History and Technology of ISDB-T
~ aiming at mobile and portable reception ~

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Argentina

DiBEG, JAPAN

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Pioneer

DiBEG
Digital Broadcasting Expert Group

Biography

1944 Born in Tokyo

1967 Graduated from Waseda University and joined NHK

1971 Started research of new broadcasting systems

1975-1985 Engaged in the development of Teletext

1985-1992 Engaged in the development of FM multiplex broadcasting

1986-2002 Engaged in the development of terrestrial digital broadcasting

1991-2000 Engaged in the development of satellite digital broadcasting

1999-2002 Director General of NHK Science and Technical Research Laboratories

2002 left NHK and Joined Pioneer

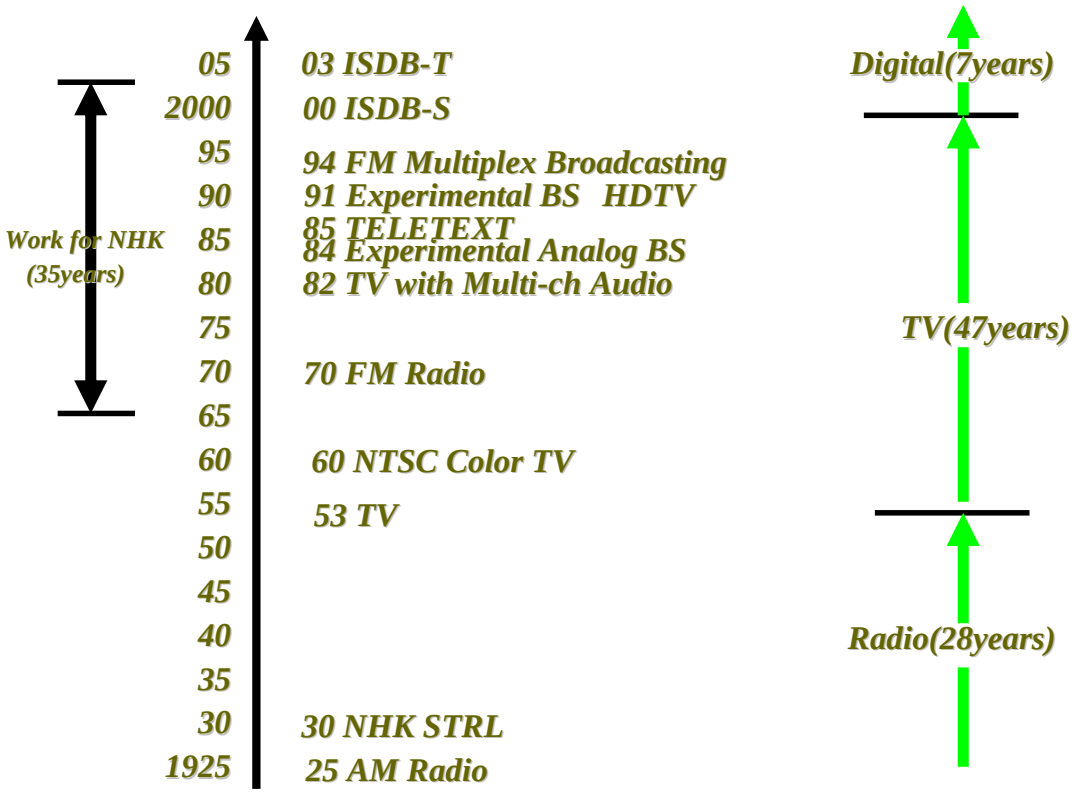
2005 Senior Managing Director of Pioneer

2007 Executive Corporate Adviser, R&D

Contents

1. Broadcasting History in Japan

History of Broadcasting Technology in Japan



Research History

1975～1985 **TELETEX**

1985～1994 **FM Multiplex Broadcasting**

1992～2000 **ISDB-S**

1986～2002 **ISDB-T**

2. TELETEXT
(1975～1985)

TELETEXT

(1) TELETEX is the first service with digital technology in analog broadcasting age.

(2) Characters and graphics are coded and multiplexed with the vertical blanking period of analog TV signals.

(3) In 1970s, three systems, System A (France), System B (UK), System C (North America), and System D (Japan) had been developed.

(4) At present, System B, and System D are available.

(5) Japanese each character has a different meaning. Bit errors give erroneous information, therefore bit error can't be permitted.

(6) Only Japanese TELETEXT system had been making much of the development of error correcting codes.

(7) Japanese TELETEXT never shows incorrect characters, because of the new error correcting method we developed.

Field Trials of TELETEXT

Field Trial in Wakayama

Error Pattern Analizer

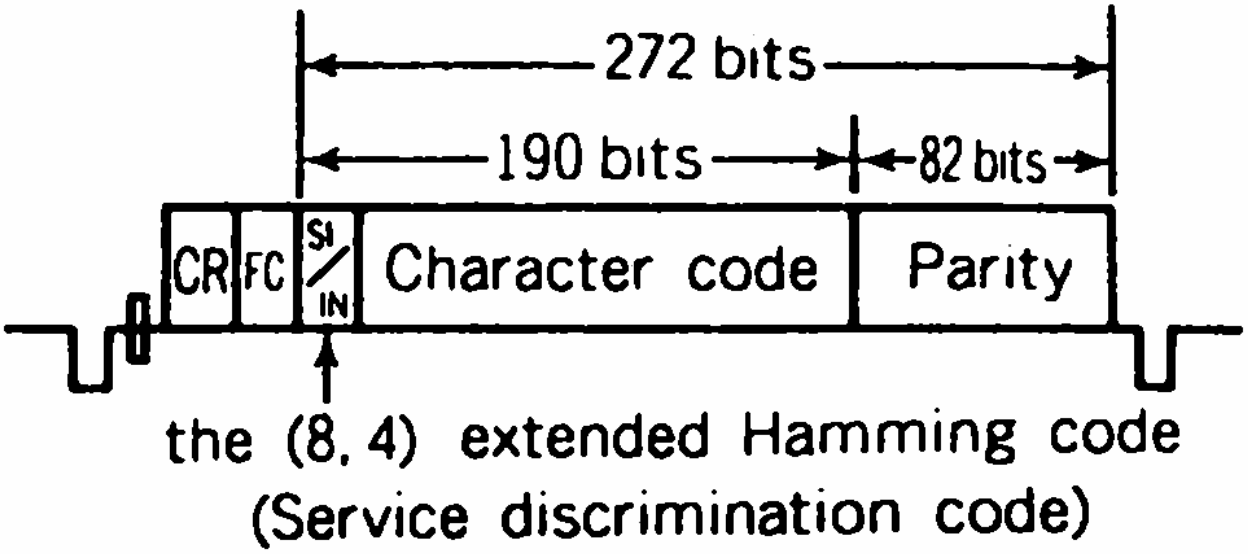
Research Result

(1) The simulation results using error patterns collected in the actual field trials showed that the (272,190) code was the best.

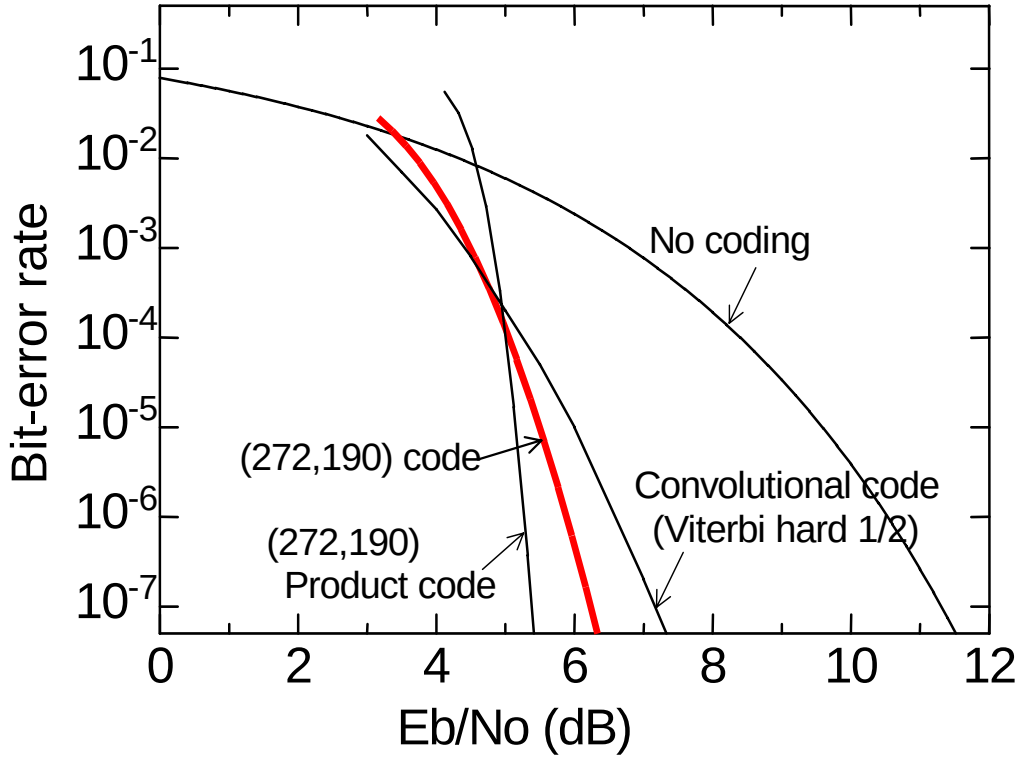
(2) The (272,190) code is one of the majority logic decodable codes, and it is called a difference Set Cyclic Code.

(3) The (272,190) code is one of LDPCs (Low Density Parity Check), which are hot topics in an error correcting code field.

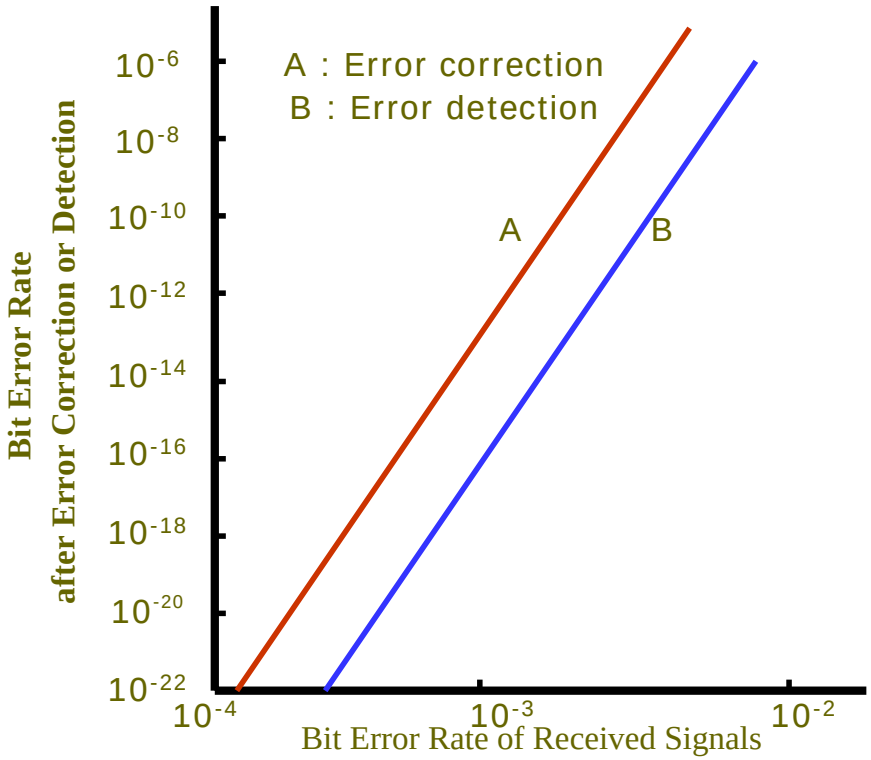
Packet Signals of TELETEXT



Error Correcting Capability of the (272,190) Code



Error Correcting Capability of the (272,190) Code



Effect of the (272,190) Code

Random noise
(Input level:31dBμV,
Bit-error-rate:2.4x10^{-2})

Ghost interference
(Delay time:2.5μs,D/U=7dB,
Bit-error-rate:4.03x10^{-3})

Applications of the (272,190) Code

(1) TELETEXT : (272,190)

(2) FM multiplex Broadcasting : Product Code-(272,190)X(272,190)

(3) Optical Card System for immigration card in U.S.A : Product Code-(272,190)X(272,190)

(4) Protection for key of BS Pay TV : (272,190)

(5) ISDB-T : Shortened (184,102) for TMCC signals

What we were taught

(1) Digital signals are robust against random noise, but very weak against wave distortion.

(2) Error correction is one of the key technologies in digital broadcasting, and indispensable technology for digital transmission.

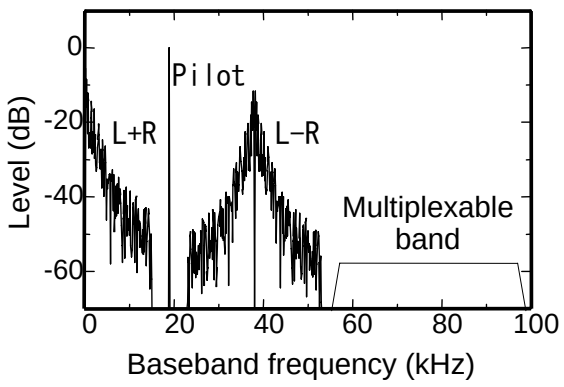
(3) Thanks to the progress of LSI, theoretically difficult themes can be realized.

(4) Though analog TV can be received in running cars to some extent, TELETXE signals(5.27Mbps) can't be received.

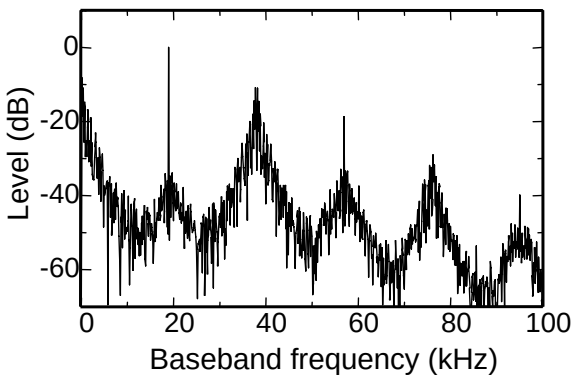
(5) At that time, I believed that digital terrestrial TV broadcasting would be impossible, because of high bit rate of video signals and difficulty of mobile reception.

3. FM Multiplex Broadcasting —DARC(Data Radio Channel)— (1986～1995)

Frequency Spectrum of FM Stereo Broadcasting Signals

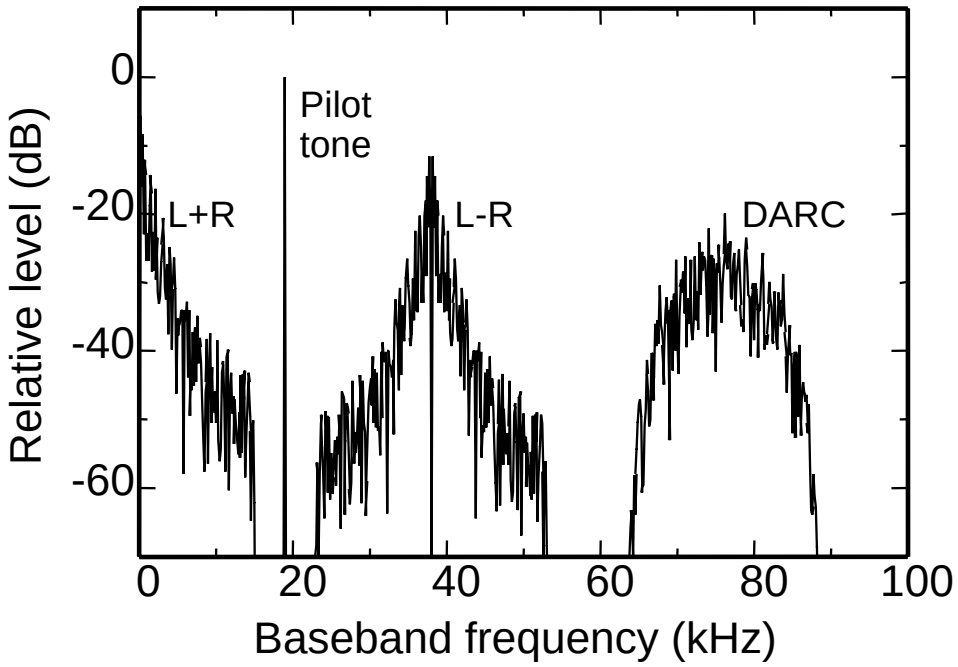


Original baseband spectrum and multiplexable band of FM stereo broadcasting



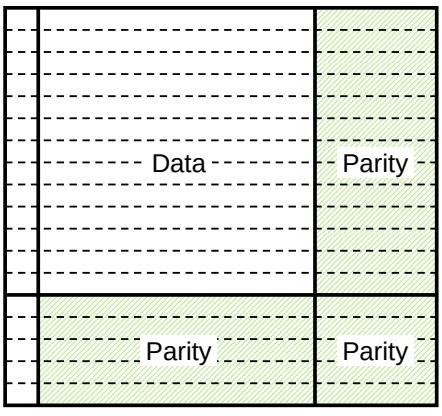
Baseband spectrum of FM stereo broadcasting under multipath interference

Frequency Spectrum of DARC



Error Correction of DARC

- Powerful error correction by (272,190) product code

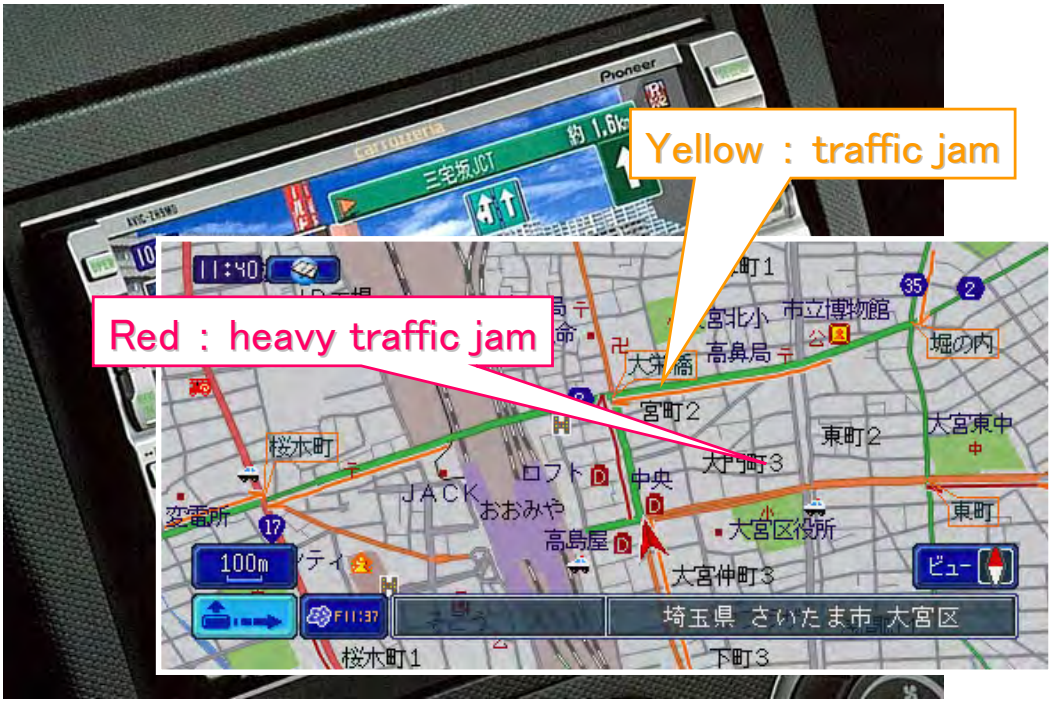


Product code

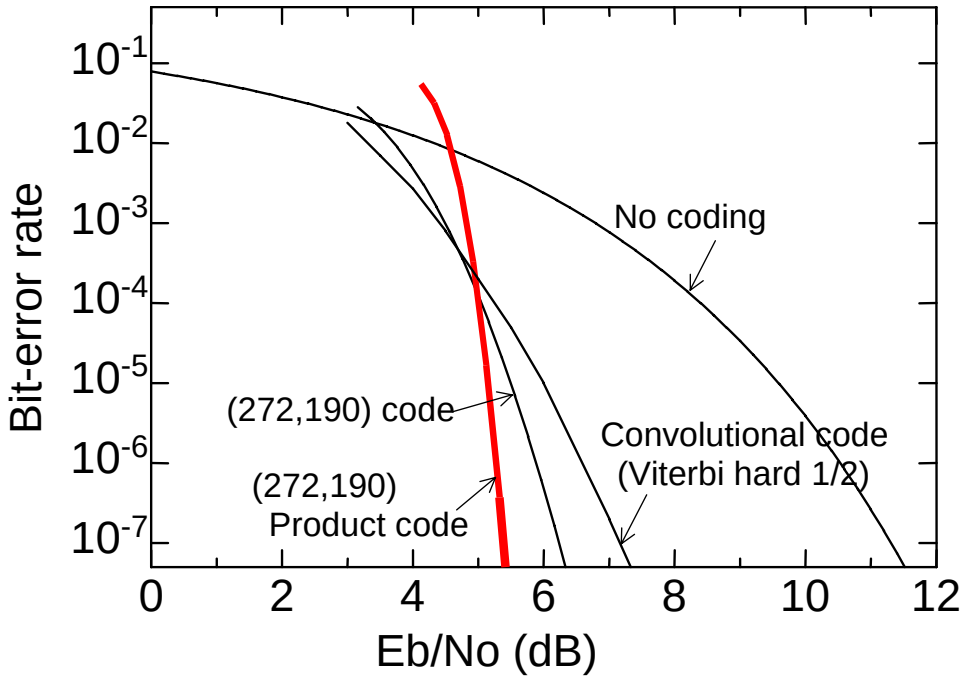
Car Navigation System with VICS
(Vehicle Information Communication System)

Penetration in March, 2006
1.5 Million

Example of VICS



Performance of the (272,190) product code



Comparison of DARC and RDS

System	DARC	RDS
Subcarrier	76 kHz	57 kHz
Multiplex level	4∼10%	2∼3%
Modulation	LMSK	BPSK
Bitrate	16 kbit/s	1.2 kbit/s
Error correction	(272,190) product code	(26,16) code

What we were taught

(1) Many kind of digital modulation methods

(2) Difficulty of mobile reception : poor antenna gain, fading interference, ghost interference

(3) For example, the difference of antenna gain between fixed reception and mobile reception is more than 15 dB.

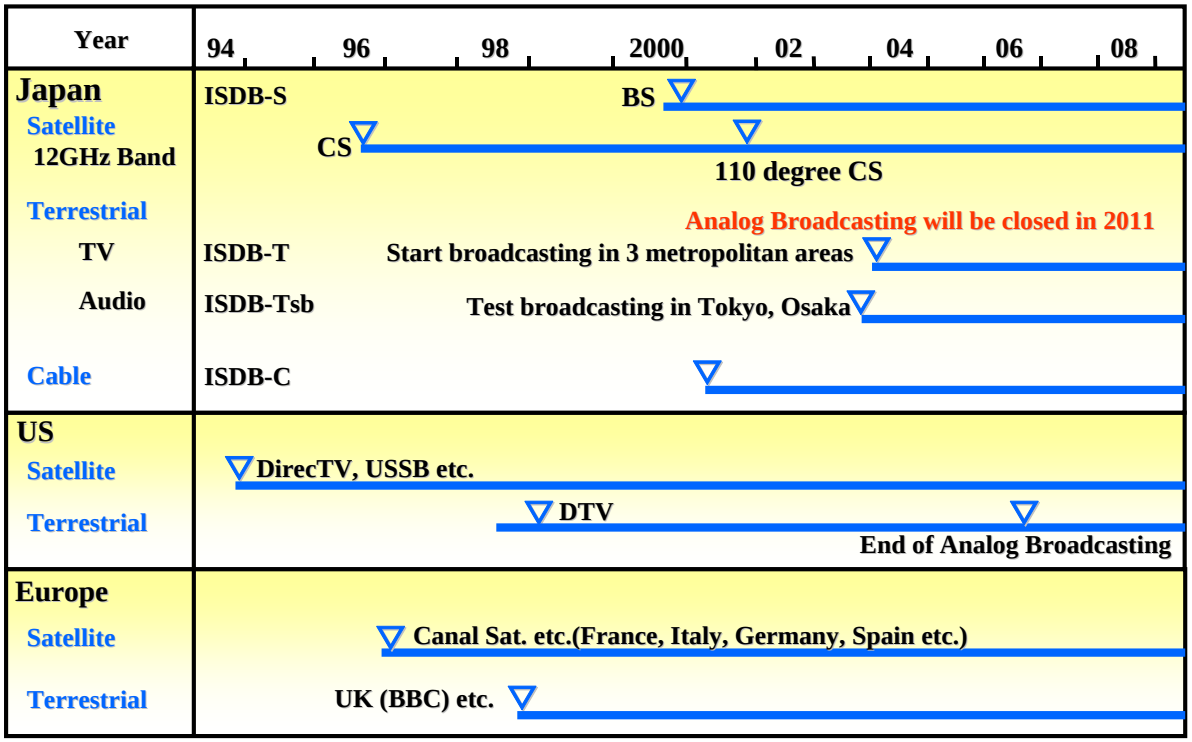
(4) Existence of potential need, so called traffic information service

4. ISDB-T
(1986-2002)

Merits of Digital Broadcasting

(1) Robustness against noise
(2) Easy channel assignment
(3) Effective use of bandwidth
(4) Mobil and portable reception
(5) High video quality
(6) Affinity to computer and Internet
(7) Easy to add new services
(8) Fit for LSI technology

Introduction of Digital Broadcasting



Implementation Schedule of ISDB-T in Japan

Jul. 2011	Analog disappears
Oct. 2006	Start of ISDB-T (main city of the whole country)
Apr 1.st 2006	Start of 1-Segment Broadcasting
Dec 1.st 2003	Start of ISDB-T (Tokyo, Nagoya, Osaka)
Apr. 2003	Provisional licenses were awarded
Feb.2003	Start of Analog channel relocation
1999-2003	Real Scale Experiment Broadcasting
1999	MPT established technical standard
1998	Issue of Digital Broadcasting Study Group Report
1994	MPT asked to Council for technical requirement

System Requirements and Principal Technologies

(1) Excellent transmission characteristics
OFDM

(2) HDTV, mobile and portable services
OFDM, time interleave, hierarchical transmission and one seg

(3) System flexibility
Segment structure

(4) Effective use of frequency
SFN

Why Mobile and Portable Reception

(1) All kind of TV programs including data services can be received at home in the future, via satellite, cable, internet, etc..

(2) People's outside life times are increasing in the present-day life.

(3) Broadcasters have to anytime serve information including video, audio, and data.

(4) Especially, the emergency information service is related to a matter of life and death, therefore it is a very important role for broadcasters to provide people with emergency information anytime and anywhere.

(5) Above media in (1), can't provide people such services, and VHF and UHF band frequency used by broadcasters, are the best for mobile and portable reception.

(6) In the age of the convergence of broadcasting and communication, Broadcasters can't survive without mobile and portable services.

4.1 OFDM
(Orthogonal Frequency Division Multiplex)

DAB (Digital Audio Broadcasting)

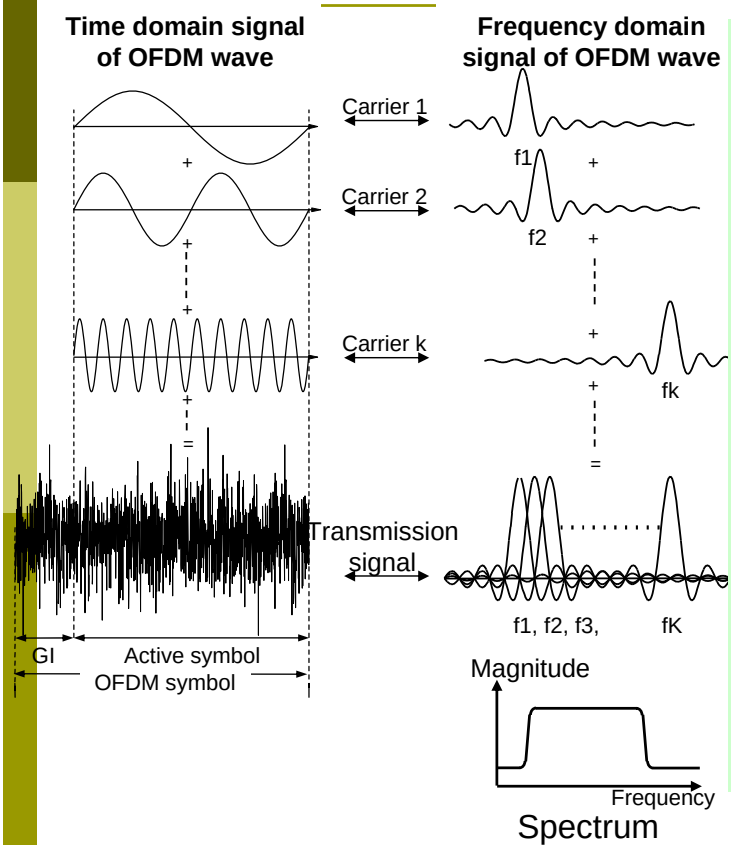
(1) In 1980's, EBU developed Digital Audio Broadcasting (DAB).

(2) DAB adopted two new digital technologies, OFDM (Orthogonal Frequency Division Multiplex, CCETT in France) and digital audio compression technology (IRT in Germany).

(3) We started the research of OFDM as a digital modulation technology for mobile TV.

(4) We knew that Dr. Hirosaki (NEC) had already presented the OFDM technology for the first time in the world.

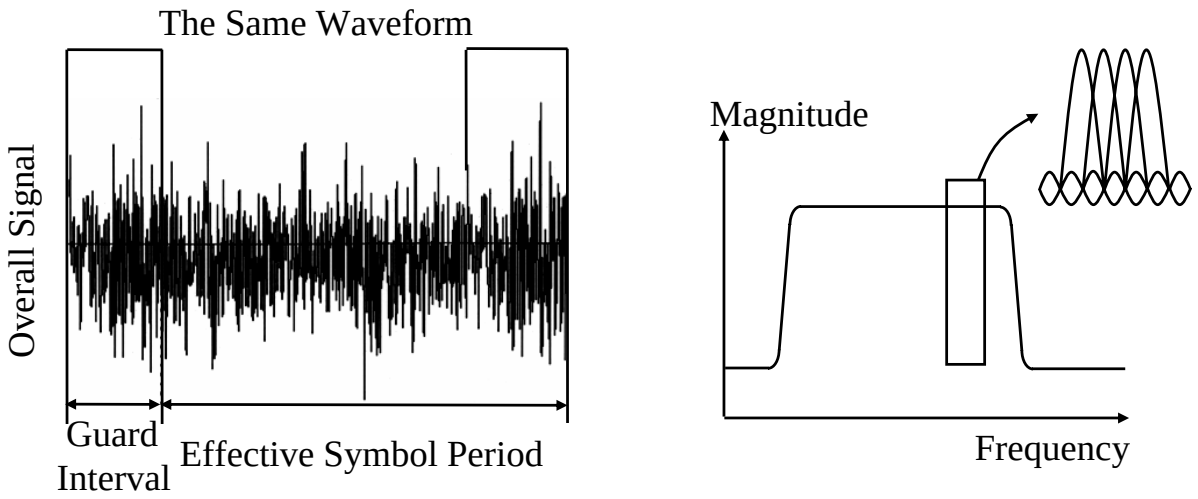
OFDM Signals



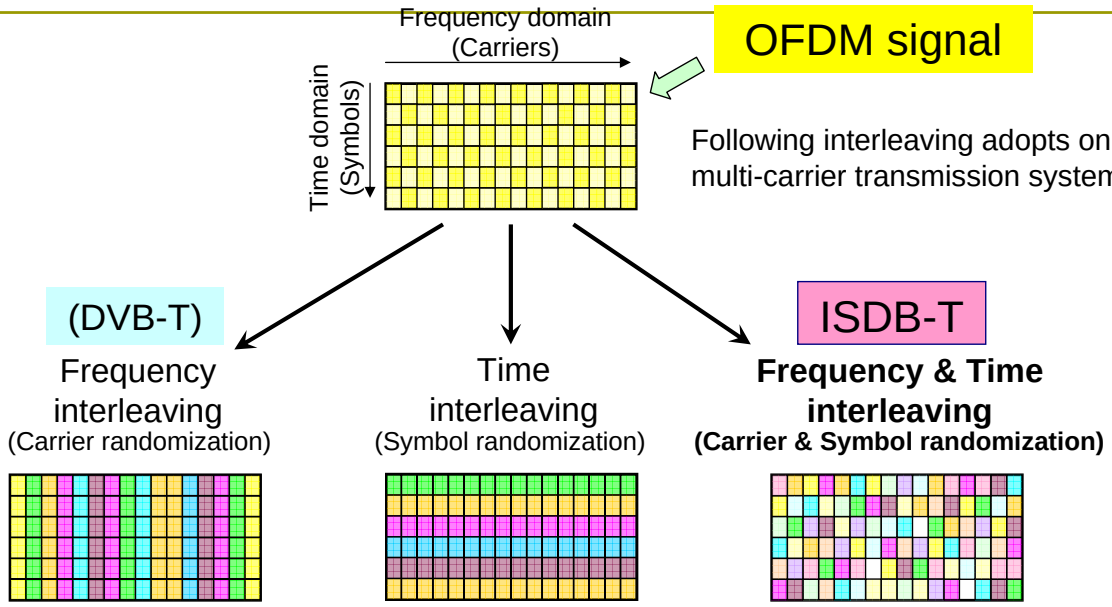
OFDM is

- Multi-carrier modulation
  - More than 2,000 carriers in a 6MHz TV channel
  - Long symbol duration compare to single-carrier transmission system
- Multipath proof modulation
  - by adding guard interval
- Modulation/demodulation can be processed by **IFFT/FFT.**

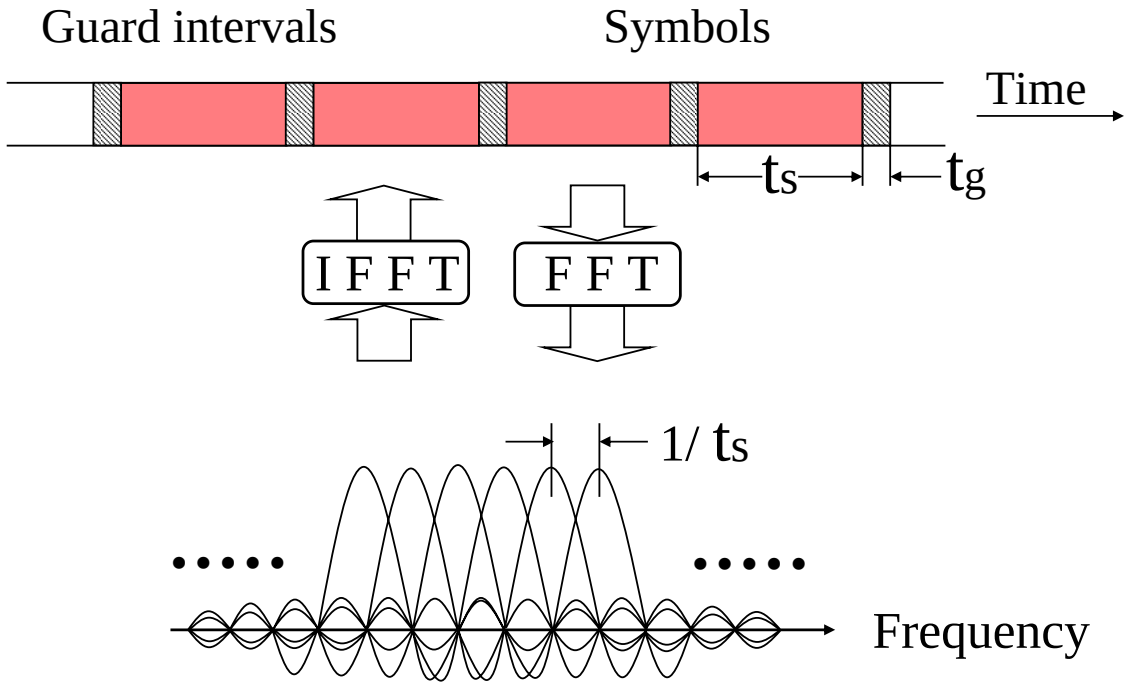
OFDM Signals



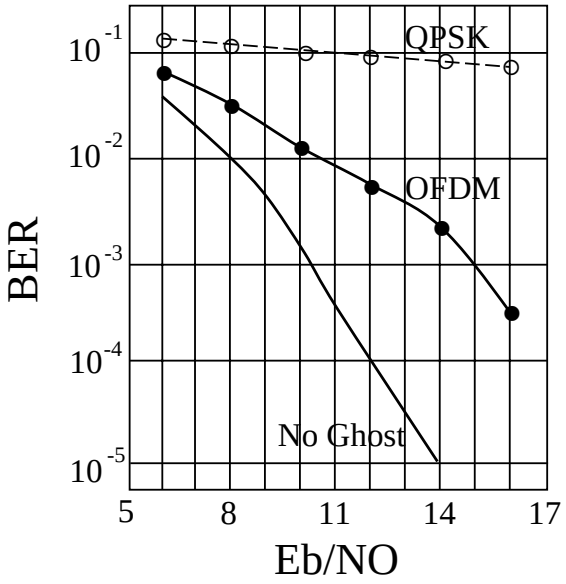
Frequency and Time Interleaving

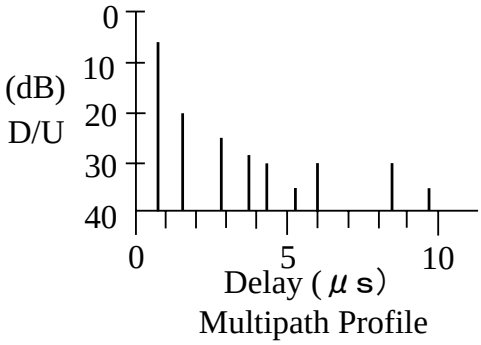


Modulated OFDM signals (Time and Frequency domains)



Superiority of OFDM

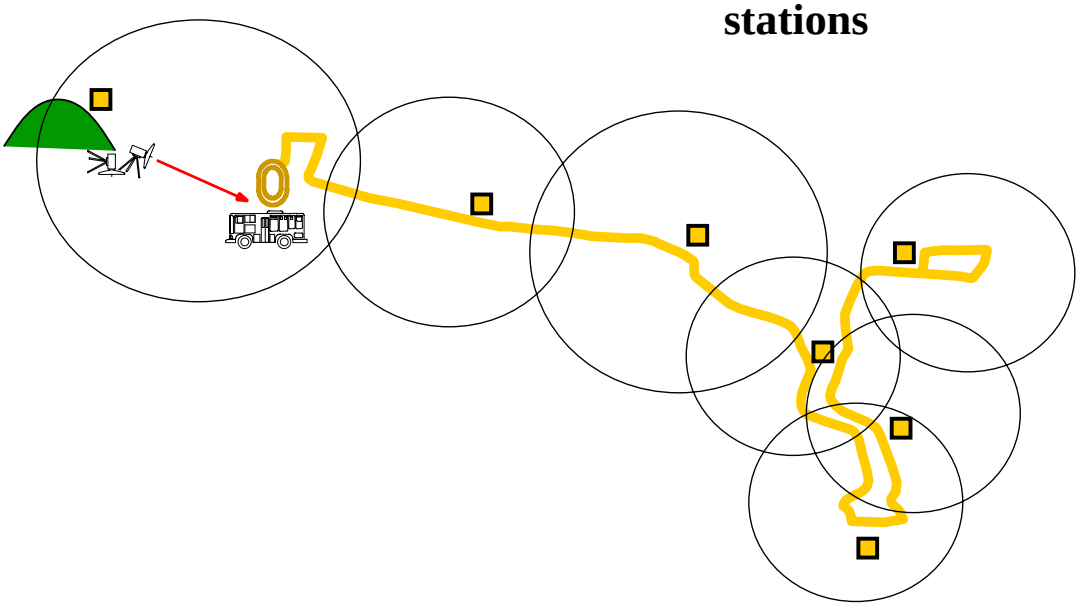




4.2 Frequency Assignment

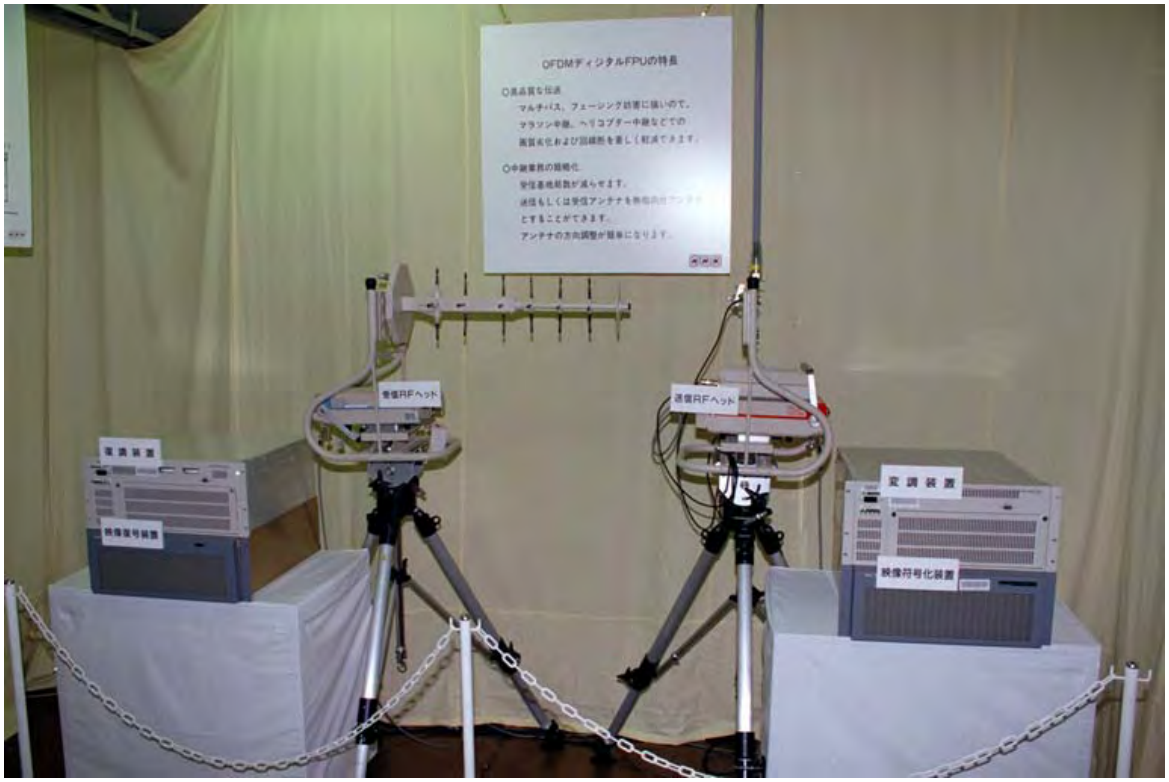
Application for Marathon Relay Station

25 analog FPU receiving stations ⇒ 7 digital FPU receiving stations



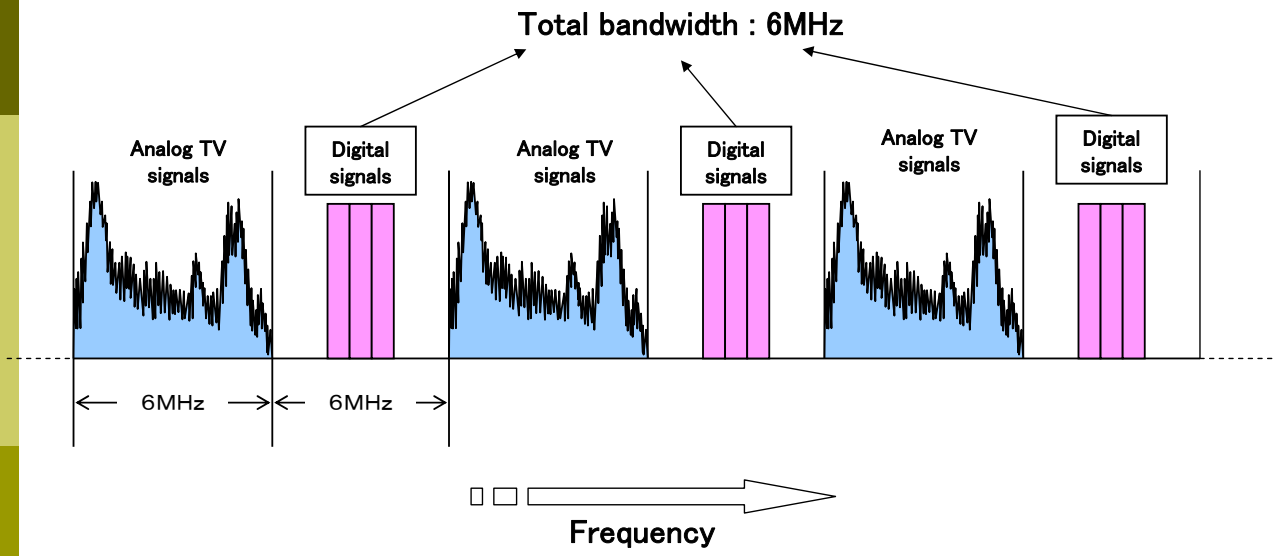
: Receiving stations

FPU(Field Pick Up) Transmitter and Receiver



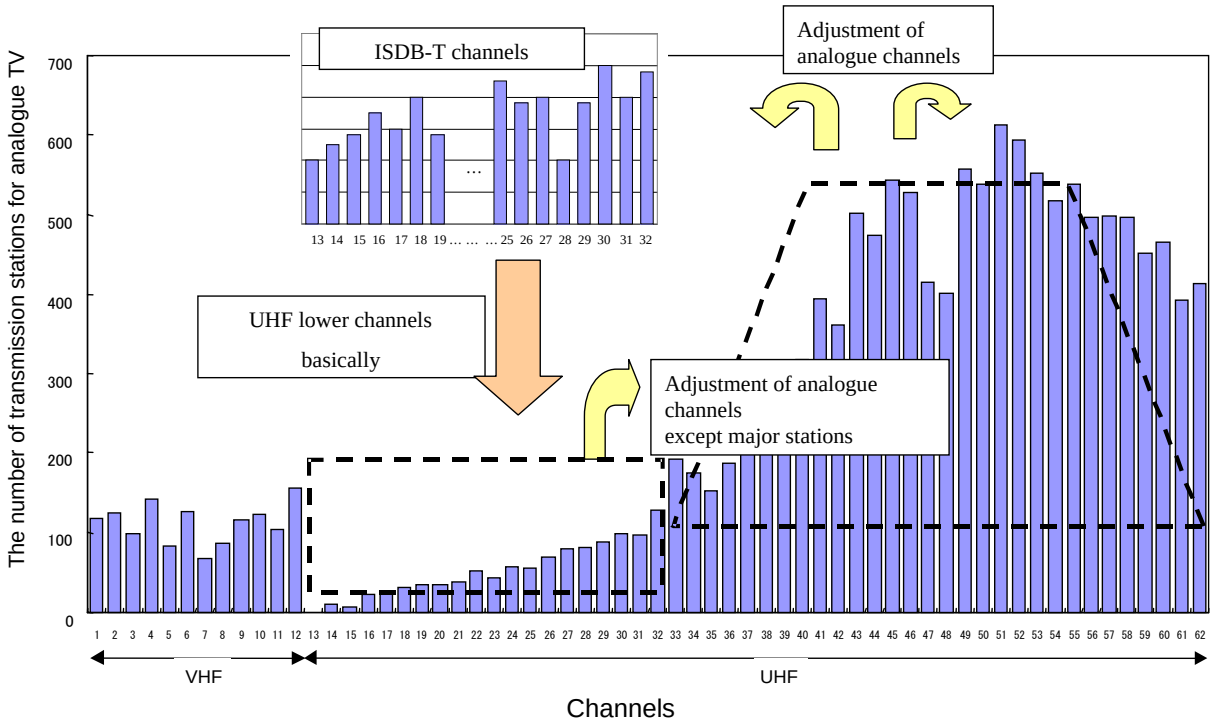
Comparison of FPU between OFDM and FM

Original of BST-OFDM (Band Segmented Transmission-OFDM)



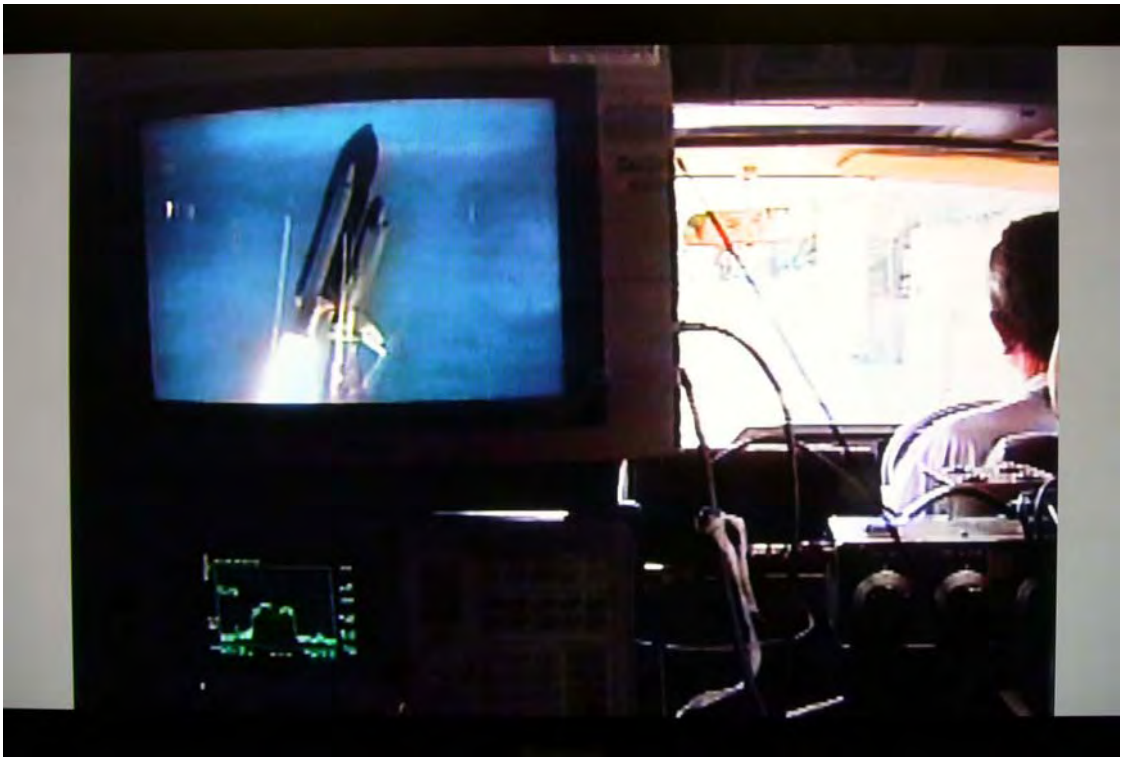
[Old name was BST(Band-Split-Transmission)-OFDM]

Channel Reassignment (Analog-Analog Frequency Conversion)



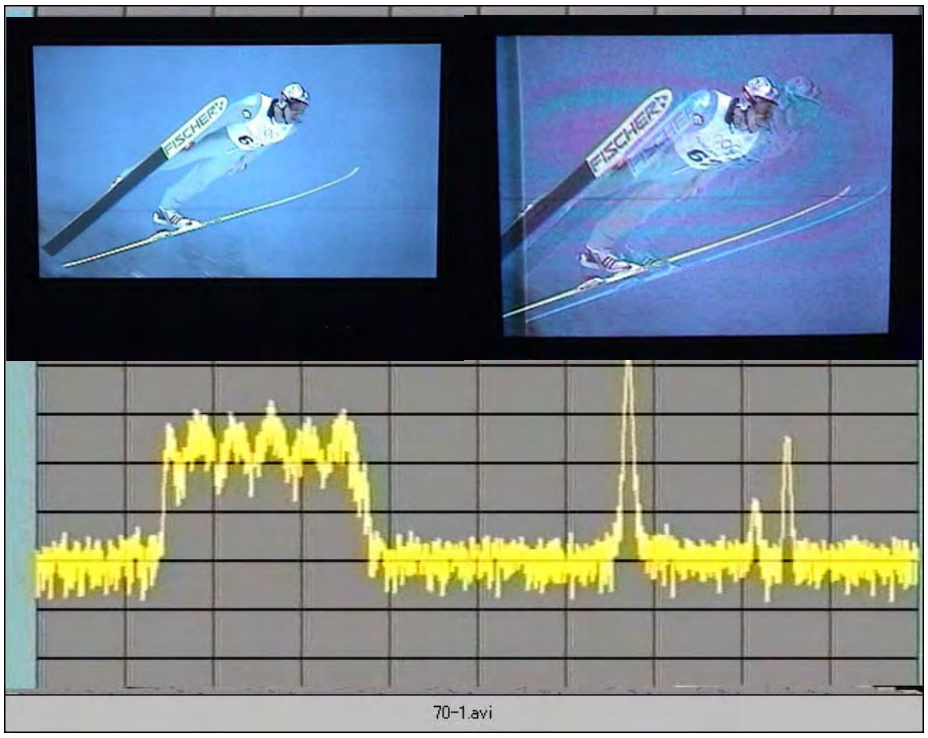
4.3 Mobile Reception

Field Trials of Mobile Reception TV for the First Time in the World (1993)



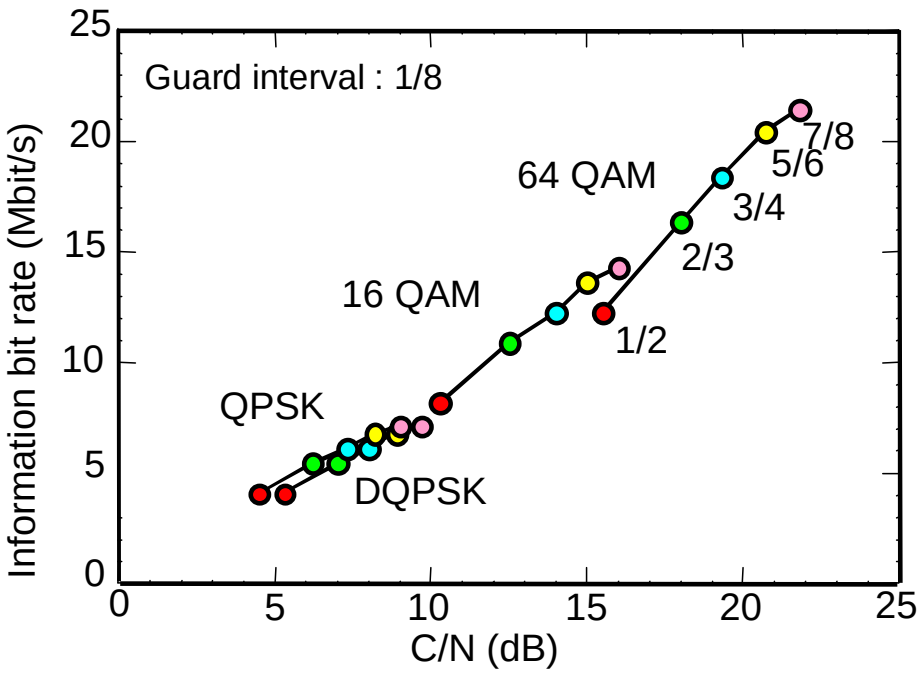
Comparison between Digital(OFDM) and Analog Broadcasting

OFDM

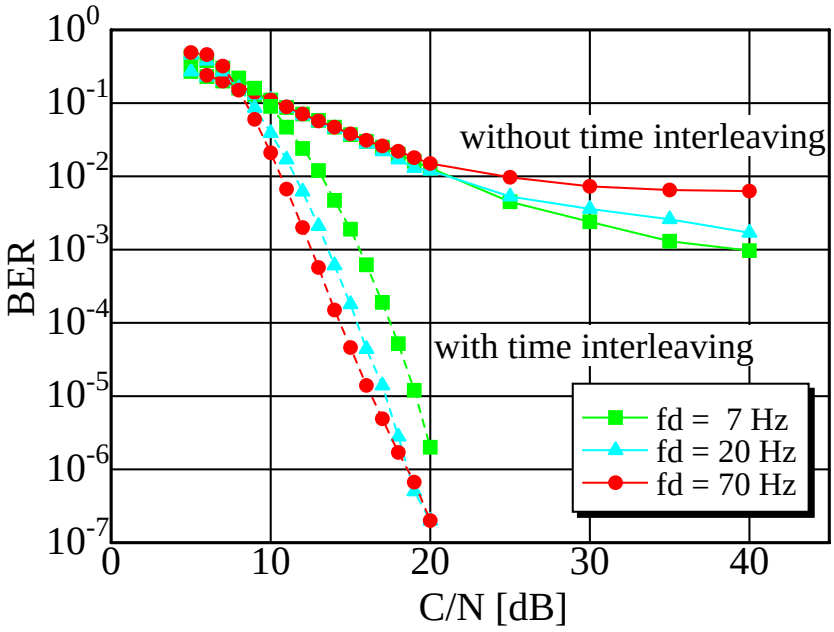


Analog

Information Bit-rate v.s. C/N

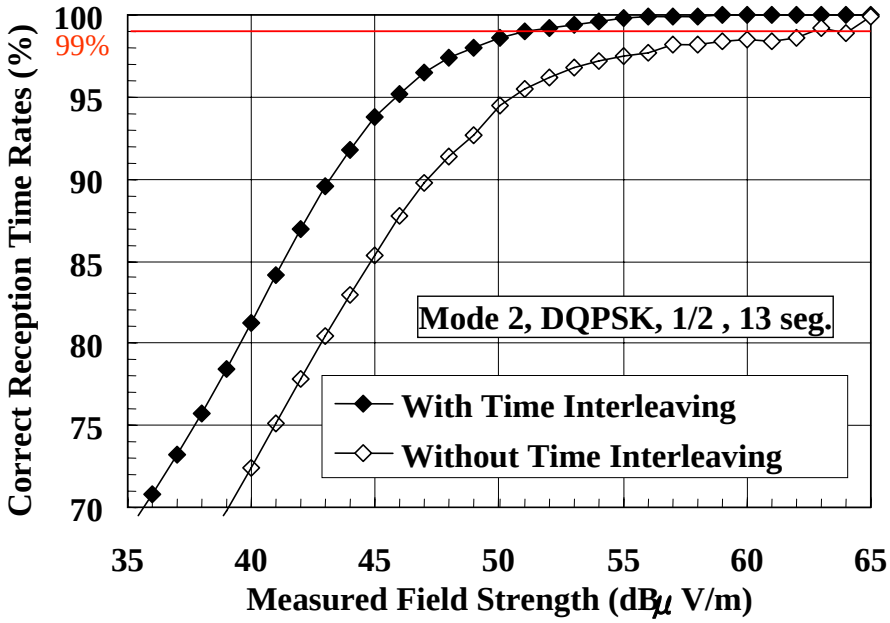


Effect of Time Interleaving (1)



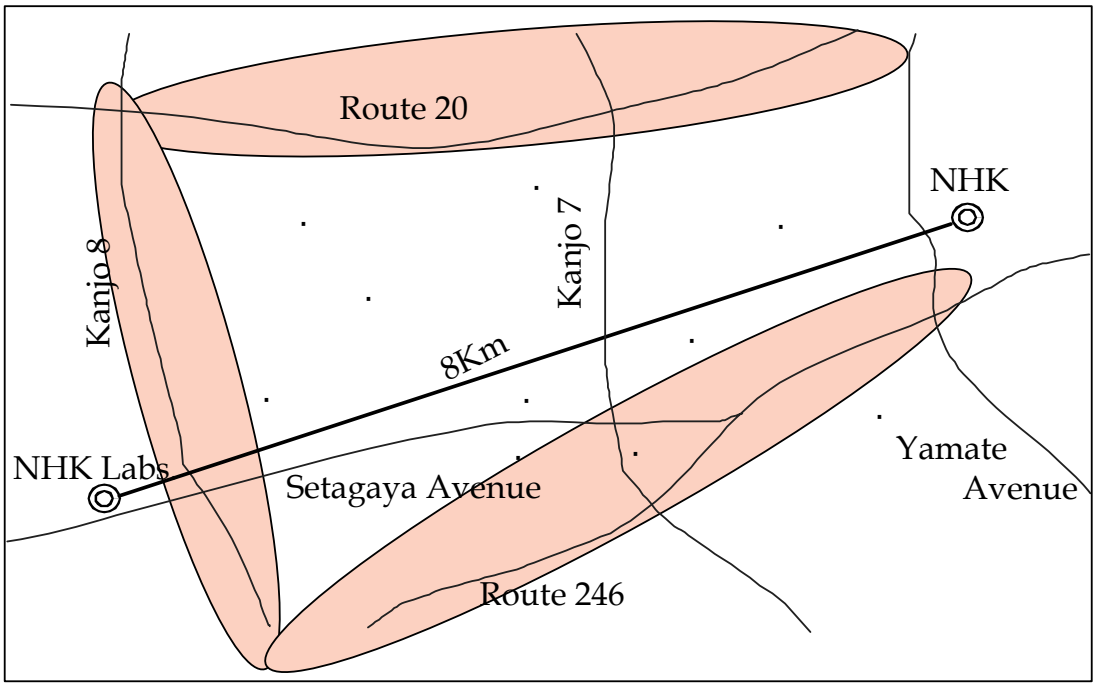
Effect of Time Interleaving (2)

Result of field trials



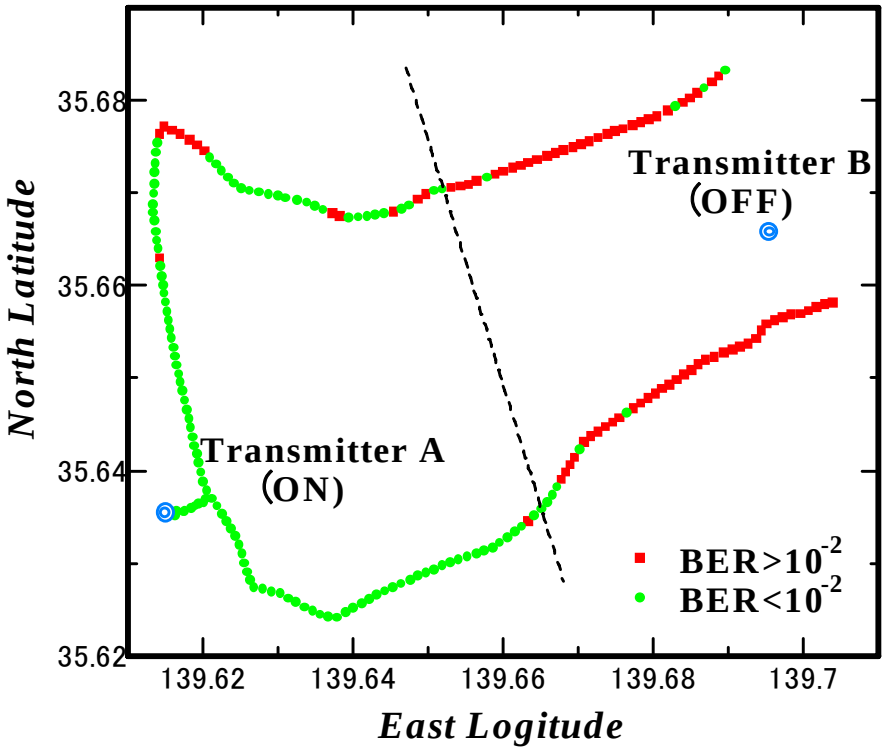
4.4 Effective Usage of Frequency (SFN : Single Frequency Network)

Routes of Mobile Reception Measurements

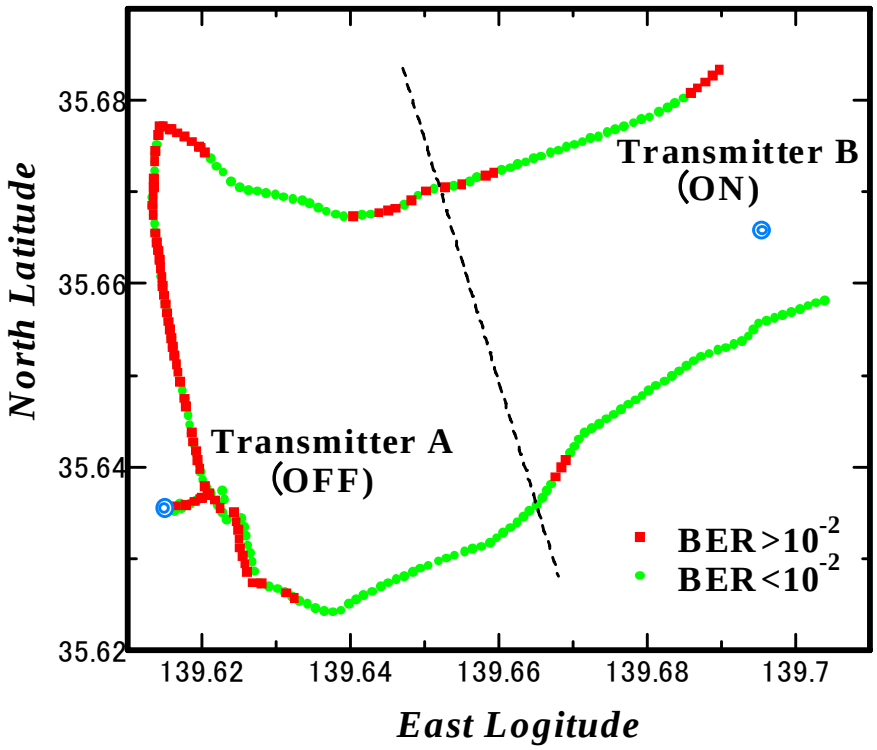


Measured Points

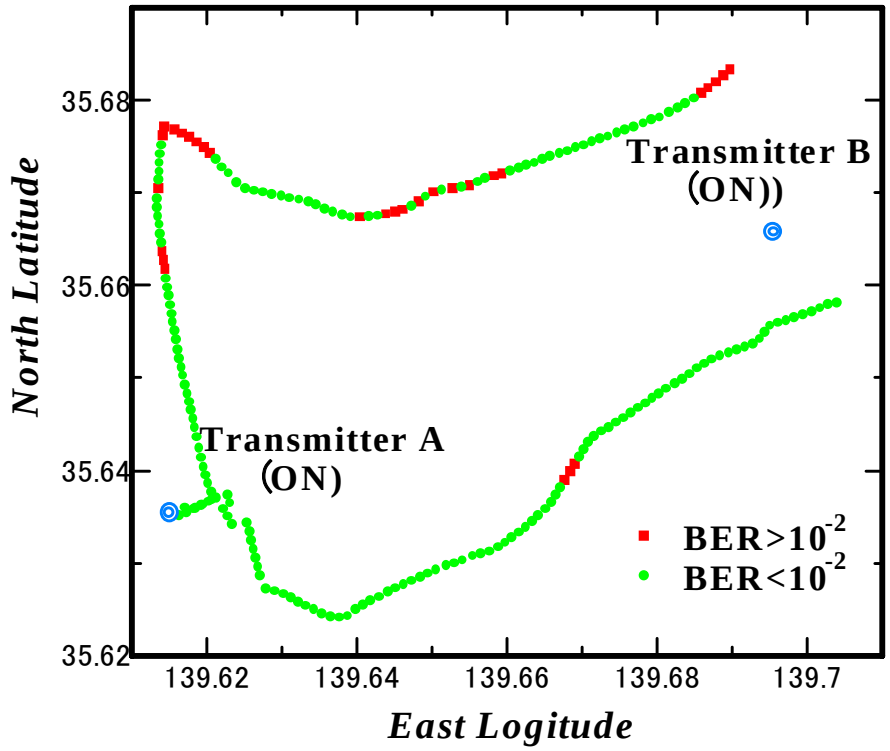
Transmitter A : ON, B : OFF



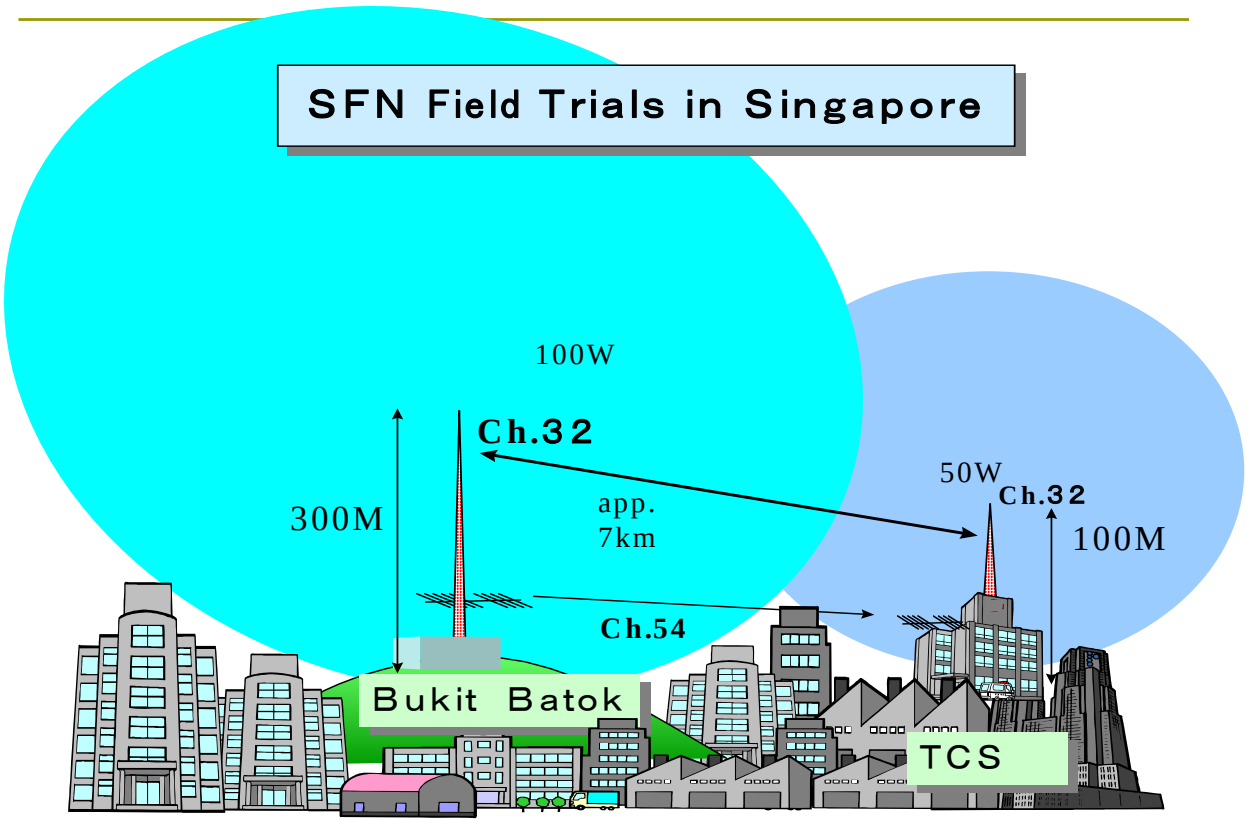
Transmitter A : OFF, B : ON



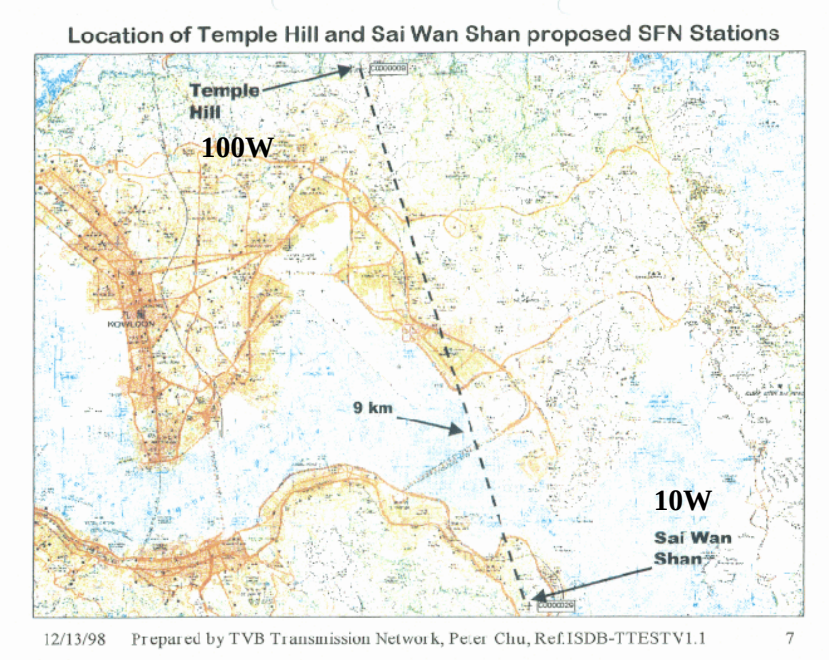
Transmitter A : ON, B : ON



SFN Field Trials in Singapore

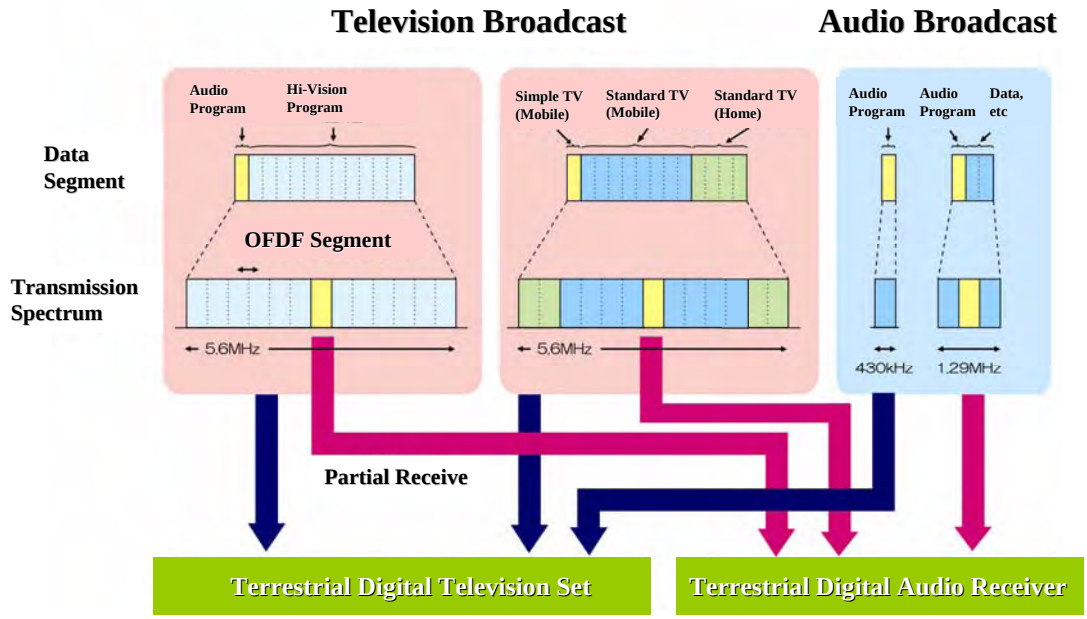


SFN field trials in Hong Kong

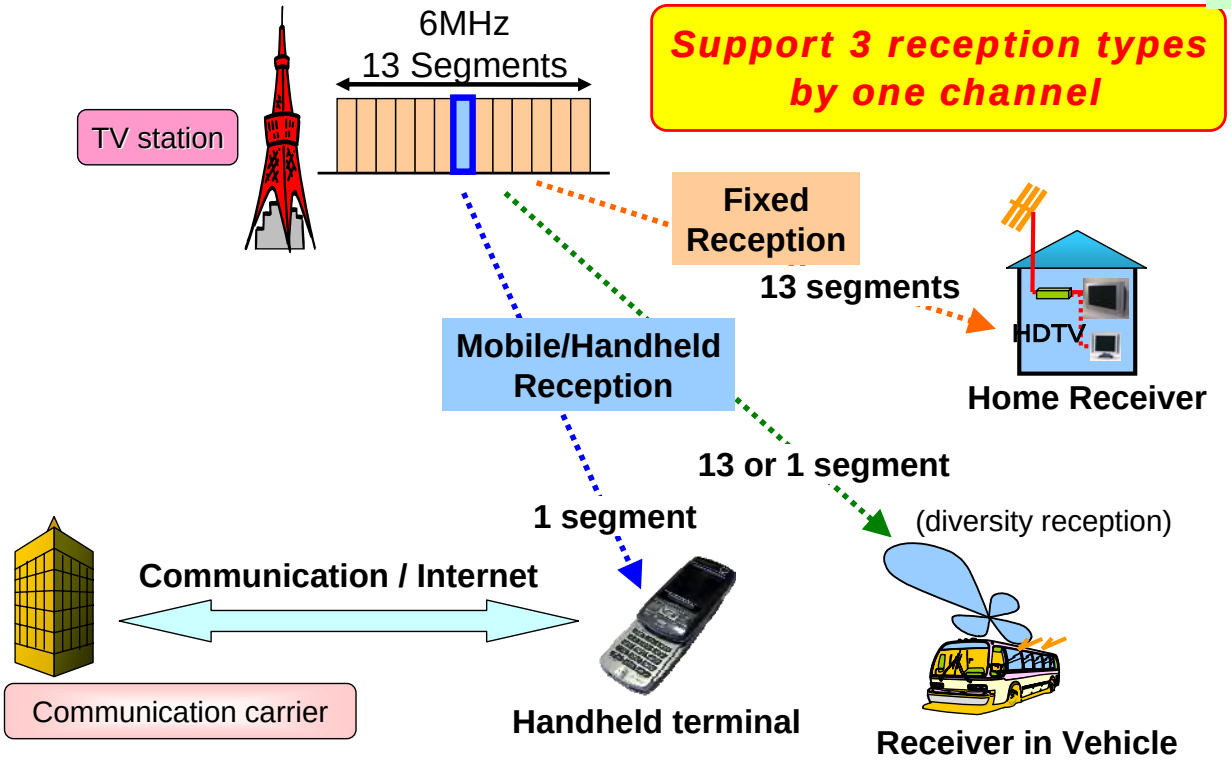


4.5 System Parameter and BST-OFDM

Segmentation



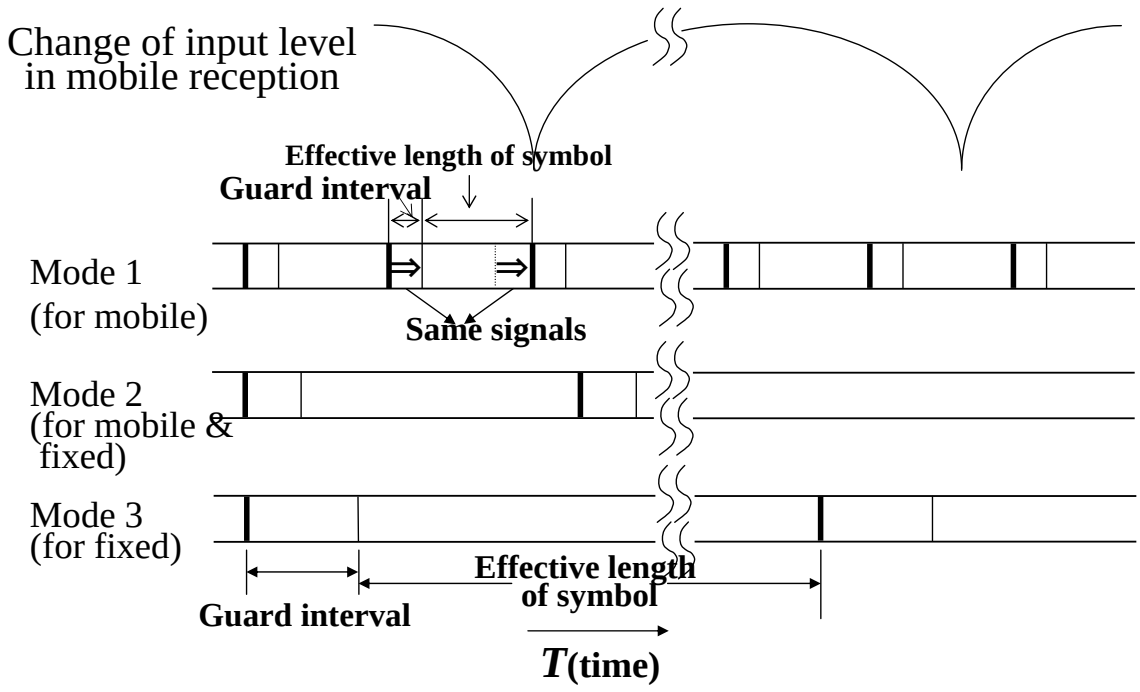
Features of ISDB-T system



Transmission Parameters

Mode		Mode 1 (Mobile)	Mode 2 (Mobile, Fixed)	Mode 3 (Fixed)
Number of carrier		1405	2809	4992
Carrier distance		3.968kHz	1.984kHz	0.992kHz
Valid symbol length		0.252ms	0.504ms	1.008ms
Guard interval length		1/4, 1/8, 1/16, 1/32 of valid symbol length		
Error correction	inner coding	Convolution coding (1/2, 2/3, 3/4, 5/6, 7/8)		
	outer coding	Reed-Solomon (208, 188)		
Time domain interleave		Convolution 0, 0.1, 0.2, 0.4 second		
OFDM segment		13		
Bit rate		3.65 – 23.23 Mbps		

Difference of Modes

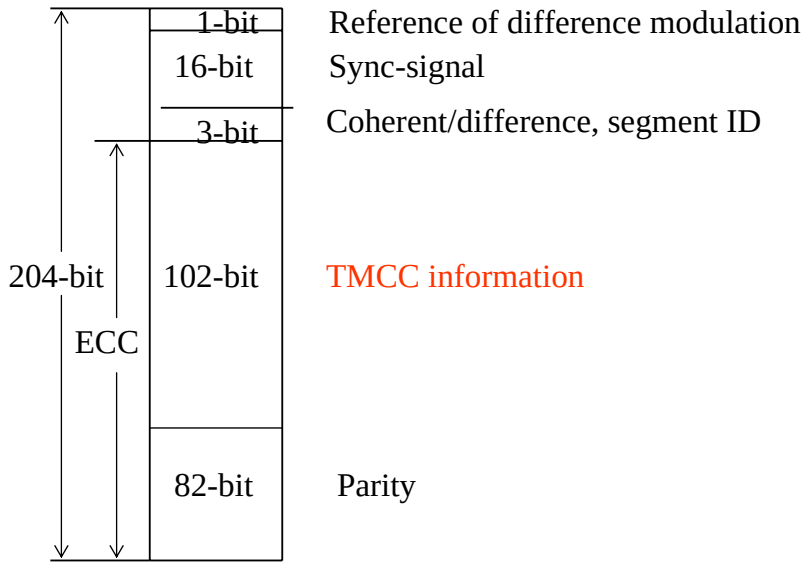


ARIB Standards and ITU-R Recommendations for ISDB-T

Items	Contents	ARIB Standards	ITU-R Recommendations
Video coding	MPEG-2 Video (ISO/IEC 13818-2)	STD-B32	BT.1208
Audio coding	MPEG-2 AAC (ISO/IEC 13818-7)	STD-B32	BS.1115
Data broadcasting	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 access	Multi 2	STD-B25	—
Transmission	ISDB-T transmission	STD-B31	BT.1306 System C
Receiver	ISDB-T receiver	STD-B21	—
Operational guideline	ISDB-T broadcasting operation	TR-B14	—

TMCC(Transmission and Multiplexing Configuration Control)

TMCC signals are transmitted on specified carriers every segment to show the transmission parameters, modulation, error correction, partial reception, etc..
TMCC signals are modulated with BPSK, and error protected by the (184,102) code.



Contents of TMCC Information

Number of bit	Content	
2	System ID(TV/Audio)	
4	Count down counter	
1	Emergency	
1	Current information	Flag of partial reception(one seg)
13		Transmission parameter of layer A
13		Transmission parameter of layer B
13		Transmission parameter of layer C
40	Next information	
15	Reserve	

Video Format

Vertical	Horizontal	Aspect ratio	Frame frequency
1080(1125)	1440, 1920	16:9	29.97(i)
480(525)	720	16:9	59.94(p)
480(525)	720, 480	16:9, 4:3	29.97(i)
720(750)	1280	16:9	59.94(p)
1080(1125) *	1440, 1920	16:9	59.94(p)

(i) : interlace

(p) : progresive

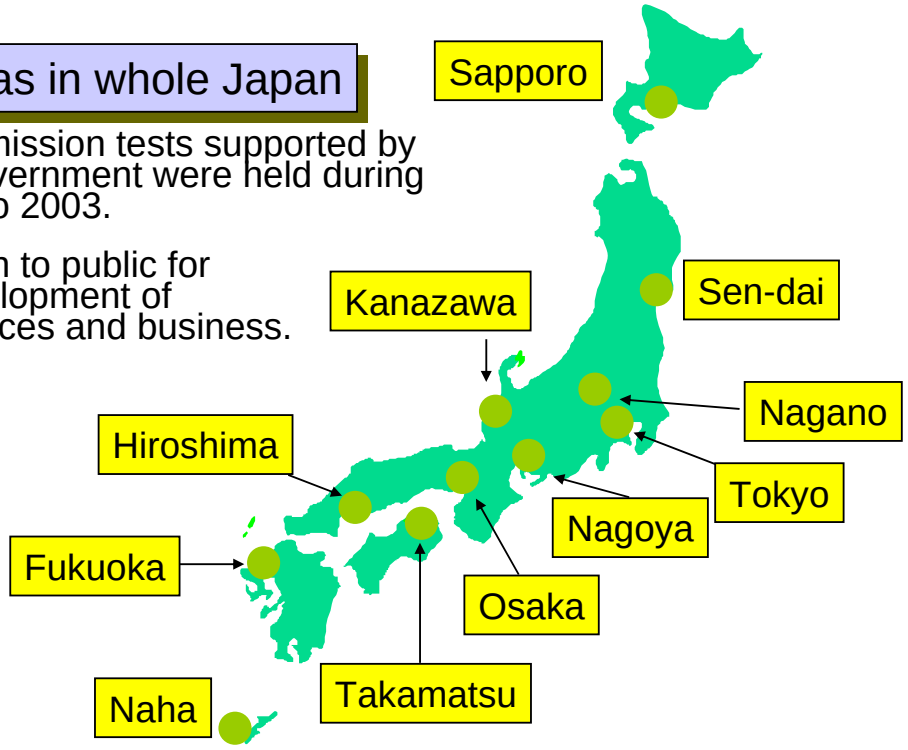
* : Future system

Pilot Broadcasting in Japan

11 Areas in whole Japan

Transmission tests supported by the government were held during 1999 to 2003.

Open to public for development of services and business.



Features of ISDB-T

(1) System flexibility :
Segmentation, Hierarchical transmission

(2) Robustness against impulse noise and multi-path interference :
OFDM, Time interleaving

(3) Mobile reception :
OFDM, Time interleaving,

(4) Portable reception :
OFDM, Time interleaving, One seg(partial reception)

(5) Effective frequency usage :
SFN

(6) Compatibility with radio services :
Segmentation

Only ISDB-T can provide fixed, mobile and portable services simultaneously. ATSC and DVB-T can't do.

Comparison of Three DTTBs

Item	Japan (ISDB-T)	Europe (DVB-T)	US (DTV)	Note
Format	BST-OFDM	OFDM	8VSB	
Ghost	○	○	△	Japan and Europe employ OFDM, which is robust against ghost. 8VSB of US can suppress ghost with ghost canceller.
Effective use of bandwidth	○	○	×	OFDM can make network with one frequency (SFN).
Mobile receiver	○	△	×	DVB-T can mobile reception in a good condition area.
Flexibility	○	△	×	The segmentation technology allows ISDB-T to provide HDTV and audio/SDTV programs simultaneously

Data Services

(1) Program linked data services
Actor's information, out line of the story, etc.

(2) Program non-linked services
News, weatherforecast, stock market information, etc.

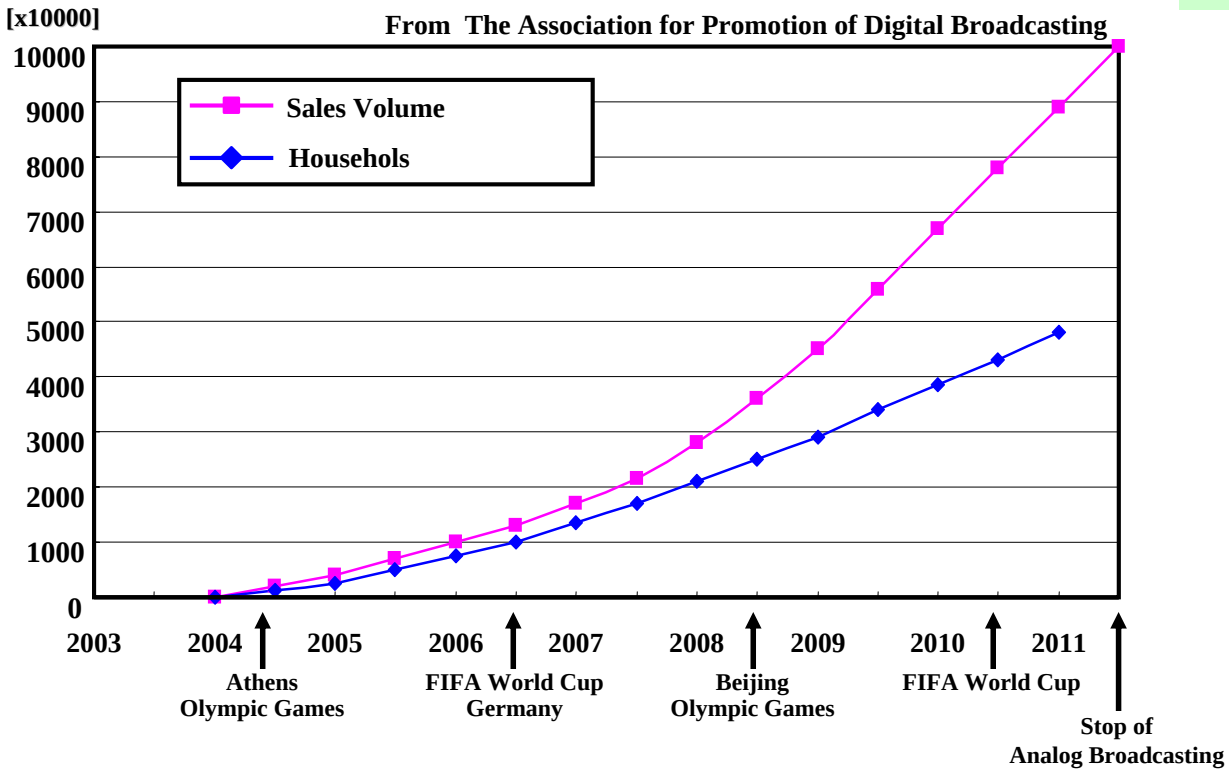
(3) Closed caption
for hearing impaired persons

(4) Interactive services
via telephone line, via internet

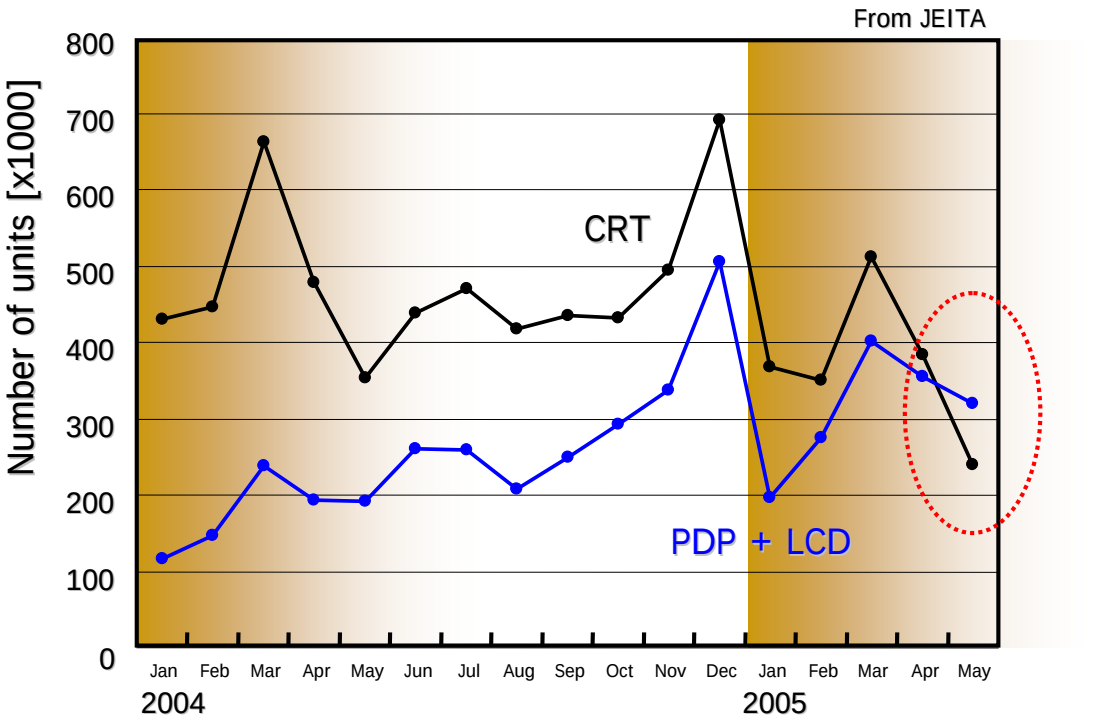
(5) EPG(Electronic Program Guide)
TV program guide, booking to record programs, etc.

4.6 Receivers

Estimation of the Number of Digital Broadcasting Receivers in Japan



TV Shipments (domestic market)

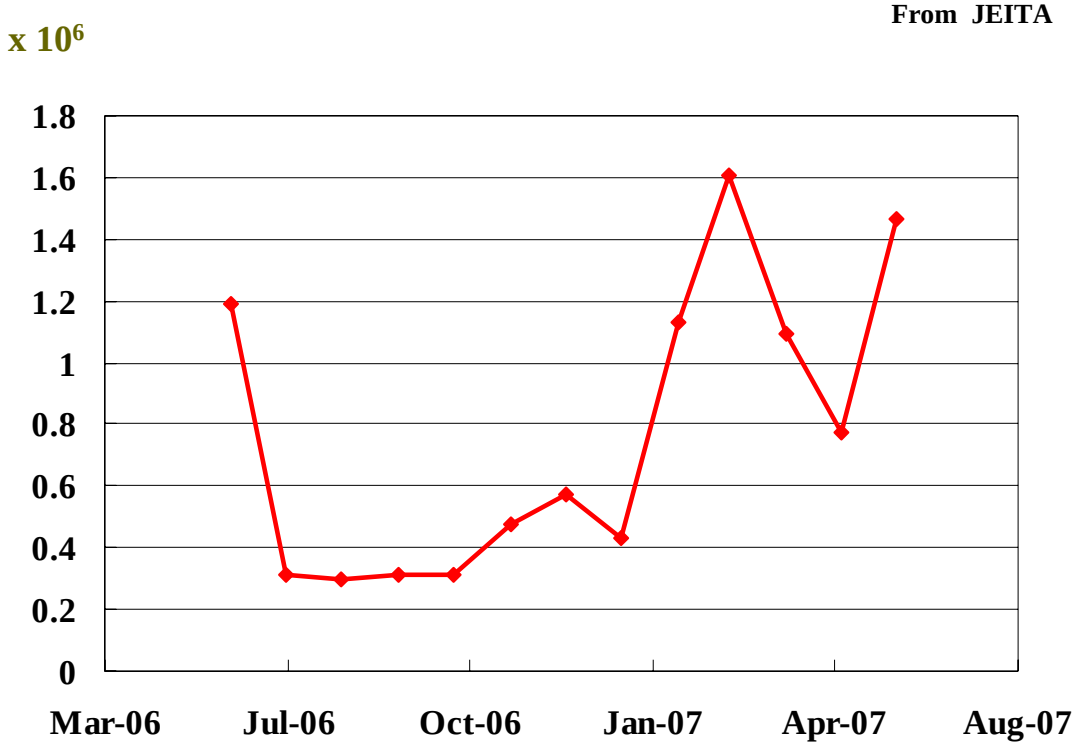


JEITA : Japan Electronics and Information Technology Industries Association

Cellular Phones with One-Seg

Penetration of Cellular Phone with One Seg

From JEITA



In-car TV Receivers

Navigation System
Full-Seg/One-Seg

Tuner separated model

Strada CN-HDS965TD

Panasonic

AVIC-VH099G

Pioneer

All-in-one model

HS706D-A

NISSAN/SANYO

One-Seg Only

※Full-Seg is Optional

GORILLA NV-HD830DT

SANYO

Portable Navigation Device
One-Seg Only

Mini GORILLA
NV-SD10DT

SANYO

In-Car TV
One-Seg Only

CAV-TD85D1

SANYO

PCs with ISDB-T tuner (One-Seg)

※画像はVGN-TX92S

SONY

SONY

Tuner

FUJITSU

USB Type ISDB-T Tuners for One-Seg

インターネット、もっと使いやすく

BUFFALO

Logitec

SANWA SUPPLY

PCTV-hiwasa

Portable DVD Player with ISDB-T tuner (One-Seg)

Panasonic

TOSHIBA

TOSHIBA

Other Portable One-Seg Receivers

Portable Audio Player

Portable Electronic Dictionary

Portable Navigator

Portable TV

Penetration of ISDB-T Receivers

- **Tuner, CRT, LCD, PDP, STB, DVD Recorder, PC**
  24.1 Million
- **Mobile Phone with One Seg**
  9.9 Million
- **Car TV**
  0.65 Million
- **PC with One Seg**
  0.12 Million

Total 34.77 Million

JEITA 2007.6

4.7 New Technologies for Receivers

Error Concealment Technology

- Enable the stable reception of Digital terrestrial HDTV broadcasting in a moving car
- When demodulated data include errors, it conceals errors of video/audio and reduce eyesore.

Nov.2005 released

with Error Concealment

without Error Concealment

Smooth Handover between 12seg and 1seg

- Both decoding HDTV & H.264 at border area enable
  - Quick response
  - Free from “Blackout” picture

Apr.2006 released

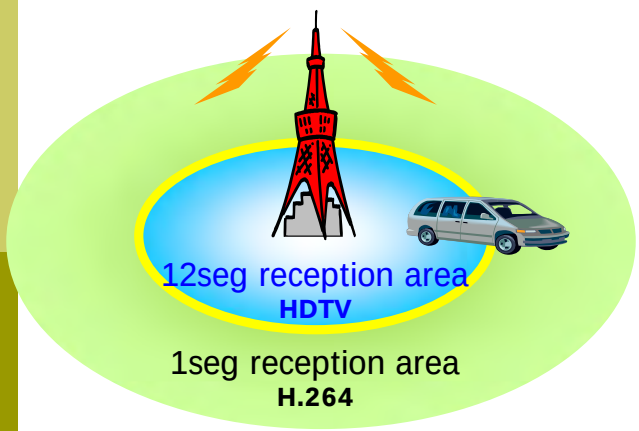
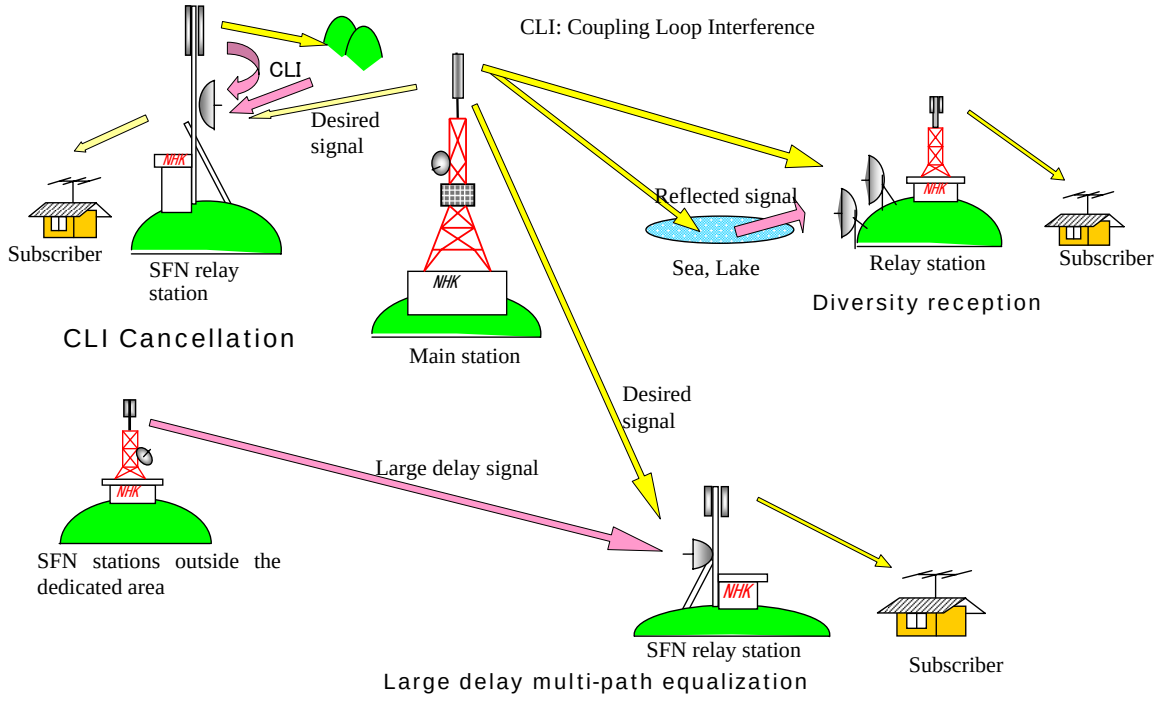


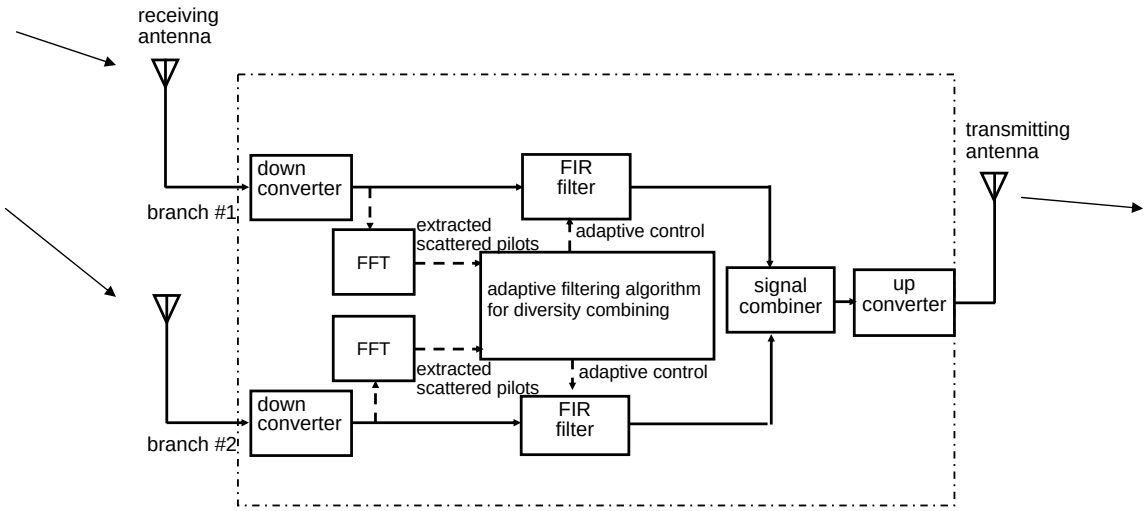
Image of border area

4.8 New Technologies for SFN

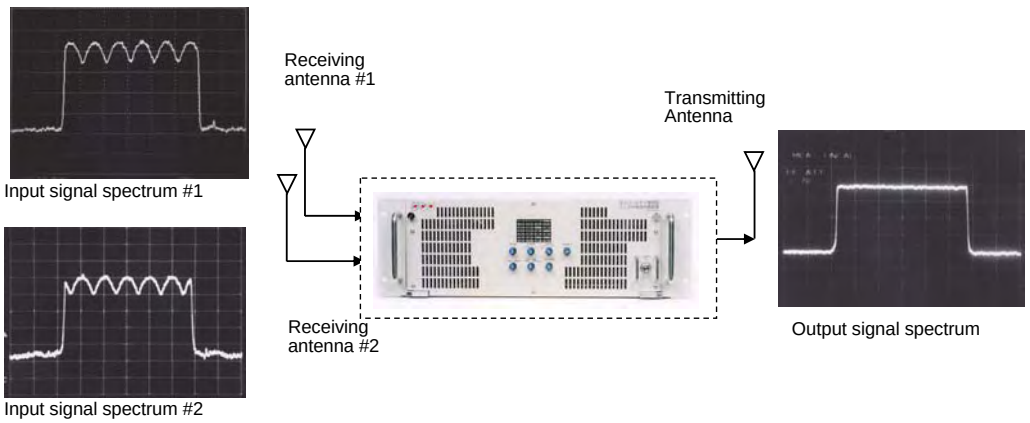
Reception in SFN



Diversity Reception System for Relay Broadcasting

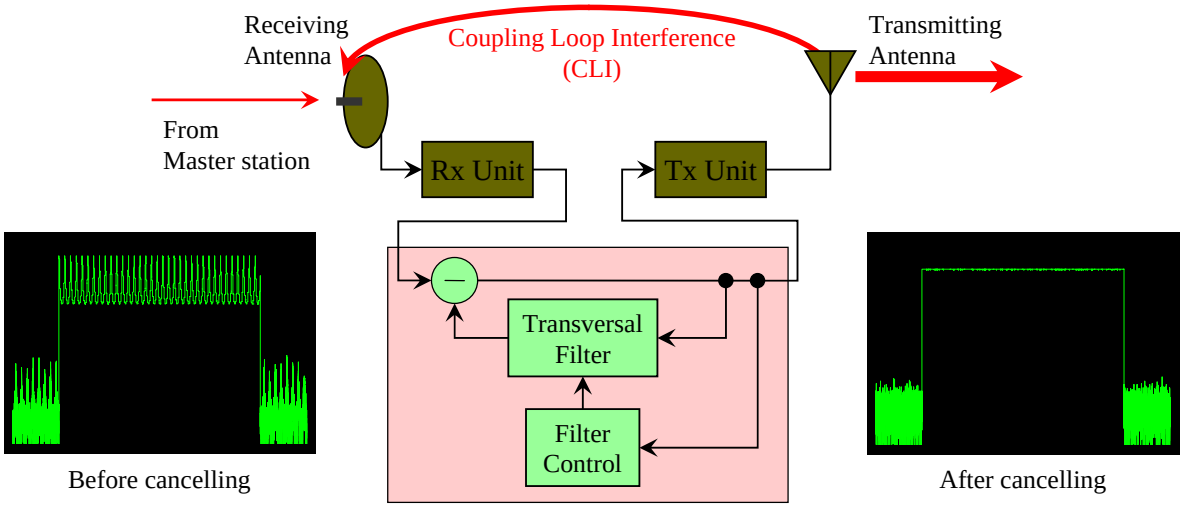


Example of Two Branch Operation



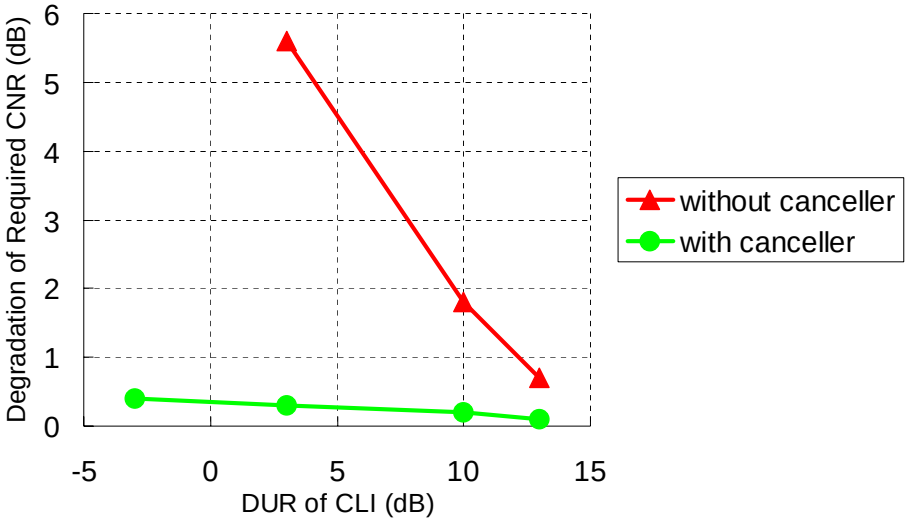
Signal improvement by diversity reception relay system
(Multi-path condition: D/U = 6dB, delay time = 1μ sec)

Coupling Loop Interference Canceller

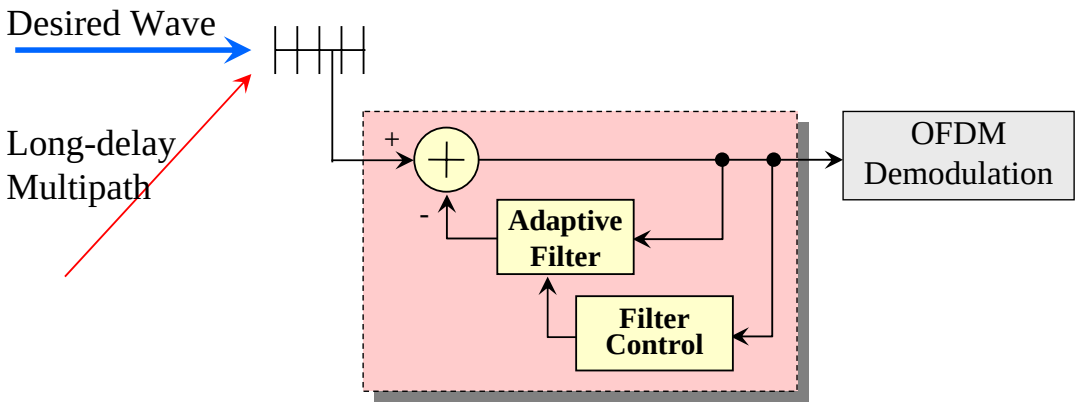


Coupling Loop Interference Canceller

Improvement in CNR



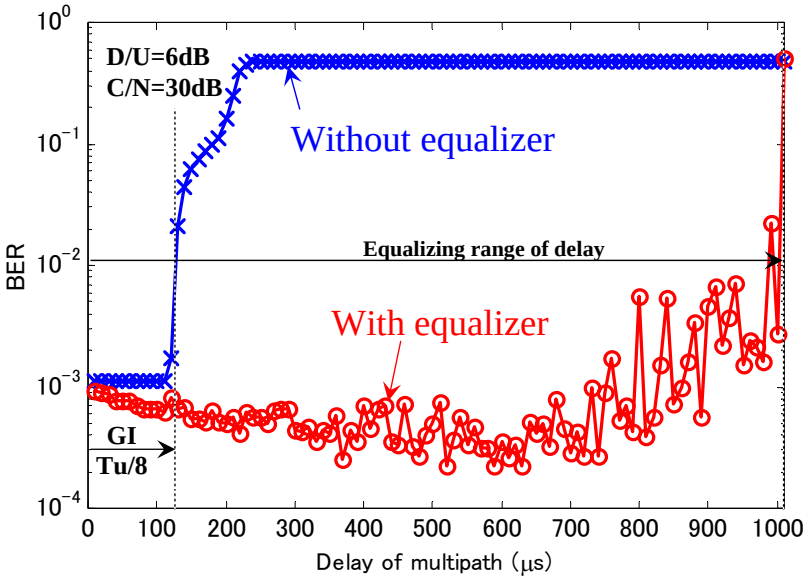
Long-delay Multipath Equalizer



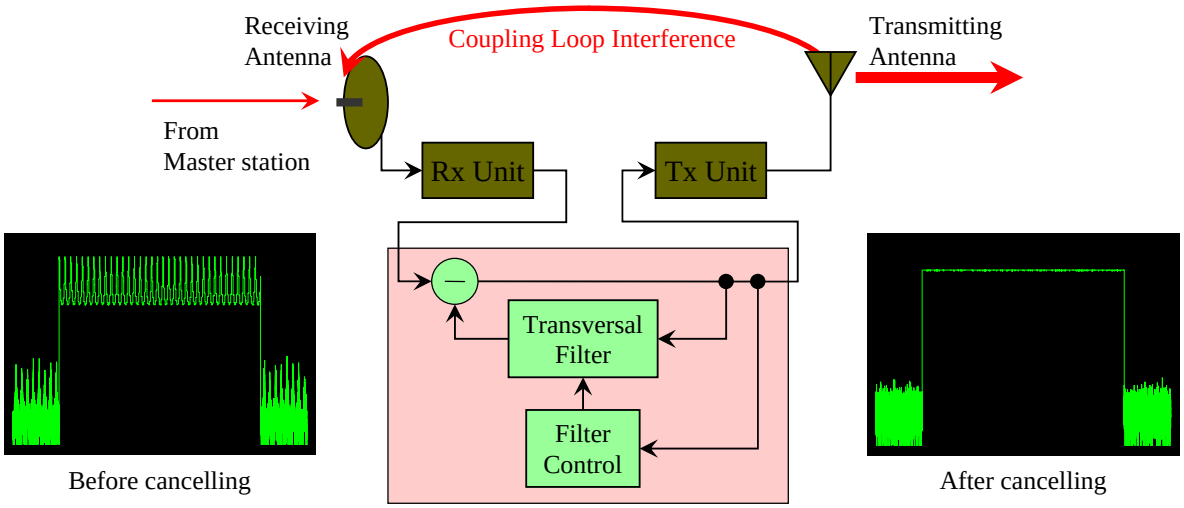
Long-delay Multipath Equalizer

Multi-path delay detection : based on the decision of all OFDM carriers

Extended Equalization Range



Coupling Loop Interference Canceller



Coupling Loop Interference Canceller

- About 10 companies are developing cancellers.
- The development is advanced by a national project of TAO.

(TAO: Telecommunications Advancement Organization of Japan)

4.9 International Activities

International Activities

(1) In 1990s, ISDB-T had been reported in ITU-R, TG11/3, and recommended as a international broadcasting system in ITU-R Assembly meeting held in Istanbul in 2000.

(2) Asian-Pacific Broadcasting Union (ABU) had held Workshop on DTTV since 1998, and DiBEG had been participating in it.

(3) Since 1990s, the ISDB-T group participated in many international meetings on DTTV to explain the superiority of ISDB-T to the world, ITU-R, ABU, IBC, NAB, BroadcastingAsia, SMPTE, SET(Brazil), ISBT(China), etc..

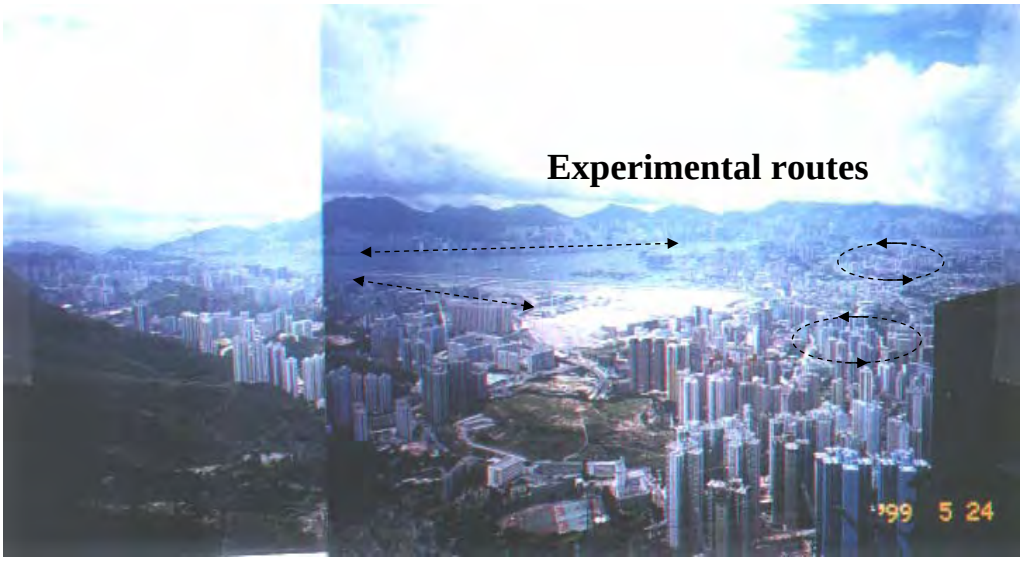
(4) In 1998, DiBEG participated in Singapore and Hong Kong carried out the comparison tests of three systems.

(5) In 2000, Brazil carried out the same comparison tests, and they unveiled tests results for the first time in the world. The results showed ISDB-T was the best.

(6) DiBEG has been proceeding with the penetration activities of ISDB-T in the world, focusing on South America and Asia.

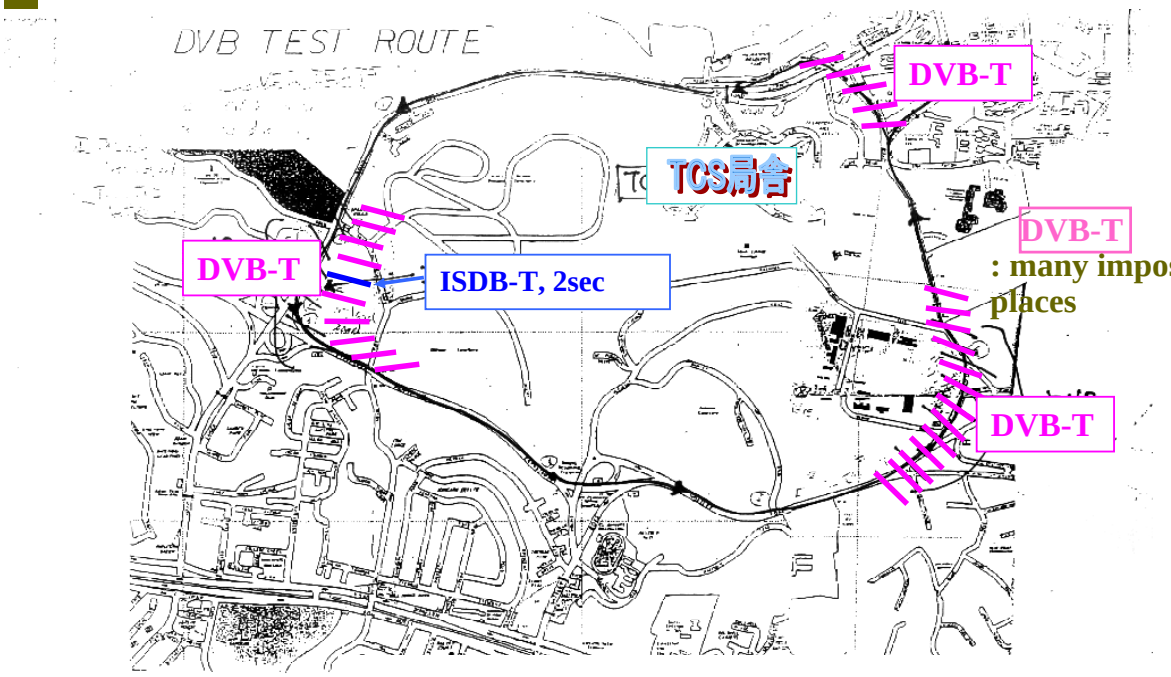
Trial Area(Singapore)

(Sight from Temple Hill Station)



Results of Mobile Reception In Singapore

Comparison tests between DVB-T and ISDB-T

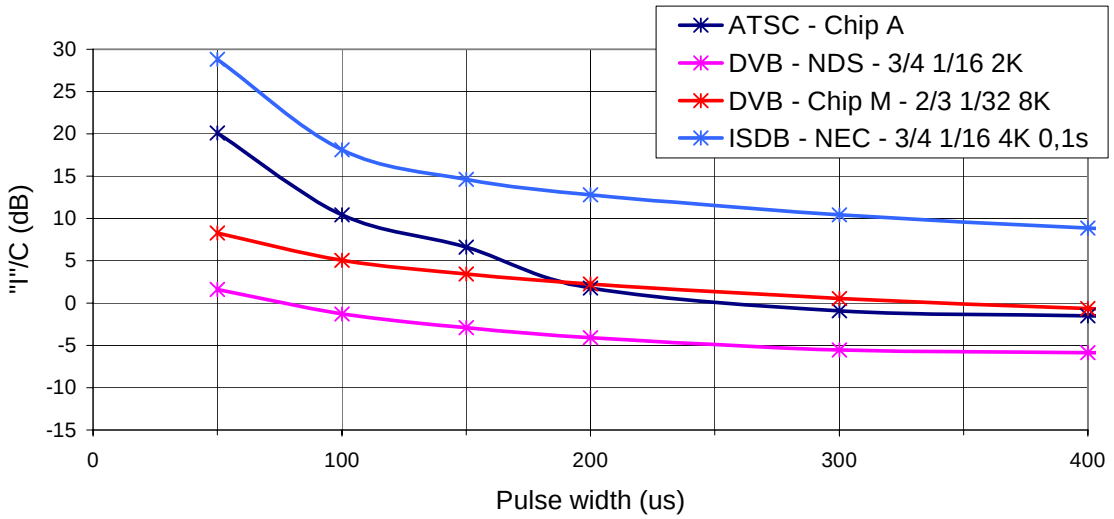


Systems Prameters for Tests(in Brazil)

	ATSC	DVB-2K	DVB-8K	ISDB-T
Modulation	8VSB	COFDM	COFDM	COFDM
Payload	19,39 Mbits/s	19,75 Mbits/s	18,09 Mbits/s	19,33 Mbits/s
Receivers	Zenith	NDS	NDS	NEC
New receivers	Chip T	Chip N	Chip L	Chip J
	Chip U			
	Chip S		Chip M	
	Chip A			

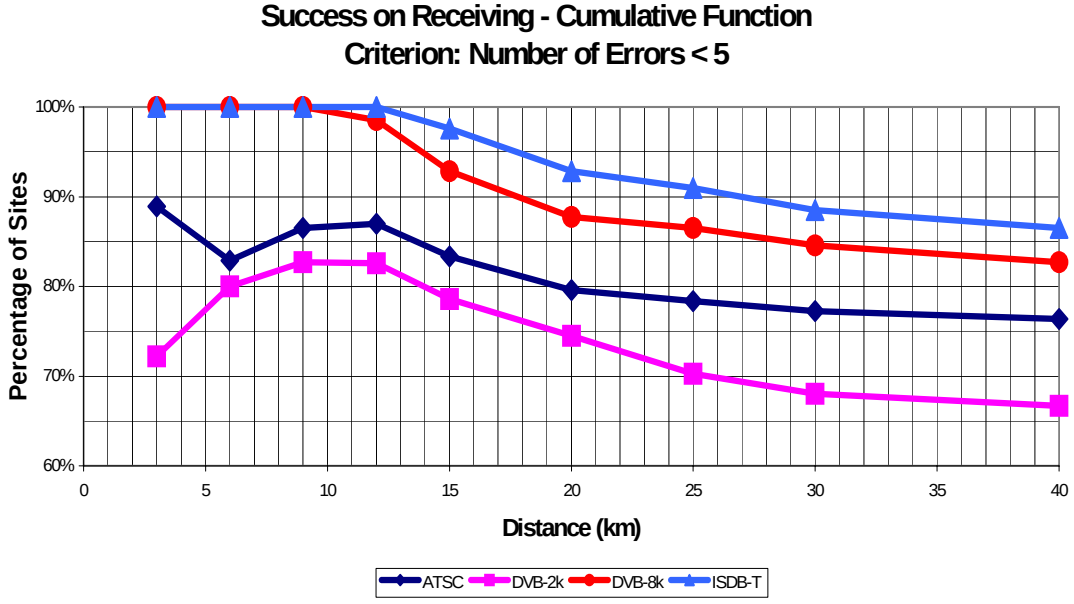
Impulse Noise

Relation between the noise pulse width & interference to signal ratio



- Better performance of the ISDB-T system, by introducing time interleaving

Outdoor: Coverage



Tests Results of Mobile Reception in Brazil

Experiment of field mobile in Brazil

Standard	Parameter				Transmission Rate (Mbps)	Errors (Times)
	Modulation	Convolution	Guard Length	Carrier		
ISDB-T	16QAM	2/3	1/16	2k	11.45	0
	64QAM	2/3	1/16	2k	17.18	6
	16QAM	2/3	1/16	4k	11.45	0
DVB-T	QPSK	1/2	1/16	2k	4.39	1
	QPSK	2/3	1/16	2k	5.85	Many
	QPSK	1/2	1/32	8k	4.52	Many
ATSC	8VSB				19.39	Out of measurement

For ATSC's Insistence

ATSC : The ATSC's service area is larger than DVB-T and ISDB-T.

"This is the natural result. In addition to pure information, both DVB-T and ISDB-T are transmitting guard interval signals against multi-path interferences. The guard interval signals are redundant, but to transmit such a countermeasure signals is indispensable against multi-path interferences, which always take palace and are inevitable in the terrestrial transmission paths."

"ATSC doesn't have such a function as the guard interval, and transmission power is used only for the information transmission. Therefore, the ATSC's service area is large, but the actual receiving performance are very poor, as people always experience. ATSC don't use the transmission power for the countermeasure signals against indispensable multi-path interferences in the terrestrial transmission."

"ATSC is just like without error correcting codes in digital systems. ATSC is the naked system against multi-path interferences"

"The ATSC side always says "that the next generation multi-path equalizer has been under development". At present, I heard the next generation was the fifth. They maybe have to continue to develop the next generation equalizer for ever."

For DVB-T's Insistence

DVB-T :
(1) The one seg function can't be adopted for the GSM cellular phones.
(2) Concerning mobile reception, DVB-H can cover these services.
(3) ISDB-T's receivers are very expensive.

" All above comments are incorrect. "

" In Japan, GSM is not used, therefore currently there are not the GSM cellular phones with one seg in the market. Therefore, it is not a technical matter and not a crucial matter, but a false charge against us. Docomo and other manufactures are supposed to put their cellular phones with roaming function and one seg this year. "

" DVB-H is a different system from the original DVB-T. Since DVB-T doesn't have a hierarchical transmission function, DVB-T can't broadcast HDTV with high bit rate and mobile services simultaneously. "

" As I mentioned in my presentation, many kinds of ISDB-T receivers from many manufactures are on the market. The price is going down year by year. As there are not DVB-T receivers for 6MHz and for HDTV reception in the market, we can't make comments on the price of DVB-T receivers. "

5. Conclusion

Conclusion

(1) Digital broadcasting has been penetrating in the world and leading digital consumer electronics.

(2) The number of digital broadcasting receivers has been increasing rapidly in the world.

(3) The Japanese terrestrial digital broadcasting (ISDB-T) had been developed based on the experiences of the development of TELETEXT and FM multiplex broadcasting systems.

(4) In Japan, ISDB-T receivers have been penetrating fastest in the world.

(5) ISDB-T has a lot of merits, system flexibility, mobile and portable reception, SFN, robustness against any interferences etc.

(6) Brazil decided to adopt ISDB-T as their national system last year, on the results of comparison of three systems.

(7) Only ISDB-T can satisfy the need of all people, and contribute to the improvement of the life of all people.

ISDB-T is the best.

Once Again

Since radio frequencies are the common resources for people, we have to use them usefully.

The most effective usage for VHF and UHF is for mobile and portable applications.

Once we decide the DTTB system as a national broadcasting standard, we can't change the system anymore.

We should select the best system for descendants not to regret it later.

If you make a correct selection, we, Japanese side will do our best for Argentina.

Let's work together !