

ISDB-T

Single Transmission for Fixed, Vehicular and Handheld Receivers

18 July, 2007

Manila, Philippines

DiBEG in ARIB, JAPAN

Koichiro IMAMURA (NHK)





Contents

- 1. Comparison of Three DTTB Systems
- 2. Features of ISDB-T System
- 3. DTTB Implementation in Japan
- 4. Low-cost Network Technologies
- 5. ISDB-T Receiver Technologies
- 6. Emergency Warning System for Broadcasting

7. Conclusion





ISDB-T Seminar

1. Comparison of Three DTTB Systems





What is ISDB-T?

ISDB-T is ...

One of the DTTB (Digital Terrestrial Television Broadcasting) system in the world

There are 3 DTTB systems recommended as ITU-R BT.1306.
 ISDB-T, DVB-T and ATSC

The most flexible system

 HDTV, multi-SDTV, EPG, data broadcasting, internet-access, mobile reception, cellphone TV, etc.

The most robust system

- OFDM, time-interleaving, etc.
- Brazilian comparison test results have proven it.
- Developed in Japan



Results of Brazilian Tests

- **Comparison tests for three DTTB systems**
 - •ATSC, DVB-T, ISDB-T
- **Carried** out from Aug. 1999 to April 2000
- Laboratories tests
 - OAWGN, impulse noise, multipath, Doppler effect
- Field tests
 - Coverage, gap-filler, indoor reception, etc.

ISDB-T shows superior performances especially for following items
(1) Robustness against impulse noise (urban noise)
(2) Coverage; robustness of ISDB-T system leads wide cover area
(3) Indoor reception; Robustness against impulse noise and fading leads good performance of indoor reception

Selected transmission parameters

Transmission parameter : almost same bit rate

• Fixed, 8VSB FEC=2/3 (19,39 Mbit/s)

DVB-2K : 64QAM FEC=3/4 GI=1/16 2K (19,75 Mbit/s)
 DVB-8K : 64QAM FEC=2/3 GI=1/32 8K (18,09 Mbit/s)

ISDB-T

DVB-T

ATSC

ISDB-4k : 64QAM FEC=3/4 GI=1/16 4K 0,1s (19,33 Mbit/s)
 Reference BER

• After RS decoding : 3×10^{-6}

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)





Indoor Reception









Summary of Comparison (1/2)

Any improvement of digital receiver was not considered to make the table below.

Requirements	System conform to requirements	
Maximum bit rate under Gaussian noise environment	ATSC	
Robustness against multi-path distortion	(note1)	
Robustness against impulse noise	ISDB-T	
Wide area single frequency network (SFN) operation	DVB-T, ISDB-T	
Mobility and Portability	DVB-T, ISDB-T	

(note1) Indoor reception can be available, which reduces reception cost





Summary of Comparison (2/2)

Any improvement of digital receiver was not considered to make the table below.

Requirements	System conform to requirements
Hierarchical transmission (Multiple modulation systems simultaneously in the same channel is possible)	ISDB-T>> DVB-T
Both portable and fixed reception service by single channel and single transmitter	ISDB-T(note1)
System commonality with digital terrestrial sound broadcasting (One-Seg receiver is available)	ISDB-T(note2)

(note1) Save both frequency resource and infrastructure cost

(note2) Multi purpose portable receiver is available





Comparison of DTTB Systems

System Item	ATSC	DVB-T	ISDB-T
HDTV/ SDTV Fixed reception	HDTV	SDTV Multi-ch	HDTV & SDTV Multi-ch
Data broadcasting	In operation	In operation	In operation
SFN operation		In operation	In operation
HDTV mobile reception	Under study ×	Possible for SDTV	Practical even for HDTV
Portable reception with cellphone	Under study ×	(DVB-H)	In Operation (One-seg)
Internet access	-	-	In operation





Technical Details of DTTB Systems

System		ATSC	DVB-T	ISDB-T
Modulation		8VSB	COFDM (QPSK,16QAM,64QAM)	Segmented COFDM (DQPSK,QPSK, 16QAM,64QAM)
	Bit/Symbol	Yes	Yes	Yes
Inter-	Frequency	-	Yes	Yes
leaving	Time	-	-	0s, 0.1s, 0.25s, 0.5s
Guard Interval		-	1/4,1/8,1/16,1/32	1/4, 1/8,1/16,1/32
TMCC		-	-	Yes
Information bit rate		19.39 Mbps	3.69 -23.5Mbps	3.65 -23.2 Mbps
Channel bandwidth		6/7/8 MHz	6/7/8 MHz	6/7/8 MHz





Essence of comparison test results

- The OFDM modulation scheme is suitable for DTTB in real broadcast circumstances.
- Time interleaving scheme, adopted in ISDB-T, is a key technology for <u>mobile</u> reception and is also effective to cope with <u>impulse nose</u> degradation.
- ISDB-T showed the best results in Brazil's comparison tests.





ISDB-T Seminar

2. Features of ISDB-T System





Features of ISDB-T

- Excellent mobile reception
- Flexibility
 - >HDTV, multi-channel SDTV and One-Seg
- Effective frequency utilization
- Low-cost system
- Broadcasting services using communication
- Qualified for Emergency Warning System



ISDB-T transmission concept and its reception



18



Excellent Mobile Reception (1/3)

- Two-dimensional frequency-time interleaving
 - Only ISDB-T has time interleaving scheme and it has a great effect on mobile reception.





Excellent Mobile Reception (2/3)

HDTV mobile reception technology

The space diversity reception technology for OFDM enables HDTV mobile reception

The same HDTV broadcasted for fixed receiver can be viewed in motor vehicle

No more than a single channel or a single transmission equipment is required.

> You can see what a cost-effective system ISDB-T is!





Excellent Mobile Reception (3/3)

One-Seg service for handheld receivers

- Mobile broadcasting service using robust modulation and coding over interferences
- HDTV and mobile service can be transmitted simultaneously using a single transmitter
 - There is no need to have overlapping investment in transmission facility for fixed and handheld TV services.





Flexible Broadcasting Service

ISDB-T promises flexible broadcasting services through hierarchical transmission



As shown above, ISDB-T transmission system supports maximally 3 reception style. Therefore, any of transmission system can be arranged according to the service concept in one frequency channel and one transmitter



Digital Broadcasting Experts Group



Examples of Hierarchical Transmission

(1) Single layer multi-program for stationary reception





ISDB-T Services (Fixed and Mobile)

- Digital Terrestrial Television Broadcasting
 - Recommended as System C of Recommendation ITU-R BT.1306-3
 - > 13 OFDM-segments system
 - HDTV broadcasting
 - One-Seg service (services for mobile reception terminals)
 - Multi-broadcasting (broadcasting plural programs simultaneously)
 - Data broadcasting
 - Engineering services to increase receiver functions and resolve problems by using broadcast waves
- Terrestrial Digital Sound Broadcasting (ISDB-T_{SB})
 - Recommended as System F of Recommendation ITU-R BS.1114-5
 - 1 or 3 OFDM-segments system
 - Providing high-quality sound broadcasting and data broadcasting based on text, still pictures, simplified videos, etc.
 - Compatible with One-Seg service for mobile





ISDB-T Transmission Scheme, Related ARIB Standards and ITU-R Recommendations

Item			Contents	ARIB Standards	ITU-R Recommendations	
Video coding		g	MPEG-2 Video (ISO/IEC 13818-2)	STD-B32	BT.1208	
	Audio codin	g	MPEG-2 AAC (ISO/IEC 13818-7)	STD-B32	BS.1115	
	Data broadcas	ting	BML (XHTML), ECMA Script	STD-B24	BT.1699	
	Multiplex		MPEG-2 Systems (ISO/IEC 13818-1)	STD-B10, STD-B32	BT.1300, BT.1209	
	Conditional acc	cess	Multi 2	STD-B25	-	
	Transmissio	n	ISDB-T transmission			
	Channel Bandwidth		6MHz, 7MHz, 8MHz			
	Modulation		Segmented OFDM (13 segment / ch)			
	Mode, guard		Mode : 1, 2, 3 Guard Interval ratio : 1/4, 1/8, 1/16, 1/32			
	Carrier Mod	ulation	QPSK,16QAM,64QAM, DQPSK			
	Error	Inner	Convolutional code (Coding rate : 1/2, 2/3, 3/4, 5/6, 7/8)	STD-B31	BT.1306 System C	
	correction	Outer	(204,188) Reed-Solomon code			
	Interlea	ve	Frequency and time interleave Time interleave : 0 - 0.5 sec			
	Information bit rate (depends on parameters)		6MHz : 3.7 – 23.2 Mbit/s 7MHz : 4.3 – 27.1 Mbit/s 8MHz : 4.9 – 31.0 Mbit/s			
	Receiver		ISDB-T receiver	STD-B21	-	
Operational guideline		leline	ISDB-T broadcasting operation	TR-B14	-	



http://www.dibeg.org/aribstd/ARIBSTD.htm



ISDB-T Seminar

3. DTTB Implementation in Japan



Digital Broadcasting Experts Group



Schedule for Transition to DTTB in Japan





DTTB Rollout in Japan





DTTB Transmission

- Distribution of DTTB signals throughout Japan
 - Requires a large number of relay stations.
 - The equipment cost has become a serious issue.

Main transmitters and relay stations of NHK Digital General TV





Channel Assignment Plan

There are not enough channels for DTTB in Japan.

SFN (single frequency network) operation is required.





SFN: Single Frequency Network

ISDB-T enables SFN

- Addition of guard interval of OFDM
 - Robustness to multipath interference
- Effective utilization of frequency resources





Digital Broadcasting Experts Group



"Analog to Analog" Conversion



32



Criteria for DTTB Coverage Planning

- Fixed reception (HDTV)
- 64QAM with rate 7/8 error coding
- 60dBµV/m for broadcasting coverage
- Interference protection ratio

Desired	Interference	Lower adjacent channel	Co-channel	Upper adjacent channel
Analog	Analog	10dB	28dB	0dB
	Digital	0dB	45dB	10dB
Digital	Analog	-21dB	20dB	-24dB
	Digital	-26dB	28dB	-29dB





Growth of Digital Broadcast Receivers

22.23 million (+0.87)

receivers shipped that can receive terrestrial digital broadcasts

*Survey by JEITA and Japan Cable Laboratories as of May 2007.

(1) CRT TVs	0.72 million (-)
(2) LCD TVs	10.7 million (+0.47)
(3) PDP TVs	1.92 million (+0.07)
(4) Tuners	0.34 million (+0.01)
(5) Digital recorders	3.74 million (+0.21)
(6) PC	0.73 million (+0.03)
(7) Cable TV STBs	4.08 million (+0.08)



25.51 million subscriptions to BS digital broadcasts

*NHK survey (preliminary figures) at the end of May 2007.

23.94 million (+0.79) BS digital broadcasts receivers

CRT TVs	1.86 million	(-)
PDP/LCD TVs	13.12million	(+0.51)
Digital tuners (including tuners with internal recording functions)	4.90 million	(+0.19)
Cable TV STBs	4.06 million	(+0.09)

1.57 million households view BS digital broadcasts on cable TV (after analog conversion)

[Reference] Current state of shipment of mobile phones compatible with One-seg services

7.66 million units (Increase of 1.09 million units over the previous month) *Surveyed at the end of Apr. 2007 by JEITA



ISDB-T Seminar

4. Low-cost Network Technologies

Toward the Construction of Countrywide Digital Terrestrial Television Broadcasting Network




Broadcast-wave Relay (On-air Relay)

- Broadcast-wave relay
 - On-air wave from a station of the previous stage is received and retransmitted by a broadcast-wave relay station.
 - > It is the same method as conventional analog broadcasting.
- An broadcast-wave relay has the advantage of lower equipment cost.
 - > A dedicated link such as a microwave link is not required.
 - > Securing of frequency resources for the dedicated link is also not required.





Problem in Broadcast-wave Relay

- Interferences mixed in reception at relay station:
 - Multipath
 - Fading
 - Co-channel interference (analog / digital) from other stations
 - CLI (coupling loop interference; feed back loop) in SFN relay





Compensation Technologies to Address Interferences

Compensation technology	Interference at relay station			
	Multipath	Fading	Co-channel Interference	Coupling Loop Interference
Multipath Equalizer	0	×	×	×
Diversity Reception	0	0	×	×
CLI Canceller (On-channel Repeater)	0	×	×	0
Adaptive Array Antenna	0	0	0	×

⊚: excellent, ○: good, **x**: ineffective





Major Problem of On-channel Repeater (SFN relay)

Reflective

objects

- Problem of coupling loop interference (CLI).
 - Howling of radio wave
 Signal degradation
 Oscillation
 Transmitting antenna
 The CLI fluctuates due to surroundings

Desired on-air wave from a station of the previous stage





antenna

NHK

Relay station (on-channel repeater)



CLI Canceller (On-channel Repeater)

- Enables single frequency re-transmission (SFN relay)
- Adaptive cancelling algorithm with digital signal processing
- Estimates CLI characteristic, generates CLI replica and cancels CLI from receiving signal







Block diagram of diversity reception system





Adaptive Array Antenna System for Co-channel Interference



Adaptive array antenna system with digital signal processing

Eliminates the co-channel interference utilizing the difference in the arrival directions of desired wave and undesired interference



Digital Broadcasting Experts Group



Connected One-Seg Re-transmission System

A maximum of 13 One-Seg signals can be re-transmitted using a single 6 MHz channel. It will be possible to offer community broadcasting localized to a particular area for retransmission, in addition to One-Seg services from every broadcaster.





ISDB-T Seminar

5. ISDB-T Receiver Technologies





Hardware Components of a Basic Receiver



Phone Line, LAN, etc.

Between a Full-Seg receiver and a One-Seg receiver, the basic configurations are about the same, though there are some differences such as a tuner, video decoder, resolution of display and so on.

RF : Radio Frequency IF : Intermediate Frequency TS : Transport Stream Demux : Demultiplexer NVRAM : Non-volatile RAM



Functional Block Diagram of the Front-end





Functional Block Diagram of the Back-end





Functional Block Diagram of BML Browser





Digital Broadcasting Experts Group



Low Power Consumption System





One-Seg Receivers Introduced to the Market (1/3)





One-Seg Receivers Introduced to the Market (2/3)



Each company's press released merchandise in Japan



One-Seg Receivers Introduced to the Market (3/3)





Demand Expansion for One-Seg Cellphones

- One-Seg cellphone shipments have been expanding and will reach over 10 million by the end of July 2007.
- Presently, over 1 million One-Seg cellphones are being sold every month.





Diversity Reception System for Cellphone

- Diversity systems are applicable to cellphones as well as car receivers.
- Now, only one product (P903iTV) is equipped with diversity system.
- It has two antennas for One-Seg, a whip antenna and an internal antenna.







HDTV Mobile Reception Technology for ISDB-T

- Conventional reception
 - Robust modulation (16QAM ½ or QPSK)
 - 1 receiving antenna
 - SDTV



- HDTV mobile reception (diversity reception)
 - 64QAM (transmission same as in stationary reception)
 - 2-4 branches (number of receiving antennas)
 - HDTV
- The same HDTV broadcasted for fixed receiver can be viewed in motor vehicle
 - No more than a single channel or a single transmission equipment is necessary.



Car HDTV System Already on sale

Examples of car HDTV system (with car navigation system)



NISSAN/SANYO HS706D-A



Full-Seg is Optional

SANYO GORILLA NV-HD830DT

• The latest car HDTV systems using 4-branch diversity reception technology



Alpine VIE-X07B4



Panasonic CN-DS965TD



Pioneer AVIC-VH099G





Channel Equalizer for Multipath Interference outside the Guard Interval of OFDM

This technology enables to equalize multipath outside the guard interval (GI) of OFDM.





ISDB-T Seminar

6. Emergency Warning System for Broadcasting





Emergency Warning System for Broadcasting

- Remote activation of Radio & TV ready for EWS
 - AM, FM Radio & TV : Control and Alert Sound
 - Digital Broadcasting (ISDB-T) : Emergency Warning Control Flag
- EWS has been operated since September 1985 in Japan
- Test signals are monthly broadcasted in Japan





Date	Place	Fatalities	Magnitude
Dec. 26, 2004	Off northwest coast of Sumatra, Indonesia	300,000	9.3
Feb. 22, 2005	Zarand, Iran	Over 500	6.4
Mar. 28, 2005	Northern Sumatra, Indonesia	1,000-2,000	8.7
Oct. 8, 2005	Kashmir, Pakistan	100,000 (estimated)	7.6
May. 26, 2006	Java, Indonesia	Over 6,000	6.3
July. 17, 2006	Java, Indonesia	Over 500	7.7





Functions of Broadcasting in Disaster Management

- 1. Gathering/receiving disaster information from administrative organizations
- 2. Filtering information
- 3. Delivering disaster information to the general public
- Broadcasting offers reliable information
 There are no "spam" information in broadcasting
- Always connected to everybody There are no congestions like in communication
- 6. Always active : 24 hour operation

• Broadcasting is an ideal media to deliver disaster information



ISDB-T Seminar in Manila, Philippines



EWS for Digital Broadcasting ISDB-T One-Seg Services

- A channel slot divided into 13 segments
 - 12 segments for HDTV services
 - 1 segment for mobile / portable services
- Both services are simulcast now.



EWS for Digital Broadcasting EWS for ISDB-T One-Seg Services

- EWS for ISDB systems have already been in operation in Japan as well as analog broadcasting
- Portable EWS receivers for One-Seg are now under development
- One-Seg receivers are expected to enlarge the opportunity to avoid disaster
- Technology for saving power consumption is the key
- EWS should be prepared by other digital broadcasting systems









EWS for Digital Broadcasting EWS Signal Allocation in ISDB-T





EWS for Digital Broadcasting ISDB-T One-Seg Services & EWS

- Remote activation of mobile terminals by EWS is very effective.
- EWS bits in TMCC have to be always watched in mobile terminals.







EWS for Digital Broadcasting Conventional EWS Stand-by



- Silicon Tuner(100mW) and Demodulator(50mW) are always active
- Life of a Battery(3.7V,800mAh 3Wh) is only 20h(1 day)

More than 200h(8 days) would be required



EWS for Digital Broadcasting Saving Power Consumption for EWS Stand-by



- Silicon Tuner(10mW) and EWS bit detector(5mW) are active only for necessary duration
- Life of a Battery(3.7V,800mAh 3Wh) improved to 200h(8.3 days)





EWS Application

Not only

Tsunami forecast

But also

- Earthquake forecast
- Typhoon forecast
- Flood warning
- Eruption warning
- Fire warning
- Other warning





Conclusion (EWS)

- EWS (Emergency Warning System)
 - Broadcasting is an ideal media to deliver disaster information
 - EWS for broadcasting remotely activates radio and TV ready for the system
 - EWS for analog radio and TV has already been in operation in Japan
- Preparation for EWS toward digital broadcasting
 - Portable receiver woken up by EWS signal alerts you quickly with earthquake, tsunami warning and so forth.
 - Saving power consumption during EWS-stand-by mode has almost completed.
- EWS has been approved as Recommendation ITU-R BT.1774-1





ISDB-T Seminar

6. Conclusion





Conclusion

- ISDB-T is the most cost-effective system
 - ISDB-T performs services fixed and mobile simultaneously
 - HDTV for fixed and mobile receivers
 - One-Seg mobile TV for handheld receivers
 - ISDB-T enables both digital TV service for fixed and mobile by just one facility investment
 - ISDB-T has low-cost network technologies of compensation technologies, which address interferences in broadcast-wave relay.
- ISDB-T performs the most effective frequency utilization
 - > SFN, broadcast-wave relay, on-channel repeater and so forth
 - Broadcast-wave relay (on-air relay) technologies enable not only cost-effectiveness but also effective frequency utilization.
- There are many cutting-edge technologies in ISDB-T system.




ISDB-T Seminar

Thank you for your kind attention!

DiBEG (Digital Broadcasting Expert Group)

http://www.dibeg.org/

NHK (JAPAN BROADCASTING CORPORATION)

http://www.nhk.or.jp/english/

http://www.nhk.or.jp/strl/english/

