ISDB-T technical seminar(2007)
in Argentina

Seminar #2

Structure/Features of ISDB-T

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Digital Broadcasting Expert Group (DiBEG)

Japan

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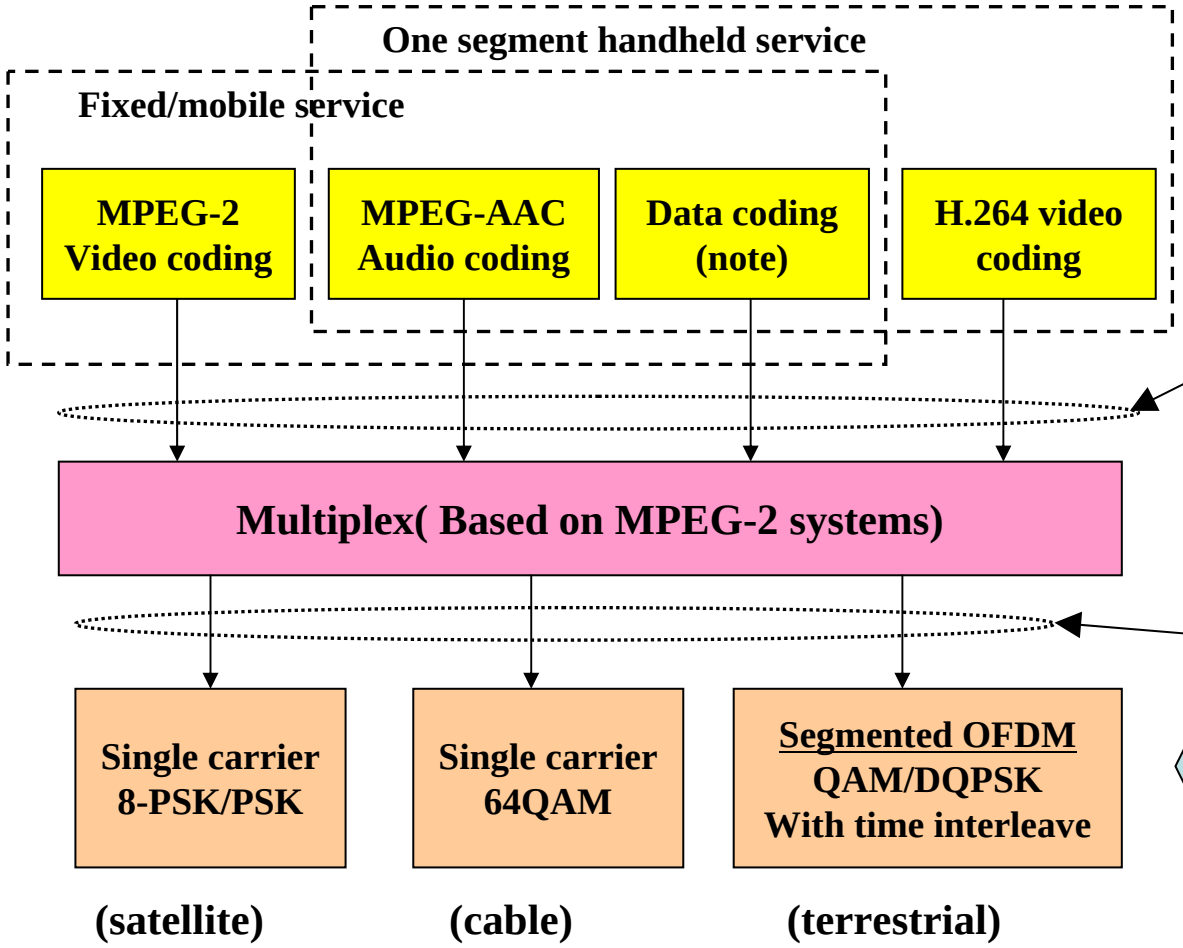
Contents

1. Structure of ISDB-T

Figure 1-1



Source coding
(any of service are available)

Common interface (Transport Stream interface)

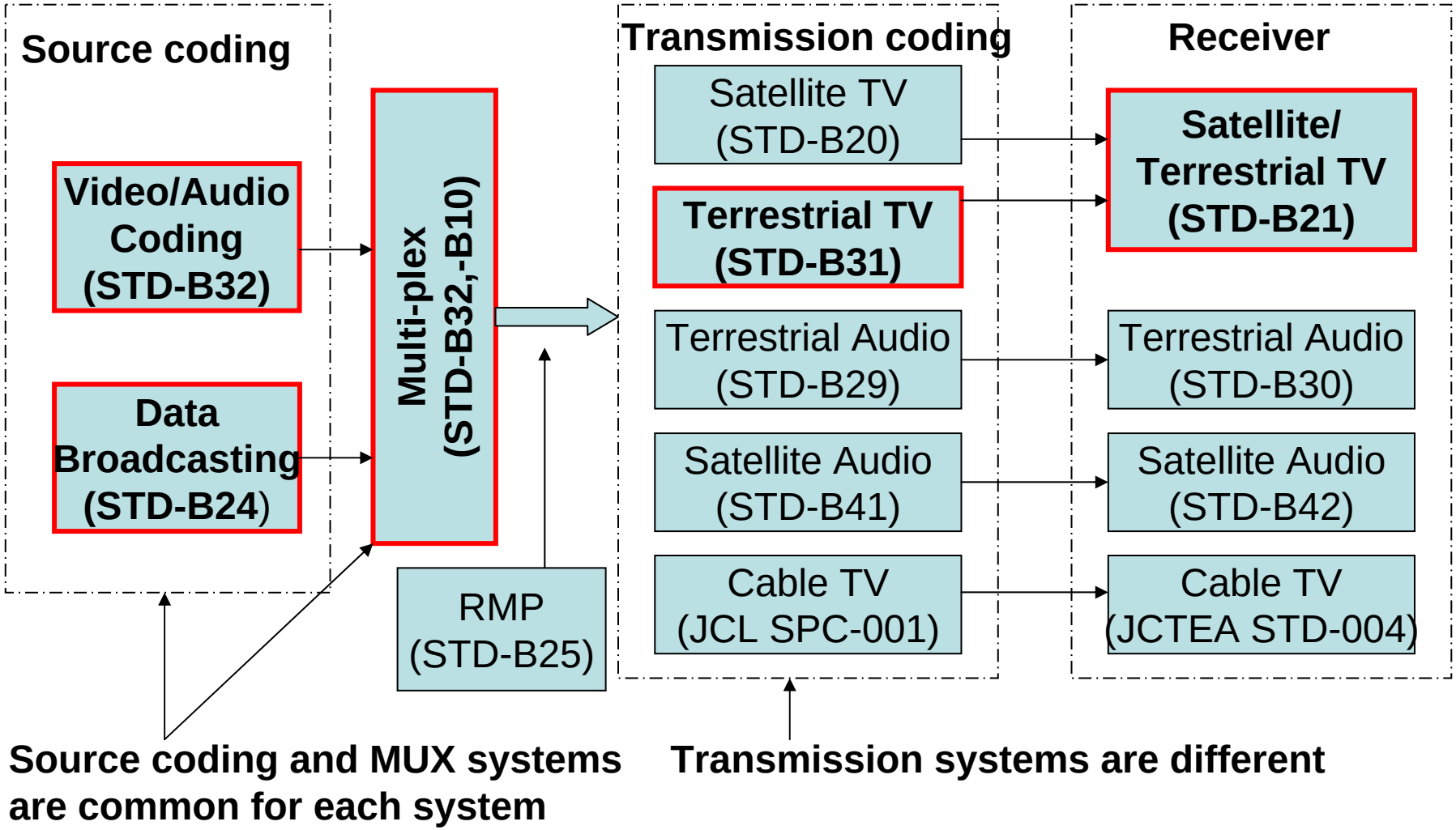
Mulitplex

Common interface (Framed Transport Stream interface)

Transmission coding

(note) both BML and MHP are available,
But in Japan now BML is only service in.

Figure 1-2



Note: Cable transmission system standards are defined at another consortium

As shown in Figure 1-1, in generally Digital broadcasting system is composed by 3 functional blocks, (1)Source coding block, (2)Multiplex block, and (3)transmission coding block.

In designing of digital broadcasting system, considering contents of broadcasting service, configuration of broadcasting service(ie; stationary reception/ mobile reception/portable reception), structure of digital broadcasting system and technologies used in system are decided and specification and/or guideline for broadcasting are decided.

In Japan, according to the structure of digital broadcasting, specifications of each functional block are standardized as ARIB standard(note).

(note)ARIB; Association of Radio Industries and Business, Voluntary organization for Radio and Broadcasting system standardization.

Features of ISDB-T

2. High quality/Service Flexibility

2.1 High quality

2.2 Service Flexibility

2.2 Features of Transmission system

(1) OFDM transmission technology(robustness against multi-path, SFN)

(2) Segmented OFDM transmission(Portable service in same channel)

(3) Time Interleave(Robustness against urban noise, Mobility & Portability)

(4) Comparison of Transmission system

2.3 Commonality

2.1 High quality/Service Flexibility

(1) High quality

Japan started the research and development for HDTV about 30 years ago, and has a leadership for HDTV hardware/software in the world. Because of these background, High quality is the most important requirement for digital broadcasting system.

In satellite broadcasting in Japan, started from 1997, HDTV service is real broadcast service, so ,even in digital terrestrial broadcasting service, HDTV is also adopted.
Japan adopts MPEG-2 for HDTV/SDTV compression system. So both HDTV/SDTV are supported in Digital broadcasting.

(2) Service flexibility

In ISDB-T system, service flexibility is realized by 2 techniques written below.

(a) MPEG-2 video coding technology/ MPEG-AAC audio coding technology

MPEG-2 video coding technology, which is adopted in Japanese digital broadcasting, supports many kinds of video quality/format. For video quality/format, Japanese digital broadcasting adopt many kinds of video quality/format described in Table 2-1

For audio system, MPEG-AAC, highest compression and quality audio coding system, is adopted for digital broadcasting in Japan. MPEG-AAC also supports many kinds of audio quality/format In Table 2-2, audio quality/format specified in Japanese digital broadcasting are shown.

Digital broadcasting receiver in Japan should be specified to decode any kinds of video/audio quality/format described in Table2-1 and table2-2.

In addition above, digital receiver specification specifies that the video output format to display should be selectable according to display specification.
So ,following format conversion is possible, (1)HDTV→SDTV, (2)SDTV→HDTV.
As described above, ISDB-T receiver has a flexibility for video/ audio quality/ format.

And it is possible to enjoy HDTV program on SDTV display by converting video format. Therefore, ISDB-T receiver can support the variation of broadcasting service, such as, HDTV,HDTV+SDTV, multi-SDTV, etc, by one receiver.

For audio system, many quality/format, such as monaural/ stereo/bi-lingual/ multi-channel stereo are supported, and more, down-mix from multi-channel to monaural and stereo is specified, so legacy audio system can be used.

Table 2-1

Number of lines		525	525	750	1125
Number of active lines		483	483	720	1080
Scanning system		Interlaced	Progressive	Progressive	Interlaced
Frame frequency		30/1.001 Hz	60/1.001 Hz	60/1.001 Hz	30/1.001 Hz
Field frequency		60/1.001 Hz			60/1.001 Hz
Aspect ratio		16 : 9 or 4 : 3	16 : 9	16:9	16 : 9
Line frequency f_H		15.750/ 1.001kHz	31.500/ 1.001 kHz	45.000/ 1.001 kHz	33.750/ 1.001 kHz
Sampling frequency	Luminance signal	13.5 MHz	27 MHz	74.25/1.001MHz	74.25/1.001MHz
	Color-difference signals	6.75 MHz	13.5 MHz	37.125/ 1.001MHz	37.125/ 1.001MHz
Numbers of samples per line	Luminance signal	858	858	1650	2200
	Color-difference signals	429	429	825	1100
Number of samples per active line	Luminance signal	720	720	1280	1920
	Color-difference signals	360	360	640	960
Filter characteristics		See Fig. 1	See Fig. 2	See Fig. 3	
Line synchronizing signal		See Fig. 4		See Fig. 5	See Fig. 6
Field synchronizing signal		See Fig. 7	See Fig. 8	See Fig. 9	See Fig. 10

(ARIB STD-B32 Part 1, chapter 2.4)

Table 2-2

Parameter	Restriction
Audio mode Possible audio modes	Monaural, stereo, multichannel stereo (3/0, 2/1, 3/1, 2/2, 3/2, 3/2+LFE) (Note 1), 2-audio signals (dual monaural), multi-audio (3 or more audio signals) and combinations of the above
Recommended audio mode	Monaural, stereo, multichannel stereo (3/1, 3/2, 3/2+LFE) (Note 2), 2-audio signals (dual monaural)
Emphasis	None

(Note 1) Number of channels to front/rear speakers:	Example:3/1 = 3 front + 1 rear 3/2 = 3 front and 2 rear
(Note 2) LFE = Low frequency enhancement channel	

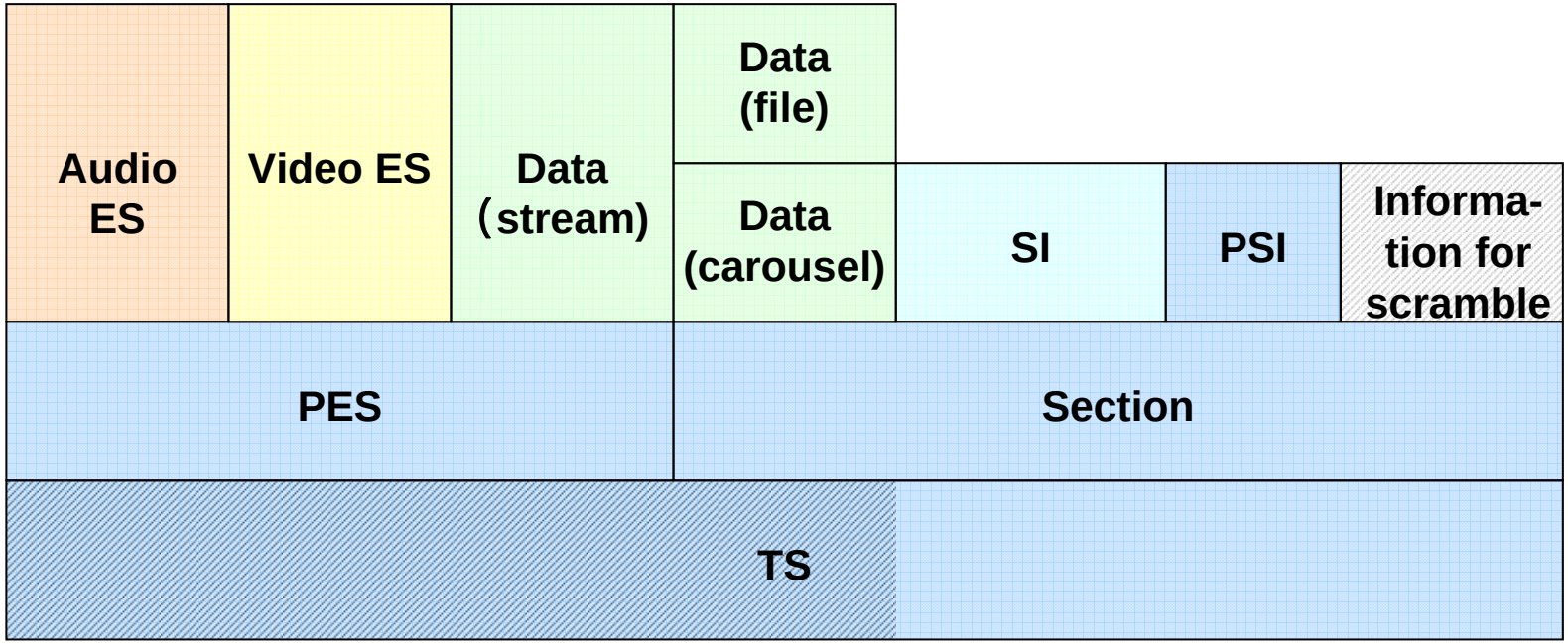
ARIB STD-B32 part 2 Chapter 5.1

(b) MPEG-2 systems for multiplex

ISDB-T adopts MPEG-2 systems as multiplex technology. In MPEG-2 systems, all broadcast contents, video/audio/data are multiplexed by Transport stream Packet format . Therefore, any type of contents/service can be multiplexed.
The concept of Multiplex is shown in Figure 2-3

As shown in Figure 2-3, stream type contents, such as video, audio and stream type data, are converted to PES(Packet Elementary Stream) format and finally converted to TS format and Multiplexed, on the other hand, non stream type data contents are converted to Section format and finally converted to TS format and multiplexed.

Figure 2-3 Multiplexed format In ISDB-T system



(note) signal format of PES, TS and Section area is defined in ARIB STD-B32, based on MPEG-2 systems

(note) PSI is defined in both STD-B32 and STD B10. In STD-B32, only outline related to MPEG -2 systems is defined

Features of ISDB-T

2. Features of Transmission system (Robustness, Reception System Flexibility, Frequency Utilization, Mobility & Portability)

(1) OFDM transmission technology(robustness against multi-path, SFN)

(2) Segmented OFDM transmission(Portable service in same channel)

(3) Time Interleave(Robustness against urban noise, Mobility & Portability)

Details of transmission system of ISDB-T are explained seminar #3, so, in this part, pick up advanced features of Transmission system

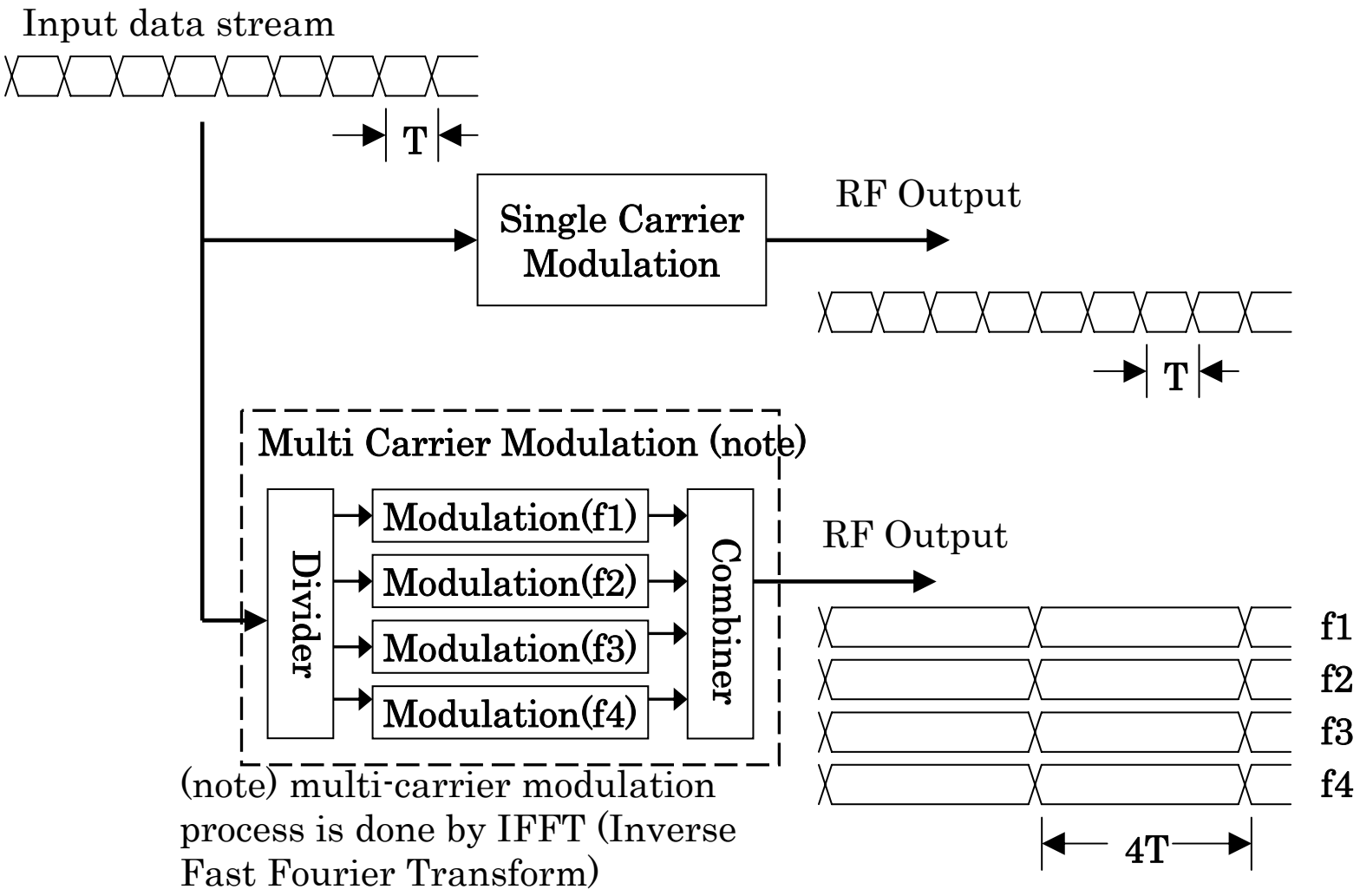
(1) OFDM transmission technology (robustness against multi-path, SFN)

OFDM(Orthogonal Frequency Division Multiplex) transmission technology is the one of multi-carrier transmission system. In OFDM transmission system, digital data is divided to multi-carrier and sent, as a result, transmission symbol length is longer than single carrier transmission system.

If transmission symbol is longer, less degraded by Inter Symbol Interference(ICI) caused by multi-path interference(this interference is called “ghost”).

In figure 3-1, concept of difference between multi-carrier system and single carrier system is shown.

Figure 3-1



(note) multi-carrier modulation process is done by IFFT (Inverse Fast Fourier Transform)

Figure 3-1 shows 4 –carrier case as multi-carrier system. As shown in Figure 3-1, in multi-carrier system, symbol length is extended 4 times, on the other hand, in single carrier system, symbol length is same as symbol length of input signal.

Figure 3-2 shows the influence of multi-path interference. As shown in figure, it is easy to understand that Inter Symbol Interference(ISI) is inverse proportional to symbol length, therefore, under multi-path condition, longer symbol transmission system is better.

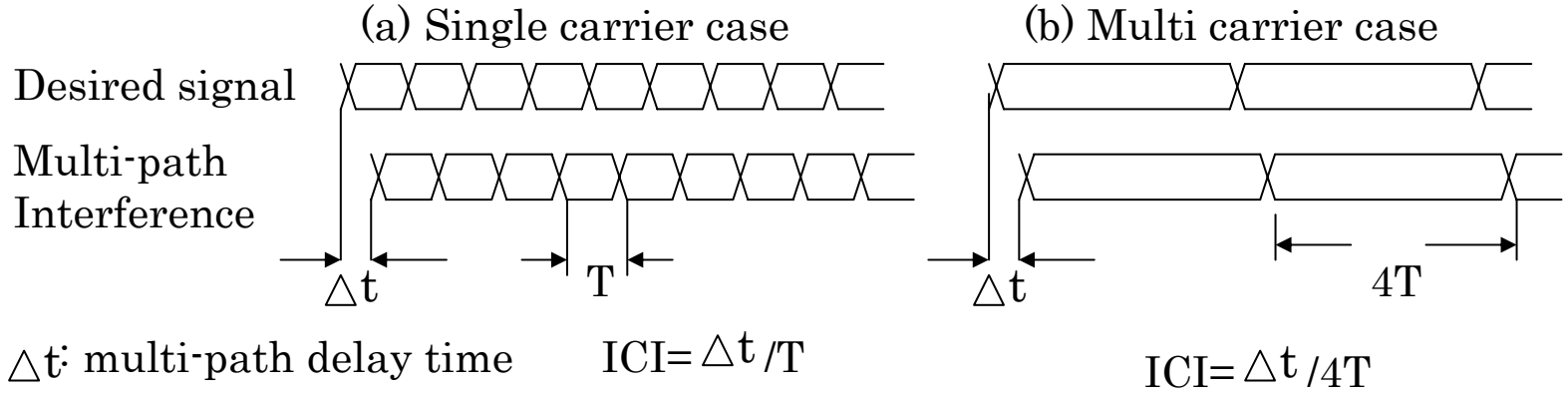


Figure 3-2 relation of multi-path delay and ISI

In addition above, in ISDB-T system, Guard Interval is added to each symbol. As a result, robustness against multi-path interference is improved to almost 0dB D/U ratio (Desired to Undesired ratio) during the period of Guard Interval length.

As shown in Figure 3-3, ISDB-T shows the robustness during +/- Guard interval length. DVB-T also similar characteristics because it adopts OFDM transmission system. On the other hand, robustness of ATSC system is weak, because of its transmission system, single carrier transmission. ATSC adopts adaptive filter technology to improve the robustness, but, performance is not good compare to ISDB-T.

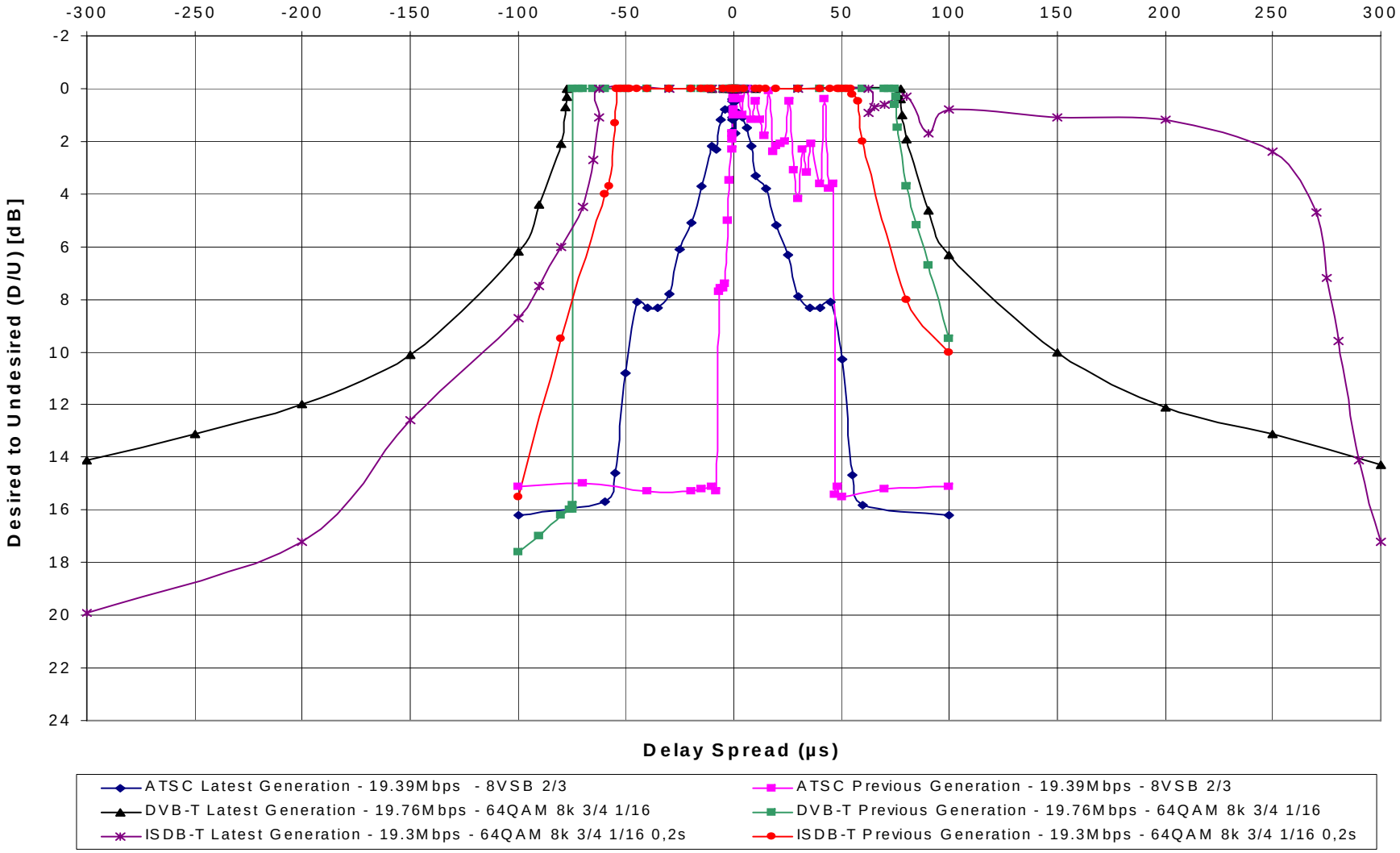


Figure 3-3 Robustness against static multi-path interference (3 DTTB systems)

Robustness against multi-path is very important factor for digital terrestrial broadcasting, because of following reasons

(1) In VHF/UHF band, multi-path always exist. As you know, just ghost in analog TV. Multi-path interference occurs by mountain, building and many others, so, multi-path exists not only mountain area but also urban area. ISDB-T shows excellent reception performance even though under such receiving condition.

(2) By making use of robustness against multi-path interference, SFN (Single Frequency Network) can be easily constructed. This leads following advantages; (a)save frequency resource, (b)no channel change for mobile/portable service, (c)easily widen cover area, such as shadow of mountain and building, etc, by small power repeater.

3.2 Time Interleave (Robustness against urban noise, Mobility & Portability)

In digital transmission system, generally, error correction system is adopted to reduce the degradation caused by any kinds of interference(including thermal noise).

3 DTTB system adopts same correction system, named concatenated error correction(chain of Convolutional coding/Viterbi decoding + Reed-Solomon (RS) coding/decoding)

Error correction system,generally, shows best performance against random error such as thermal noise, but not work well against burst error (concatenated error)

Therefore, technology for randomization of error is adopted with error correction system, this technology is called “Interleave” technology.

As shown in following Figure, ISDB-T has 4 kinds of Interleave. These are; (1) Bite interleave, (2) Bit interleave, (3)Time interleave, (4)Frequency interleave,

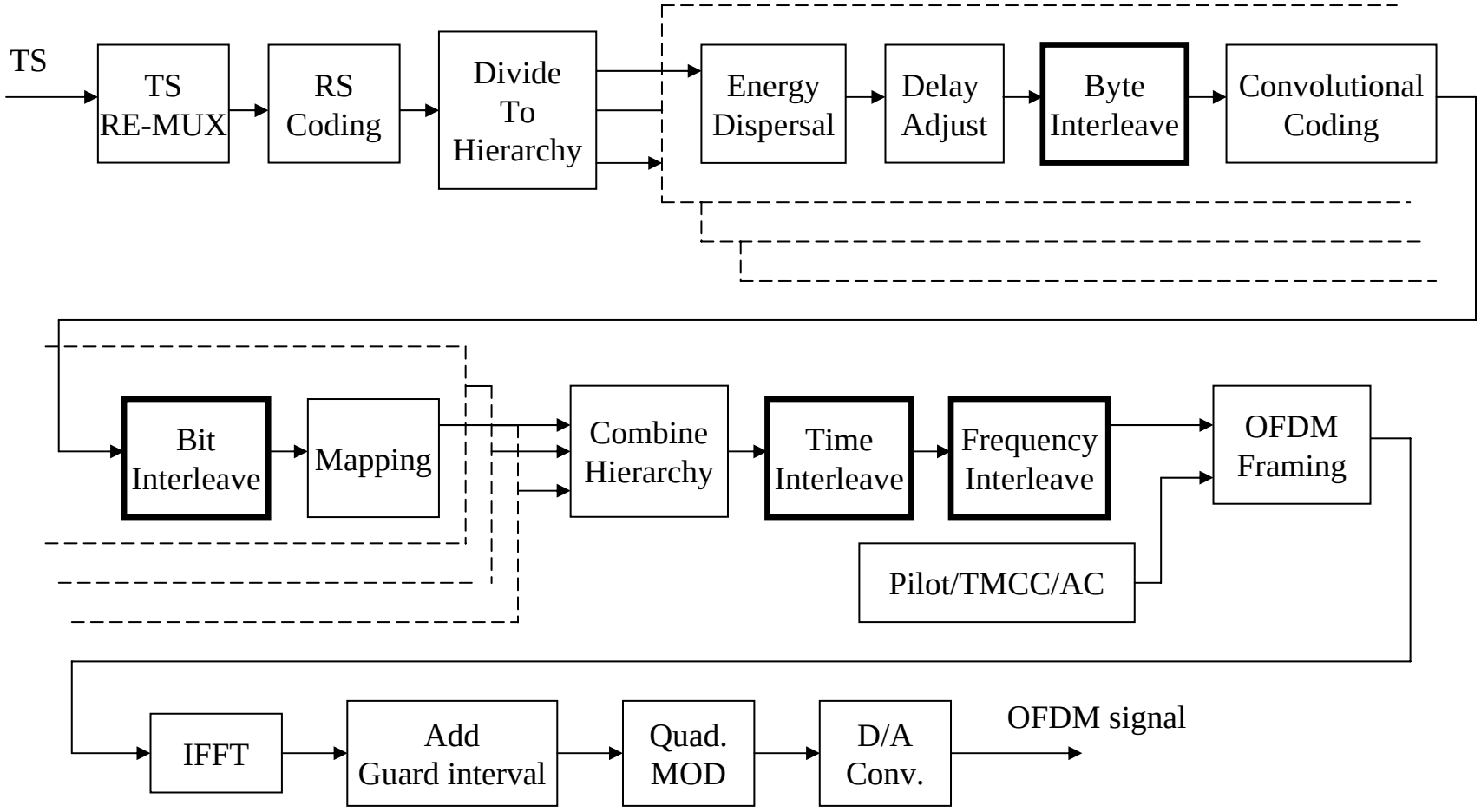
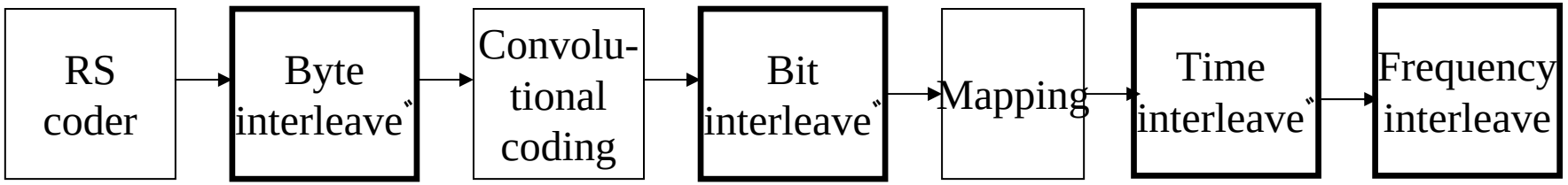


Figure 3-4 Functional block diagram of ISDB-T



Byte interleave

Byte interleave is located between outer coder and inner coder. Randomize the burst error of Viterbi decoder output

Bit interleave

Bit interleave is located between convolutional coding and mapping. Randomize the symbol error before Viterbi decoding

Time interleave

Time interleave is located at the output of Mapper. Randomize the burst error of time domain which is mainly caused by impulse noise, fading of mobile and portable reception, etc.

Frequency interleave

Frequency interleave is located at the output of time interleave. Randomize the burst error of frequency domain which is mainly caused by multi-path , carrier interference, etc.

Figure 3-5 position of interleave circuits and these effect

As shown in figure, "Time Interleave" is quite effective to improve both robustness against impulse noise and performance for mobile/portable reception.

Impulse noise is dominant degradation factor in urban area, which caused from car engine, switching of electric equipment, called "manmade noise".

ISDB-T only has the function of "Time Interleave". Both DVB-T and ATSC do not have this function.

As a result, ISDB-T is significantly superior than other 2 systems, ATSC and DVB-T in reception performance of urban area and mobile/ portable reception performance.

As an example, Figure 3-6 shows the reception performance under impulse noise condition

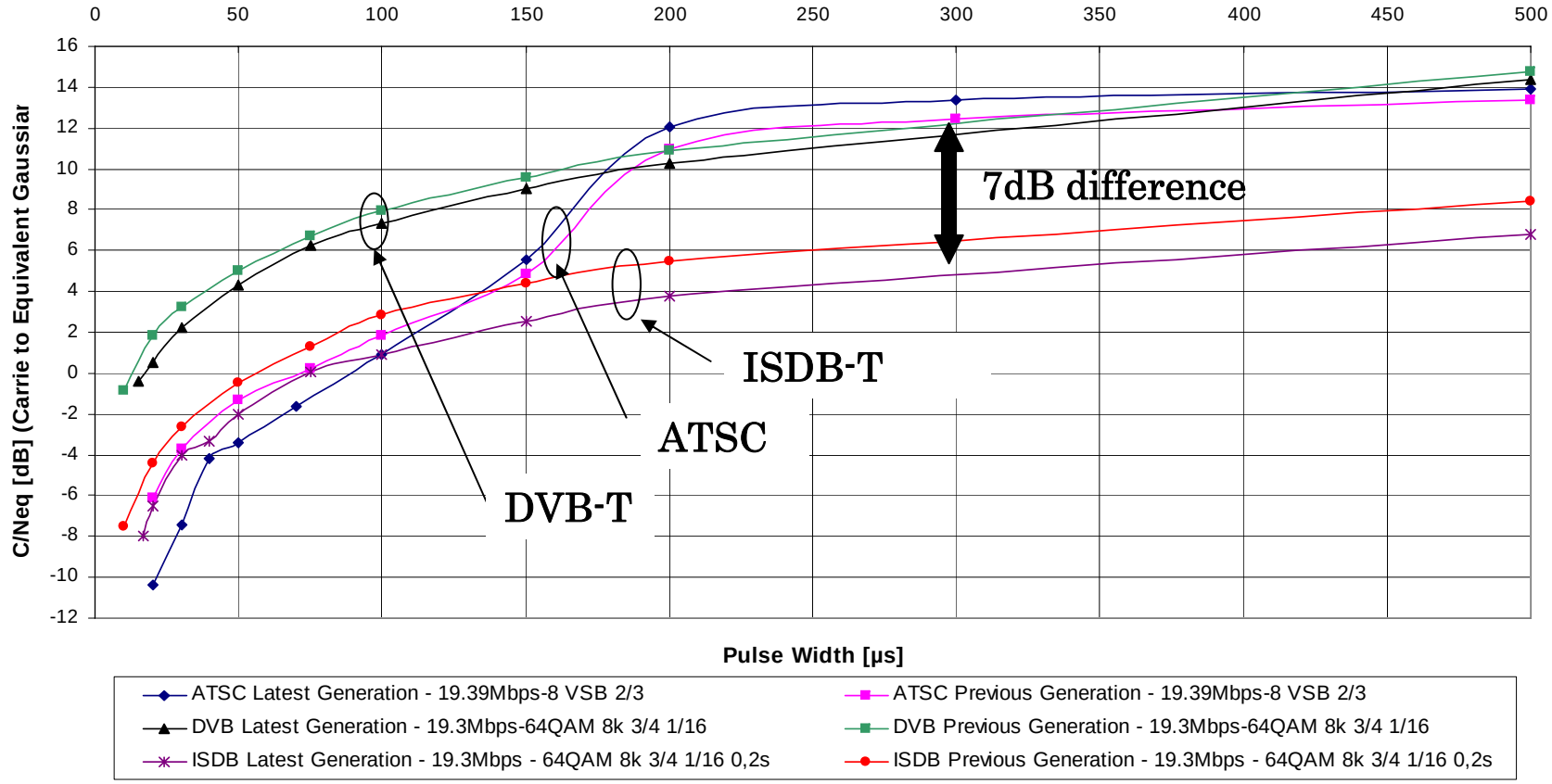


Figure 3-6 Reception performance under Impulse noise condition (3 DTTB systems)

(3) Segmented OFDM transmission(Portable service in same channel)

Segmented OFDM transmission is the unique transmission system which enable to transmit different kinds of transmission parameter signals in same bandwidth.

This transmission system is also called “Hierarchical transmission system”

Figure 3-7 shows just image of “Hierarchical transmission system”

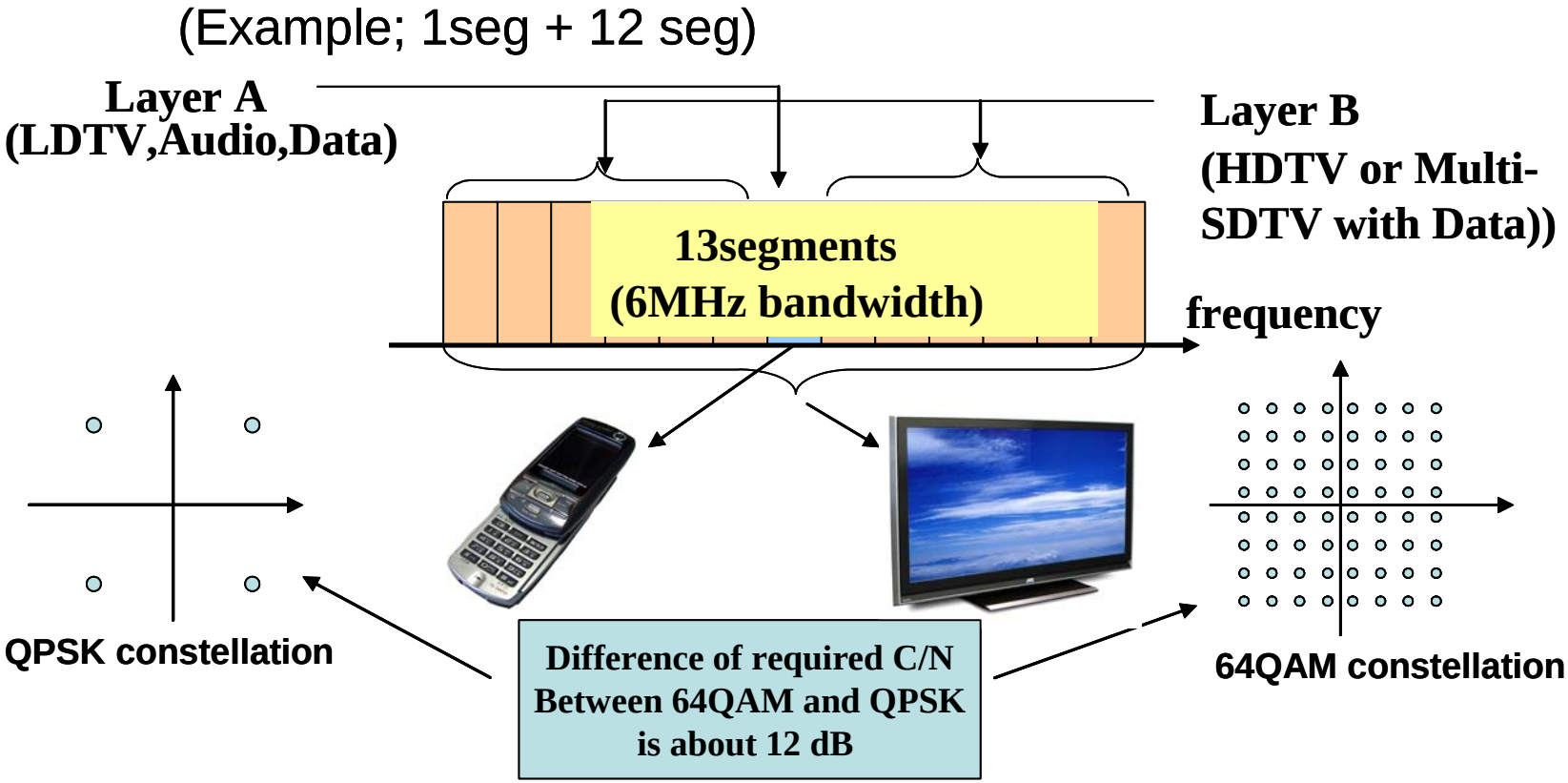


Figure 3-7 Image of "Hierarchical transmission system" (2 layer case)

Figure 3-7 shows the 2 layer transmission case.

1 segment of the center of transmission bandwidth is used for portable reception service, and other 12 segment are used for HDTV fixed reception service.

For 1segment transmission, considering the serious receiving condition ,such as low receiving antenna height, low antenna gain and signal level fluctuation, more strong transmission parameter is desirable, that is QPSK.

On the other hand, for 12 segment which is used for fixed reception, considering high antenna position and high antenna gain, more high bit rate transmission is desirable, that is 64QAM.

As mentioned above, in hierarchical transmission system, it is possible to select adequate transmission parameter according to reception style in same channel.

This system leads following advantages;

- **Save frequency resource;**

in one channel, plural types of service are possible, so another channel is not need.

- **Save transmission infrastructure cost;**

only one transmitter for fixed/ mobile/ portable reception service

ISDB-T only adopts this transmission system in 3 DTTB systems. As you know, **"One-seg"** service which is the unique service in ISDB-T, can be enable by making use of "Hierarchical transmission" technology.

Table 3-1 An example of transmission parameter (HD+ One-seg, in Japan)

Item	Layer A(note 1)	Layer B(note 2)	note
Service type	Portable reception	Fixed reception	
No. of segment	1	12	Total 13
Mode	3		Common for both layers
Guard interval	1/8 of symbol length(note 2)		
Modulation	QPSK	64QAM	(note 3)
Inner coding rate	2/3	3/4	
Bit rate	416 kbps	16.85 Mbps	(note 2)
Service contents	LDTV + data	HDTV +data	example

(note 1) in Hierarchical transmission system, strongest layer is named “A”, next is “B”

(note 2) In Japan, considering SFN operation, 1/8 of guard interval length is used, but in another case, 1/16 of guard interval length is possible. In this case, maximum bit rate increases about 7%(Layer A: up to 440 kbps, Layer B; up to 17.84 Mbps)

(note 3) parameter set of each layer can be chosen indepnedently

Table 3-2 Comparison of 3 DTTB systems on transmission aspect

Item	ISDB-T	ATSC	DVB-T	note
Required transmission power	1	2	2	(note1)
Portable reception in same channel	Yes	No	No (note 2)	
Mobile/portable reception performance	good	Not good	Not good	(note 3)
SFN & Gap filler	Yes	difficult	Yes	

(note 1) as described in section 3-2, in urban area, ISDB-T save transmitter power.
(note 2) “DVB-T + DVB-H in same band service” is only trial level and this service has a problem.
(note 3)the difference is just “Time Interleave” is adopted or not.

4. Commonality

ISDB-T has a commonality with ISDB-S (digital satellite broadcasting), ISDB-C (digital cable broadcasting), and ISDB-Tsb (Digital terrestrial sound broadcasting).

Especially, with ISDB-Tsb, ISDB-T has commonality not only for coding/decoding, but also for transmission system.

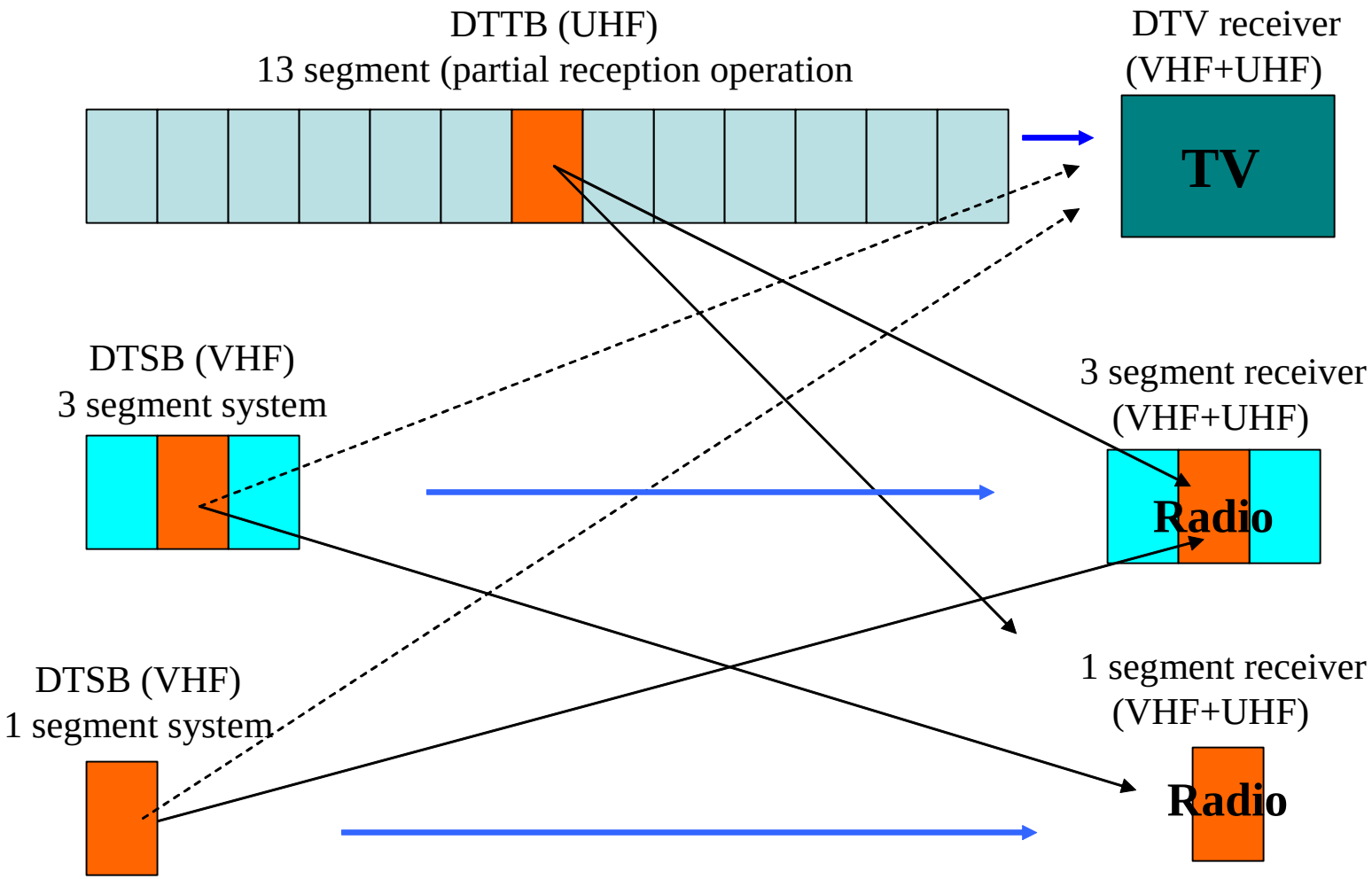
2 types of transmission system, 1segment transmission and 3 segment transmission, are specified in ISDB-Tsb standard. The construction of segment is same as ISDB-T.

In figure 4-1, relationship between ISDB-T and ISDB-Tsb is written.

As shown in Figure, one segment of DTTB is same structure of 1 segment of digital radio. Therefore, 1 segment receiver can receive any of One-seg service of DTTB, center segment of 3 segment radio and 1 segment radio.

Common one segment receiver for digital TV and digital radio has been developed and now in market.

Figure 4-1


DTTB (UHF)
13 segment (partial reception operation
DTV receiver
(VHF+UHF)
TV
DTSB (VHF)
3 segment system
3 segment receiver
(VHF+UHF)
Radio
DTSB (VHF)
1 segment system
1 segment receiver
(VHF+UHF)
Radio

5. One-seg service in same channel

1 reduction of power consumption of portable receiver

As described in 3.(3), One-seg service is based on “Segmented OFDM transmission” technology.

In addition above, One-Seg service adopt unique technology, named **partial reception**, to reduce receiver power consumption.

The most important factor to reduce power consumption is to decrease the signal processing speed in receiver.

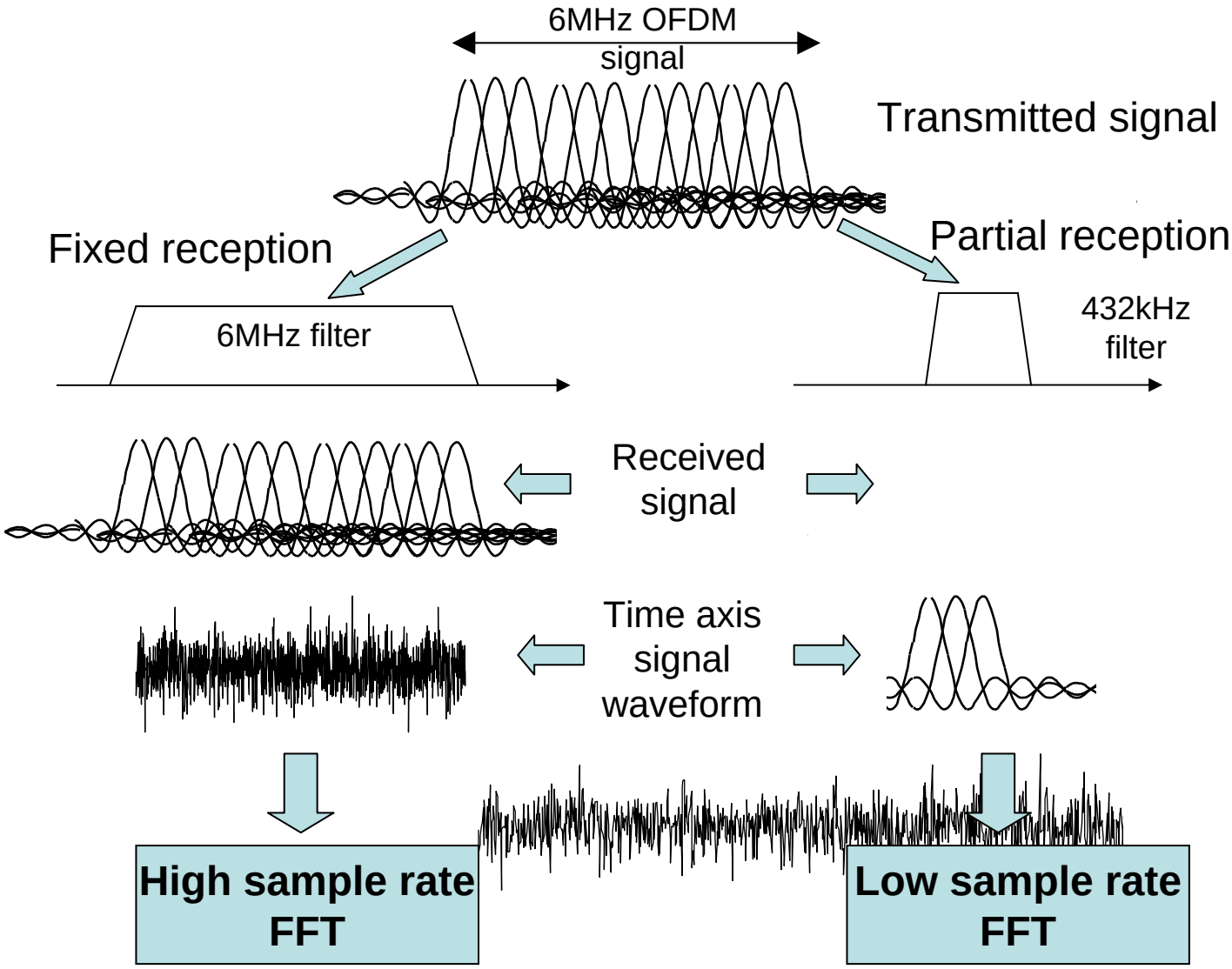


Figure 1-1 signal processing for wideband reception and partial reception

As shown in figure, in case of partial reception(right of figure), center segment of 6MHz OFDM signal is filtered by narrow bandpass filter, its pass band is as equal as 432 kHz.

Filtered narrow band signal is demodulated by low sample rate FFT(Fast Fourier Transform). Its sample rate is 1/8 of high sample rate of FFT which is used for full band demodulation.

As a result, signal process speed of demodulation block is decreased to 1/8

On the other hand, DVB-H, new standard of DVB-T for portable reception, adopts same demodulation circuit and after demodulation, to reduce signal processing speed, pick up necessary date block. This technology is called “Time slicing”.

But, mentioned above, signal processing speed of demodulator portion of DVB-H receiver is same as DVB-T receiver, therefore, consumption power saving is only done at backend circuit.

In One-seg receiver with partial reception, **both demodulator circuit and backend circuit operate in low sample rate**.

So, regarding power consumption, One-seg partial reception seems to be better than DVB-H.

2. adaptive choosing in mobile reception

Figure 2-1 shows the transport stream(TS) of transmission side and reception side in case of 2 layer transmission.

Case 1 in figure shows wideband transmission and wideband reception. Wideband receiver is usually used for fixed receiver and mobile receiver.
Case 2 in figure shows wideband transmission and partial reception. Partial reception receiver is usually used for portable receiver.

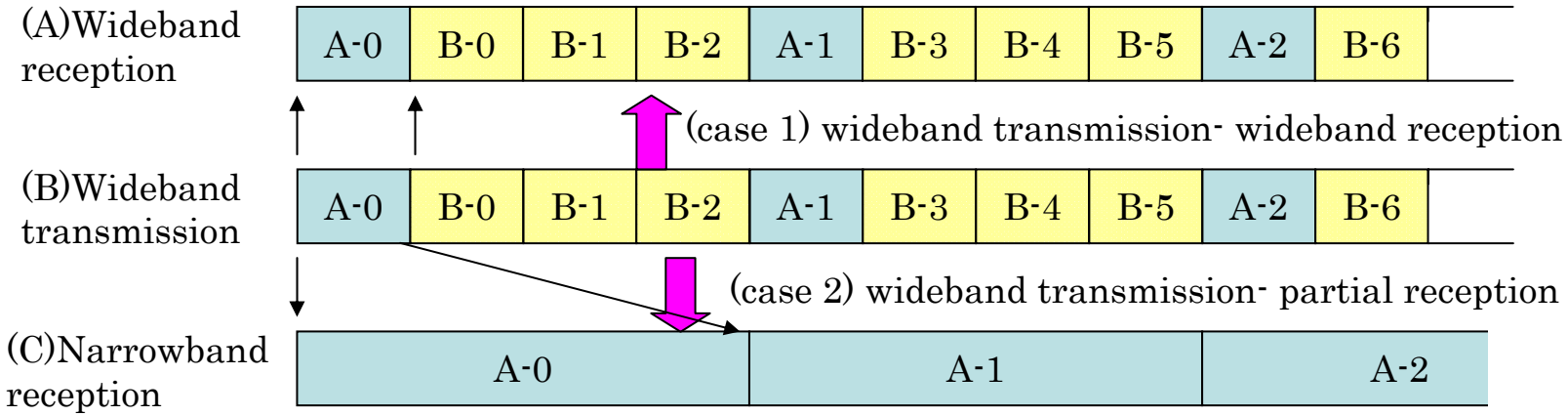


Figure 2-1Transport stream of transmission side and reception side

As shown in figure, Transport stream of transmission side includes the TS packet of 2 layers, these are A layer and B layer. As a result, wideband receiver receives both A layer packets and B layer packet.

If the program of A layer and B layer are same (simulcast for A and B layer), mobile receiver can display any program of A layer or B layer. So, If receiving condition of mobile receiver is not good because of low field strength, etc, such time display layer A.
On the other hand, receiving condition is good , such time display layer B program, that is HD quality.
To select A layer data or B layer data, mobile receiver can continue TY reception service.

This technique is adopted mobile receiver in Japan, people are enjoying TV in any time in car.

END of Seminar #2

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