

ANNEX-AA. Structure of ISDB-T system and its technical features

As written in Section 2. of main body of “ISDB-T technical report”, ISDB-T has many technical advantages. These advantages are mainly based on its structure. So, in this ANNEX, structure and feature of ISDB-T is introduced.

1. Structure of ISDB-T

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.

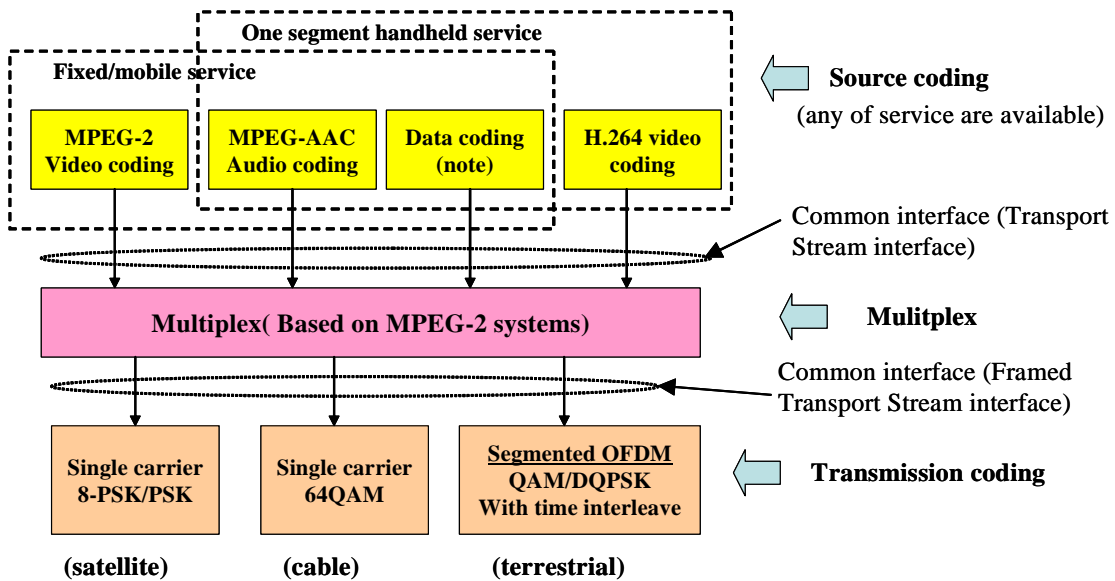


Figure 1-1. Structure of digital broadcasting system(Japanese ISDB-T)

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.

The Standard for digital broadcasting system in Japan is shown in figure 1-2.

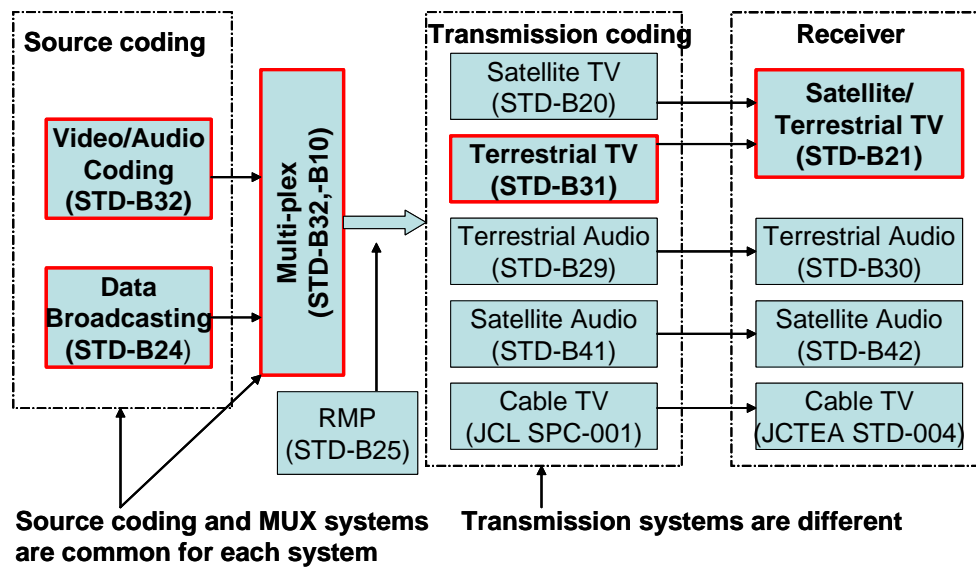


Figure 1-2 Digital broadcasting standard in Japan

In following sections, technical methods to realize the features of ISDB-T system are described.

2. High quality/Service Flexibility

2.1 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.

2.2 Service flexibility

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

(1) 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.

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 2-1 Video quality/format adopted in digital broadcasting

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	

Table 2-2 Audio quality/format adopted in digital broadcasting

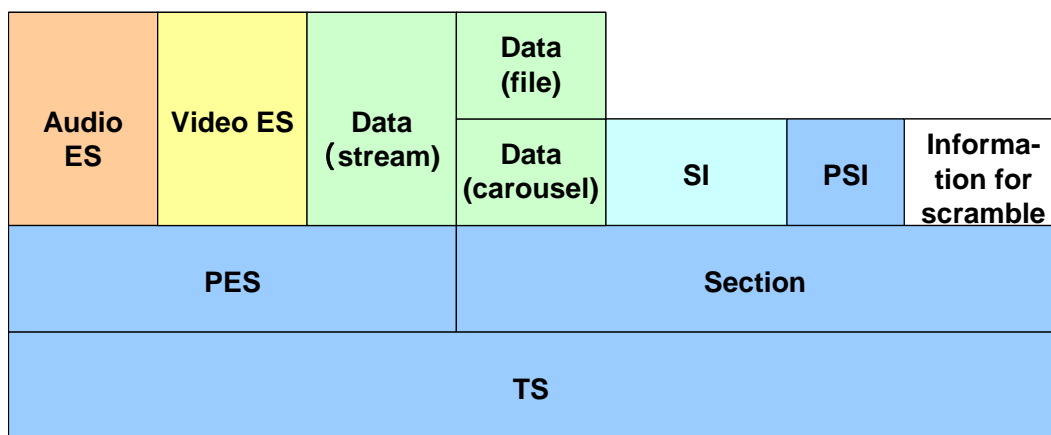
As described above, by adopting ISDB-T, any type of broadcasting service is possible in one receiver.

(note) In South America, Dolby 5.1 surround system is already used. For compatibility between MPEG-AAC and Dolby surround, AAC/DTS converter assure the compatibility. (In Brazil, reached to above conclusion in March, 2007)

(2) 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



(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

Figure 2-3 Multiplexed format In ISDB-T system

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.

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

Most important feature of ISDB-T is its transmission system. In following section, features of ISDB-T and technologies used in ISDB-T are introduced

3.1 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.

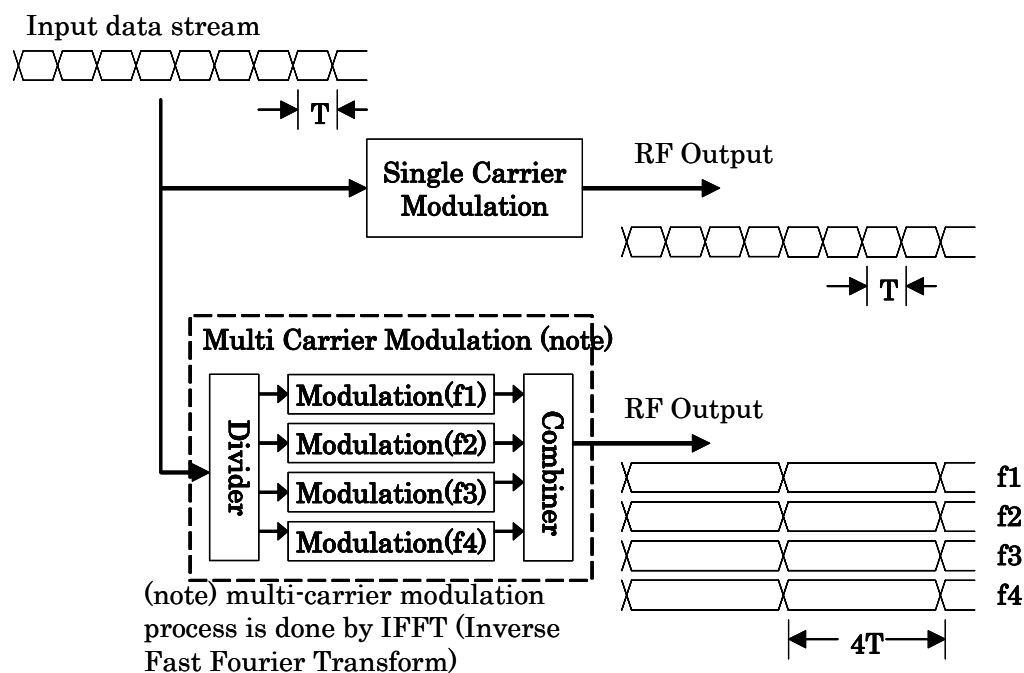


Figure 3-1 Conceptual diagram for relationship between modulation and symbol length

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(ICI) is inverse proportional to symbol length, therefore, under multi-path condition, longer symbol transmission system is better.

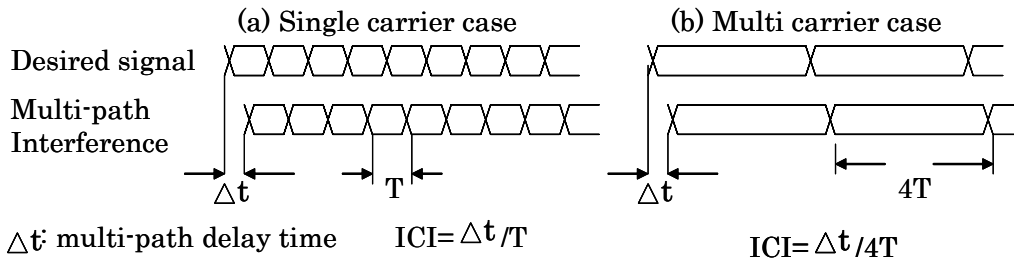
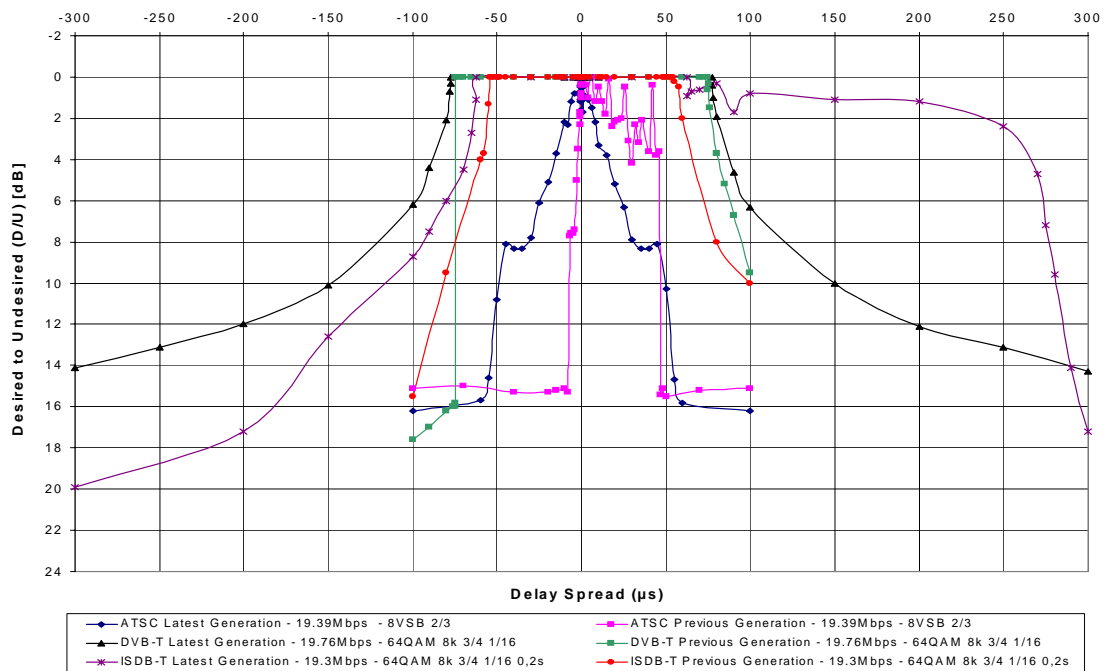


Figure 3-2 relation of multi-path delay and ICI

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.



(note) this data is quoted from ref.1

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

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.

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).

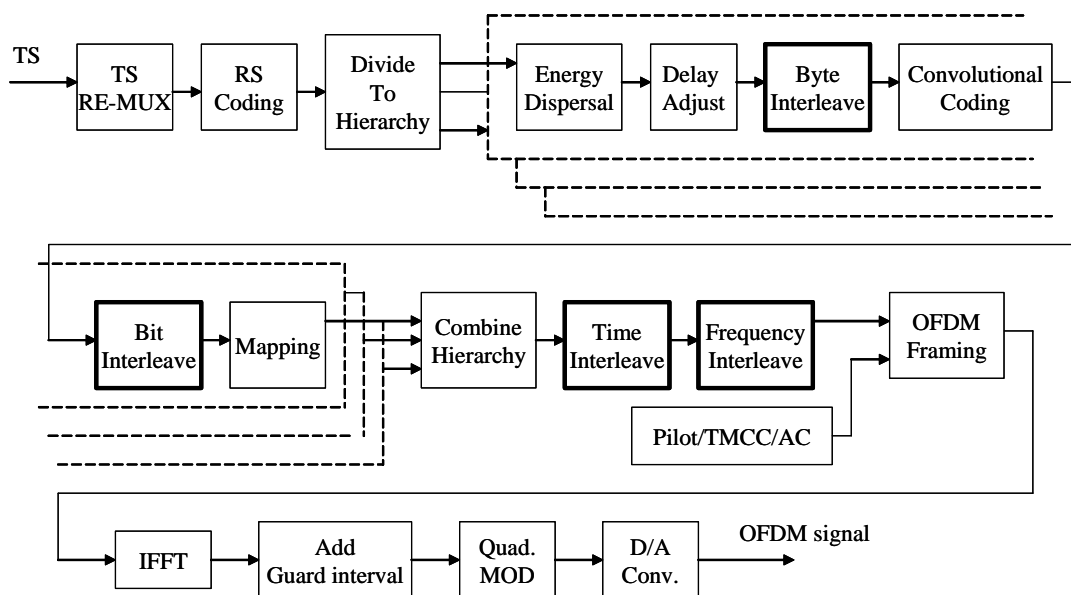


Figure 3-4 Functional block diagram of ISDB-T

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.

For an example, show at forward page the functional block diagram of ISDB-T in Figure 3-4.

As shown in Figure, ISDB-T has 4 kinds of Interleave. These are;

- (1) Bite interleave, (2) Bit interleave, (3)Time interleave, (4)Frequency interleave,
- Effect of these interleave function is described in Figure 3-5.



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

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

Frequency interleave

Frequency interleave is located at the output of mapping. 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

As shown in figure, over 150 us pulse width, ISDB-T is about 7dB better than other 2 system for reception performance.

7dB improvement means 1/5 less power of transmitter!

That is, if ATSC and DVB-T require 1 kW power of transmitter, ISDB-T require only 200W for same coverage!

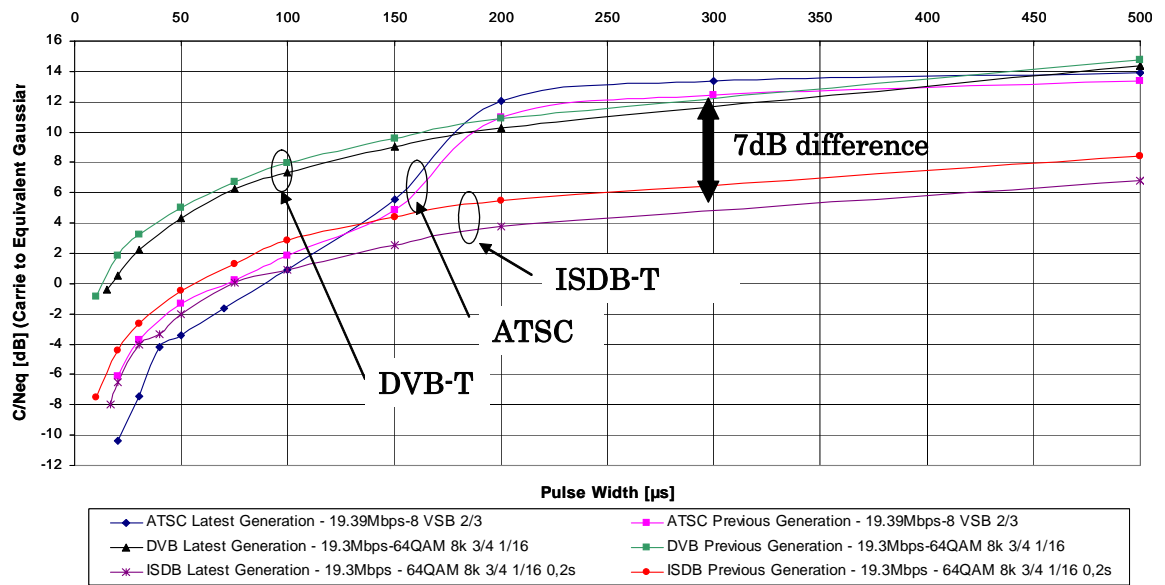


Figure 3-6 Reception performance under Impulse noise condition (3 DTTB systems)

3-3 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”

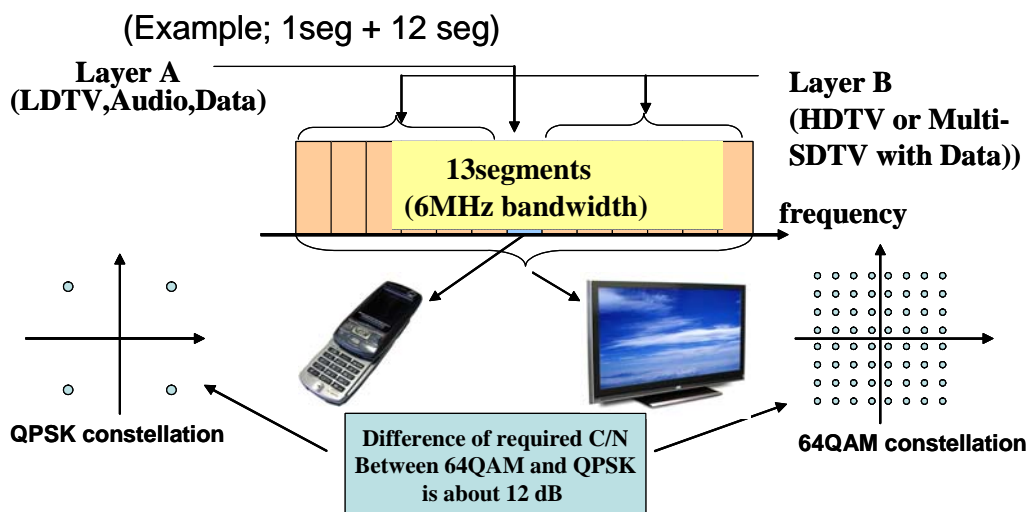


Figure 3-7 Image of “Hierarchical transmission system”(2 layer case)

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;

- (1) Save frequency resource; in one channel, plural types of service are possible, so another channel is not need.
- (2) 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.

In Table 3-1, as an example, shows the transmission parameter sets for “fixed(note) HDTV +portable One-seg” service in one channel.

(note) by making use of diversity reception technology, “HDTV mobile reception in car” is possible

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 indepedently

3-4 Comparison of the transmission performance of 3 DTTB systems

As described above sections, ISDB-T adopts very unique technologies in transmission system. As a result, ISDB-T has many advantages compare to another DTTB systems.

In Table 3-2, show the comparison of 3 DTTB systems on the point of transmission system.

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

As described in section 2 of main body, 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, 1 segment 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.

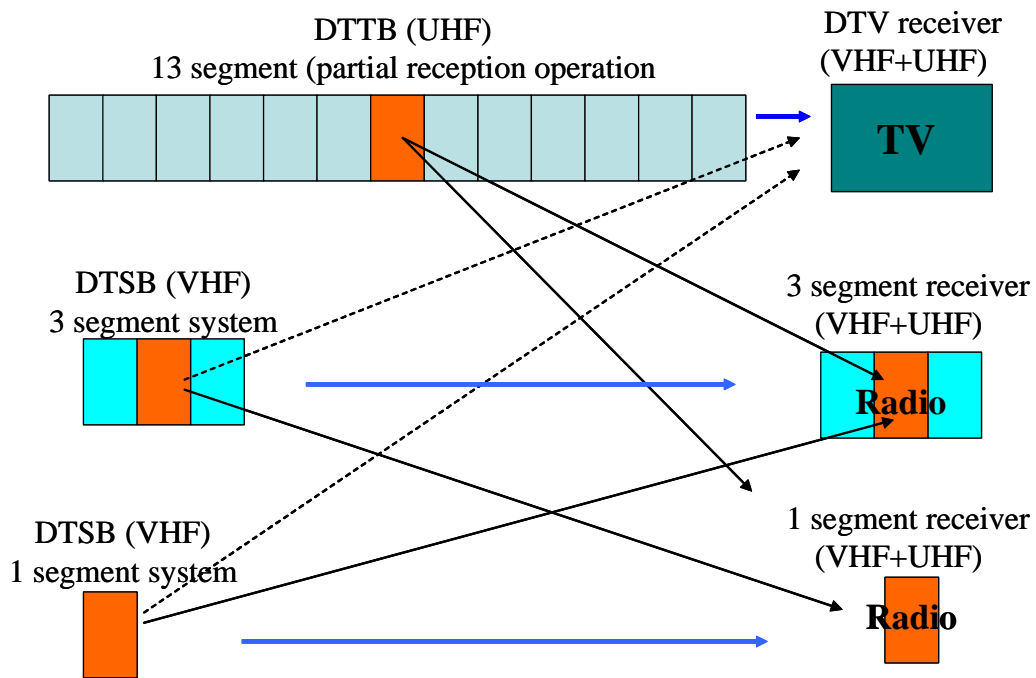


Figure 4-1 Relationship between ISDB-T and ISDB-Tsb

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.