, etc. are transmitted as TMCC information. The current information describes the current hierarchical configuration and transmission parameters, while the next information describes the transmission parameters and others following configuration switching.

The next information can be specified or changed at the desired time prior to the countdown starting. However, no changes can be made during countdown.

Tables 3-19 and 3-20 show the TMCC-information bit assignment and the transmission parameters, respectively.

Of the 102 bits of TMCC information, 90 bits have been defined as of today. The remaining 12 bits are reserved for future extension. All the reserved bits are stuffed with “1”s.

Note that for transmission parameter information for hierarchical layers B and C of one-segment-type, bits are secured in terms of bit assignment in order to maintain compatibility with 13-segment-type. Note also that, however, the information referring to unused hierarchical layers shall be assigned as mentioned later.

Table 3-19: TMCC Information

Bit assignment	Description		Remarks
B_{20} – B_{21}	System identification		See Table 3-21.
B_{22} – B_{25}	Indicator of transmission-parameter switching		See Table 3-22.
B_{26}	Startup control signal (Start flag for emergency-alarm broadcasting)		See Table 3-23.
B_{27}	Current information	Partial-reception flag	See Table 3-24.
B_{28} – B_{40}		Transmission-parameter information for hierarchical layer A	See Table 3-20.
B_{41} – B_{53}		Transmission-parameter information for hierarchical layer B	
B_{54} – B_{66}		Transmission-parameter information for hierarchical layer C	
B_{67}	Next information	Partial-reception flag	See Table 3-24.
B_{68} – B_{80}		Transmission-parameter information for hierarchical layer A	See Table 3-20.
B_{81} – B_{93}		Transmission-parameter information for hierarchical layer B	
B_{94} – B_{106}		Transmission-parameter information for hierarchical layer C	
B_{107} – B_{109}	Phase-shift-correction value for connected segment transmission		See Table 3-29.
B_{110} – B_{121}	Reserved		1 for all bits

(Notification No. 304, Annexed Table 1)

Table 3-20: Contents of Transmission-Parameter Information

Description	Number of bits	Remarks
Carrier modulation mapping scheme	3	See Table 3-25.
Convolutional-coding rate	3	See Table 3-26.
Time interleaving length	3	See Table 3-27.
Number of segments	4	See Table 3-28.

(Notification No. 304, Annexed Table 1, Annexed Statement 5)

[Description]

The bit assignment for a TMCC signal must be the same as that specified in ARIB STD-B31 and ARIB STD-B29. This is because it makes feasible the decoding processing of the TMCC signal and is instrumental in mitigating the burden on receivers. Note that B_{27} and B_{67} are referred to as a "type identification flag" in ARIB STD-B29, but are specified as a "partial reception flag" in accordance with ARIB STD-B31.

With respect to the hierarchical configuration and transmission parameters, the present information (current information) and the information following switching (next information) are intended to be transmitted together. This is aimed at enhancing the response capability of receivers with the use of the current information, assuming the situations in which the power of receivers is activated during countdown and the channels are switched.

As for the phase-shift-correction value for connected segment transmission, the amount of the phase adjustment between the demodulating segment and upper adjacent segment is transmitted. The use of this data makes it possible to adjust the lowermost carrier phase of the upper adjacent segment and also to demodulate coherent modulated segments at the time of connected transmission.

3.15.5.1 System identification

Two bits are assigned to the signal provided for system identification purposes. “00” and “01” are provided to represent the 13-segment type compatible with ISDB-T (digital terrestrial television broadcasting system) and the one-segment type compatible with ISDB-T_{SB} (digital terrestrial sound broadcasting system), respectively. The remaining values are reserved. Table 3-21 shows the contents of the system identification bits.

Table 3-21: System Identification

B_{20} B_{21}	Meaning
00	Digital terrestrial television broadcasting system
01	Digital terrestrial sound broadcasting system
10, 11	Reserved

(Notification No. 304, Annexed Table 1, Annexed Statement 1)

3.15.5.2 Indicator of transmission-parameter switching

To switch between sets of transmission parameters, the contents of the indicator of transmission-parameter switching are counted down in order to inform the receiver of the transmission-parameter switching and timing. These indicator bits are normally set to “1111.” However, when it is necessary to switch parameters, the countdown starts 15 frames prior to switching, thus decrementing the contents of these bits by 1 every frame. Note that when the contents reach “0000,” they must be set back to “1111.”

Switching must be performed in synchronization with the next frame that outputs “0000.” That is, a new set of transmission parameters apply, starting with the frame with which the contents of the bits are set back to “1111.” Table 3-22 shows the meaning of each indicator of transmission-parameter switching.

Table 3-22: Indicator of Transmission-Parameter Switching

B_{22} B_{23} B_{24} B_{25}	Meaning
1111	Normal value
1110	15 frames prior to switching
1101	14 frames prior to switching
1100	13 frames prior to switching
:	:
0010	3 frames prior to switching
0001	2 frames prior to switching
0000	1 frame prior to switching
1111	A new set of transmission parameters is applied.

(Notification No. 304, Annexed Table 1, Annexed Statement 2)

When switching any of the transmission parameters and flags contained in the current information and the next information in Table 3-19 (partial-reception flag, carrier modulation scheme, convolutional-coding rate, time interleaving length, and the number of segments), the contents of the 4-bit indicator of transmission parameter switching shown in Table 3-22 are counted down.

When switching only the startup control signal (the start flag for emergency-alarm broadcasting) or the phase-shift-correction value for connected segment transmission, the contents of the indicator for transmission parameter switching are not counted down.

3.15.5.3 Startup control signal (Start flag for emergency-alarm broadcasting)

The content of the startup control signal must be “1” and “0” when the receiver startup is and is not controlled, respectively. Table 3-23 shows the meaning of the startup control signal (the start flag for emergency-alarm broadcasting) in each case.

Table 3-23: Startup Control Signal (Start Flag for Emergency-Alarm Broadcasting)

B_{26}	Meaning
0	No startup control
1	Startup control available (When an emergency-alarm signal is transmitted)

(Notification No. 304, Annexed Table 1, Annexed Statement 3)

3.15.5.4 Partial-reception flag

Table 3-24 shows the meaning of the contents of the partial-reception flag. The content of partial-reception flag for 13-segment type is set to “1” and “0” when segment No. 0 is and is not used for partial reception, respectively. When segment No. 0 is used for partial-reception, segment No. 0 is stipulated as the hierarchical layer A in Table 3-19.

Note that the content of this flag for one-segment type is set to “0.”

Note also that the content of this flag is set to “1” if there is no next information.

Table 3-24: Partial-Reception Flag

B_{27}/B_{67}	Meaning
0	No partial reception
1	Partial reception available

(Notification No. 304, Annexed Table 1, Annexed Statement 4)

3.15.5.5 Carrier modulation mapping scheme

Table 3-25 shows the meanings of carrier modulation mapping scheme bits.

Note that the content of these bits is “111” for an unused hierarchical layer, or when there is no next information.

Table 3-25: Carrier Modulation Mapping Scheme

B_{28}–B_{30}/B_{41}–B_{43} B_{54}–B_{56}/B_{68}–B_{70} B_{81}–B_{83}/B_{94}–B_{96}	Meaning
000	DQPSK
001	QPSK
010	16QAM
011	64QAM
100–110	Reserved
111	Unused hierarchical layer

(Notification No. 304, Annexed Table 1, Annexed Statement 6)

With a TMCC signal, the meanings of all sets of bit contents are the same for all three hierarchical layers. When signals of two hierarchical layers or fewer are transmitted, the content of these bits for vacant hierarchical layer(s) must be “111”. Note also that the content of these bits must be “111” if there is no next information, as when broadcasting ends.

3.15.5.6 Convolutional-coding rate

Table 3-26 shows the meanings of contents of convolutional-coding-rate bits.

Note that the content of these bits is “111” for an unused hierarchical layer or when there is no next information.

Table 3-26: Convolutional-Coding Rate

B_{31}–B_{33}/B_{44}–B_{46} B_{57}–B_{59}/B_{71}–B_{73} B_{84}–B_{86}/B_{97}–B_{99}	Meaning
000	1/2
001	2/3
010	3/4
011	5/6
100	7/8
101–110	Reserved
111	Unused hierarchical layer

(Notification No. 304, Annexed Table 1, Annexed Statement 7)

3.15.5.7 Time interleaving length

Table 3-27 shows the meanings of contents of time-interleaving-length bits. This information represents time interleaving length I shown in Table 3-8. Note that the content of these bits is “111” for an unused hierarchical layer or when there is no next information.

Table 3-27: Time Interleaving Length

B_{34}–B_{36}/B_{47}–B_{49} B_{60}–B_{62}/B_{74}–B_{76} B_{87}–B_{89}/B_{100}– B_{102}	Meaning (value I)
000	0 (Mode 1), 0 (Mode 2) , 0 (Mode 3)
001	4 (Mode 1) , 2 (Mode 2) , 1 (Mode 3)
010	8 (Mode 1) , 4 (Mode 2) , 2 (Mode 3)
011	16 (Mode 1) , 8 (Mode 2) , 4 (Mode 3)
100	32 (Mode 1), 16 (Mode 2), 8 (Mode 3)
101–110	Reserved
111	Unused hierarchical layer

(Notification No. 304, Annexed Table 1, Annexed Statement 8)

Note also that “100” in Table 3-27, that is, 32 (Mode 1), 16 (Mode 2), and 8 (Mode 3), are assigned to the use of digital terrestrial sound broadcasting system and are not used in this system.

3.15.5.8 Number of segments

Table 3-28 shows the meanings of the contents of number of segments bits.

Note that the content of these bits is “1111” for an unused hierarchical layer or when there is no next information.

Table 3-28: Number of Segments

B_{37}–B_{40}/B_{50}–B_{53} B_{63}–B_{66}/B_{77}–B_{80} B_{90}–B_{93}/B_{103}–B_{106}	Meaning
0000	Reserved
0001	1 segment
0010	2 segments
0011	3 segments
0100	4 segments
0101	5 segments
0110	6 segments
0111	7 segments
1000	8 segments
1001	9 segments
1010	10 segments
1011	11 segments
1100	12 segments
1101	13 segments
1110	Reserved
1111	Unused hierarchical layer

(Notification No. 304, Annexed Table 1, Annexed Statement 9)

3.15.5.9 Phase-shift-correction value for connected segment transmission

Table 3-29 shows the meanings of phase-shift-correction value for connected segment transmission when conducting connected transmission. When the reception segment uses the lowermost carrier of the upper adjacent segment as a reference signal in connected transmission, this signal is used to adjust the relevant carrier phase for every symbol. Note that the content of these bits is “111” when there is no phase adjustment including unconnected transmission.

Table 3-29: Phase-shift-correction Value for Connected Segment Transmission

B_{107} B_{108} B_{109}	Meaning (×2π)
000	-1/8
001	-2/8
010	-3/8
011	-4/8
100	-5/8
101	-6/8
110	-7/8
111	0 (Without phase adjustment)

(Notification No. 304, Annexed Table 1, Annexed Statement 10)

[Description]

Connected transmission is a transmission form aimed at receiving only a desired segment (1 or 13) in a selective manner from among the OFDM signals generated collectively from multiple segment signals on the transmission side. As receivers receive a signal at the center frequency of reception segment, the center frequency of the transmission signal is generally different from that on the receiving side.

Due to this, the difference Δf between the center frequency of transmission signal f_t and that of reception signal f_r causes an advance in phase during the guard interval, which in some cases leads to the symbol not being correctly demodulated. The signal must be transmitted with the phase difference incorporated in advance into the transmission side using the reception segment position relative to the center frequency of the transmission signal.

No problem is anticipated to occur on the reception side if demodulation is completed within the reception segment, but for the coherent modulation segment, there is a need to know the phase adjustment amount of the upper adjacent segment because the lowermost carrier of the upper adjacent segment is used for demodulation. Accordingly, the phase difference between the reception segment and upper adjacent segment must be transmitted using TMCC.

Note that, for the details of phase difference adjustment in connected transmission, Section 4.3 shall be referred to.

3.15.6 Channel-coding scheme

B_{20} to B_{121} of TMCC information are error-correction coded by means of the shortened code (184,102) of the difference-set cyclic code (273,191). The following shows the generating polynomial of the (273,191) code:

$$g(x) = x^{82} + x^{77} + x^{76} + x^{71} + x^{67} + x^{66} + x^{56} + x^{52} + x^{48} + x^{40} + x^{36} + x^{34} + x^{24} + x^{22} + x^{18} + x^{10} + x^{4} + 1$$

(Ordinance Annexed Table 12, Item 2)

[Description]

As TMCC information is an important signal used to specify transmission parameters and control the receiver operation, it must be transmitted with a higher degree of reliability than program signals. Program signals use the concatenated code based on convolutional code and RS code, but due to the difficulties involved with a receiver using the same decoding circuit for TMCC information and program signals, and in consideration of the fact that the handling by another system using block code is advantageous in terms of its shorter processing time, the shortened code (184,102) of the difference-set cyclic code (273,191) is used as an error-correction code. TMCC signals are transmitted by means of multiple carriers. Therefore, it is possible to reduce the required C/N by simply adding these signals, thus ensuring improved reception performance. These error-correction techniques and the addition process make it possible to receive TMCC signals at a lower C/N than for program signals.

Note that the synchronizing signal and segment type identification are excluded from the error-correction interval. This is because the parity bits are intended to be the same for all TMCC information, which makes it possible to determine the content of each bit including a parity bit by determining the contents of the majority of the carriers.

3.15.7 Modulation scheme

TMCC carriers must be modulated through DBPSK.

3.16 AC (auxiliary channel) signals

This section stipulates the transmission system for AC signals.

3.16.1 Overview

AC signals are transmitted using the AC carriers stipulated in Section 3.13.

"AC signal" refers to an additional information signal on broadcasting.

The additional information on broadcasting means the additional information on the transmission control of modulating wave or the seismic motion warning (Earthquake Early Warning) information.

The seismic motion warning information is transmitted using the AC carriers of segment No. 0 (see Section 3.14).

(Ordinance Article 22)

It is possible to transmit the additional information on the transmission control of modulating wave using arbitrary AC carriers.

3.16.2 AC signal bit assignment

Table 3-30 shows the bit assignment of B_0 to B_{203} for 204-bit AC signal arranged on segment No. 0.

Table 3-30: AC Signal Bit Assignment

B_0	Reference signal for demodulation of AC symbols
B_1–B_3	Configuration identification
B_4–B_{203}	Additional information on the transmission control of modulating wave or seismic motion warning information

(Ordinance Annexed Table 18)

3.16.3 Reference signal for demodulation of AC symbols

The reference amplitude and phase reference signal for demodulating of AC symbols is given by W_i in Table 3-12.

(Ordinance Annexed Table 18, Note 1)

3.16.4 Configuration identification

To identify the configuration of an AC signal, three bits are assigned as configuration identification. Table 3-31 shows the meanings of bit assignment for configuration identification.

Table 3-31: Configuration Identification

$B_1 - B_3$	Meaning
000	Transmits the additional information on the transmission control of modulating wave
010	
011	
100	
101	
111	
001	Transmits the seismic motion warning information
110	

(Ordinance Annexed Table 18, Note 2)

“001” and “110” representing the transmission of seismic motion warning information must be the same codes as those of the top three bits ($B_1 - B_3$) of a TMCC synchronizing signal, and their outputs are transmitted alternatively to each frame at the same timing as the TMCC signal.

3.16.5 Additional information on the transmission control of modulating waves

In consideration of versatile usage possibilities, no bit assignment is stipulated to the transmission means for the additional information on the transmission control of modulating waves.

3.16.6 Seismic motion warning information

Table 3-32 shows the bit assignment for seismic motion warning information.

Table 3-32: Seismic Motion Warning Information

Bit assignment	Explanation	Remarks
$B_4 - B_{16}$	Synchronizing signal	Refer to Table 3-33.
$B_{17} - B_{18}$	Start/ending flag	Refer to Table 3-34.
$B_{19} - B_{20}$	Update flag	
$B_{21} - B_{23}$	Signal identification	Refer to Table 3-35.
$B_{24} - B_{111}$	Detailed seismic motion warning information	Refer to Table 3-36.
$B_{112} - B_{121}$	CRC	Refer to Fig. 3-34.
$B_{122} - B_{203}$	Parity bit	

(Notification No. 306)

The seismic motion warning information is transmitted by the AC carriers of the segment No. 0. Note that the seismic motion warning information must be the same in all AC carriers within the segment No. 0.

[Description]

Letting the seismic motion warning information be the same in all AC carriers within the segment No. 0 enables the seismic motion warning information transmitted by different AC carriers to be added in analog on the receiver side, thus making reception possible even in lower CN ratios.

3.16.6.1 Synchronizing signal

When transmitting the seismic motion warning information, 13 bits are assigned as a synchronizing signal. The value identical to 13 bits (B_4–B_{16}) excluding the top three bits of the TMCC synchronizing signal must be taken.

Table 3-33: Example of Synchronizing Signal Transmission

Frame number	Synchronizing signal
1	1010111101110
2	0101000010001
3	1010111101110
4	0101000010001
:	:

Note: Frame numbers are assigned for the convenience of explanation.
(Notification No. 306, Note 3)

The code with the configuration identification and synchronizing signal combined must be the synchronizing word (w0=0011010111101110, w1=1100101000010001) with 16 bits identical to that for the TMCC synchronizing signal, and w0 and w1 are fed alternatively every frame at the same timing as the TMCC synchronizing signal.

[Description]
As it is possible to add TMCC and AC signal in analog, the reception sensibility for frame synchronization in receivers can be enhanced.

3.16.6.2 Start and ending flag

Two bits are assigned as the start and ending flag of seismic motion warning information. Table 3-34 shows the meanings of the start and ending flag bits.

Table 3-34: Start and Ending Flag

B_{17} – B_{18}	Meaning
00	Detailed seismic motion warning information available(Note)
11	Detailed seismic motion warning information not available
10, 01	Not used

Note: Includes a test signal for detailed seismic motion warning information
(Notification No. 306, Note 4)

When initiating to feed the seismic motion warning information, the start and ending flags are changed from “11” to “00.” Furthermore, when completing to feed the seismic motion warning information, the start and ending flags are changed from “00” to “11.”

[Description]
When there is no additional information on broadcasting, all bits of the AC signal are modulated to “1” as stipulated in Section 3.13.4. Therefore, the start and ending flags when

indicating the detailed seismic motion warning information or its test signals must be set to "00." In addition, in order to enhance the reliability in start and ending flags, an inverse signal with its inter-code spacings set to the maximum must be employed using two bits for the start and ending flags. To ensure reliability in start and ending flags, "10" and "01" must not be used. The start and ending flags can be used as the startup signal of receivers.

3.16.6.3 Update flag

An update flag must be incremented by one every time there is a change in the content of a series of the detailed seismic motion warning information to be transmitted when the start and ending flags are "00," and its starting value must be set to "00" while it must return to "00" after "11." When the start and ending flag is "11," the update flag must be set to "11."

(Notification No. 306, Note 5)

[Description]

While the value of start and ending flags of the seismic motion warning information is maintained in the state of "00," and when the signal identification (B_{21}–B_{23}) or the content of the seismic motion warning information (B_{56}–B_{111}) shown in Table 3-36 is updated, the value of the update flag must be incremented by one as indicated in Fig. 3-33, and the fact that the signal identification or the seismic motion information is updated must be notified to receivers.

An example of the update flag outputs is shown in Fig. 3-33.

Start/ending flag	"11"	"00"					"11"
Update flag	"11"	"00"	"01"	"10"	"11"	"00"	"11"
Signal identification	"111"	"000"					"111"
Contents of seismic-motion information	None	No. 1 report	No. 2 report	No. 3 report	No. 4 report	No. 5 report	None

Fig. 3-33: Example of Update Flag Output

Note: No. 1 report, No. 2 report, etc., show the state of changes in the signal identification indicated in Table 3-37 or the content of seismic motion information indicated in Table 3-36. There must be no change in the value of the update flag even if the changes occur in the current time or the page classification indicated in Table 3-36.

Note that a variety of patterns are conceivable in the output configurations and the updating of contents, and the details of specific output methods and update flag operation methods are stipulated separately.

3.16.6.4 Signal identification

The signal identification of seismic motion warning information is a signal used to identify the types of the detailed seismic motion warning information. The meanings of signal identification bit values must be set as shown in Table 3-35.

Table 3-35: Signal Identification

B_{21}– B_{23}	Meaning
000	Detailed seismic motion warning information (with relevant area)(Note 1)
001	Detailed seismic motion warning information (without relevant area)(Note 2)
010	Test signal for detailed seismic motion warning information (with relevant area)(Note 1)
011	Test signal for detailed seismic motion warning information (without relevant area)(Note 2)
100	Reserved
101	
110	
111	No detailed seismic motion warning information available

Note 1: This means that there are target areas for a seismic motion warning within broadcasting areas.
Note 2: This means that there are no target areas for a seismic motion warning within broadcasting areas.

(Notification No. 306, Note 6, Annexed Table 1)

When the start and ending flags are "00" and "11," the signal identification "000"/"001"/"010"/"011" and "111" are fed, respectively.

The test signal for the detailed seismic motion warning information (with/without relevant areas) and the detailed seismic motion warning information (with/without relevant areas) are not fed simultaneously.

[Description]
As shown in Table 3-38, it is possible to feed a maximum of two pieces of seismic motion warning information, but it is not allowed to feed a test signal and a real signal simultaneously.

In addition, when the signal identification feeds the seismic motion information with relevant area and without

Relevant area simultaneously, either information is fed as the seismic motion information with relevant area. By doing so, it is possible to promptly notify receivers of at least one piece of seismic motion information as the information with the relevant area.

3.16.6.5 Detailed seismic motion warning information

The bit assignment for the detailed seismic motion warning information is stipulated on a signal identification basis.

3.16.6.5.1 Detailed seismic motion warning information

Table 3-36 shows the bit assignment of detailed seismic motion warning information for the signal identification “000”/“001”/“010”/“011” (when the signal identification represents the detailed seismic motion warning information or the test signal for detailed seismic motion warning information).

Table 3-36: Detailed Seismic Motion Warning Information for Signal Identification “000”/“001”/“010”/“011”

Bit assignment	Explanation	
$B_{24} - B_{54}$	Current time	The information of current time information when the seismic motion warning information is fed.
B_{55}	Page classification	The code used to identify the types of information on seismic-motion, which is the target of seismic motion warning
$B_{56} - B_{111}$	Seismic motion information	When the value of page classification (B_{55}) is “0”: refer to Table 3-37 “1”: refer to Table 3-38

(Notification No. 306, Annexed Table 2)

When the seismic motion information is not fed, the page classification must be “0” and all of the seismic motion information must be “1.”

The current time must be expressed by a binary number system with its elapsed seconds starting from the reference year, month, day, hour, minute, and second separately defined, and low 31 bits are assigned by MSB first.

[Description]

When transmitting the seismic motion warning information, checking the time of receivers against the output time information enables us to confirm the reliability of the seismic motion warning information received in the receivers compatible with the automated starting equipped with a time adjustment function through TOT (Time Offset Table), communication lines, etc.

Note that, in the seismic motion information, the bit assignment for the information to be transmitted varies depending on the codes of page classification. It is possible for receivers to know which information is transmitted by the confirmation of page classifications. When the page classification is “0,” the information for the target area of the seismic motion warning is transmitted as shown in Table 3-37. When the page classification is “1,” the information for the epicenter of the seismic motion warning is transmitted as shown in Table 3-38. However, both of the page classifications “0” and “1” seismic motion information are not necessarily transmitted.

(1) Seismic motion information for page classification “0”

If the page classification is “0,” this classification must mean the information indicative of the seismic motion warning target area. Table 3-37 shows the bit assignment to areas. The bit assigned to the areas including the seismic motion warning target areas must be “0,” while the bit assigned to the areas not including the seismic motion warning target areas must be “1.” Note that if the seismic motion information is not fed, the bit must be “1” in all areas.

Table 3-37: Seismic Motion Information for Page Classification “0”

Bit	Area	Bit	Area	Bit	Area
B_{56}	Hokkaido Center	B_{75}	Niigata Prefecture	B_{94}	Hiroshima Prefecture
B_{57}	Hokkaido South	B_{76}	Toyama Prefecture	B_{95}	Tokushima Prefecture
B_{58}	Hokkaido North	B_{77}	Ishikawa Prefecture	B_{96}	Kagawa Prefecture
B_{59}	Hokkaido East	B_{78}	Fukui Prefecture	B_{97}	Ehime Prefecture
B_{60}	Aomori Prefecture	B_{79}	Yamanashi Prefecture	B_{98}	Kochi Prefecture
B_{61}	Iwate Prefecture	B_{80}	Nagano Prefecture	B_{99}	Yamaguchi Prefecture
B_{62}	Miyagi Prefecture	B_{81}	Gifu Prefecture	B_{100}	Fukuoka Prefecture
B_{63}	Akita Prefecture	B_{82}	Shizuoka Prefecture	B_{101}	Saga Prefecture
B_{64}	Yamagata Prefecture	B_{83}	Aichi Prefecture	B_{102}	Nagasaki Prefecture
B_{65}	Fukushima Prefecture	B_{84}	Mie Prefecture	B_{103}	Kumamoto Prefecture
B_{66}	Ibaraki Prefecture	B_{85}	Shiga Prefecture	B_{104}	Oita Prefecture
B_{67}	Tochigi Prefecture	B_{86}	Kyoto Prefecture	B_{105}	Miyazaki Prefecture
B_{68}	Gunma Prefecture	B_{87}	Osaka Prefecture	B_{106}	Kagoshima
B_{69}	Saitama Prefecture	B_{88}	Hyogo Prefecture	B_{107}	Amami Islands
B_{70}	Chiba Prefecture	B_{89}	Nara Prefecture	B_{108}	Okinawa main islands
B_{71}	Tokyo	B_{90}	Wakayama Prefecture	B_{109}	Daito Island
B_{72}	Izu Islands	B_{91}	Tottori Prefecture	B_{110}	Miyako Island
B_{73}	Ogasawara	B_{92}	Shimane Prefecture	B_{111}	Yaeyama
B_{74}	Kanagawa Prefecture	B_{93}	Okayama Prefecture		

Note 1) Hokkaido Center refers to Akabira-shi, Ashibetsu-shi, Ishikari-shi, Iwamizawa-shi, Utashinai-shi, Eniwa-shi, Ebetsu-shi, Otaru-shi, Kitahiroshima-shi, Sapporo-shi, Sunagawa-shi, Takikawa-shi, Chitose-shi, Bibai-shi, Fukagawa-shi, Mikasa-shi and Yubari-shi, and areas within the jurisdiction of Ishikari, Shiribeshi, and Sorachi General Subprefectural Bureaus.

Note 2) Hokkaido South refers to Date-shi, Tomakomai-shi, Noboribetsu-shi, Hakodate-shi, Hokuto-shi and Muroran-shi, and areas within the jurisdiction of Iburi, Oshima, Hidaka, and Hiyama General Subprefectural Bureaus.

Note 3) Hokkaido North refers to Asahikawa-shi, Shibetsu-shi, Nayoro-shi, Furano-shi, Rumoi-shi and Wakkanai-shi, and areas within the jurisdiction of Kamikawa, Souya, and Rumoi General Subprefectural Bureaus.

Note 4) Hokkaido East refers to Abashiri-shi, Obihiro-shi, Kitami-shi, Kushiro-shi, Nemuro-shi and Monbetsu-shi, and areas within the jurisdiction of Okhotsk, Kushiro, Tokachi, and Nemuro General Subprefectural Bureaus.

Note 5) Tokyo refers to the Tokyo Metropolitan Area (excluding areas within the jurisdiction of the Oshima, Ogasawara, Hachijo Island, and Miyake Island Branch Offices).

Note 6) Izu Islands refers to areas within the jurisdiction of the Oshima, Hachijo Island, and Miyake Island Branch Offices (excluding Sumisuto Island, Torishima Island, and Bayonaise Rocks).

Note 7) Ogasawara refers to areas within the jurisdiction of the Ogasawara Islands Branch Office.

Note 8) Kagoshima refers to Kagoshima Prefecture (excluding Amami-shi and Oshima District).

Note 9) Amami Islands refers to Amami-shi and Oshima District.

Note 10) Okinawa main islands refers to Itoman-shi, Urazoe-shi, Uruma-shi, Okinawa-shi, Ginowan-shi, Tomigusuku-shi, Nago-shi, Naha-shi, Nanjo-shi, Kunigami District, Shimajiri District (excluding Kitadaito-mura and Minamidaito-mura), and Nakagami District.
Note 11) Daito Island refers to Shimajiri District (restricted to Kitadaito-mura and Minamidaito-mura).
Note 12) Miyako Island refers to Miyakojima-shi and Miyako District.
Note 13) Yaeyama refers to Ishigaki-shi and Yaeyama District.

(Notification No. 306, Annexed Table 2, Annexed Statement 1)

[Description]

When multiple seismic motion warnings are generated simultaneously (the total number is two at maximum), there may be the cases where the page classification "0" seismic motion information (area information) is fed with the first one and the second one being fed independently. In this case, the update flag is not updated when the output of seismic motion warning information (area information) is changed from the first one to the second one or from the second one to the first one.

(2) Seismic motion information for page classification “1”

Table 3-38 shows the seismic motion information for page classification “1.”

Table 3-38: Seismic Motion Information for Page Classification “1”

Bit assignment	Explanation	
B_{56}	Total amount of seismic motion information	This is used to identify the total number of the seismic motion information being transmitted. When the total number are 1 and 2, “0” and “1” must be used respectively.
B_{57}	Seismic motion information identification	This is used to identify the seismic motion information being transmitted.
B_{58}–B_{66}	Seismic motion warning identification(Note)	This is used to identify the seismic motion warning.
B_{67}	Information type	This is used for the identification of types of seismic motion warnings. “0” must be indicated when the seismic motion information shows that a seismic motion warning was issued, while “1” must be indicated when the information shows that the seismic motion warning was cancelled. Note that B_{68}–B_{110} must all be “1” when the information shows that the seismic motion warning was cancelled.
B_{68}	Northern latitude and southern latitude flag	“0” and “1” indicate northern latitude and southern latitude, respectively.
B_{69}–B_{78}	Latitude information(Note)	This is the domain used to indicate the latitude of an epicenter, and the value shall be determined by 10 times the latitude, which is expressed using a binary system.
B_{79}	West longitude and east longitude flag	“0” and “1” indicate east latitude and west latitude, respectively.
B_{80}–B_{90}	Longitude information(Note)	This is the domain used to indicate the longitude of an epicenter, and the value shall be determined by 10 times the longitude, which is expressed using a binary system.
B_{91}–B_{100}	Depth information(Note)	This is used to indicate the depth of an epicenter. The value shall be the depth (km), which is expressed using a binary system.
B_{101}–B_{110}	Occurrence time(Note)	This is used to indicate the occurrence time of seismic motion.
B_{111}	Reserved	This must be “1.”

Note: Numerical values must be expressed by a binary system and assigned by MSB first.

(Notification No. 306, Annexed Table 2, Annexed Statement 2)

The seismic motion information identification for B_{57} must be “0” if the seismic motion information being transmitted is the first one, while that must be “1” if the information is the second one.

The occurrence time is determined on the basis of the reference year, month, day, hour, minute, and second identical to the current time indicated in B_{24}–B_{54}, and the elapsed seconds from the reference time is expressed by a binary system in which low 10 bits are assigned by MSB first.

[Description]

For “seismic motion warning identification,” nine bits are assigned to identify the seismic motion warning information when multiple seismic motion warnings are generated. When discriminating multiple seismic motion warning information based on the time (on the second time scale), the use of nine bits seismic motion warning identification allows the identification of the seismic motion warning information for the past eight minutes and 32 seconds.

A comparison between the current time of B_{24}–B_{54} and the occurrence time of B_{101}–B_{110} makes it possible to know the elapsed number of seconds from the occurrence of the seismic motion.

3.16.6.5.2 Detailed seismic motion warning information for signal identification "100"/"101"/"110"

This is used for future extension, and must be "1" in all cases.

3.16.6.5.3 Detailed seismic motion warning information for signal identification "111"(Note)

Table 3-39 shows the bit assignment for the detailed seismic motion warning information for the signal identification "111" (the case where the signal identification indicates "detailed seismic motion warning information is not available").

Table 3-39: Detailed Seismic Motion Warning Information for Signal Identification "111"

Bit assignment	Explanation	
B_{24}–B_{55}	Reserved	Must be "1" in all cases
B_{56}–B_{66}	Identification of broadcasting organizations	Code used to identify broadcasting organizations
B_{67}–B_{111}	Reserved	Must be "1" in all cases

(Notification No. 306, Annexed Table 3)

Note: When the start/ending flag is "11," the signal identification "111" is fed.

[Description]

Broadcasting company identification 11 bits are uniquely assigned to broadcasting organizations across the country. The broadcasting organizations that send the seismic motion warning information can be identified by this AC signal only.

3.16.6.6 CRC

CRC bits must be generated from B_{21}–B_{111} of the seismic motion warning information by using the generating polynomial shown in Fig. 3-34, and the initial value of each register of the circuit must be "0."

Generating polynomial: $g(x)=x^{10}+x^9+x^5+x^4+x+1$

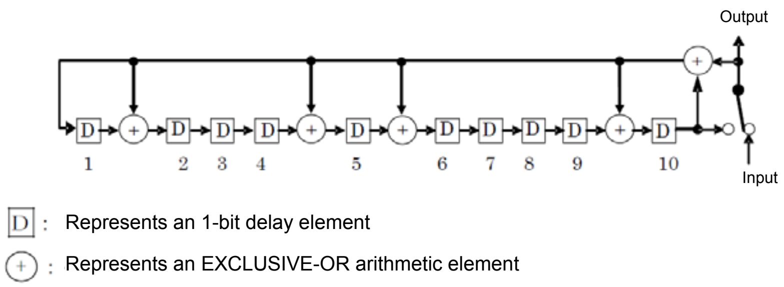


Fig.: 3-34: CRC Generating Circuit

(Notification No. 306, Note 8)

[Description]

The information on detailed seismic motion warning information is important information and is required to have a high degree of reliability. Therefore, after decoding with the error-correction codes indicated in Section 3.16.6.7, the detection of errors by CRC shall be made possible.

3.16.6.7 Parity Bit

Parity bits shall be generated from B_{17}–B_{121} of the seismic motion warning information by the shortened (187,105) code of the (273,191) difference-set cyclic code. The generating polynomial of the (273,191) difference-set cyclic code shall be as follows.

$$\text{Generating polynomial: } g(x) = x^{82} + x^{77} + x^{76} + x^{71} + x^{67} + x^{66} + x^{56} + x^{52} + x^{48} + x^{40} + x^{36} + x^{34} + x^{24} + x^{22} + x^{18} + x^{10} + x^{4} + 1$$

(Notification No. 306, Note 9)

[Description]

The information on the seismic motion warning information is important information and is required to have a high degree of reliability. Therefore, the information is protected by the error-correction code using different-set cyclic code, as is the case with TMCC. Configuration identification and synchronizing signals shall be excluded from the error-correction, and the shortened (187,105) codes of the (273,191) difference-set cyclic codes shall be used.

3.16.7 Modulation scheme

The modulation of AC carriers shall be implemented through DBPSK. (See Section 3.13.4)

Chapter 4: Connected Transmission Signal Types

4.1 Connected transmission configuration

The connected transmission based on ISDB-Tmm refers to transmitting multiple segments (13-segment type and one-segment type) without guard bands from the same transmission site. Here, with the aim of clarifying the consistency with ISDB-T (ARIB STD-B31) and ISDB-T$_{SB}$ (ARIB STD-B29), a type-A super segment and a type-B super segment are defined, and the one-segment-type connected transmission within the type-B super segment and the connected transmission of the super segments are stipulated. Note that when the connected transmission is simply mentioned, this refers to both the aforementioned one-segment-type connected transmission within the type-B super segment and the connected transmission of the super segments.

Fig. 4-1 shows an example of the connected transmission of nine TSs: TS1 and TS2, all the way to TS9. Here, the 13-segment type from TS1 and TS9, that is the type-A super segment, is generated, and the one-segment type from TS2–TS8, and further, the type-B super segment connecting them all, is formed. An ISDB-Tmm signal is generated after connecting three super segments and is subjected to IFFT/guard interval adding processing. When the three super segments are connected, the phase compensation for the difference of the center frequency between the total segments and 13-/one-segment and the phase adjustment for pilot modulation phase mismatch are implemented.

Note that the restricted matters imposed on parameters at the time of connected transmission are shown as follows.

(1) Modes must be the same.
As there is a necessity to take OFDM symbol timing synchronization reciprocally in connected transmission, the mixing of modes with different symbol lengths is not allowed.

(2) Guard interval lengths must be the same.
Due to the same reason as mentioned above (1), mixing is not allowed because the use of different guard intervals results in different OFDM symbol lengths.

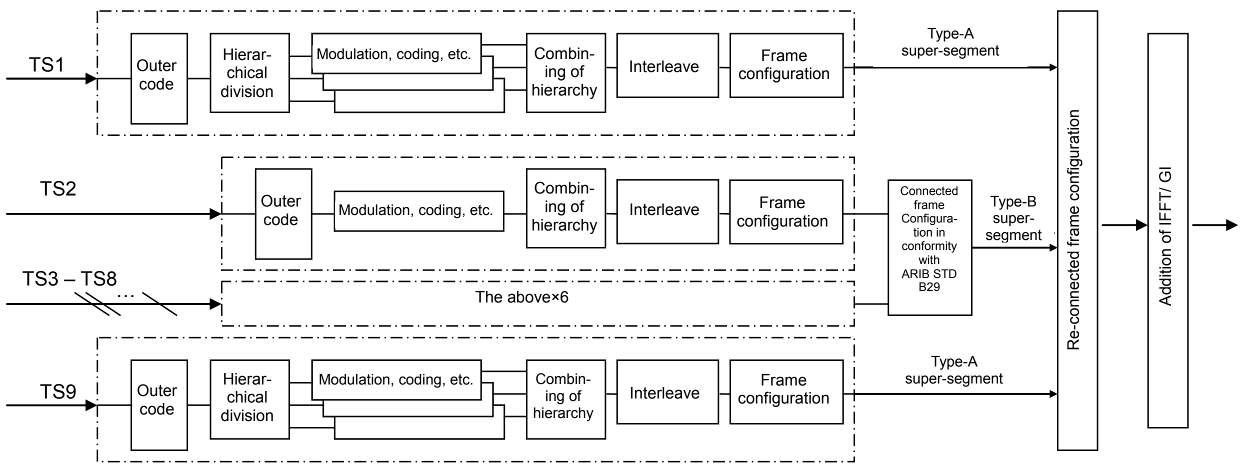


Fig. 4-1: Example of ISDB-Tmm Connected Transmission

4.2 CP carriers when conducting connected transmission

In 13-segment-type and one-segment-type independent transmission, a single CP carrier is arranged in the uppermost bandwidth as shown in Fig. 4-2 and is used as a demodulating reference signal in the coherent modulation segment. In the connected transmission, the lowermost carrier of the upper adjacent segment as seen from the reception segment shall be applied as CP as shown in Fig. 4-3, and a single CP shall be arranged at the upper end of all connected bands in obedience to the provision in Section 3.13.2.

Note that consideration must be paid to the fact that the lowermost carrier of the upper adjacent segment applied as CP may not be CP.

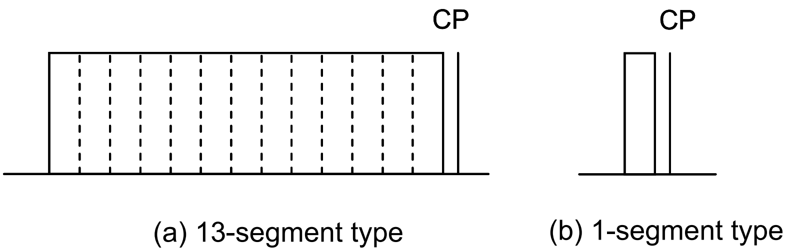


Fig. 4-2: CP Carrier Arrangement in Independent Transmission

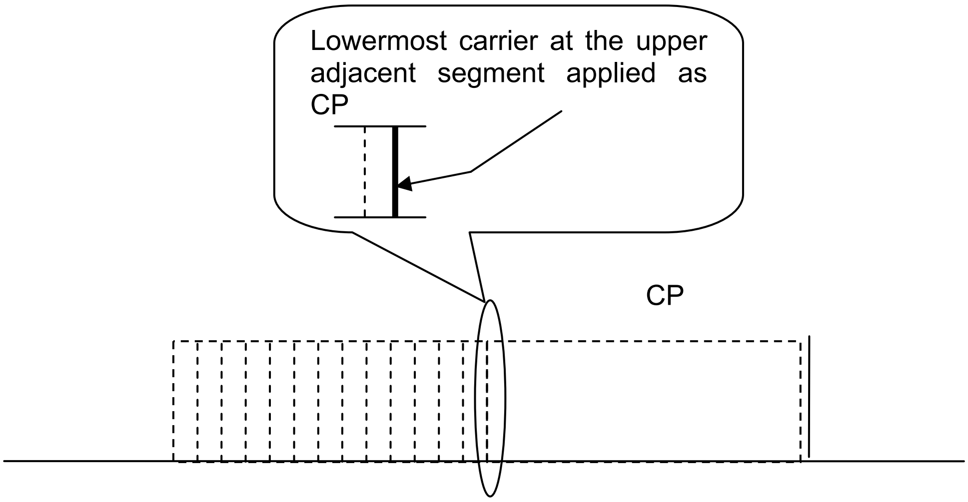


Fig. 4-3: CP Carrier Arrangement in Connected Transmission

4.3 Segment signal phase adjustment in connected transmission

4.3.1 Transmission signal

4.3.1.1 Phase compensation for the difference from center frequency

The phase rotation, which is determined according to the difference between the RF frequency (ft) corresponding to the direct current (DC) component of the ISDB-Tmm connected transmission baseband signal and the RF center frequency (fr) of the demodulating segment (13 or 1), is implemented for every symbol for transmission. The difference Δf (fr–ft) from the center frequency shall be stipulated by the number of segments, and the phase rotation compensation value φ is defined as shown in Table 4-1. Note that the phase compensation for connected-transmission bandwidth-end CP shall be the same as that for the segment using this CP.

Table 4-1: Phase Compensation Value φ (×2π) per Symbol on the Transmission Side

		Difference from center frequency Δf (f_r–f_t)																	
Mode	Guard interval ratios	−n	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
1	1/32	-mod(3n,8)/8	0	-5/8	-1/4	-7/8	-1/2	-1/8	-3/4	-3/8	0	-5/8	-1/4	-7/8	-1/2	-1/8	-3/4	-3/8	0
	1/16	-mod(3n,4)/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0
	1/8	-mod(n,2)/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1/32	-mod(3n,4)/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0	-1/4	-1/2	-3/4	0
	1/16	-mod(n,2)/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0
	1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1/32	-mod(n,2)/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0	-1/2	0
	1/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		Difference from center frequency Δf (f_r–f_t)																	
Mode	Guard interval ratios	+n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1/32	Mod(3n, 8)/8	0	3/8	3/4	1/8	1/2	7/8	1/4	5/8	0	3/8	3/4	1/8	1/2	7/8	1/4	5/8	0
	1/16	Mod(3n, 4)/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0
	1/8	Mod(n, 2)/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1/32	Mod(3n, 4)/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0	3/4	1/2	1/4	0
	1/16	Mod(n, 2)/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0
	1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1/32	Mod(n, 2)/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0	1/2	0
	1/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The phase rotation period on the transmission side is estimated at eight symbol periods at the longest, while the accumulated phase amounts to $2n\pi$ for two frames. For this reason, the phase rotation value is stipulated as 0 in the top symbol of the frame in which the TMCC synchronizing word becomes w0.

4.3.1.2 Phase compensation for the mismatch of pilot signal modulating phases in super-segment connected transmission

In super-segment connected transmission, when there is a disagreement between the PRBS output W_i' value (0 or 1) corresponding to the lowermost carrier (hereinafter referred to as the "applied CP") of the upper adjacent super segment applied as CP and the PRDS output W_i (refer to *Fig. 3-28: PRBS-Generating Circuit*) corresponding to the upper adjacent continuous carrier CP derived from the relevant super segment, the phase adjustment shall be made sequentially in units of a super segment for all carriers of the super segment adjacent to the upper side with the super segment arranged in the lower end as its reference—such that the difference in the phase adjustment value between super segments causing the disagreement be π radian.

[Description]

In the independent 13-segment-type and one-segment-type transmission, the transmission is conducted with the continuous carrier CP added to the bandwidth upper end. At this moment, CP is modulated through BPSK in accordance with the PRBS output W_i that determines the modulation phase of the pilot signal of the relevant segment (refer to *Section 3.14 Transmission Spectrum Configuration*).

On the other hand, the lowermost carrier of the upper adjacent segment is applied as CP in the super-segment connected transmission.

At this moment, the pilot signal transmitted by the carrier applied as CP is modulated through BPSK in accordance with the PRBS output W_i' that determines the modulation phase of the pilot signal of the connected upper adjacent segment.

In the super-segment connected transmission, when the PRBS output W_i that determines the CP modulation phase at the time of independent transmission is different from the PRBS output W_i' that determines the pilot signal modulation phase transmitted by the carrier applied as CP, the modulation phase of the pilot signal of the carrier applied as CP ends up being different from the modulation phase that is expected as the CP at the time of independent transmission.

When the mismatch occurs in the pilot signal modulation phase in the super-segment connected transmission, the adjustment made to each super segment's overall phase on a super-segment basis is instrumental in resolving the mismatch of the pilot signal modulation phase.

4.3.2 Reception signal

When the reception segment (1 or 13) uses as its reference signal the upper adjacent segment lowermost carrier, the phase of the relevant carrier needs to be adjusted for each symbol in a receiver in order to correspond it to the reception segment phase. The phase adjustment values are shown in Table 4-2 with the transmission modes and guard interval ratios as their parameters.

Table 4-2: Value Δφ (X2π) of Adjustment for Each Symbol Made to the Lowermost Carrier of the Upper Adjacent Segment

Reception segment type	Guard interval ratio	Upper Adjacent Segment Type: 1			Upper Adjacent Segment Type: 13		
1	1/32	-3/8 (I),	-3/4(II),	-1/2 (III)	-5/8,	-1/4,	-1/2
	1/16	-3/4,	-1/2,	0	-1/4,	-1/2,	0
	1/8	-1/2,	0,	0	-1/2,	0,	0
	1/4	0,	0,	0	0,	0,	0
13	1/32	-5/8,	-1/4,	-1/2	-7/8,	-3/4,	-1/2
	1/16	-1/4,	-1/2,	0	-3/4,	-1/2,	0
	1/8	-1/2,	0,	0	-1/2,	0,	0
	1/4	0,	0,	0	0,	0,	0

(I), (II), and (III) indicate Modes 1, 2, and 3.

4.3.3 TMCC information

The adjustment value in a receiver is transmitted to a receiver using three bits of the phase-shift-correction value for connected segment transmission (B_{107}–B_{109}) of the TMCC information (refer to Section 3.15.5.9)

[Description]

- Phase adjustment to a transmission signal

Connected transmission is a form of transmission for receiving only the desired segment (1 or 13) selectively from the OFDM signals that are generated on the transmission side by multiple segment signals with carriers keeping their orthogonality relation. As the receiver receives at the reception segment center frequency, generally speaking, the RF frequency corresponding to the DC component of the baseband signal is different from the center frequency on the reception side.

For this reason, when connected transmission waves are generated collectively by IFFT, the difference Δf between the RF frequency ft corresponding to the baseband signal DC component of the transmission signal and the reception segment center frequency fr causes an advance in phase on the reception side during the guard interval, thus in some cases resulting in the false demodulation of the symbol. The phase adjustment to a transmission signal is made with the aim of offsetting the phase difference beforehand, using the segment position relative to the segment with its center frequency set to the RF frequency corresponding to the baseband signal DC component of the transmission signal. The adjustment value is determined in such a way that the phase difference after adjustment is $2n\pi$.

- Phase adjustment to a reception signal

Due to the presence of the phase difference between segments in the connected transmission signal, the phase of the upper adjacent segment's lowermost carrier needs to be adjusted as far as the reception of the coherent modulation segment using the upper adjacent segment's lowermost carrier for demodulation is concerned.

4.3.4 RF signal format for ISDB-Tmm

The signal format for one-segment-type and 13-segment-type connected ISDB-Tmm signals in the RF band shall be stipulated as follows. The following are derived with the leftmost unit transmission wave (b = 0) on the frequency axis as its phase reference.

$$s(t) = \mathrm{Re}\left\{ e^{j \cdot 2\pi \cdot f_c \cdot t} \cdot \sum_{n=0}^{\infty} \sum_{b=0}^{S_1+S_{13}-1} e^{-j \cdot (\phi(b) n + \theta(b))} \sum_{k=0}^{N(b)-1} c(b,n,k) \cdot \Psi(b,n,k,t) \right\}$$

where

$$\Psi(b,n,k,t) = \begin{cases} e^{j \cdot 2\pi \cdot \frac{\left(\sum_{i=0}^{b} N(i) - N(b) + k \right) - K_{fc}}{T_u} \cdot (t - T_g - n \cdot T_s)} & n \cdot T_s \le t < (n+1) \cdot T_s \\ 0 & \text{else} \end{cases}$$

$$\phi(b) = -2\pi \cdot \frac{T_g}{T_u} \left(\left(\sum_{i=0}^{b} N(i) - N(b) + K_c(b) \right) - K_{f_c} \right)$$

$$\theta(b) = \begin{cases} \pi \sum_{i=1}^{b} \left(W_{0,i} \oplus W_{N(i-1),(i-1)} \right) & b > 0 \\ 0 & b = 0 \end{cases}$$

n	: Symbol number
S_1	: Number of one-segment-type unit transmission wave
S_{13}	: Number of 13-segment-type unit transmission wave
b	: One-segment-type and 13-segment-type unit transmission wave number (The leftmost unit transmission wave on the frequency axis is numbered as “0.”)
k	: Carrier number for each unit transmission wave (The leftmost carrier number on the frequency axis is numbered as “0.”)
$N(b)$	: Total number of unit transmission wave b carriers

(However, as for the unit transmission wave of $b \neq S_1 + S_{13} - 1$:

For one-segment type, Mode 1: 108, Mode 2: 216, Mode 3: 432, and

For 13-segment type, Mode 1: 1404, Mode 2: 2808, Mode 3: 5616.

As for the unit transmission wave of $b = S_1 + S_{13} - 1$, including the rightmost CP on the frequency axis of entire transmission waves:

For one-segment type, Mode 1: 109, Mode 2: 217, Mode 3: 433, and

For 13-segment type, Mode 1: 1405, Mode 2: 2809, Mode 3: 5617)

(Continued on the following page)

(Ordinance Annexed Table 24)

T_u : Effective symbol duration length

T_g : Guard interval duration length

(However, as for the unit transmission wave of $b \neq S_1 + S_{13} - 1$:

For one-segment type, $T_u = 7N(b)/3 \times 10^{-5}$

For 13-segment type, $T_u = 7N(b)/39 \times 10^{-5}$

As for the unit transmission wave of $b = S_1 + S_{13} - 1$:

For one-segment type, $T_u = 7(N(b)-1)/3 \times 10^{-5}$

For 13-segment type, $T_u = 7(N(b)-1)/39 \times 10^{-5}$

Carrier interval: $1/T_u$)

T_s : Symbol duration length ($T_s = T_u + T_g$)

f_c : Center frequency of any of OFDM segments included in transmission waves

K_{f_c} : Carrier number corresponding to f_c (However, the leftmost carrier on the frequency axis of all the transmission waves is numbered as "0" including connected transmission, and consecutive numbers are used over the entire transmission waves for indication.)

$K_c(b)$: Carrier number corresponding to the center frequency of unit transmission wave b

(For one-segment type: Mode 1: 54, Mode 2: 108, Mode 3: 216

For 13-segment type: Mode 1: 702, Mode 2: 1404, Mode 3: 2808)

$W_{k,b}$: PRBS output bit Wi value that determines the modulation phase of the pilot signal (SP or CP) transmitted by the carrier number k of unit transmission wave b

$c(b,n,k)$: Complex signal point vector corresponding to unit transmission wave b, symbol number n , and carrier number k

$s(t)$: RF signal

(Ordinance Annexed Table 24)

[Description]

A carrier wave modulating signal is obtained first by the inverse fast Fourier transform of the 13-segment-type OFDM frame or the connected frame of a one-segment-type OFDM frame and a 13-segment-type OFDM frame, which is followed by the addition of a guard interval to this signal. The signal thus derived must follow the above equations.

Where,

$\varphi(b)$: Phase compensation value for the difference from center frequency (See Section 4.3.1.1.)

$\theta(b)$: Phase compensation value for the mismatch of the pilot signal modulation phase (See Section 4.3.1.2.)

Note that the connected OFDM frame always includes one 13-segment-type OFDM frame or more. Therefore, it follows that S_{13} of the above equation is one or more.

Chapter 5: Frequency Utilization Requirements

For the frequency utilization requirements mentioned in this chapter, "Radio Equipment Regulations (Radio Regulatory Commission Rules No. 18, 1950)" is mostly referred to. Note that the channel bandwidth of terrestrial television broadcasting in Japan is 6 MHz, and the digital terrestrial broadcasting ISDB-T currently used in Japan is a 6-MHz system. Therefore, the frequency bandwidth, transmission spectrum mask, and others for the ISDB-Tmm terrestrial multimedia broadcasting used in Japan are stipulated with its channel (reference channel) bandwidth set to 6 MHz.

5.1 Applicable frequency bandwidth

The applicable frequency bandwidth shall be the VHF frequency band of 207.5 MHz to 222 MHz.

5.2 Frequency bandwidth and others

The permissible value of the occupied frequency bandwidth shall be as follows.
Rounded up to the nearest whole number of the value derived with (6,000/14 × n + 38.48) kHz.
However, n shall be the number of OFDM segments included in an OFDM frame.

The carrier frequency must be the center frequency of the frequency bandwidth.

(Ordinance Article 26, Annexed Table 21, Radio Equipment Regulations
Annexed Table 2, No. 55)

Note that the OFDM frames definitely include one 13-segment-type frame or more, and n shall be 13 or more and 33 or less because the maximum number of segments possible to be assigned to the applicable frequency bandwidth 14.5 MHz is 33.

5.3 Permissible transmission-frequency deviation

The permissible transmission-frequency deviation must be 1 Hz.

Note 1 A deviation of 500 Hz is allowed if the Minister for Internal Affairs and Communications approves it on the grounds that it will not substantially hinder the efficient use of radio waves.

Note 2 Broadcasting is conducted only by means of relaying the broadcasting programs of other broadcasting stations.

(a) Power applied to antenna transmission lines above 0.5 W: 3 kHz

(b) Power applied to antenna transmission lines below 0.5 W: 10 kHz

(c) The target of broadcasting is closed and the narrow area when the characteristics of radio wave propagation are taken into account, and the power applied to antenna transmission lines is 0.05 W or lower (excluding the area not constituting single frequency network*1): 20 kHz

Note 3 For two or more broadcasting stations constituting a single frequency network*1, the relative deviation among the two or more relevant stations must be within 10 Hz, in addition to following the above provisions.

*1: In the same broadcasting target areas (which mean the broadcasting target areas stipulated in Paragraph 2, Item 2 of the *Broadcast Act*, Article 26-2), this network refers to a group of stations adjoining other broadcasting stations transmitting the broadcasting programs identical to those of the relevant other stations through the same frequency radio waves.

(Radio Equipment Regulations Annexed Table 1, 6-5, Notification No. 174, Item 1)

5.4 Transmission spectrum mask

Supposing that n is the number of connected segments, the transmission spectrum mask and its breaking point shall be given by Fig. 5-1 and Table 5-1. Note that Fig. 5-1 is an example of n = 13.

Note also that, with respect to the power applied to the antenna transmission line in 202.5 MHz (outside the applicable frequency bandwidth), the provision for the power applied to the antenna transmission line's upper limit described in Table 5-2 must be met, in addition to satisfying the provision for the above-mentioned transmission spectrum mask.

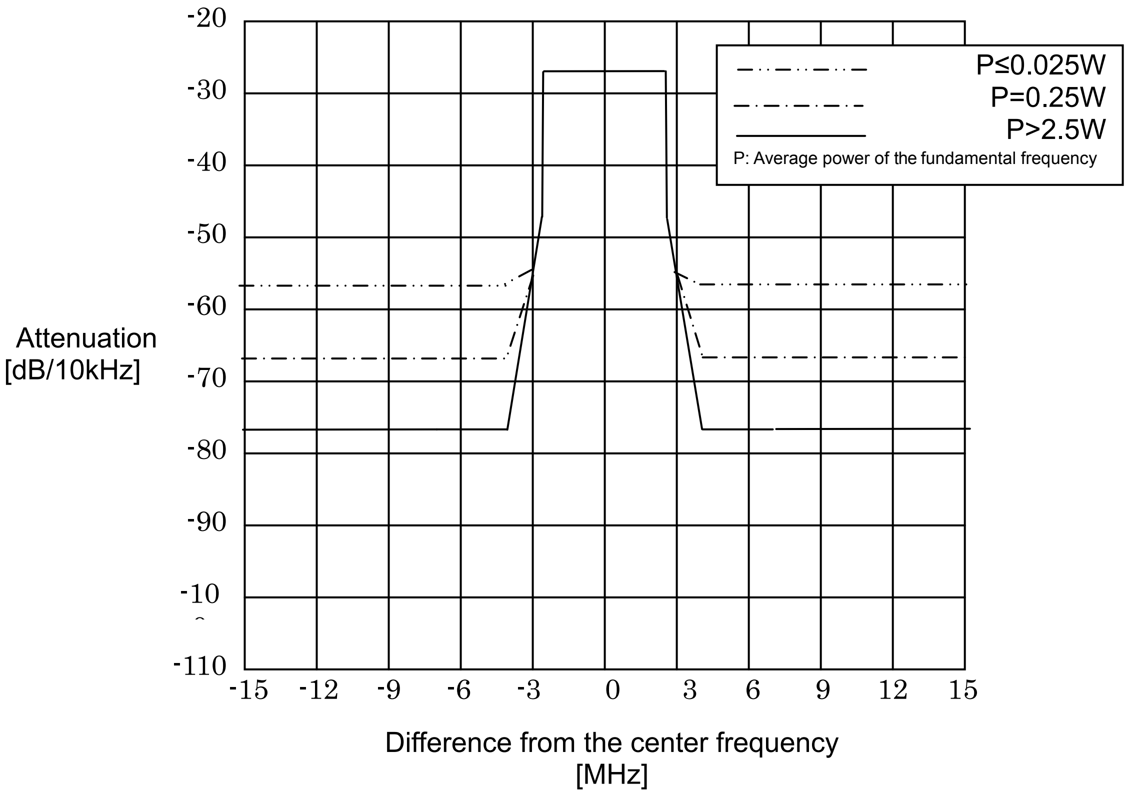


Fig. 5-1: Transmission Spectrum Mask for ISDB-Tmm Terrestrial Multimedia Broadcasting
(An Example of n = 13)

Table 5-1: Breakpoints for Transmission-Spectrum Mask (n≧13)

Difference from the center frequency (MHz)	Attenuation from the average power P of the fundamental frequency [dB/10kHz]	Type of stipulation
±(3*n/14+0.25/126)	10log(10/(6000/14*n))	Upper limit
±(3*n/14+0.25/126+1/14)	-20+10log(10/(6000/14*n))	Upper limit
±(3*n/14+0.25/126+3/14)	-27+10log(10/(6000/14*n))	Upper limit
±(3*n/14+0.25/126+22/14)	-50+10log(10/(6000/14*n))*1	Upper limit

*1: For radio equipment with power applied to an antenna transmission line above 0.025*n/13 W and equal to or below 2.5*n/13 W, it must be -(73.4 + 10logP) dB/10 kHz; and for radio equipment with power applied to an antenna transmission line equal to or below 0.02.5*n/13 W, it must be -57.4 dB/10 kHz.

Note 1 For the adjacent inter-channels of radio equipment that amplify multiple waves together, the attenuation of 10log(10/(6000/14*n)) [dB/10kHz] from the average power P is allowed as its upper limit regardless of the above table.

Note 2 The specified extent for the permissible values of carrier wave modulation spectrum must be ±2.5 *(6/14*n + 38.48/1000)) [MHz] with the carrier wave frequency as its center.

Note 3 n shall be the number of OFDM segments included in the OFDM frames for digital broadcasting.

Note 4 Regardless of the above table, the upper limit of the power P applied to an antenna transmission line in the frequency of 202.5 [MHz] shall be set as shown below.

Table 5-2: Provision for the Upper Limit of the Power Applied to an Antenna Transmission Line in 202.5 MHz

The power supplied to antenna transmission line [W/MHz]	Upper limit of the power applied to an antenna transmission line in 202.5 MHz [dBW/10kHz]
P > 1,000 / 6	-62.4
1,000 / 6 ≥ P > 100 / 6	10log(P)-20-65
100 / 6 ≥ P	-72.4

Where P is the average power of fundament frequency

(Radio Equipment Regulations Annexed Figure 4, 8-8-2)

5.5 Maximum permitted power level of spurious emission or unwanted emission

Table 5-3 shows the maximum permitted power level of spurious emission or unwanted emission.

Table 5-3 Maximum Permitted Power Level of Spurious Emission or Unwanted Emission

<table>
<tr><th>The power supplied to antenna transmission line</th><th>Maximum permitted power level of spurious emission in out-of-band domain</th><th>Maximum permitted power level of unwanted emission in spurious domain</th></tr>
<tr><td>Above 42 W</td><td rowspan="2">1 mW or less, and 60 dB lower than the average power of the fundamental frequency</td><td>1 mW or less, and 60 dB lower than the average power of the fundamental frequency</td></tr>
<tr><td>Above 1.68 W, and 42 W or less</td><td rowspan="2">25 μW or less</td></tr>
<tr><td>1 W or less</td><td>100 μW or less</td></tr>
</table>

Note 1 Frequency at the boundaries of out-of-band domains and spurious domains

Frequency at the boundary: fc±2.5BN

* “BN” refers to the necessary frequency bandwidth used to estimate the frequencies at the boundaries of the out-of-bound domains and spurious domains. The necessary frequency bandwidth in this case shall be the permitted value of the occupied frequency bandwidth.

* “fc” refers to the center frequency (the frequency at the center of necessary frequency bandwidth).

Note 2 Reference bandwidth

Reference bandwidth: 100 kHz

* “Reference bandwidth” refers to the frequency bandwidth used to specify the permitted power level of the unwanted emission in a spurious domain.

(Radio Equipment Regulations Annexed Table 3, Item 5 (5))

Annex A: Transmission Parameters and Information Bit Rates When the Reference Channel Bandwidths are 7 MHz and 8 MHz

As with ISDB-T, in which a 6-MHz bandwidth system can be extended to 7-MHz and 8-MHz bandwidth systems, ISDB-Tmm can be extended to the systems with a reference channel bandwidth of 7 MHz or 8 MHz by increasing the signal bandwidth or the carrier spacings of the reference channel bandwidth 6-MHz system by 7/6 or 8/6 times, respectively. When extended this way, the FFT sampling frequency is also increased by 7/6 and 8/6 times, while this leads to a decrease in the effective symbol length by 6/7 and 6/8 times, respectively. Note that the broadcasting TS transmission clock is four times the IFFT sampling clock, and the same shall be applied to 7-MHz and 8-MHz systems.

Table A-1 through Table A-4 show one-segment-type transmission signal parameters, 13-segment-type transmission signal parameters, one-segment-type information bit rates, and 13-segment-type information bit rates of the reference channel bandwidth 7-MHz system. Note that in a similar way, Table A-5 through Table A-8 show the transmission signal parameters and the information bit rates of the reference channel bandwidth 8-MHz system.

Table A-1: One-segment-type Transmission Signal Parameters (Reference Channel Bandwidth 7 MHz)

Mode		Mode 1	Mode 2	Mode 3
Segment bandwidth (Bws)		7000/14 = 500 kHz		
Bandwidth (Bw)		Bws + Cs = 504.6…kHz	Bws + Cs = 502.3…kHz	Bws + Cs = 501.1…kHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s ($n_s+n_d=1$)		
Spacings between carrier frequencies (Cs)		Bws/108 = 4.629…kHz	Bws/216 = 2.314…kHz	Bws/432 = 1.157…kHz
Number of carriers	Total count	108 + 1 = 109	216 + 1 = 217	432 + 1 = 433
	Data	96	192	384
	SP	$9\times n_s$	$18\times n_s$	$36\times n_s$
	CP*1	$n_d + 1$	$n_d + 1$	$n_d + 1$
	TMCC*2	$n_s + 5\times n_d$	$2\times n_s + 10\times n_d$	$4\times n_s + 20\times n_d$
	AC1*3	2	4	8
	AC2*3	$4\times n_d$	$9\times n_d$	$19\times n_d$
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbols)		204		
Effective symbol length		216 μs	432 μs	864 μs
Guard interval		54 μs (1/4), 27 μs (1/8), 13.5 μs (1/16), 6.75 μs (1/32)	108 μs (1/4), 54 μs (1/8), 27 μs (1/16), 13.5 μs (1/32)	216 μs (1/4), 108 μs (1/8), 54 μs (1/16), 27 μs (1/32)
Frame length		55.08 ms(1/4), 49.572 ms (1/8), 46.818ms(1/16), 45.441ms(1/32)	110.16 ms (1/4), 99.144 ms (1/8), 93.636 ms (1/16), 90.882 ms (1/32)	220.32ms(1/4), 198.288ms(1/8), 187.272ms(1/16), 181.764 ms(1/32)
FFT sampling frequency		256/216 = 1.185185… MHz		
Interleave	Frequency	Intra-segment frequency interleave		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional byte interleave per 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4 : The inner code is taken as a convolutional code in which the mother-code with a constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table A-2: 13-segment-type Transmission Signal Parameters (Reference Channel Bandwidth 7 MHz)

Mode		Mode 1	Mode 2	Mode 3
Number of OFDM segment (N_s)		13 segments		
Bandwidth (Bw)		Bws × N_s + Cs = 6.504…MHz	Bws × N_s + Cs = 6.502…MHz	Bws × N_s + Cs = 6.501…MHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s (n_s+n_d=N_s)		
Spacings between carrier frequencies (Cs)		Bws/108 = 4.629…kHz	Bws/216 = 2.314…kHz	Bws/432 = 1.157…kHz
Number of carriers	Total count	108×N_s + 1 = 1405	216×N_s + 1 = 2809	432×N_s + 1 = 5617
	Data	96×N_s = 1248	192×N_s = 2496	384×N_s = 4992
	SP	9×n_s	18×n_s	36×n_s
	CP*1	n_d + 1	n_d + 1	n_d + 1
	TMCC*2	n_s + 5×n_d	2×n_s + 10×n_d	4×n_s + 20×n_d
	AC1*3	2×N_s= 26	4×N_s= 52	8×N_s= 104
	AC2*3	4×n_d	9×n_d	19×n_d
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbols)		204		
Effective symbol length		216 μs	432 μs	864 μs
Guard interval		54 μs (1/4), 27 μs (1/8), 13.5 μs (1/16), 6.75 μs (1/32)	108 μs (1/4), 54 μs (1/8), 27 μs (1/16), 13.5 μs (1/32)	216 μs (1/4), 108 μs (1/8), 54 μs (1/16), 27 μs (1/32)
Frame length		55.08 ms (1/4), 49.572 ms (1/8), 46.818ms (1/16), 45.441ms (1/32)	110.16 ms (1/4), 99.144 ms (1/8), 93.636 ms (1/16), 90.882 ms (1/32)	220.32ms (1/4), 198.288ms (1/8), 187.272ms (1/16), 181.764 ms (1/32)
FFT sampling frequency		2048/216 = 9.481… MHz		
Interleave	Frequency	Inter-segment and intra-segment frequency interleave		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional byte interleave every 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4 : The inner code is taken as a convolutional code in which the mother-code with constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table A-3: One-segment-type Information Bit Rates (Reference Channel Bandwidth 7 MHz)

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information Bit Rates (kbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	12 / 24 / 48	327.66	364.07	385.49	397.17
	2/3	16 / 32 / 64	436.89	485.43	513.99	529.56
	3/4	18 / 36 / 72	491.50	546.11	578.23	595.76
	5/6	20 / 40 / 80	546.11	606.79	642.48	661.95
	7/8	21 / 42 / 84	573.42	637.13	674.61	695.05
16QAM	1/2	24 / 48 / 96	655.33	728.15	770.98	794.34
	2/3	32 / 64 / 128	873.78	970.87	1027.98	1059.13
	3/4	36 / 72 / 144	983.00	1092.22	1156.47	1191.52
	5/6	40 / 80 / 160	1092.22	1213.58	1284.97	1323.91
	7/8	42 / 84 / 168	1146.84	1274.26	1349.22	1390.11
64QAM	1/2	36 / 72 / 144	983.00	1092.22	1156.47	1191.52
	2/3	48 / 96 / 192	1310.67	1456.30	1541.97	1588.69
	3/4	54 / 108 / 216	1474.50	1638.34	1734.71	1787.28
	5/6	60 / 120 / 240	1638.34	1820.38	1927.46	1985.87
	7/8	63 / 126 / 252	1720.26	1911.40	2023.83	2085.16

Table A-4: 13-segment-type Information Bit Rates*2 (Reference Channel Bandwidth 7 MHz)

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information Bit Rates (Mbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	156/ 312 / 624	4.259	4.732	5.011	5.163
	2/3	208 / 416 / 832	5.679	6.310	6.681	6.884
	3/4	234 / 468 / 936	6.389	7.099	7.517	7.744
	5/6	260 / 520 / 1040	7.099	7.888	8.352	8.605
	7/8	273 / 546 / 1092	7.454	8.282	8.769	9.035
16QAM	1/2	312 / 624 / 1248	8.519	9.465	10.022	10.326
	2/3	416/ 832 / 1664	11.359	12.621	13.363	13.768
	3/4	468 / 936 / 1872	12.779	14.198	15.034	15.489
	5/6	520/ 1040 / 2080	14.198	15.776	16.704	17.210
	7/8	546/ 1092 / 2184	14.908	16.565	17.539	18.071
64QAM	1/2	468 / 936 / 1872	12.779	14.198	15.034	15.489
	2/3	624 / 1248 / 2496	17.038	18.931	20.045	20.653
	3/4	702 / 1404 / 2808	19.168	21.298	22.551	23.234
	5/6	780 / 1560 / 3120	21.298	23.664	25.057	25.816
	7/8	819 / 1638 / 3276	22.363	24.848	26.309	27.107

*1: Represents the number of TSPs transmitted per frame

*2: The information bit rates are an example because hierarchical transmission is possible with the coding rates of modulation and convolutional codes set as variables.

Table A-5: One-segment-type Transmission Signal Parameters (Reference Channel Bandwidth 8 MHz)

Mode		Mode 1	Mode 2	Mode 3
Segment bandwidth (Bws)		8000/14 = 571.4… kHz		
Bandwidth (Bw)		Bws + Cs = 576.7…kHz	Bws + Cs = 574.0…kHz	Bws + Cs = 572.7…kHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s (n_s+n_d=1)		
Spacings between carrier frequencies (Cs)		Bws/108 = 5.291…kHz	Bws/216 = 2.645…kHz	Bws/432 = 1.322…kHz
Number of carriers	Total count	108 + 1 = 109	216 + 1 = 217	432 + 1 = 433
	Data	96	192	384
	SP	9×n_s	18×n_s	36×n_s
	CP*1	n_d + 1	n_d + 1	n_d + 1
	TMCC*2	n_s + 5×n_d	2×n_s + 10×n_d	4×n_s + 20×n_d
	AC1*3	2	4	8
	AC2*3	4×n_d	9×n_d	19×n_d
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbols)		204		
Effective symbol length		189 μs	378 μs	756 μs
Guard interval		47.25 μs (1/4), 23.625 μs (1/8), 11.8125 μs (1/16), 5.90625 μs (1/32)	94.5 μs (1/4), 47.25 μs (1/8), 23.625 μs (1/16), 11.8125 μs (1/32)	189 μs (1/4), 94.5 μs (1/8), 47.25 μs (1/16), 23.625 μs (1/32)
Frame length		48.195 ms (1/4), 43.3755 ms (1/8), 40.96575ms(1/16), 39.760875ms(1/32)	96.39 ms (1/4), 86.751 ms (1/8), 81.9315 ms (1/16), 79.52175 ms (1/32)	192.78 ms (1/4), 173.502 ms (1/8), 163.863 ms (1/16), 159.0435 ms (1/32)
FFT sampling frequency		256/189 = 1.354497… MHz		
Interleave	Frequency	Frequency interleave within segment		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional byte interleave per 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4 : The inner code is taken as a convolutional code in which the mother-code with a constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table A-6: 13-segment-type Transmission Signal Parameters (Reference Channel Bandwidth 8 MHz)

Mode		Mode 1	Mode 2	Mode 3
Number of OFDM segments (N_s)		13 Segments		
Bandwidth (Bw)		Bws × N_s + Cs = 7.433…MHz	Bws × N_s + Cs = 7.431…MHz	Bws × N_s + Cs = 7.429…MHz
Number of segments of differential modulations		n_d		
Number of segments of coherent modulations		n_s (n_s+n_d=N_s)		
Spacings between carrier frequencies (Cs)		Bws/108 = 5.291…kHz	Bws/216 = 2.645…kHz	Bws/432 = 1.322…kHz
Number of carriers	Total count	108×N_s + 1 = 1405	216×N_s + 1 = 2809	432×N_s + 1 = 5617
	Data	96×N_s = 1248	192×N_s = 2496	384×N_s = 4992
	SP	9×n_s	18×n_s	36×n_s
	CP*1	n_d + 1	n_d + 1	n_d + 1
	TMCC*2	n_s + 5×n_d	2×n_s + 10×n_d	4×n_s + 20×n_d
	AC1*3	2×N_s= 26	4×N_s= 52	8×N_s= 104
	AC2*3	4×n_d	9×n_d	19×n_d
Carrier modulation scheme		QPSK, 16QAM, 64QAM, DQPSK		
Symbols per frame (OFDM symbols)		204		
Effective symbol length		189 μs	378 μs	756 μs
Guard interval		47.25 μs (1/4), 23.625 μs (1/8), 11.8125 μs (1/16), 5.90625 μs (1/32)	94.5 μs (1/4), 47.25 μs (1/8), 23.625 μs (1/16), 11.8125 μs (1/32)	189 μs (1/4), 94.5 μs (1/8), 47.25 μs (1/16), 23.625 μs (1/32)
Frame length		48.195 ms (1/4), 43.3755 ms (1/8), 40.96575ms(1/16), 39.760875ms(1/32)	96.39 ms (1/4), 86.751 ms (1/8), 81.9315 ms (1/16), 79.52175 ms (1/32)	192.78 ms (1/4), 173.502 ms (1/8), 163.863 ms (1/16), 159.0435 ms (1/32)
FFT sampling frequency		2048/189 = 10.835… MHz		
Interleave	Frequency	Inter-segment and intra-segment frequency interleave		
	Time	I=0 (0 symbols), I=4 (380 symbols), I=8 (760 symbols), I=16 (1,520 symbols)	I=0 (0 symbols), I=2 (190 symbols), I=4 (380 symbols), I=8 (760 symbols)	I=0 (0 symbols), I=1 (95 symbols), I=2 (190 symbols), I=4 (380 symbols)
Inner code *4		Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Byte interleave		Convolutional byte interleave per 12 bytes		
Outer code		RS (204,188)		

*1: The number of CPs includes the sum of those CPs in segments, plus one CP added to the upper end of the entire bandwidth.

*2: TMCC (transmission and multiplexing configuration control) is inserted with the aim of transmitting control information.

*3: AC (auxiliary channel) is used as a signal intended to transmit additional information, and the same number for AC1 is inserted into all segments, while AC2 is inserted only into differential segments.

*4 : The inner code is taken as a convolutional code in which the mother-code with a constraint length of 7 (number of states: 64) and a coding rate of 1/2 is punctured.

Table A-7: One-segment-type Information Bit Rates (Reference Channel Bandwidth 8 MHz)

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information Bit Rates (kbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	12 / 24 / 48	374.47	416.08	440.56	453.91
	2/3	16 / 32 / 64	499.30	554.78	587.41	605.21
	3/4	18 / 36 / 72	561.71	624.13	660.84	680.87
	5/6	20 / 40 / 80	624.13	693.47	734.27	756.52
	7/8	21 / 42 / 84	655.33	728.15	770.98	794.34
16QAM	1/2	24 / 48 / 96	748.95	832.17	881.12	907.82
	2/3	32 / 64 / 128	998.60	1109.56	1174.83	1210.43
	3/4	36 / 72 / 144	1123.43	1248.26	1321.68	1361.74
	5/6	40 / 80 / 160	1248.26	1386.95	1468.54	1513.04
	7/8	42 / 84 / 168	1310.67	1456.30	1541.97	1588.69
64QAM	1/2	36 / 72 / 144	1123.43	1248.26	1321.68	1361.74
	2/3	48 / 96 / 192	1497.91	1664.34	1762.25	1815.65
	3/4	54 / 108 / 216	1685.15	1872.39	1982.53	2042.61
	5/6	60 / 120 / 240	1872.39	2080.43	2202.81	2269.56
	7/8	63 / 126 / 252	1966.01	2184.45	2312.95	2383.04

Table A-8: 13-segment-type Information Bit Rates*2 (Reference Channel Bandwidth 8 MHz)

Carrier modulation	Convolutional code	Number of TSPs transmitted *1 (Mode 1/2/3)	Information Bit Rates (Mbit/s)			
			Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
DQPSK QPSK	1/2	156/ 312 / 624	4.868	5.409	5.727	5.900
	2/3	208 / 416 / 832	6.490	7.212	7.636	7.867
	3/4	234 / 468 / 936	7.302	8.113	8.590	8.851
	5/6	260 / 520 / 1040	8.113	9.015	9.545	9.834
	7/8	273 / 546 / 1092	8.519	9.465	10.022	10.326
16QAM	1/2	312 / 624 / 1248	9.736	10.818	11.454	11.801
	2/3	416/ 832 / 1664	12.981	14.424	15.272	15.735
	3/4	468 / 936 / 1872	14.604	16.227	17.181	17.702
	5/6	520/ 1040 / 2080	16.227	18.030	19.091	19.669
	7/8	546/ 1092 / 2184	17.038	18.931	20.045	20.653
64QAM	1/2	468 / 936 / 1872	14.604	16.227	17.181	17.702
	2/3	624 / 1248 / 2496	19.472	21.636	22.909	23.603
	3/4	702 / 1404 / 2808	21.907	24.341	25.772	26.553
	5/6	780 / 1560 / 3120	24.341	27.045	28.636	29.504
	7/8	819 / 1638 / 3276	25.558	28.397	30.068	30.979

*1: Represents the number of TSPs transmitted per frame

*2: The information bit rates are an example because hierarchical transmission is possible with the coding rates of modulation and convolutional codes set as variables.

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Attachment

Operational Guidelines for Terrestrial Mobile Multimedia Broadcasting Based on Connected Segment Transmission

Attachment: Operational Guidelines for Terrestrial Mobile Multimedia Broadcasting Based on Connected Segment Transmission

Contents

Chapter 1: Objective

This attachment presents operational guidelines as recommendations for terrestrial multimedia broadcasting (connected segment transmission system) for mobile and portable terminals in relation to program broadcasting and transmission equipment.

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Chapter 2: Transmission-Spectrum Arrangement

2.1 Number of connected transmission segments

The number of connected transmission segments must be 33 segments.

[Reason]

As shown in Chapter 5 of this standard, it stipulates that the frequency band where ISDB-Tmm can be applied is the VHF frequency band of 207.5 MHz–222 MHz (14.5 MHz), and that this applicable frequency bandwidth must include one or more 13-segment types; further, 13 or more and 33 or less OFDM segments can be transmitted.

The operation of ISDB-Tmm is based on the premise of nationwide SFN, and for the effective utilization of frequency, the number of connected transmission segments must be the maximum number (33 segments) possible to take within the applicable frequency bandwidth.

2.2 OFDM carrier corresponding to carrier frequency

The OFDM carrier corresponding to carrier frequency must be the OFDM carrier shown in Table 2-1 that is the center segment of 33 segments.

Table 2-1: OFDM Carrier Number Corresponding to the Carrier Frequency

Transmission mode	Mode 1	Mode 2	Mode 3
Carrier number corresponding to the center frequency	54	108	216

OFDM carrier number when “0” is assigned to the lowermost carrier along the RF frequency axis

[Reason]

As shown in Chapter 5 of this standard, Ordinance stipulates that the frequency of carrier waves must be defined as the center frequency of the frequency bandwidth.

The OFDM segment consists of an even number of OFDM carriers regardless of modes. In addition, the OFDM segments consisting of 33 segments are connected for transmission in the operation of ISDM-Tmm. When transmitting the OFDM segments, it is stipulated that at least one continuous carrier (CP) must be arranged at the bandwidth high end of transmission signals regardless of a single or connected transmission.

For this reason, the number of OFDM carriers constituting an ISDB-Tmm signal (33 segments) is an odd number regardless of modes. Therefore, the OFDM carrier corresponding to the carrier wave frequency must be the number shown in Table 2-1 for the center segment.

2.3 Center frequency of carrier waves

The center frequency of carrier waves (OFDM carrier frequency corresponding to the carrier wave frequency) must be 214 + 5/7 MHz (= 214.714285…MHz).

[Reason]

The sub-channel is stipulated in Section 3.13.1.2 of this standard for the reference channel bandwidth of 6 MHz, but the sub-channel takes 1/7-MHz (= 142.857…kHz) steps. Incidentally, the carrier wave frequency for a digital terrestrial television broadcasting signal employs the frequency shifted upward by 1/7 MHz (= 142.857…kHz) from the band center frequency of television channels.

In consideration of the easiness in manufacturing receivers and arranging in the above-mentioned sub-channel, it is desirable that the carrier wave center frequency be the frequency of an integral multiple of 1/7 MHz (= 142.857…kHz).

For the 33-segment connected transmission in the applicable frequency bandwidth (207.5 MHz–222 MHz), the values possible for the center frequency to take are two patterns: 214 + 5/7 MHz (= 214.714285…MHz) and 214 + 6/7 MHz (= 214.857142…MHz).

There is a guard band of 5 MHz available in the lower adjacent frequency band, but no guard band is available to the "aerial navigation radio system" in the upper adjacent frequency band, and at the same time, this system is already in operation. Therefore, it is desirable that the lower one of the above-mentioned two patterns be employed as the center frequency to reduce the unnecessary radiation to "aerial navigation radio systems" as much as possible.

For this reason, the carrier wave center frequency of ISDB-Tmm must be 214 + 5/7 MHz (= 214.714285…MHz).

2.4 Arrangement of super segments

The arrangement of super segments shall be the three patterns shown in Fig. 2-1.

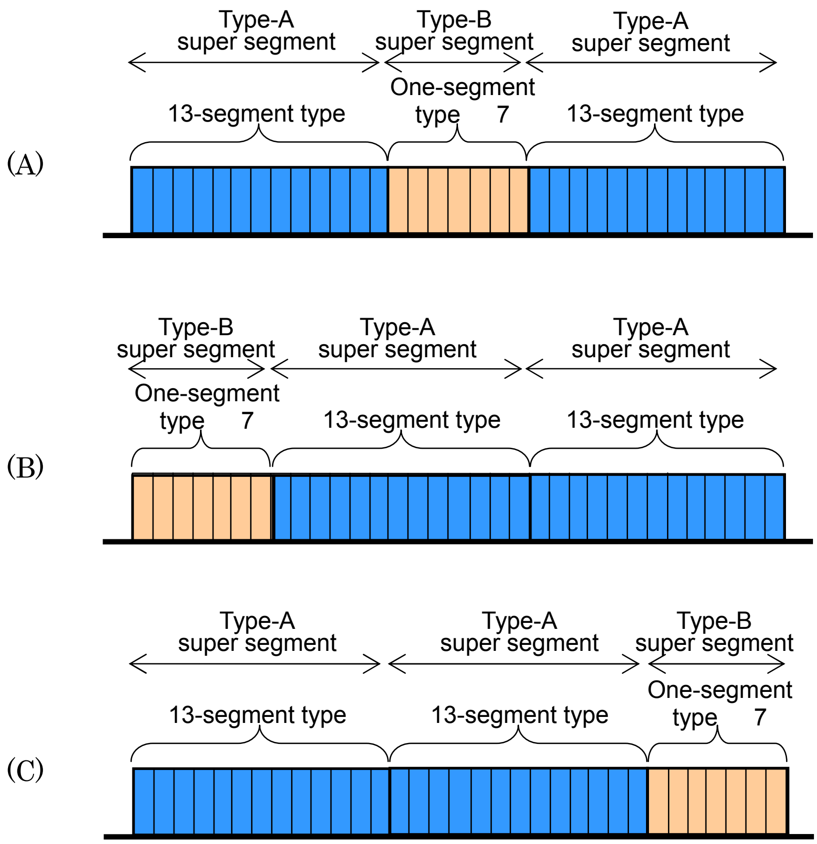


Fig. 2-1: Super-segment Arrangement Pattern

[Reason]

Chapter 5 of this standard stipulates that ISDB-Tmm must transmit with one or more 13-segment types included.

For the connected transmission with 33 segments, the transmission is possible with a maximum of two 13-segment types included, and ISDM-Tmm operates with the patterns selected from the three arrangement patterns shown in Fig. 2-1 that are conceivable in that case.

Note that (A) is considered to have the ample tolerance against interference from the system of an adjacent frequency band. With the aim of allowing the transmission service carriers to change the segment arrangement in the future, however, the three patterns must be stipulated here.

2.5 One-segment-type sub-channel numbers

The sub-channel number of each unit transmission wave in the one-segment type × 7 connected super segment must be defined as shown in Fig. 2-2. Note that the numbers in the figure indicate the sub-channel center numbers of one-segment types.

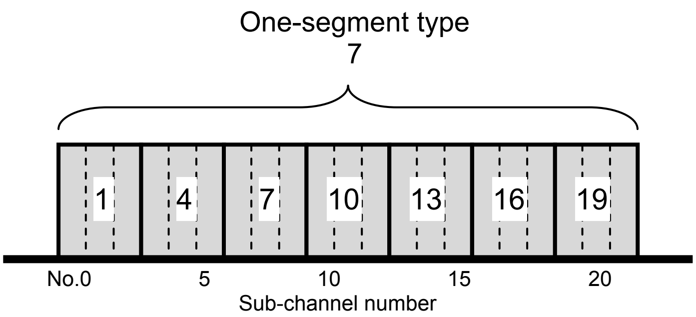


Fig. 2-2: One-segment Type × 7 Sub-channel Number

Note: For the relation between the definition of the sub-channel number and the segment, refer to Fig. 3-29 of Chapter 3 in this standard.

Chapter 3: Operational Guidelines for Hierarchical Transmission

3.1 Outline

Terrestrial multimedia broadcasting for mobile and portable terminals (connected segment transmission system) allows switching between transmission systems and the use of multiple such systems in the 13-segment type. This enables the operation of a maximum of three hierarchical layer transmissions.

3.2 Multiplexed signals for hierarchical transmission

3.2.1 Ranking of hierarchical layers

The ranking of hierarchical layers is shown in Table 3-1.

Table 3-1: Robustness of Hierarchical Layers

Ranking of hierarchical layers	Strong ← ------------------------------ → Weak																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Modulation scheme	DQ	Q	DQ	Q	DQ	Q	DQ	Q	DQ	Q	16QAM					64QAM				
Inner-code coding rate	1/2	1/2	2/3	2/3	3/4	3/4	5/6	5/6	7/8	7/8	1/2	2/3	3/4	5/6	7/8	1/2	2/3	3/4	5/6	7/8

DQ : DQPSK
Q : QPSK

QPSK is preferable to DQPSK in terms of the required C/N. However, DQPSK offers better performance at the time of time variations under mobile-reception conditions. Therefore, DQPSK is robuster than QPSK.

3.2.2 Notes on multiplexing transmission

When transmission control signals are transmitted with multiple hierarchical layers, including those for partial reception, the continuity of the continuity_counter for transport-stream packets conveying transmission control signals must be taken into consideration.

Because this counter is continuous even for narrow-band receivers that reproduce only the hierarchical layer for partial reception, duplicate packets must be used*1.

For this reason, when transmission control signals are multiplexed into multiple hierarchical layers, duplicate packet transmission must be used. Note, however, that if different time interleaving lengths are specified for the partial-reception hierarchical layer and the robustest hierarchical layer, it is necessary to exercise caution when duplicate packet transmission is used.

*1: A duplicate packet, as defined in "MPEG-2 systems," is designed to send two TSPs (transport packets) successively within the same PID. Note that the contents of these TSPs other than PCR are the same within the transport stream. Note also that the contents of the continuity counter are the same for both of these TSPs.

3.2.3 Multiplexing PCR packets at the partial-reception hierarchical layer

When a service is provided using the partial-reception hierarchical layer, PCR packets for this service must be transmitted in accordance with Table 3-2.

To reduce power consumption, the rate at which a single-segment receiver reproduces TS is likely to be lower than that for a 13-segment receiver. Therefore, the intervals at which TS packets are reproduced by the single-segment receiver do not always match those at which TS packets at the partial-reception hierarchical layer are reproduced by the 13-segment receiver, resulting in PCR jitter (see Fig. 3-1).

To prevent this problem, limitations are imposed on PCR transmission as shown in Table 3-2. These limitations ensure that PCR packets are reproduced by single- and 13-segment receivers at equal intervals, thus eliminating the need for a PCR jitter correction step, although some difference in offset is produced.

Table 3-2: Regulations for PCR-Packet Transmission at the Partial-Reception Hierarchical Layer

Mode	PCR-packet transmission regulations
Mode 1	For the duration of a single multiplex frame, only one PCR packet must be multiplexed per service, and the multiplexing position must remain constant for all multiplex frames (see Fig. 3-2).
Mode 2	For the duration of a single multiplex frame, two PCR packets must be multiplexed per service at the same intervals (see Fig. 3-3).
Mode 3	For the duration of a single multiplex frame, four PCR packets must be multiplexed per service at the same intervals (see Fig. 3-4).

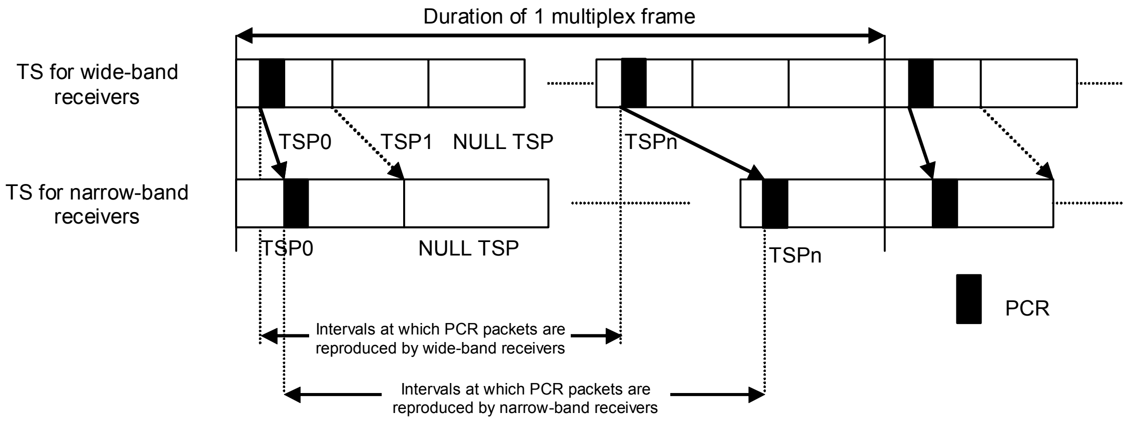


Fig. 3-1: TSs Reproduced by Wide- and Narrow-Band Receivers
(No Limitations on PCR Transmission)

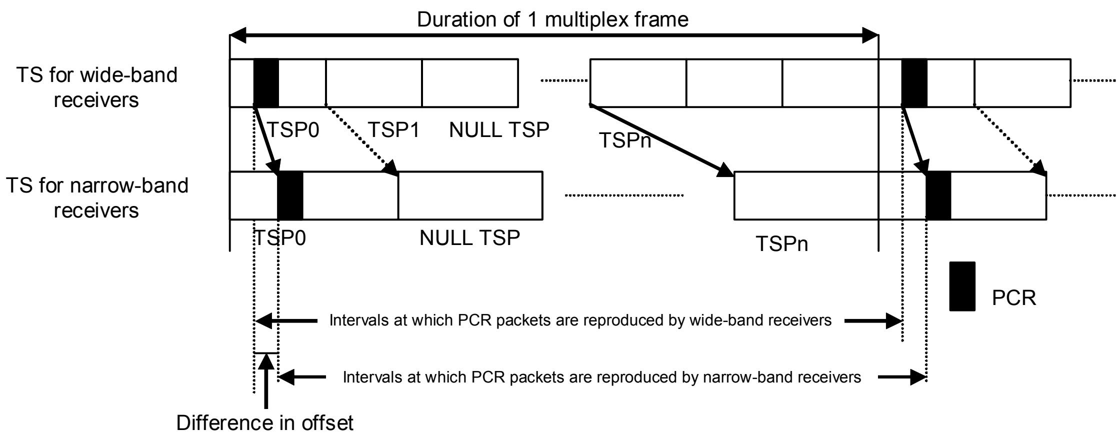


Fig. 3-2: PCR-Packet Transmission in Mode 1

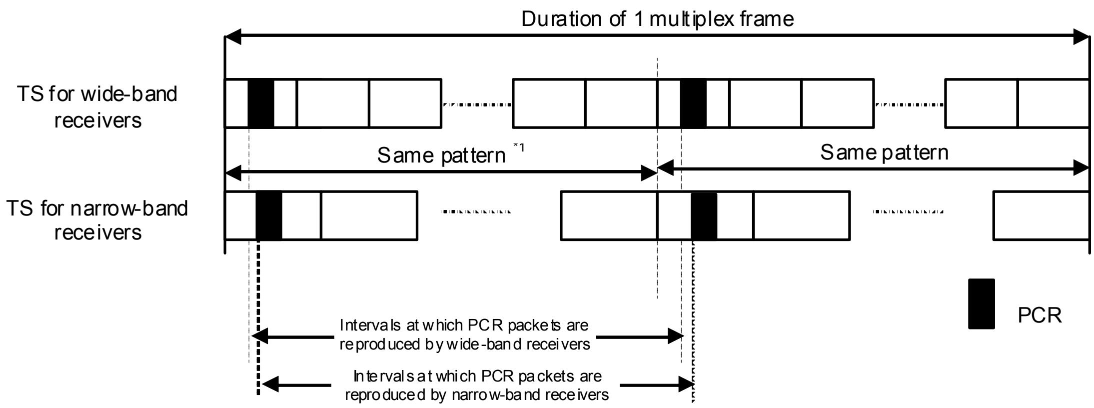


Fig. 3-3: PCR-Packet Transmission in Mode 2

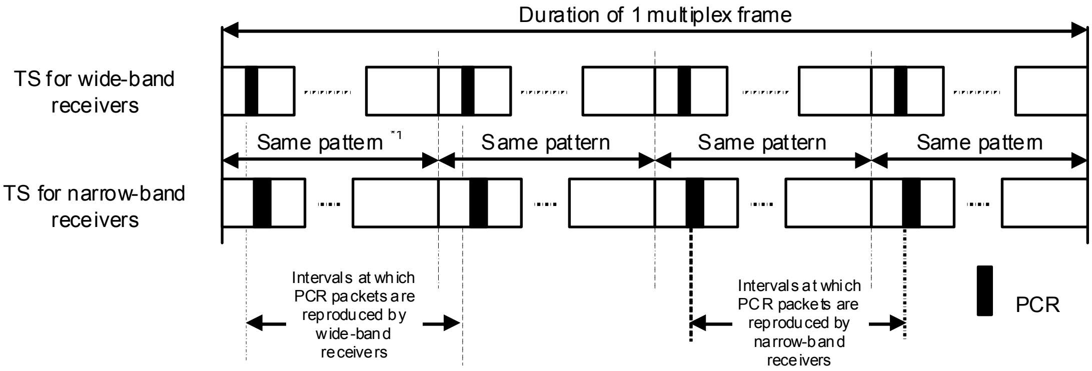


Fig. 3-4: PCR-Packet Transmission in Mode 3

*1 "Same pattern" in the figures indicates that each PCR packet is arranged in the same relative position within the stream.

3.3 Channel-coding scheme for hierarchical transmission

TS is divided into TSPs, each of which is assigned to the specified hierarchical layer, as described in Section 3.4 of Chapter 3 of this standard. Switching between hierarchical layers is performed every 204 bytes (starting with the byte next to the TS synchronization byte (47H)).

The following Fig. 3-5 and 3-6 show examples of the clock periods required by the channel coding in which two hierarchical layers are available (one layer modulated through DQPSK 1/2 and with 5 segments, and the other modulated through 64QAM 7/8 and with 8 segments) and a guard interval of 1/8 is selected. Note that "Fs" in the figure represents the FFT sampling clock. Figs. 3-7 and 3-8 show examples of the signal processes for time interleaving and delay adjustment.

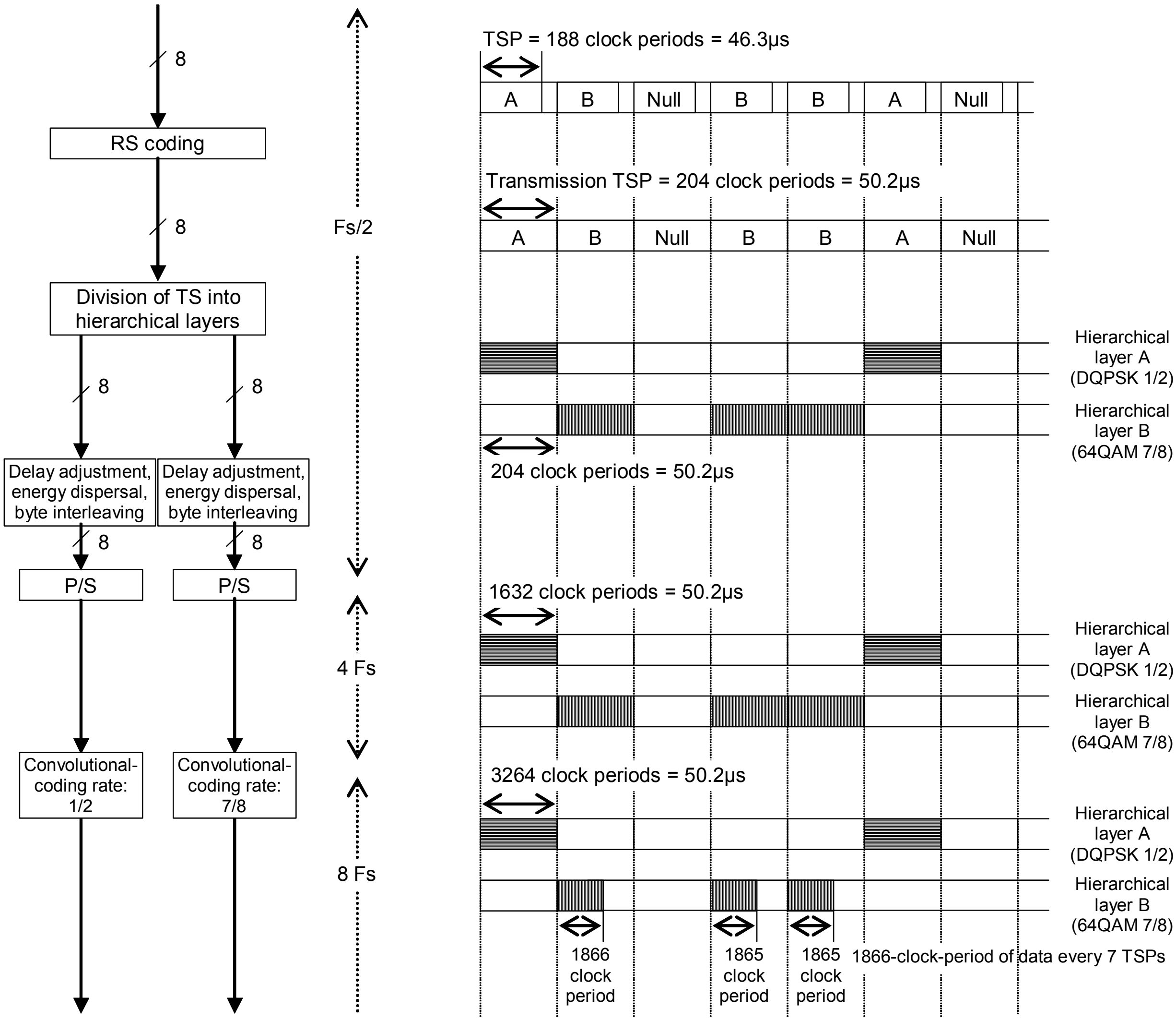


Fig. 3-5: An Example of a Signal Transmission System (1)

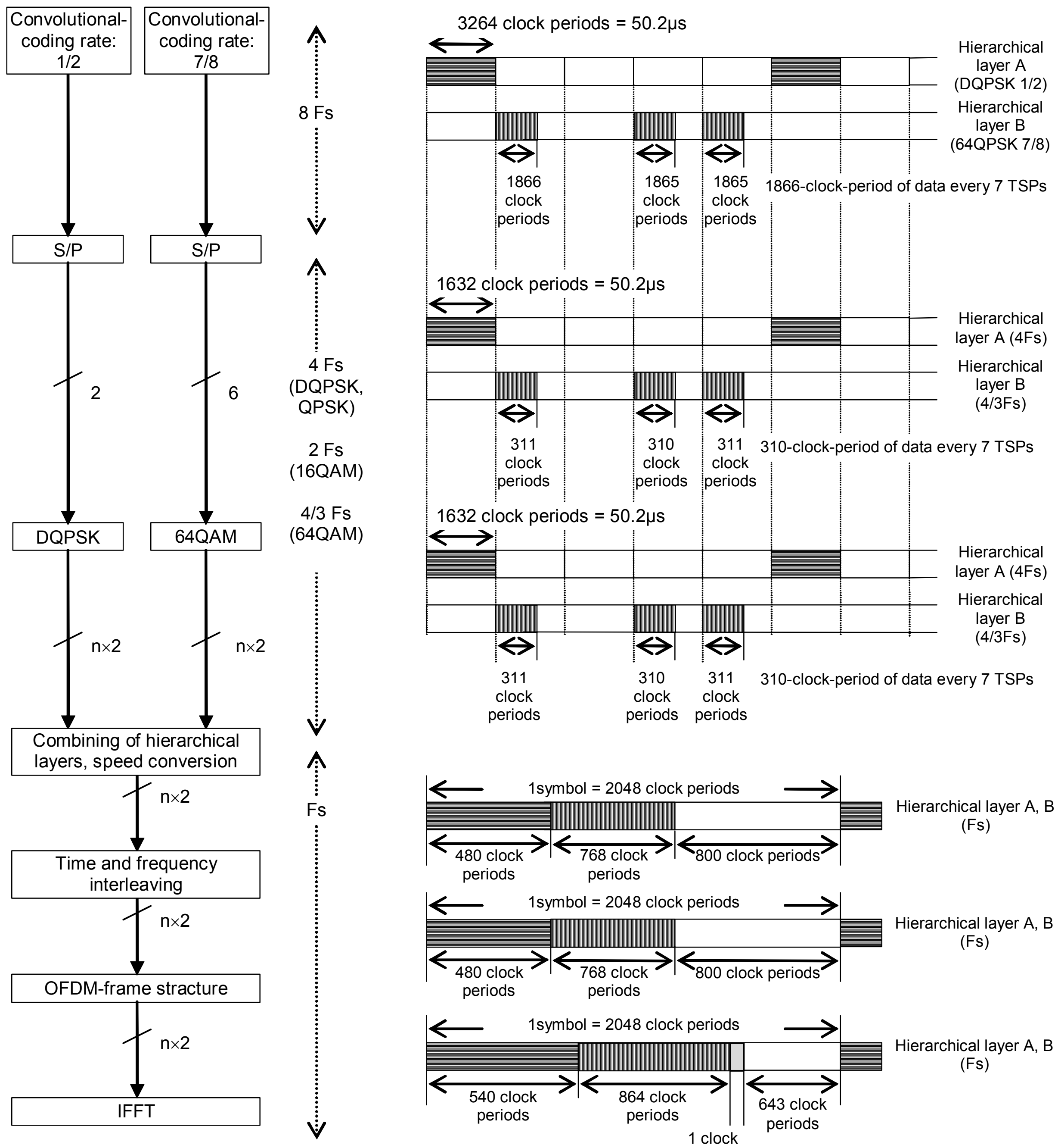
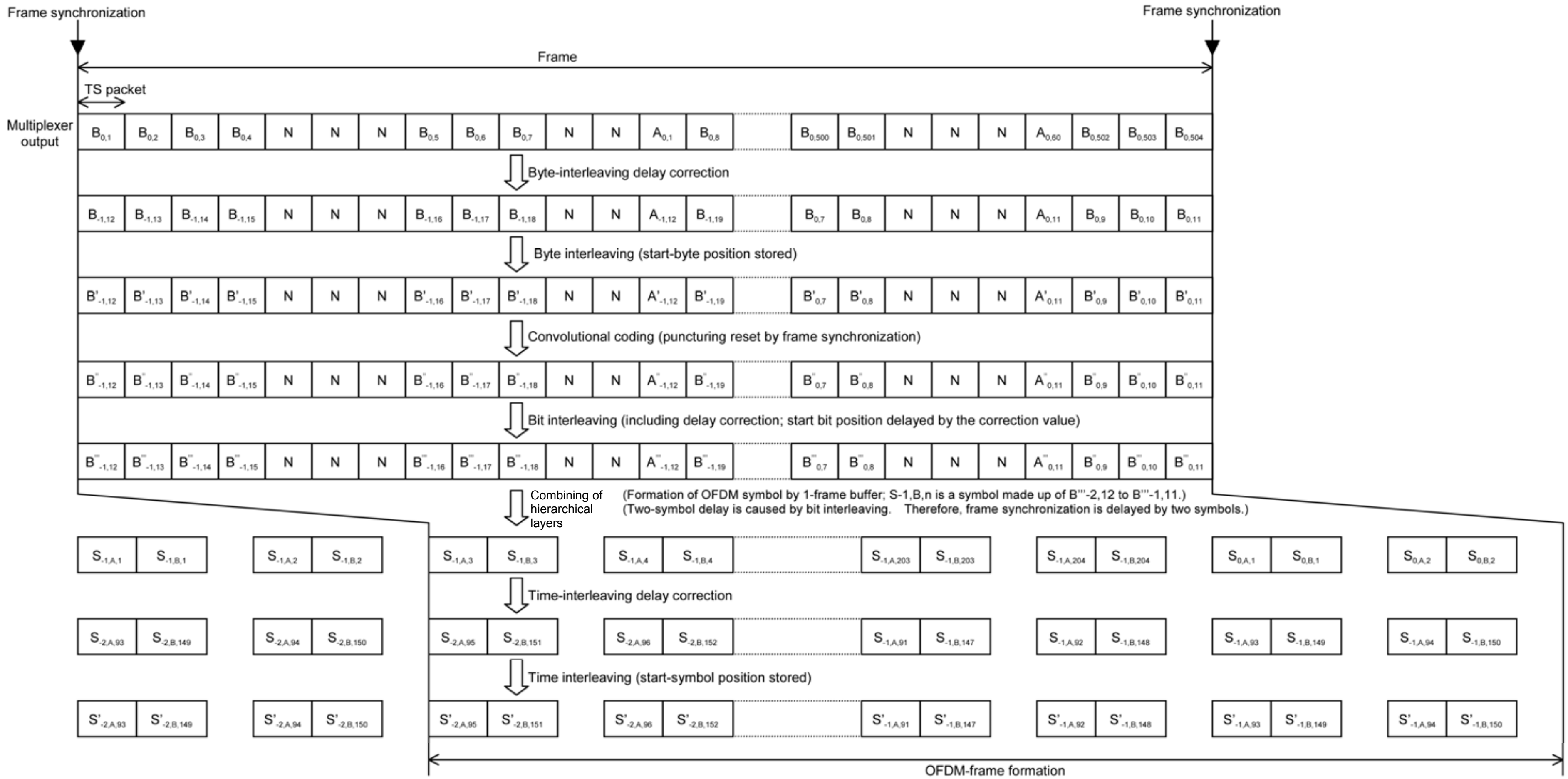


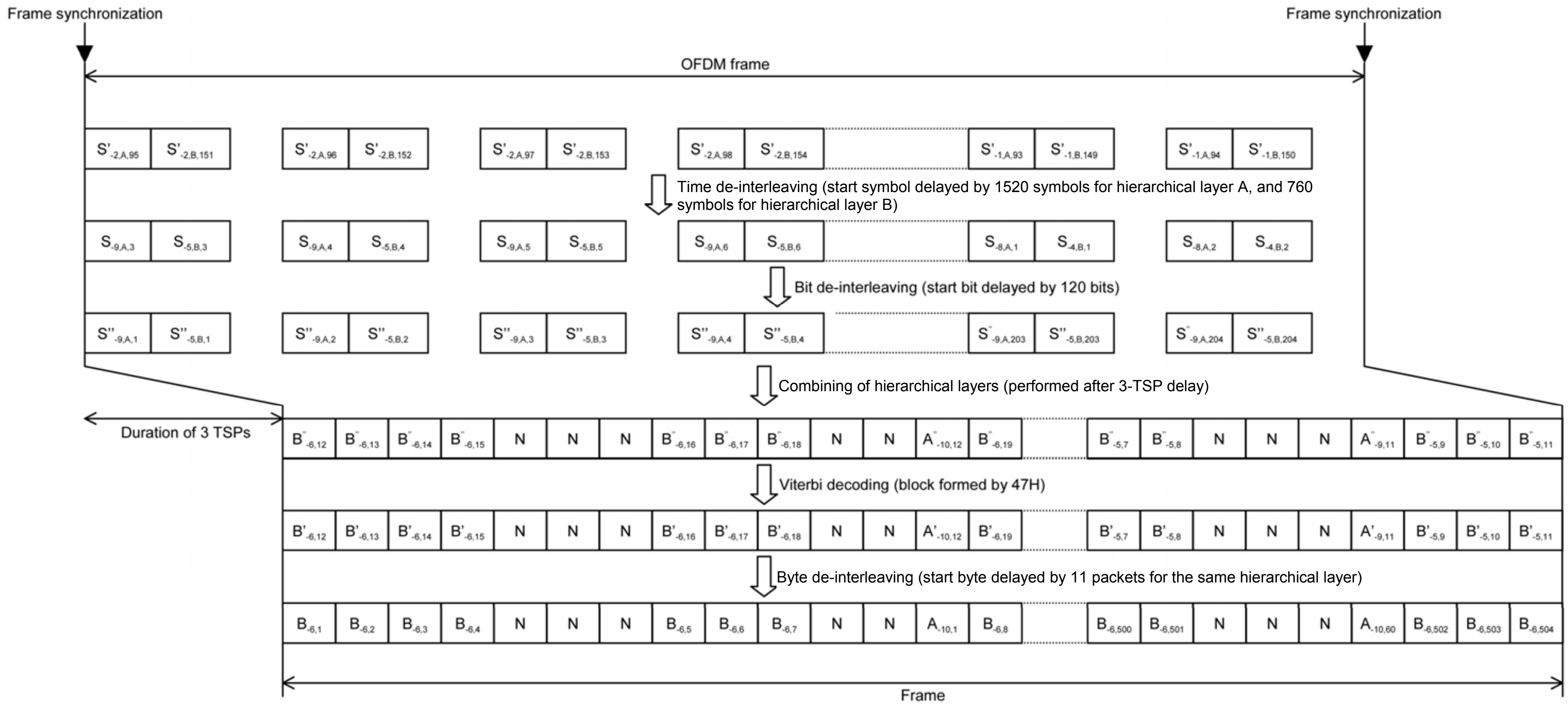
Fig. 3-6: An Example of a Signal Transmission System (2)



$A_{n,m}$: mth TSP of the nth frame of hierarchical layer A   N: Null TSP $S_{n,B,m}$: mth OFDM symbol of the nth frame of hierarchical layer B

(Hierarchical layer A: DQPSK, convolutional-coding rate of 1/2, 5 segments, I = 16)
(Hierarchical layer B: 64QAM, convolutional-coding rate of 7/8, 8 segments, I = 8)

Fig. 3-7: Time Interleaving and Delay Adjustment (An Example of Processing on the Transmitting Side)



(Hierarchical layer A: DQPSK, convolutional-coding rate of 1/2, 5 segments, I = 16)
(Hierarchical layer B: 64QAM, convolutional-coding rate of 7/8, 8 segments, I = 8)

Fig. 3-8: Time Interleaving and Delay Adjustment (An Example of Processing on the Receiving Side)

Chapter 4: Guidelines for Synchronization

4.1 Synchronization for SFN

To implement SFN, the following requirements must be met in order to establish synchronism between broadcast waves:

4.1.1 Transmission frequency

To prevent interference between carriers within the SFN service area, the variations in the transmission frequency of each broadcast wave must be 1 Hz or less.

4.1.2 IFFT sampling frequency

To implement SFN by means of OFDM signals generated by different IFFT sample clocks, as when multiple OFDM modulators are used, all IFFT sample-clock frequencies must be identical.

If one of the frequencies differs from the others, the difference affects the OFDM symbol period, that is, symbol speed. Consequently, a symbol shift beyond the guard interval length is produced between OFDM signals, causing interference between symbols.

Note also that the frequency of each of the uppermost and lowermost carriers of the frequency band must not vary any more than 1 Hz as a result of variations in the sample frequency.

4.1.3 OFDM signals

When multiple OFDM modulators are used, the output OFDM-signal waveforms must be the same at all SFN stations.

Note that it is preferable to select a transmission timing such that the difference in delay time within the service area is shorter than the guard interval.

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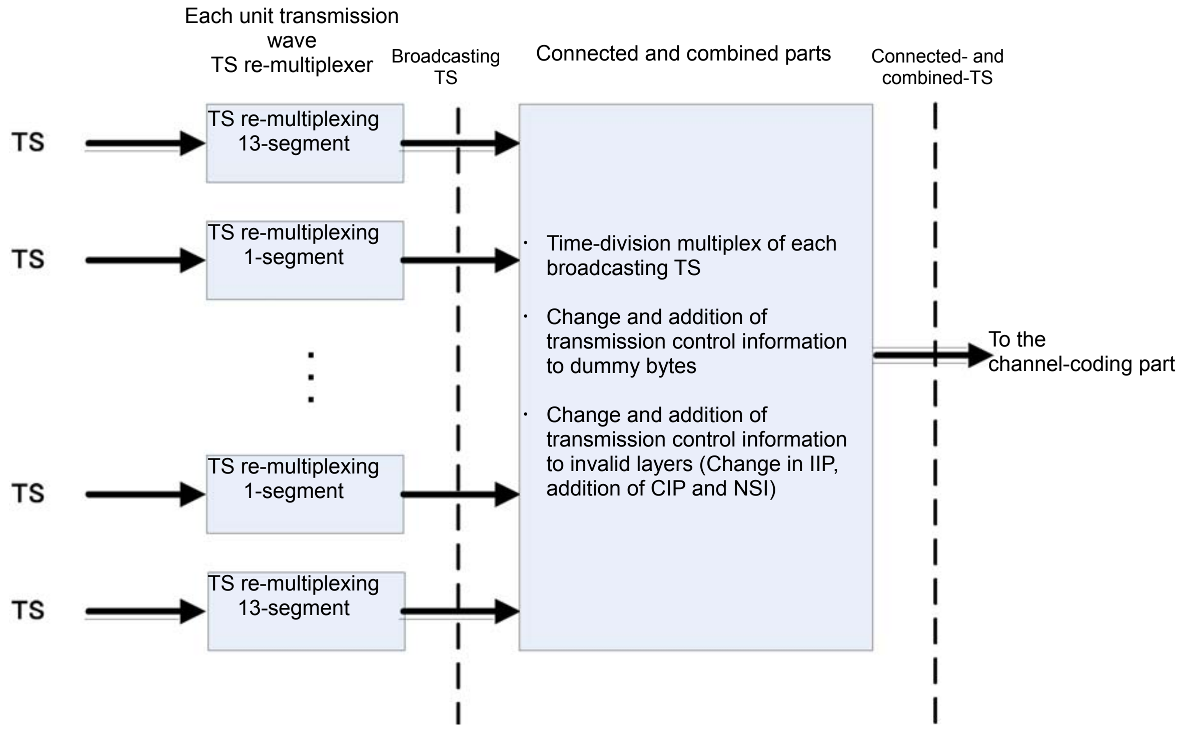
Chapter 5: Broadcasting TS and Connected and Combined TS

This chapter specifies the broadcasting TS that is the signal format following the re-multiplexing of each unit transmission wave in the ISDB-Tmm terrestrial multimedia broadcasting, and the connected and combined TS that is the signal format following the connecting and combining processing for bundling TSs together in one stream used for the connected transmission of each broadcasting TS.

5.1 Interface point

Interface points are indicated in the figures as shown below.



Broadcasting TS: The TS signal in conformity with MPEG-2 systems, which has a multiplexed frame construction of ISDB-Tmm terrestrial multimedia broadcasting signals; hereinafter referred to as “broadcasting TS”; this is the signal following TS re-multiplexing specified in Section 3.2, Chapter 3 of this standard, having multiplexed frame construction. The transmission rate for 13-segment types is about 32 Mbps (= (512/63) × 4 Mbps). The transmission rate for one-segment types is about 2 Mbps (= (512/63)/4 Mbps).

Connected and combined TS: The TS signal in which the broadcasting TS for each transmission wave is time division multiplexed; hereinafter referred to as “connected and combined TS”
The transmission rate is the sum of the transmission rate of each broadcasting TS connected and combined.
For specific examples, refer to Section 5.3.2.

Fig. 5-1: Interface Point

5.2 Broadcasting TS

This section specifies the types of transmission control information and the transmission methods needed for the control of transmission stations at the time of broadcasting TS transmission from among the interface points shown in Fig. 5-1.

5.2.1 Types of additional information

There are the following two types of multiple positions when multiplexing the transmitting control information to the broadcasting TS.

(1) Multiplexed to the dummy byte part of each TSP (Transport Stream Packet)
(2) Multiplexed as invalid hierarchical TSP (such as IIP, ISDB-T Information Packet).

Transmission is made as shown below, according to the transmission items of the transmitting control information.

Table 5-1: Transmission items of the transmitting control information and multiplex position

No.	Transmission item	Description	Multiplex position	
			Dummy byte	Invalid hierarchy
1	TMCC ID	'00': BS digital '10': Digital terrestrial TV '11': Digital terrestrial audio	○	
2	Buffer reset flag	Synchronization device buffer reset control	○	
3	Starting control for emergency-alarm broadcasting	Designating the duration of emergency-alarm broadcast execution	○	○
4	TMCC change head packet flag	Designation of head packet to change	○	
5	Frame head packet flag	Designation of head packet of multiplexed frame	○	
6	Frame synchronization designation (w0,w1)	Designation of duration of even number or odd number frames	○	○
7	Hierarchy information of each TSP	Hierarchy discrimination of A, B, C, NULL Designation of TSP that carries IIP, CIP or that carries AC data	○	
8	Transmission parameter switching index		○	○
9	TSP counter	Multiplexed frame head packet is 0. Incremented in the order of packet.	○	
10	TMCC (including mode and GI)	TMCC and modulation device control information		○
11	Broadcasting network control information	Control information such as delay at SFN		Optional
12	AC data	Information transmitted by AC	Optional	Optional
13	Service providers' organized data	Data multiplexed to broadcasting TS independently by service providers		Optional
14	Discriminated information of broadcasting TS and connected and combined TS	Discrimination of broadcasting TS and connected and combined TS	○	

However, for items overlapping both dummy byte and invalid hierarchy, it should be multiplexed so as not to contradict each other.

When the seismic motion warning information is transmitted by AC data, it must be multiplexed to dummy bytes.

5.2.2 Multiplex to dummy byte part

(1) Multiplex position

Interface signal format should be re-multiplexing TS format having multiplexed frame construction of 204 bytes and should be multiplexed on 8 bytes (dummy byte part) other than information part of 188 bytes, and information shown in Table 5-1 should be multiplexed.

Information part	Multiplex position	Parity (option)
188 bytes	8 bytes	8 bytes

Fig. 5-2: Multiplex position on dummy byte

Additional information multiplexed on the above dummy byte (multiplex position) indicates the information of its TS packet. The multiplexed additional information is called ISDB-Tmm_information.

It should be possible to add the following parity when required.

The parity should apply the shortened (204,196) Reed-Solomon code generated by adding 00HEX of 51 bytes in front of the input data byte in the case of (255,247) Reed-Solomon code and deleting the top 51 bytes.

As for the original (255, 247) Reed-Solomon code, GF(2^8) element and the primitive polynomial defining GF(2^8) are as follows:

$$p(x) = x8 + x4 + x3 + x2 + 1$$

For generator polynomial of the (255, 247) Reed-Solomon code:

$$g(x) = (x-\lambda^0)(x-\lambda^1)(x-\lambda^2)(x-\lambda^3)(x-\lambda^4)(x-\lambda^5)(x-\lambda^6)(x-\lambda^7)$$

where, $\lambda = 02_{HEX}$

(2) Multiplex information

Table 5-2: Syntax of ISDB-Tmm_information

Data Structure	Number of Bits	Bit String Notation
ISDB-Tmm_information(){		
TMCC_identifier	2	bslbf
reserved	1	bslbf
buffer_reset_control_flag	1	bslbf
switch-on_control_flag_for_emergency_broadcasting	1	bslbf
initialization_timing_head_packet_flag	1	bslbf
frame_head_packet_flag	1	bslbf
frame_indicator	1	bslbf
layer_indicator	4	bslbf
count_down_index	4	bslbf
AC_data_invalid_flag	1	bslbf
AC_data_effective_bytes	2	bslbf
TSP_counter	13	bslbf
if(AC_data_invalid_flag==1)		
stuffing_bit	24	bslbf
else{		
AC_data	24	bslbf
}		
super_segment_indicator	3	bslbf
super_segment_type	1	bslbf
transmission_unit_indicator	4	bslbf
}		

Table 5-3: Description of ISDB-Tmm_information syntax (bit0 = LSB)

Byte	bit	Syntax	Description
0	7	TMCC identifier (TMCC discrimination)	'10': 13-segment type '11': One-segment type
	6		
	5	reserved	Should be '1'
	4	buffer_reset_control_flag (Buffer reset flag)	Synchronized device buffer reset control signal In case of buffer reset, '1' Normally, '0'
	3	switch-on_control_flag_for_ emergency_broadcasting (Start control for emergency-alarm broadcasting)	Receiver unit start control signal in case of emergency broadcasting. During emergency broadcasting, '1' Normally, '0'
	2	initialization_timing_head_pac ket_flag (Changing designation)	The changed head packet is '1'. Normally, it is '0'. (The transmission parameter switching index is counted down and when it returned to '1111,' the head packet of the frame is '1.'
	1	frame_head_packet_flag (Frame head flag)	Discriminates the head of multiple frames. The multiple frame head packet is '1' regardless of even number or odd number frames. Others are '0.'
	0	frame_indicator (Frame synchronization discrimination)	During even frame (w0) of the OFDM frame, it is '0.' During odd frame (w1) of the OFDM frame, it is '1.'
1	7-4	layer_indicator (Hierarchy information for each TSP)	Indicates the hierarchy by which the TSP is transmitted. '0000': A NULL-TSP which is not transmitted by any of hierarchical layers A, B, or C. '0001': TSP transmitted by hierarchical layer A. '0010': TSP transmitted by hierarchical layer B '0011': TSP transmitted by hierarchical layer C '0010': TSP which transmits AC data but not transmitted by any of hierarchical layers A, B, or C '0101'~'0111': TSP that service providers multiplex originally organized data '1000': TSP which transmits the IIP or CIP but not transmitted by any of hierarchical layers A, B, or C. '1001'~'1111': TSP that service providers multiplex originally organized data
	3-0	count_down_index (Transmission parameter switching index)	Transmission parameter switching index described in the TMCC information.
2	7	AC_data_invalid_flag (AC data flag multiplexed on the dummy byte part)	When AC data is not added to the dummy byte part: '1' When AC data is added to the dummy byte part: '0'
	6-5	AC_data_effective_bytes (Actual number of AC data bytes to be transmitted by broadcasting waves)	'00': 1-byte '01': 2-byte '10': 3-byte '11': AC data is not added to the dummy byte part. Among bytes 4 to 6, the byte position to be used should be specified by each service provider.
	4-0	TSP_counter (TSP counter)	A counter in which the head packet of the multiplex frame is 0 and increments one by one in the order of packet. Increments including NULL-TSP, TSP that transmits IIP or AC data, etc.
3	7-0		
4	7-0	AC_data (AC data)	Area for AC data (Is not transmitted in the case of AC_data_invalid_flag ='1')
5	7-0	AC_data (AC data)	
6	7-0	AC_data (AC data)	

7	7-5	super_segment_indicator (Super-segment information)	Broadcasting TS and connected and combined TS should be discriminated. Note that for connected and combined TS, it indicates the super segment and others to which the relevant TSP is transmitted. It should be '111' for broadcasting TS. For connected and combined TS, Table 5-4 should be referred to.
	4	super_segment_type (Super-segment type)	It should be '1' for broadcasting TS. The following should be followed for connected and combined TS. '0' : type-A super segment '1' : type-B super segment
	3-0	transmission_unit_indicator (Unit transmission wave information)	It should be '1111' for broadcasting TS. For connected and combined TS, Table 5-5 should be referred to.

Table 5-4: Super-segment Information

super_segment_indicator
Broadcasting TS and connected and combined TS should be discriminated. Note that for connected and combined TS, it indicates the super segment and others to which the relevant TSP is transmitted. Note also that the super-segment numbers are arranged in ascending order of RF frequencies. '000': TSP transmitted for use as common information '001': TSP transmitted by super segment 1 '010': TSP transmitted by super segment 2 '011': TSP transmitted by super segment 3 '100': TSP transmitted by super segment 4 '101': TSP transmitted by super segment 5 '110': Not used '111': Indicates as being broadcasting TS

Table 5-5: Unit Transmission Wave Information

transmission_unit_indicator
For connected and combined TS, it indicates the unit transmission wave and others to which the relevant TSP belongs. Note that the unit transmission wave numbers are arranged in ascending order of frequencies. When the relevant TSP is common information, the unit transmission wave information should be '0001'. When the relevant TSP is the type-A super segment, the unit transmission wave information should be '0001'. When the relevant TSP is the type-B super segment, the following should be indicated. '0000': Not used '0001': TSP transmitted by unit transmission wave 1 '0010': TSP transmitted by unit transmission wave 2 • • '1110': TSP transmitted by unit transmission wave 14 '1111': Not used

5.2.3 Multiplex to invalid hierarchy IIP (ISDB-Tmm_Information_Packet)

(1) Multiplex position

Data of the IIP is inserted in the 188 bytes of the packet information part in which the layer_indicator in Table 5-2 becomes ‘1000,’ and only this one packet is multiplexed in one multiplex frame.

Information carried by IIP indicates the information of the multiplex frame after the multiplex frame to which the packet belongs.

(2) IIP information

Table 5-6: Syntax of IIP (ISDB-Tmm_Information_Packet)

Data Structure	Number of Bits	Bit String Notation
ISDB-Tmm_information_packet(){		
TSP_header{		
sync_byte	8	bslbf
transport_error_indicator	1	bslbf
payload_unit_start_indicator	1	bslbf
transport_priority	1	bslbf
PID	13	uimsbf
transport_scrambling_control	2	bslbf
adaptation_field_control	2	bslbf
continuity_counter	4	uimsbf
}		
payload{		
IIP_packet_pointer	16	uimsbf
modulation_control_configuration_information( )	160	bslbf
NSI_branch_number	8	uimsbf
last_NSI_branch_number	8	uimsbf
network_synchronization_information_length	8	uimsbf
for(i=0;i<159;i++){		
stuffing_byte(0xFF)	8	bslbf
}		
}		
}		

Table 5-7: Description of Syntax of IIP

Syntax	Description
sync_byte	TSP synchronization byte. 0x47('0100 0111')
transport_error_indicator	Not used. Should be always '0'
payload_unit_start_indicator	Should be always '1'
transport_priority	Not used. Should be always '0'
PID	Should be service provider defined. However, the same PID is used for terrestrial multimedia broadcasting.
transport_scrambling_control	Not used. Should be always '00'
adaptation_field_control	Should be always '01' (only payload)
continuity_counter	Should be used in accordance with ISO/IEC13818-1.
IIP_packet_pointer	Indicates the number of packet from the multiplex position to the next multiplex frame head in the multiplex frame of the ISDB-Tmm_information_packet. The value of the last TPS of the multiplex frame should be 0 and should be counted from the multiplex position of the ISDB-Tmm_information_packet to the next multiplex frame head in TSP unit.
NSI_branch_number	It should be 0x00 for broadcasting TS. However, it should indicate the following when NSI information is transmitted after the completion of a connecting and combining process. It should indicate the branch number of the relevant NSI. To prepare for NSI not to be stored within one packet, NSI can be overlapped on multiple packets. Let this branch number circulate every packet. The packet not containing NSI information should be designated as 0xFF. NSI_branch_number of the packet containing the first information derived from the division of NSI is 0x00.
last_NSI_branch_number	It should be 0x00 for broadcasting TS. However, it should indicate the following when NSI information is transmitted after the completion of a connecting and combining process. It should indicate NSI_branch_number of the packet containing the last information derived from the division of NSI into more than one packet. That is, when NSI comprises only one packet, 0x00 should be designated, while when NSI comprises two packets, 0x01 should be designated.
network_synchronization_ information_length	It should indicate 0x00 for broadcasting TS. However, it should indicate the following when NSI information is transmitted after the completion of a connecting and combining process. The length of subsequent network_synchronization_information should be designated in units of byte.

It follows from the fact that the IIP packet is one per the multiplex frame of the broadcasting TS for unit transmission wave in that its payload is 184 bytes. In the digital terrestrial TV system (ARIB STD-B31), when the IIP information multiplexed to broadcasting TS feeds the information in excess of 184 bytes, a proposal is made for a mechanism to feed on multiple multiplex frames. As information exceeding 184 bytes, the broadcasting network information (NSI = network_synchronization_information) is available, which is the control information used for delay and other purposes at the time of SFN. In this terrestrial multimedia broadcasting, however, this information is not defined as the signal in this interface point because the broadcasting network information is added in the course of a connecting and combining process in the broadcasting TS for unit transmission-wave. Here, let NSI_branch_number=0x00, last_NSI_branch_number=0x00, and network_synchronization_information_length=0x00, and following that, these are filled with stuffing_byte (0xFF). The broadcasting network information is multiplexed in the connecting and combining process to the position behind modulation_control_configuration_information of this IIP in accordance with Table 5-6.

(3) Configuration of modulation_control_configuration_information

Table 5-8: Syntax of modulation_control_configuration_information

Data Configuration	Number of Bits	Bit String Notation
modulation_control_configuration_information(){		
TMCC_synchronization_word	1	bslbf
AC_data_effective_position	1	bslbf
reserved	2	bslbf
mode_GI_information{		
initialization_timing_indicator	4	bslbf
current_mode	2	bslbf
current_guard_interval	2	bslbf
next_mode	2	bslbf
next_guard_interval	2	bslbf
}		
TMCC_information{		
system_identifier	2	bslbf
count_down_Index	4	bslbf
switch-on_control_flag_used_for_alert_broadcasting	1	bslbf
current_configuration_information{		
partial_reception_flag	1	bslbf
transmission_parameters_for_layer_A{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		
transmission_parameters_for_layer_B{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		
transmission_parameters_for_layer_C{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		
}		
next_configuration_information{		
partial_reception_flag	1	bslbf
transmission_parameters_for_layer_A{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		
transmission_parameters_for_layer_B{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		

transmission_parameters_for_layer_C{		
modulation_scheme	3	bslbf
coding_rate_of_inner_code	3	bslbf
length_of_time_interleaving	3	bslbf
number_of_segments	4	bslbf
}		
}		
phase_correctiton_of_CP_in_connected_transmission	3	bslbf
TMCC_reserved_future_use	12	bslbf
reserved_future_use	10	bslbf
}		
CRC_32	32	rpchof
}		

Table 5-9: Description of Syntax of modulation_control_configuration_information

Syntax	Description
TMCC_synchronization_word	Synchronizes to the OFDM frame synchronization signal allocated in B1 to B16 of the TMCC carrier and transfers as follows. w0 (0011010111101110) = '0' w1 (1100101000010001) = '1'
AC_data_effective_position	Indicates whether invalid hierarchical data or dummy byte data is used as the actual AC data to be transmitted by broadcasting waves. '0': invalid hierarchical data is used '1': dummy byte data is used (including the case in which AC data is not multiplexed)
mode_GI_information	Information of transmission mode and guard interval ratio. Note that in the case of connected transmission, same value with other unit transmission wave must be used.
initialization_timing_indicator	Indicates the switching timing of mode and guard_interval. • Normal value is 15('1111'). The value is decremented by OFDM frame unit from 15 frames before the switching timing. • The switching timing should be the start timing of the first OFDM frame when the initial setting pointer value returns from 0 to 15. During count down (when the value is other than 15), a revision of next_mode and next_guard_interval cannot be made.
current_mode	Indicates the Mode (1,2,3) now being used '00': reserved '01': Mode 1 '10': Mode 2 '11': Mode 3
current_guard_interval	Indicates the guard interval ratio now being used. '00': 1/32 '01': 1/16 '10': 1/8 '11': 1/4
next_mode	Indicates the next Mode (1,2,3)
next_guard_interval	Indicates the next guard interval
TMCC_information	Same as the TMCC information in ISDB-Tmm.
system_identifier	Same as the system discrimination in TMCC information.
count_down_index	Same as the transmission parameter switching index described in the TMCC information.
switch-on_control_flag_used _for_alert_broadcasting	Same as the startup control flag (start flag for emergency-alarm broadcasting) described in the TMCC information.
current_configuration _information	Same as the current information of the TMCC information.
partial_reception_flag	Same as the partial-reception flag described in the TMCC information.
transmission_parameters _for_layer_A	Same as the transmission-parameter information for hierarchical layer A of the TMCC information.
modulation_scheme	Same as the carrier modulation mapping scheme described in the TMCC information.
coding_rate_of_inner_code	Same as the convolution-coding ratio described in the TMCC information.
length_of_time_interleaving	Same as time interleaving length described in the TMCC information.
number_of_segments	Same as the number of segments described in the TMCC information.
transmission_parameters _for_layer_B	Same as the transmission-parameter information for hierarchical layer B in the TMCC information.
transmission_parameters _for_layer_C	Same as the transmission-parameter information for hierarchical layer C in the TMCC information.
next_configuration_information	Same as the next information of the TMCC information.

phase_correction_of_CP _in_connected_transmission	Same as the phase-shift-correction value for connected segment transmission described in the TMCC information.
TMCC_reserved_future_use	Same as the reserved bit (B_{110} to B_{121}) described in the TMCC information
reserved_future_use	Reserved bit for future extension. All of them should be '1'.
CRC_32	CRC value calculated by the following polynomial used in ISO/IEC13818-1. Ranges are to all the modulation_control_configuration_information from TMCC_synchronization_word to reserved_future_use. Polynomial=$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

5.3 Connected and combined TS

Of the interface points shown in Fig. 5-1, this section stipulates the types of transmission control information and transmission methods that are needed when the connected and combined TS is transmitted, along with the methods used for connecting and combining the broadcasting TS for each unit transmission wave.

5.3.1 Types of additional information

For the broadcasting TS for each unit transmission wave, the transmission control information shown below is added to a connected and combined TS signal. There are the following two types of multiplex positions when multiplexing the transmission control information to the connected and combined TS.

(1) Multiplexed to the dummy byte part of each TSP (Transport Stream Packet)
(2) Multiplexed as invalid hierarchical TSP (hereafter referred to as "CIP," or "Connected Transmission Information Packet")

Transmission is made as shown below, according to the transmission items of the added transmitting control information.

Table 5-10: Transmission Items of the Transmitting Control Information when connecting and combining TS and Multiplex Position

No.	Transmission item	Description	Multiplex position	
			Dummy byte	Invalid hierarchy
1	TMCC ID	Pursuant to Table 5-1	Pursuant to Table 5-1	Pursuant to Table 5-1
2	Buffer reset flag			
3	Startup control for emergency-alarm broadcasting			
4	TMCC change head packet flag			
5	Frame head packet flag			
6	Frame synchronization identification (w0,w1)			
7	Hierarchy information of each TSP	Hierarchy discrimination of A, B, C, NULL Designation of TSP that carries IIP , CIP or that carries AC data	○	
8	Transmission parameter switching index	Pursuant to Table 5-1	Pursuant to Table 5-1	Pursuant to Table 5-1
9	TSP counter			
10	TMCC (including mode and GI)			
11	Broadcasting network control information			
12	AC data			
13	Discriminated information of broadcasting TS and connected and combined TS	Discrimination of broadcasting TS and connected and combined TS	○	
14	Service providers' organized data	Data multiplexed to broadcasting TS by service providers independently		Optional
15	Connected transmission information for each TSP	Following information on relevant TSP Super-segment information Super-segment type Information on unit transmission-wave information	○	

16	Connected transmission control information	Segment configuration control information for connected transmission		○

However, for items overlapping both dummy byte and invalid hierarchy, it should be multiplexed so as not to contradict each other.

When the seismic motion warning information is transmitted by AC data, the information must be multiplexed to the dummy byte part.

5.3.1.1 Multiplex to dummy byte part

The addition must be made in accordance with the same multiplex positions and the same parity system as those for broadcasting TS shown in Section 5.2. The added connected transmission information for each TSP is multiplexed to the seventh byte position indicated in Table 5-3. As for the hierarchy information for each TSP, when CIP is multiplexed, the addition must be made such that Layer_indicator is “1000.” For this reason, part of the hierarchy information for each TSP defined in Section 5.2 is changed in the connected and combined TS in conformity to Table 5-10. When parity is optionally added, re-calculation is needed.

(1) Multiplex position

Interface signal format should be re-multiplexing TS format having multiplexed frame construction of 204 bytes and should be multiplexed on 8 bytes (dummy byte part) other than information part of 188 bytes, and information shown in Table 5-8 should be multiplexed.

Information part	Multiplex position	Parity (option)
← 188 bytes →	← 8 bytes →	← 8 bytes →

Fig. 5-3: Multiplex position on dummy byte

Additional information multiplexed on the above dummy byte (multiplex position) indicates the information of its TS packet.

It should be possible to add the following parity when required.

The parity must be the same as that shown in Section 5.2.2.

(2) Multiplex information

It must be multiplexed according to the syntax shown in Table 5-2. For its content, refer to Table 5-3.

The added connected transmission information for each TSP is multiplexed to the seventh byte position in Table 5-3. Its details are shown in Tables 5-3, 5-4, and 5-5.

5.3.1.2 Multiplexing CIP (Connected_transmission_Information_Packet) on invalid hierarchy

(1) Multiplex position

CIP is put into the 188 bytes information part of the packet in which layer_indicator indicated in Table 5-2 becomes "1000."

CIP is indicated as follows:

layer_indicator = '1000'

super_segment_indicator = '000'

transmission_unit_indicator = '0001'

CIP can multiplex the multiple packets within one multiplex frame.

Information carried by CIP indicates the information of the multiplex frame after the multiplex frame to which the packet belongs.

(2) CIP information

Table 5-11: Syntax of CIP (Connected_transmission_Information_Packet)

Data Configuration	Number of Bits	Bit String Notation
connected_transmission_information_packet(){		
TSP_header{		
sync_byte	8	bslbf
transport_error_indicator	1	bslbf
payload_unit_start_indicator	1	bslbf
transport_priority	1	bslbf
PID	13	uimsbf
transport_scrambling_control	2	bslbf
adaptation_field_control	2	bslbf
continuity_counter	4	uimsbf
}		
payload{		
CIP_packet_pointer	16	unimsbf
connected_transmission_configuration_information ( ){		
total_segment_number	5	unimsbf
total_super_segment_number	3	unimsbf
for(i=0;i<super_segment_number;i++{		
super_segment_index	3	unimsbf
reserved	5	bslbf
start_sub-channel_number	4	bslbf
transmission_unit_number	4	unimsbf
for(j=0;j<transmission_unit_number;j++{		
transmission_unit_index	4	unimsbf
transmission_unit_type	2	bslbf
transmission_on	2	bslbf
}		
}		
CRC32	32	rpchof
}		
NSI_branch_number	8	unimsbf
last_NSI_branch_number	8	unimsbf

network_syncronization_information_length
network_syncronization_information( )
for(i=0;i<(N-network_syncronization_information _length);i++{
stuffing_byte(0xFF)
}
}
	8
	
	8
		unimsbf
		
		bslbf

Table 5-12: Description of Syntax of CIP

Syntax	Description
sync_byte	TSP synchronization byte. 0x47('0100 0111')
transport_error_indicator	Not used. Should be always '0'
payload_unit_start_indicator	Should be always '1'
transport_priority	Not used. Should be always '0'
PID	Should be service provider defined. However, the same PID is used for terrestrial multimedia broadcasting.
transport_scrambling_control	Not used. Should be always '00'
adaptation_field_control	Should be always '01' (only payload)
continuity_counter	Should be used in accordance with ISO/IEC13818-1.
CIP_packet_pointer	Indicates the number of packet from the multiplex position to the next multiplex frame head in the multiplex frame of the CIP. The value of the last TPS of the multiplex frame should be 0 and should be counted from the multiplex position of the CIP to the next multiplex frame head in TSP unit. However, the multiplex frame head should be the head TSP of the broadcasting TS for the unit transmission wave in which the frequency position in the frequency arrangement of RF transmission frequency is low.
total_segment_number	Indicates the total segment number; 33 at maximum, 13 at minimum '00000'–'01010': Reserved '01011': Number of segments 13 '01100': Number of segments 14 ・ ・ '11110': Number of segments 32 '11111': Number of segments 33
total_super_segment_number	Indicates the total super segment number '000': Reserved '001': Number of super segments 1 '010': Number of super segments 2 '011': Number of super segments 3 '100': Number of super segments 4 '101': Number of super segments 5 '110'–'111': Reserved
super_segment_index	Indicates the super-segment number of the following field information '000': Reserved '001': Indicates super segment 1 '010': Indicates super segment 2 '011': Indicates super segment 3 '100': Indicates super segment 4 '101': Indicates super segment 5 '110'–'111': Reserved

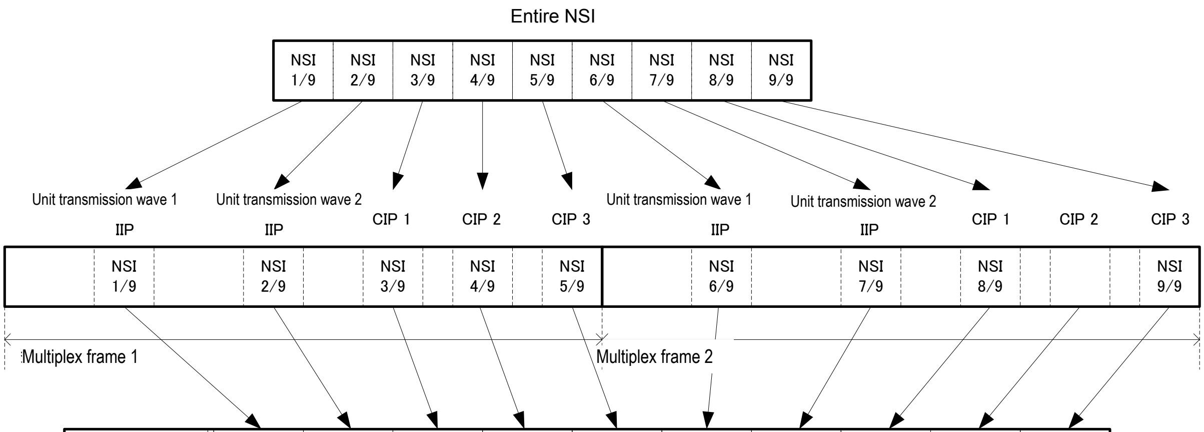
start_sub-channel_number	Indicates the sub-channel number at the center of the segment in which the frequency within the super segment is the lowest. ‘0000’: Indicates that the sub-channel number is 41,0,1 ‘0001’: Indicates that the sub-channel number is 2,3,4 ‘0010’: Indicates that the sub-channel number is 5,6,7 ‘0011’: Indicates that the sub-channel number is 8,9,10 ‘0100’: Indicates that the sub-channel number is 11,12,13 ‘0101’: Indicates that the sub-channel number is 14,15,16 ‘0110’: Indicates that the sub-channel number is 17,18,19 ‘0111’: Indicates that the sub-channel number is 20,21,22 ‘1000’: Indicates that the sub-channel number is 23,24,25 ‘1001’: Indicates that the sub-channel number is 26,27,28 ‘1010’: Indicates that the sub-channel number is 29,30,31 ‘1011’: Indicates that the sub-channel number is 32,33,34 ‘1100’: Indicates that the sub-channel number is 35,36,37 ‘1101’: Indicates that the sub-channel number is 38,39,40 ‘1110’–‘1111’: Reserved
transmission_unit_number	Indicates the number of unit transmission waves within the super segment ‘0000’: Reserved ‘0001’: Number of unit transmission waves 1 ‘0010’: Number of unit transmission waves 2 · · ‘1101’: Number of unit transmission waves 13 ‘1110’: Number of unit transmission waves 14 ‘1111’: Reserved
transmission_unit_index	Indicates the unit transmission wave number of the following field information; the number is numbered in ascending order from the unit transmission wave in which the RF frequency within the super segment is the lowest. ‘0000’: Reserved ‘0001’: Indicates unit transmission wave 1 ‘0010’: Indicates unit transmission wave 2 · · ‘1101’: Indicates unit transmission wave 13 ‘1110’: Indicates unit transmission wave 14 ‘1111’: Reserved
transmission_unit_type	Indicates the type of unit transmission wave ‘00’: One-segment type ‘01’: Reserved (three-segment type) ‘10’: 13-segment type ‘11’: Reserved
transmission_on	Indicates that the unit transmission wave is in operation ‘00’: Operation suspended ‘01’: Reserved ‘10’: Reserved ‘11’: In operation
CRC32	ARIB STD-B31 should be referred to. Ranges are from total_segment_number to transmission_on within connected_transmission_configuration_information.

NSI_branch_number	Indicates the branch number of the relevant NSI; in preparation for NST not to be stored within one packet, NSI can be overlapped on multiple packets. Let this branch number circulate every packet. The packet without storing NSI information is 0xFF. NSI_branch_number of the packet containing the first information derived from the division of NSI into multiple sections is 0x00.
last_NSI_branch_number	Indicates NSI_branch_number of the packet containing the last information derived from the division of NSI into multiple sections; that is, when NSI is constructed only by one packet, it designates 0x00, while it designates 0x01 when NSI is constructed by two packets.
network_syncronization_information_length	Length of the following network_synchronization_information is designated.

(3) NSI (network_synchronization_information) information

NSI is multiplexed to IIP and CIP. It is multiplexed to the multiplex positions in accordance with Table 5-6 and Table 5-11. When the number of NSI information bytes exceeds the number allowed for one packet to transmit, the information is transmitted to the IIP and multiple CIPs of the broadcasting TS for each unit transmission wave on multiple multiplex frames. It is possible for one IIP to exist within the multiplex frame of the broadcasting TS for each unit transmission wave and for multiple CIPs to exist within the multiplex frames after a connecting and combining process.

In the connected and combined TS consisting of two unit transmission waves, the relation between NSI_branch_number, last_NSI_branch_number, in which the information equivalent to the nine divisions of NSI is available in the data stream with three packets of CIP multiplexed, and the divided NSI information is shown as follows. In this example, NSI information is not multiplexed to CIP2 in the multiplex frame 2.



mcci/ctci	mcci_1	mcci_2	ctci	ctci	ctci	mcci_1	mcci_2	ctci	ctci	ctci
NSI_branch_number	0x00	0x01	0x02	0x03	0x04	0x05	0x06	0x07	0xff	0x08
last_NSI_branch_number	0x08	0x08	0x08	0x08	0x08	0x08	0x08	0x08	0x08	0x08
NSI	NSI 1/9	NSI 2/9	NSI 3/9	NSI 4/9	NSI 5/9	NSI 6/9	NSI 7/9	NSI 8/9	Stuffing byte	NSI 9/9

mcci : moculation_control_configuration_infomation
ctci : connected_transmission_configuration_information

Note 1: Unless there is any change in the content of modulation_control_configuration_information1, the identical content is maintained regardless of NSI_branch_number.

Note 2: Unless there is any change in the content of modulation_control_configuration_information2, the identical content is maintained regardless of NSI_branch_number.

Note 3: Unless there is any change in the content of connected_transmission_configuration_information, the identical content is maintained regardless of NSI_branch_number.

Note 4: NSI is transmitted by a repetition of the above.

Fig. 5-4: Example of NSI Information Configuration

Table 5-13: Syntax of network_synchronization_information

Data Structure	Number of Bits	Bit String Notation
network_synchronization_information(){		
synchronization_id	8	uimsbf
if(synchronization_id==0x00){		
SFN_synchronization_information{		
SFN_synchronization_information_header{		
synchronization_time_stamp	24	bslbf
maximum_delay	24	bslbf
}		
equipment_loop_length	8	uimsbf
for(i=0;i<equipment_loop_length/5;i++){		
equipment_control_information{		
equipment_id	12	uimsbf
renewal_flag	1	bslbf
static_delay_flag	1	bslbf
reserved_future_use	1	bslbf
time_offset_polarity	1	bslbf
time_offset	24	bslbf
}		
}		
}		
CRC_32	32	rpchof
}		
else if(synchronization_id==0xFF){		
for(j=0;j<N;j++){		
stuffing_byte(0xFF)	8	bslbf
}		
}		
}		

Table 5-14: Description of Syntax of network_synchronization_information

Syntax	Description
synchronization_id	‘0x00’ : SFN_synchronization_information is added ‘0x01’~’0xFE’ : For future extension ‘0xFF’ : SFN_synchronization_information is not added.
SFN_synchronization _information	Synchronization control information including delay time control in SFN network.
synchronization_time_stamp	Time difference from the reference time. Indicated in 10 MHz periodic unit (on the 100ns time scale). Indicates the delay time in the multiplex frame head (start time) of the unit transmission wave placed at the lowermost frequency position of the RF transmission frequency’s frequency arrangement on the connected and combined TS in which the next TMCC_synchronization_word is ‘0,’ against the latest 1pps signal gained from the time reference such as GPS, at the delivery output (Ex: output to STL) of the line to the broadcasting station
maximum_delay	Maximum delay time. The time interval between the delivery output (Ex: output to STL) of the line to the broadcasting station at the studio and the broadcasting wave emission from the transmission antenna of each broadcasting station in the SFN network[*Note 1.] Indicated in 10MHz periodic unit (on the 100 ns time scale). This value should be set to less than 1 second [within the range between 0 (0x000000) and 9999999 (0x98967F)].
equipment_loop_length	Indicates the following entire length of equipment_loop. Indicates in byte units.
equipment_control _information	Information to control the offset of delay time or fixed delay time individually for each broadcasting station.
equipment_id	Designates each broadcasting station to control by the equipment_control_information.
renewal_flag	Renewal flag. When renewing the values of static_delay_flag, time_offset_polarity, and time_offset, this field in equipment_control_information of the targeted equipment_id will be renewed. When renewing the value of maximum_delay, this field in all equipment_control_information syntaxes (all equipment loops) will be renewed. This field toggles between ‘1’ and ‘0’ for renewal.
static_delay_flag	Static delay flag. For the delay control of SFN, the delay time may be adjusted by the reference time such as GPS in one case and typical and static delay time may be allocated to the broadcasting station not using the reference time in another case. The static delay flag should be ‘1’ when the latter control is employed. In this case, the control information only time_offset is effective and only this value is used for delay control.
reserved_future_use	Reserved bit for future extension. The value should be ‘1’.
time_offset_polarity	Indicates polarity of the following time_offset. ‘0’ should be designated for a positive value and ‘1’ for a negative value. When static_delay_flag is '1', ‘0’ should be always designated.

time_offset	Indicated in 10-MHz periodic unit (on the 100 ns time scale). The meaning of this field changes according to the value of static_delay_flag: [When static_delay_flag = '0'] Indicates the offset of delay time at each broadcasting station against maximum_delay*Note1. This value, together with the polarity given by time_offset_polarity, is specified within the range of -1 second < time_offset < 1 second (between 0 (0x000000) and 9999999 (0x98967F) as the input value for this field). [When static_delay_flag = '1'] Indicates delay time, when setting a specific, fixed, delay time to a broadcasting station without using standard time *Note1. This value, which is less than 1 second, is specified within the range between 0 (0x000000) and 9999999 (0x98967F).
CRC_32	The CRC value is calculated by the following polynomial used in ISO/IEC13818-1. Ranges to all the SFN_synchronization_information from the (synchronization_time_stamp) which is the head of SFN_synchronization_information_header to time_offset. Polynomial=$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

* Note 1: The following time values indicated in the corresponding fields shall include the OFDM modulation time excluding the theoretical delay time due to time interleaving:

- the time interval between the delivery output of the line to the broadcasting station at the studio and the broadcasting wave emission from the transmission antenna of each broadcasting station in the SFN network (maximum_delay);
- the value of maximum_delay with the offset of delay time at each broadcasting station (maximum_delay ± time_offset) when static_delay_flag = "0";

  ["+" or "－" when time_offset_polarity is "0" or "1", respectively]
- the fixed delay time of each broadcasting station (time_offset) when static_delay_flag = "1",

Thus, the delay time required for SFN synchronization at each broadcasting station (the time between arrival at the broadcasting station and input to the modulator) needs to be calculated by deducting the time required for OFDM modulation (excluding the theoretical delay time due to time interleaving).

5.3.2 Time-division multiplex method for broadcasting TS for each unit transmission wave in connected and combined TS

The broadcasting TS for every unit transmission wave is time-division multiplexed, thus generating one stream. At this time, supposing that the transmission rate for 13-segment-type broadcasting TS and the transmission rate for one-segment-type broadcasting TS are represented by R_{13} (= 512/63 × 4 Mbps [about 32 Mbps]) and R_1 (= 512/63/4 Mbps [about 2 Mbps]) respectively, and that the number of 13-segment-type unit transmission waves is designated as M and the number of one-segment-type unit transmission waves as N, then, the total transmission capacity R_{total} is estimated by the following equation.

$$R_{total} = R_{13} \times M + R_1 \times N \text{ Mbps}$$

For instance, when the transmission capacity for 13-segment-type unit transmission waves is assumed as 2 and the transmission capacity for one-segment-type unit transmission waves is assumed as 7, and the total segment number is 33, then the transmission capacity R_{total} is estimated at:

$$R_{total} = R_{13} \times 2 + R_1 \times 7 = 512/63 \times (4 \times 2 + 7/4) = \text{approximately } 79 \text{ Mbps}$$

The transmission rate of R_{13} and R_1 is 16:1, and the broadcasting TS for each unit transmission wave is time-division multiplexed in the same proportion as this rate. Setting 1 TSP transfer time (about 0.8 ms = 204 × 8/R_1) for R_1 with the lower transmission rate at one unit time, all of the broadcasting TS for each unit transmission waves connected and combined are multiplexed within that unit time only by the number corresponding to the above-mentioned transmission rate. That is, the numbers thus estimated are 16TSP and 1TSP for 13-segment types and 1-segment types, respectively. As for sorting packets within this unit time, packets are sorted first one by one in ascending order starting from the broadcasting TS for the unit transmission wave with its frequency arrangement of the RF transmission frequency lower than others. It follows from this sorting that 1-segment-type TSPs with all packets transmitted within one unit time are already sorted at this point of time. The remaining TSPs are all 13-segment-type packets. Here, in the same way as before, packets are sorted one by one starting from the broadcasting TS for the unit transmission-wave with its frequency arrangement of the RF transmission frequency lower than others, which is repeated 15 times.

Fig. 5-5 shows how the frequency arrangement of the RF transmission frequency looks like in ascending order from TS1 (13-segment type), TS2 (one-segment type), TS3 (one-segment type), TS4 (one-segment type), TS5 (one-segment type), TS6 (one-segment type), TS7 (one-segment type), TS8 (one-segment type) to TS9 (13-segment type).

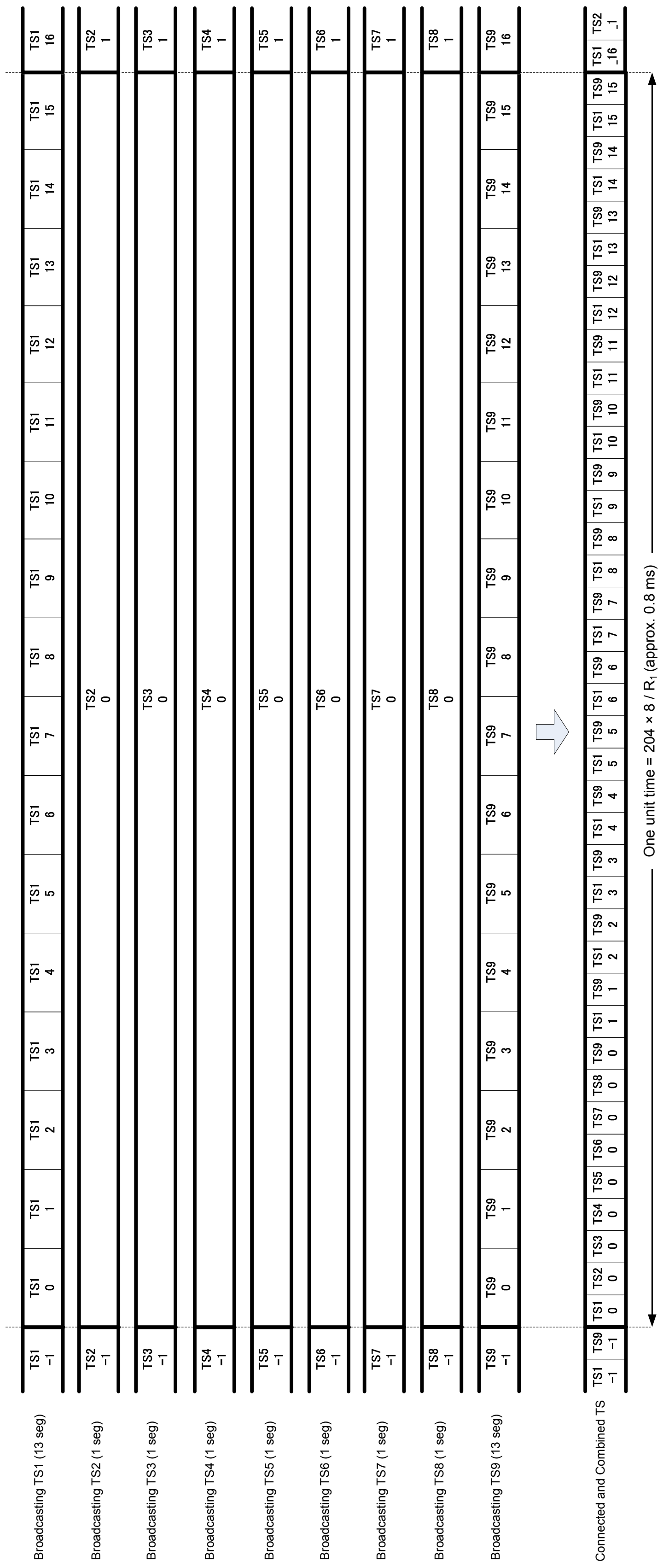


Fig. 5-5: Time-multiplexing Order of Connected and Combined TS

Chapter 6: Operational Guidelines for AC Data Transmission

This chapter defines multiplexing of AC data on broadcasting TS, timing of AC data multiplexed on broadcasting TS in relation to OFDM frames, and mapping of AC data to OFDM carriers. There are two types of multiplex positions when multiplexing AC data on broadcasting TS signals:

(1) multiplexed on the dummy byte part of each TSP (Transport Stream Packet);
(2) multiplexed on invalid hierarchy TSP.

When the seismic motion warning information is transmitted using AC data in segment No.0, AC data should be multiplexed on the dummy byte part on each broadcasting TS packet considering smaller transmission delay time.

6.1 Determination of broadcasting TS multiplex positions

Whether AC data is multiplexed on the dummy byte part or invalid hierarchy TSP is determined by looking at AC_data_effective_position of IIP's "modulation_control_configuration_information". For more information, refer to Tables 5-8 and 5-9 in (3) of Section 5.2.3 in this Attachment.

6.2 Multiplexing on dummy byte part

6.2.1 Multiplex position

When multiplexing AC data on the dummy byte part, the data should be multiplexed on the 8-byte part other than the 188-byte information part in the 204-byte broadcasting TS format. For more information, refer to Fig. 5-2 in (1) of Section 5.5.2 in this Attachment.

6.2.2 Syntax for multiplexing AC data on dummy byte part

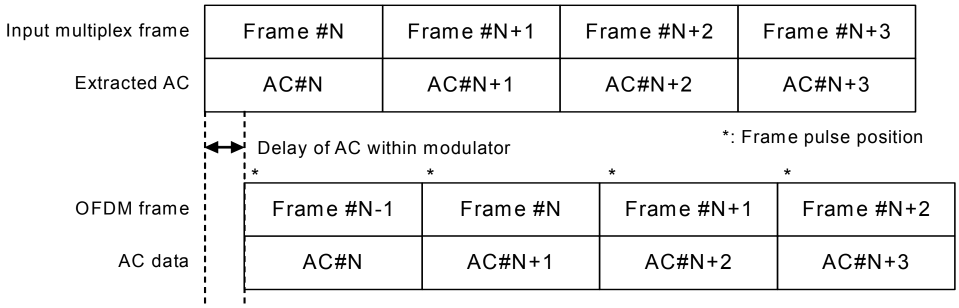
Multiplexing of AC data on the dummy byte part of TSP is defined by the syntax of ISDB-Tmm_information. For more information, refer to Tables 5-2 and 5-3 in (2) of Section 5.5.2 in this Attachment.

6.2.3 Mapping of AC data to OFDM carriers

This section defines the mapping of AC data to OFDM carriers; the AC data to be transferred as broadcasting TS. The AC data may be multiplexed on the dummy byte part or the invalid hierarchy of broadcasting TS. Multiplexing on the dummy byte part has an advantage of transmission with small delay.

6.2.3.1 Timing of multiplexing AC data in relation to OFDM frames

AC data multiplexed on the dummy byte part is transmitted in synchronization with the OFDM frame pulse that immediately follows. Fig. 6-1 shows the transmission frame timing of AC data multiplexed on the dummy byte part. The AC data AC#N multiplexed on the multiplex frame #N is transmitted in synchronization with the OFDM frame pulse that immediately follows.



Note: Indicates the case where the delay of signal processing in the main line system within the modulator is one frame plus α fraction.

Fig. 6-1: Illustrated Timing of Mapping to the Dummy Byte Part

6.2.3.2 Order of mapping to OFDM carriers

Among the AC data multiplexed on the dummy byte part of TSP with AC_data_invalid_flag = "0", the effective byte part indicated by AC_data_effective_bytes is considered as effective AC data. The positions of bytes to be used shall be specified by each service provider.

The effective data is mapped sequentially from lower- to higher-frequency AC carrier positions of OFDM. The MSB side of the effective byte part represents the head of the effective data. When mapping of data to all AC carriers of one symbol is finished, mapping advances to the next symbol. "Symbols" in this chapter means “OFDM symbols”. Fig. 6-2 shows the order of mapping to the AC carrier positions of OFDM.

When there are differential OFDM segments, multiplexed AC data is mapped sequentially, regardless of AC1 or AC2, to AC carriers in the order of lower to higher frequencies.

Since the first OFDM frame symbol (symbol 0) is the reference for differential modulation for AC carriers, AC data is not mapped to this symbol. Within one multiplex frame, therefore, the amount of AC data mapped to AC carriers (including stuffed data if required) corresponds to 203 symbols.

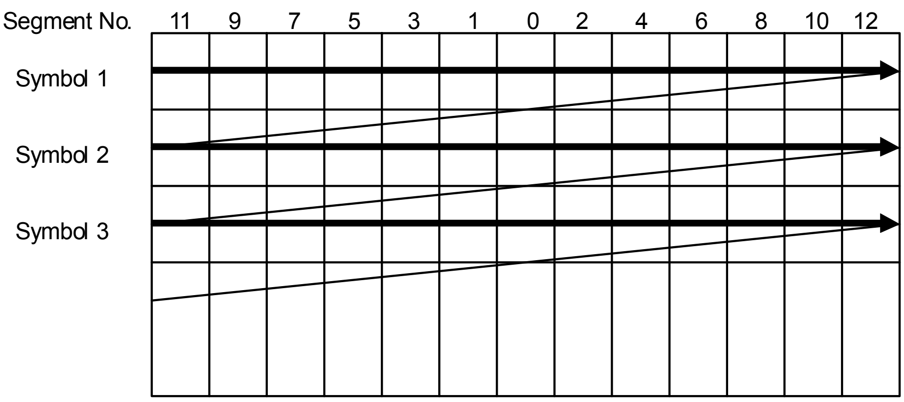


Fig. 6-2: Order of Mapping to the AC Carrier Positions of OFDM (An Example with 13-segment Type)

6.3 Multiplexing on invalid hierarchy

6.3.1 Multiplex position

When multiplexing AC data on the invalid hierarchy, the data is put into the 188-byte information part of the packet, where layer_indicator described in Table 5-3 in (2) of Section 5.2.2 in this Attachment is "0100".

6.3.2 Syntax for multiplexing AC data on invalid hierarchy

The syntax for multiplexing AC data on the invalid hierarchy is listed and explained in Tables 6-1 and 6-2, respectively.

Table 6-1: Syntax for Multiplexing AC Data on the Invalid Hierarchy

Data Structure	Number of bits	Bit String Notation
AC_data_packet(){		
TSP_header{		
sync_byte	8	bslbf
transport_error_indicator	1	bslbf
payload_unit_start_indicator	1	bslbf
transport_priority	1	bslbf
PID	13	unimsbf
transport_scrambling_control	2	bslbf
adaptation_flag_control	2	bslbf
continuity_counter	4	unimsbf
}		
payload{		
AC_select_id	4	unimsbf
reserved_future_use	4	bslbf
AC_packet_number	16	unimsbf
data_length	8	unimsbf
For(i=0;i<data_length-4;i++){		
AC_data	8	bslbf
}		
CRC_32	32	rpchof
for(j=0;j<180-data_length;j++){		
stuffing_byte(0xFF)	8	unimsbf
}		
}		
}		

Table 6-2: Description of Syntax for Multiplexing AC Data on the Invalid Hierarchy

Syntax	Description
sync_byte	Synchronization byte (0x47))
transport_error_indicator	Not used (always ‘0’)
payload_unit_start _indicator	Should be always ‘1’ when there is one packet within one multiplex frame where AC data is multiplexed. When there are multiple packets, the first packet where AC data is multiplexed is given a value of ‘1’ and all the subsequent packets are given a value of ‘0’.
transport_priority	Should be always ‘0’.
PID	Depends on the operational provisions of each service provider.
transport_scrambling _control	Not used (always ‘00’)
adaptation_flag_control	Should be always ‘01’ (only payload).
continuity_counter	Should be in accordance with ISO/IEC13818-1.
AC_select_id	When AC data is multiplexed and transmitted separately to different pieces of transmission equipment, this information allows selection of AC data that is relevant to each piece of equipment. This information is specified by service providers.
reserved_future_use	Reserved bits for future extension. All of them should be ‘1’.
AC_packet_number	Numbers assigned to packets where AC data is multiplexed. These numbers are assigned sequentially from the first multiplex frame. AC_packet_number = ‘0x0000’ for the first packet where AC data is multiplexed in the multiplex frame. Sequential numbers are given independently to each AC_select_id.
data_length	The length of data between the next byte of this syntax and CRC_32; specified in bytes.
AC_data	Multiplexed AC data. AC data is multiplexed as one or more bytes for each packet. When a fraction of byte occurs in the last packet of the multiplex frame where AC data is multiplexed, the remaining bits of the byte are stuffed by inserting ‘1’ (See Section 6.3.3 "Data arrangement on multiplex frames and TS packets").
CRC_32	The CRC value calculated from the following polynomial used in ISO/IEC13818-1: Polynomial=$x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^{8}+x^{7}+x^{5}+x^{4}+x^{2}+x+1$. The range covers entirely from the beginning to the end of AC_data.

6.3.3 Data arrangement on multiplex frames and TS packets

Data on multiplex frames and TS packets is arranged as follows:

(1) AC data multiplexed on one multiplex frame is multiplexed on the AC carriers of one OFDM frame.

(2) The number of bits in the AC data of one multiplex frame shall be made equal to the number of AC carriers for the 203 symbols excluding symbol 0, which is the reference for differential modulation. A value of "1" shall be inserted (stuffing) in AC carrier positions not used for transmitting AC data.

(3) AC data is multiplexed sequentially from data corresponding to AC carrier positions with lower frequencies to data with higher frequencies and from the MSB side of each packet. "Byte#" is a convenient name assigned to indicate the order of data within the multiplex frame.

Table 6-3: Order of Multiplexing AC Data

	Byte0	Byte1	Byte2	・・・
7 (MSB)	D0	D8	D16	
6	D1	D9	D17	
5	D2	D10	D18	
4	D3	D11	D19	
3	D4	D12	D20	
2	D5	D13	D21	
1	D6	D14	D22	
0 (LSB)	D7	D15	D23	

Mapped in the order of AC carriers of lower to higher frequencies, thus in the order of "D0, D1, D2, D3, ..."

(4) When a fraction of byte occurs in the multiplex frame by dividing the number of AC carriers on a byte basis, the last bytes of the last packet in the multiplex frame where AC data is multiplexed are stuffed with "1" (see the example below). The stuffed data is discarded in the modulator because only data corresponding to the AC carriers of one OFDM frame is acquired.

Example: Mode 3, DQPSK, hierarchical layer A, 13-segment type

AC1 carrier: 8 x 13 x 203 = 21,112 bits

AC2 carrier: 19 x 13 x 203 = 50,141 bits

Total of 71,253 bits (8,906.625 bytes)

The arrangement of AC data in this case is shown in Fig. 6-3, which only shows the packets where AC data is multiplexed and only AC data in each packet.

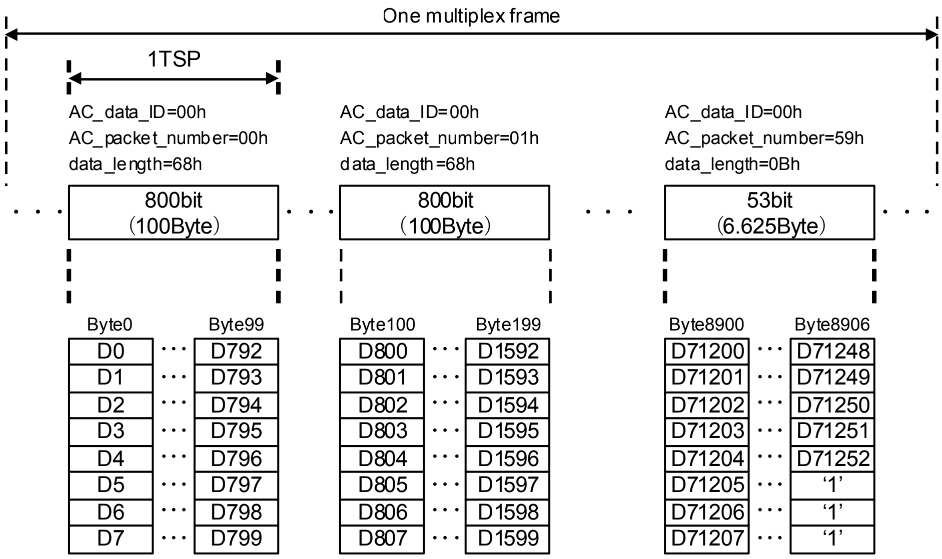


Fig. 6-3: Example of Multiplexing on a Multiplex Frame (Stuffing)

(5) When AC data whose number of bits exceeds the maximum number that can be mapped to one OFDM frame is multiplexed on one multiplex frame, the part of the AC data beyond the maximum number counted from the head of the multiplex frame will be discarded.

Example: Mode 3, DQPSK, hierarchical layer A, 13-segment type

AC1 carrier: 8 x 13 x 203 = 21,112 bits

AC2 carrier: 19 x 13 x 203 = 50,141 bits

Total of 71,253 bits (8,906.625 bytes)

When AC data consisting of 72,000 bits is multiplexed on the multiplex frame with the above number of bits that can be mapped, the AC data of 71,254th and subsequent bits will not be mapped to the OFDM frame, as shown in Fig. 6-4.

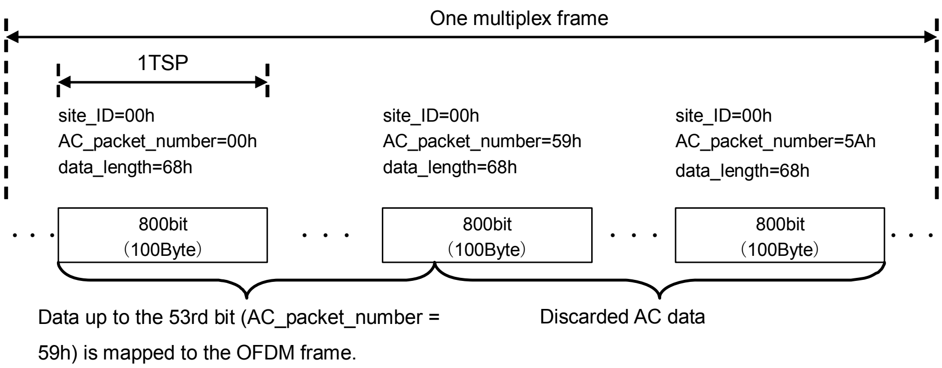
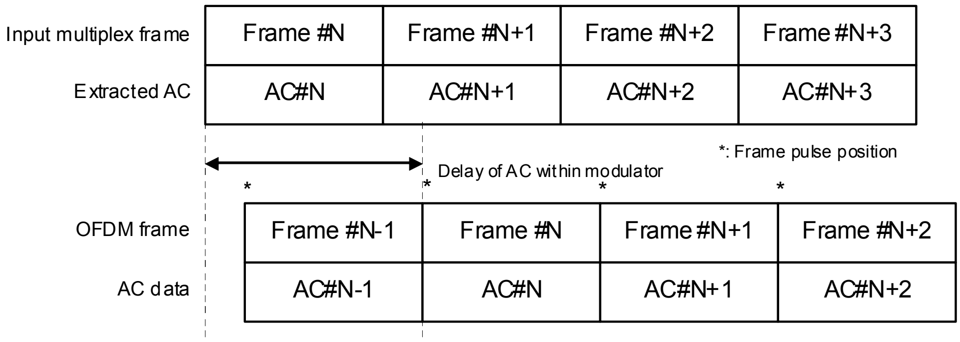


Fig. 6-4: Example of Multiplexing Data that Exceeds the Number of Bits That Can be Mapped

6.3.4 Mapping to OFDM carriers

6.3.4.1 Timing of multiplexing AC data in relation to OFDM frames

AC data multiplexed on the invalid hierarchy shall be transmitted in synchronization with the data sent by the multiplex frame to which the AC data belongs. Fig. 6-5 shows the transmission frame timing of AC data multiplexed on the invalid hierarchy.



Note: Indicates the case where the delay of signal processing in the main line system within the modulator is one frame plus α fraction.

Fig. 6-5: Illustrated Timing of Mapping When Data is Multiplexed on the Invalid Hierarchy

6.3.4.2 Procedure of mapping to OFDM carriers

Multiplexed AC data is mapped sequentially, regardless of AC1 or AC2, to AC carriers in the order of lower to higher frequencies. When mapping to all AC carriers of one symbol is finished, mapping advances to the next symbol.

Since the first OFDM frame symbol (symbol 0) is the reference for differential modulation for AC carriers, AC data is not mapped to this symbol. Within one multiplex frame, therefore, the amount of AC data mapped to AC carriers (including stuffed data if required) corresponds to 203 symbols.

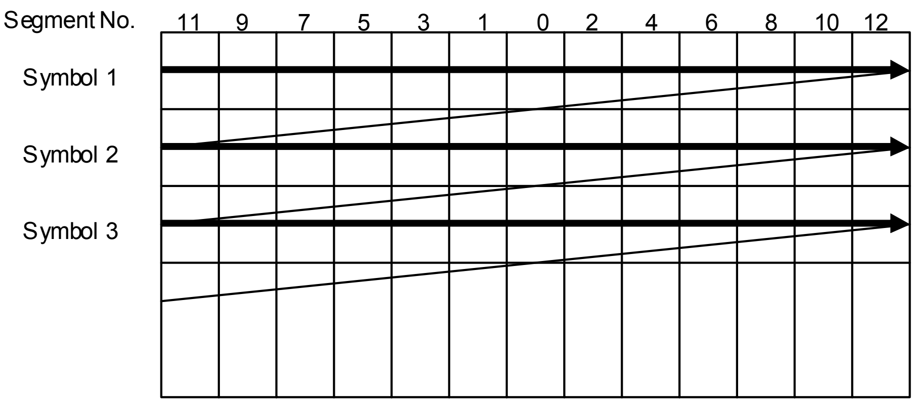


Fig. 6-6: Procedure of Mapping to the AC Carrier Positions of OFDM
(An Example with 13-segment Type)

6.4 Considerations in multiplexing AC data to broadcasting TS

6.4.1 Considerations in the order of AC data carriers

When multiplexing AC data on broadcasting TS, it is necessary to understand which AC carriers are used to transmit AC data, in light of possible use of multiple lines and partial use of AC carriers. For instance, 104 AC1 carriers are available (0 AC2 carrier) for the 13-segment type: Mode 3 and QPSK. When AC transmission is conducted using 92 carriers out of 104, the remaining 12 carriers need to be stuffed. Multiplexed AC data is mapped sequentially in the modulator, regardless of segments, AC1 or AC2, in the order of multiplexed AC data to AC carriers. Therefore, at the multiplex positions corresponding to the stuffed carriers, stuffing is carried out on a bit basis at the time of multiplexing broadcasting TS with AC_data_invalid_flag as "0" and AC_data as "1" when multiplexing on dummy bytes, and with AC_data as "1" when multiplexing on AC packet.

Since multiplexed AC data is mapped sequentially, regardless of AC1 or AC2, to AC carriers in the modulator, AC data sorted and stuffed in advance will be multiplexed if distinction of segment allocation or distinction between AC1 and AC2 is required. Because delay time of AC data transmission depends on the processing of AC data during multiplexing, delay time during multiplexing on broadcasting TS must also be taken into account if AC data needs to be transmitted with little delay.

6.4.2 Considerations in the timing of multiplexing on dummy bytes

This section describes considerations in avoiding overflow or underflow between AC data multiplexed to dummy bytes and AC data actually transmitted as broadcasting wave at the OFDM modulator.

AC data is modulated with DBPSK at the AC carriers of each symbol and then transmitted as broadcasting wave. However, AC data is not transmitted for the first symbol (symbol 0), which is the reference for differential modulation. AC data is therefore transmitted by symbols 1 to 203, excluding symbol 0, among the total of 204 symbols in one OFDM frame.

On the other hand, signals are processed (IFFT) on a symbol basis at the channel-coding IFFT block of the OFDM modulator. In the OFDM modulator, therefore, AC data to be transmitted needs to be input before or during the signal processing of a preceding symbol.

The OFDM frame defined here coincides with the multiplex frame. This means the head of the multiplex frame indicated by frame_head_packet_flag in Table 5-2 in (2) of Section 5.2.2 in this Attachment corresponds to the head of the OFDM frame. The number of bytes in the transmission TSP corresponding to the duration of one symbol is shown in Table 6-4 for different situations.

Table 6-4: Number of bytes corresponding to the duration of one symbol

(a) 13-segment type

Mode	Number of bytes of transmission TSP for the duration of one symbol			
	Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
Mode 1	1280	1152	1088	1056
Mode 2	2560	2304	2176	2112
Mode 3	5120	4608	4352	4224

(b) One-segment type

Mode	Number of bytes of transmission TSP for the duration of one symbol			
	Guard interval ratio 1/4	Guard interval ratio 1/8	Guard interval ratio 1/16	Guard interval ratio 1/32
Mode 1	80	72	68	66
Mode 2	160	144	136	132
Mode 3	320	288	272	264

It must be noted that AC data to be transmitted by the next symbol needs to be input to the OFDM modulator during or prior to the period required for transmitting the number of bytes of transmission TSP shown in Table 6-4 for the applicable mode and guard interval ratio.

(1) Guidelines on the underflow of AC data

The amount of AC data transmitted during the period of one symbol needs to be input to the OFDM modulator for each of symbols 0 to 202.

(2) Guidelines on the overflow of AC data

Given that AC data is transmitted in connection with the TSP transmitted by the same multiplex frame, the OFDM modulator has a buffer corresponding to the AC data amount of one OFDM frame. The buffer is renewed on a basis of multiplex frame defined in Table 5-2 in (2) of Section 5.2.2 in this Attachment. Thus, excessive AC data beyond the transmission limit for one OFDM frame is discarded in the OFDM modulator. AC data input during the period of symbol 203 is also discarded in the OFDM modulator.

TRANSMISSION SYSTEM
FOR TERRESTRIAL MOBILE MULTIMEDIA BROADCASTING
BASED ON CONNECTED SEGMENT TRANSMISSION

ARIB STANDARD

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