Terrestrial digital sound broadcasting system

ISDB-T_{SB}

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  (Integrated Services Digital Broadcasting for Terrestrial Sound Broadcasting)
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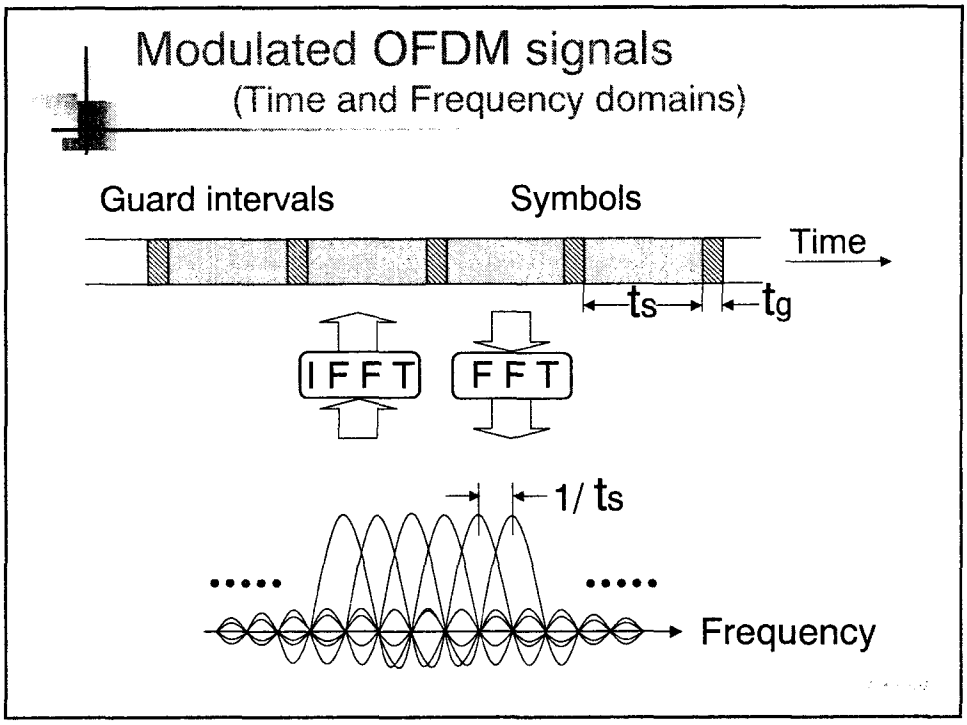
  - Channel allocation, connected transmission
- Prototype receiver
- Schedule in Japan
- Summary

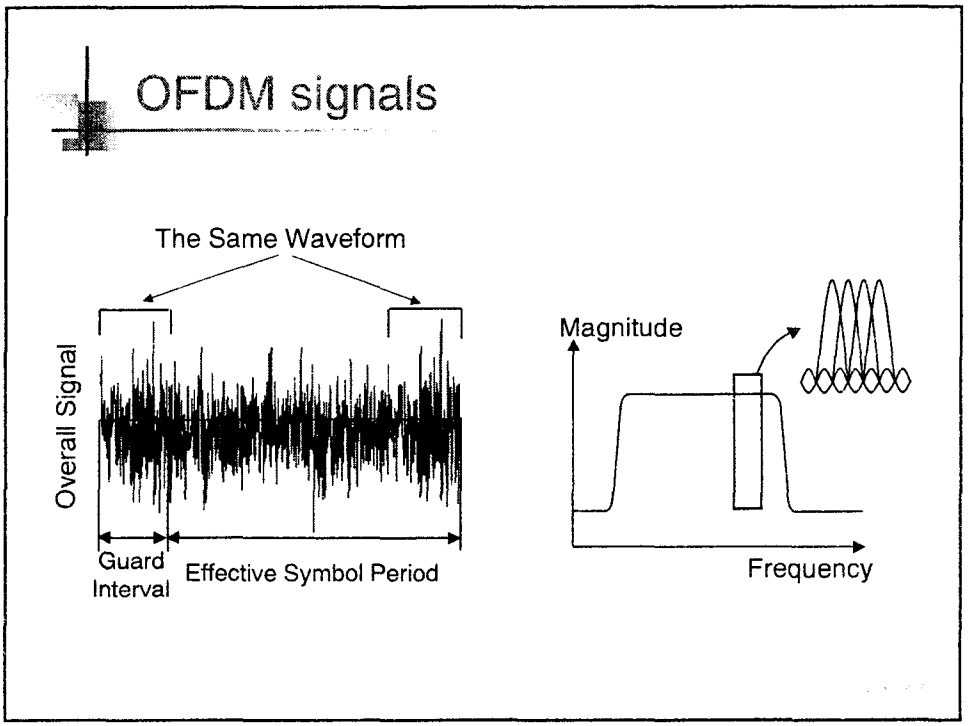
Digital terrestrial broadcasting systems in the World

	USA	Europe	Japan
Television Broadcasting	ATSC	DVB-T	ISDB-T (ISDB-T_{SB})
Sound Broadcasting	IBOC	DAB (Eureka147)	

ISDB-T (ISDB-T_{SB}) system concept

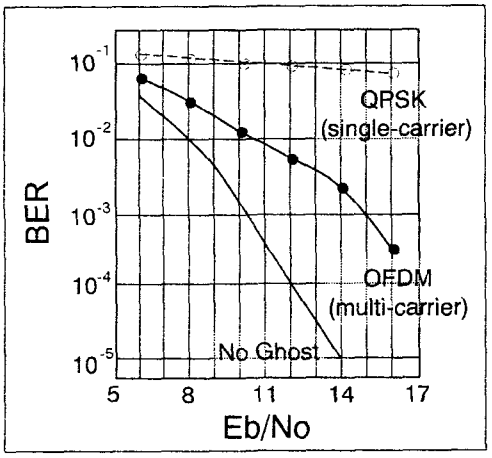
- Suitable transmission scheme for terrestrial (multipath and fading interference)
  - OFDM, time interleaving
- Common transmission scheme both television and sound broadcasting
  - Segmented OFDM transmission
- Commonality with other digital broadcasting systems
  - MPEG-2 base

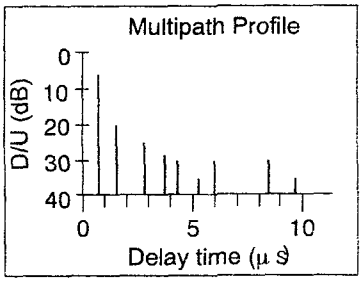

Modulated OFDM signals
(Time and Frequency domains)
Guard intervals
Symbols
Time
ts
tg
IFFT
FFT
1/ ts
Frequency


OFDM signals
The Same Waveform
Overall Signal
Guard Interval
Effective Symbol Period
Magnitude
Frequency

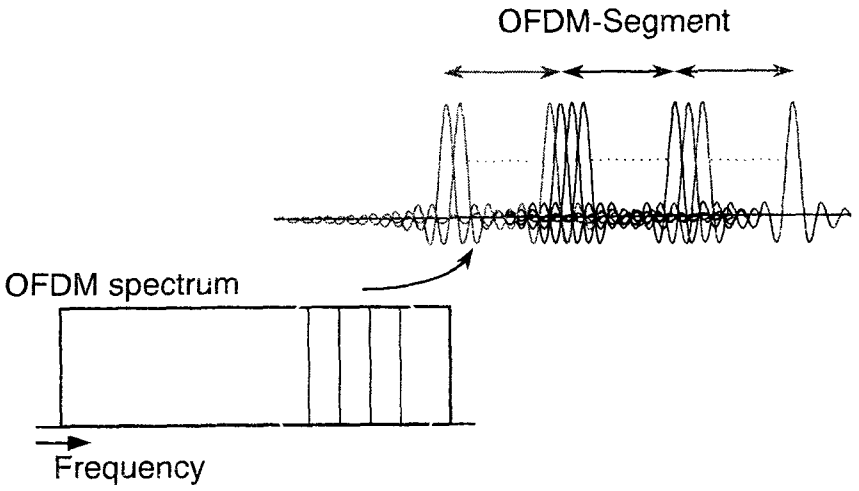
Superiority of OFDM

Performance comparison under multipath interference

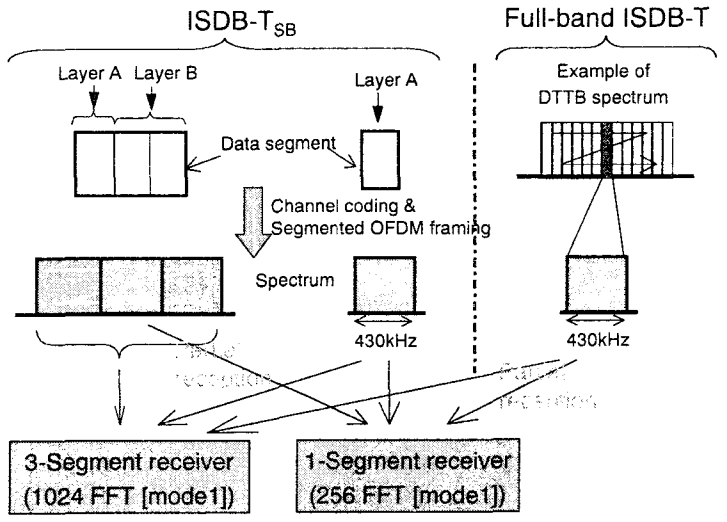




Segmented OFDM transmission



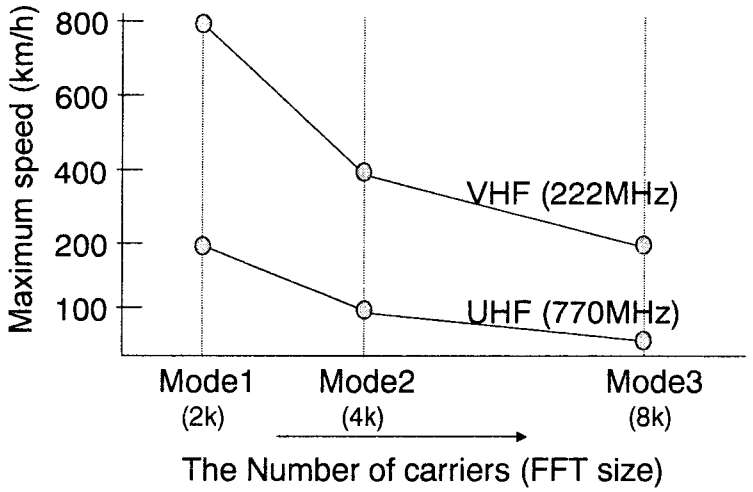
ISDB-T_{SB} transmission and partial reception



Transmission parameters of OFDM segment

ISDB-T Mode	Mode 1	Mode 2	Mode 3
Bandwidth	430kHz		
Carrier spacing	3.968kHz	1.984kHz	0.992kHz
Total number of carriers	108	216	432
Carrier modulation	QPSK, 16QAM, 64QAM, DQPSK (OFDM)		
Number of symbols per frame	204		
Useful symbol duration	252 μs	504 μs	1.008 ms
Guard Interval duration	1/4, 1/8, 1/16, 1/32 of useful symbol duration		
Frame duration	53 - 64 ms	106 - 129 ms	212 - 257 ms
Inner code	Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	RS (204,188)		
Interleaving	frequency and time interleaving		
Length of time interleaving	0, 0.1, 0.2, 0.4, 0.8s		
Information rate	280kbps - 1.8Mbps		

Maximum speed depending on Mode



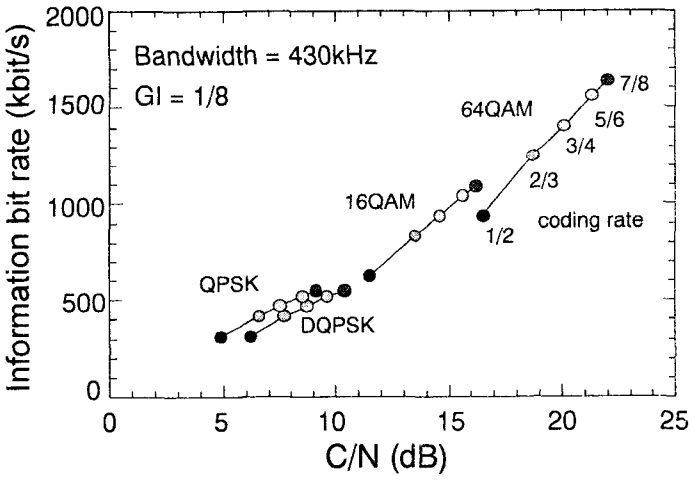
Source coding and Multiplexing

- Source coding
  - MPEG-2 AAC (Advanced Audio Coding)
  - International standard : ISO/IEC 13818-7
  - High efficiency coding
  - AAC 144 kbps audio quality is better than MPEG-1 layer 2 192 kbps audio quality.
- Multiplexing
  - MPEG-2 Systems
  - International standard : ISO/IEC 13818-1
  - Compatible with many other digital systems

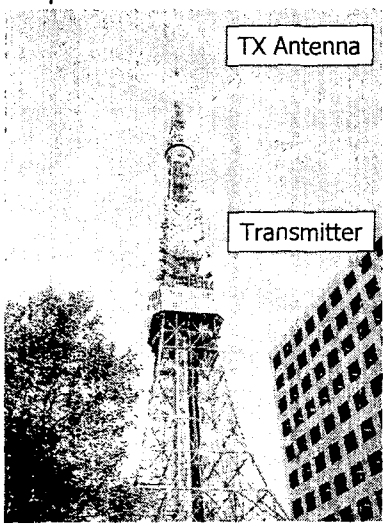
Features of ISDB-T_{SB}

- Common transmission scheme
  both television and sound broadcasting
- Mobile and portable reception possible
- Multimedia broadcasting
- High-reliability with powerful error correction
  - Convolutional code + Reed-Solomon code
- High-quality and efficient sound broadcasting
  - MPEG-2 AAC
- Flexible multiplexing
  - MPEG-2 Systems
- SFN (single frequency network) possible
- Hierarchical transmission up to two layers

Bit rate and required C/N (One segment)



Experimental transmitting station

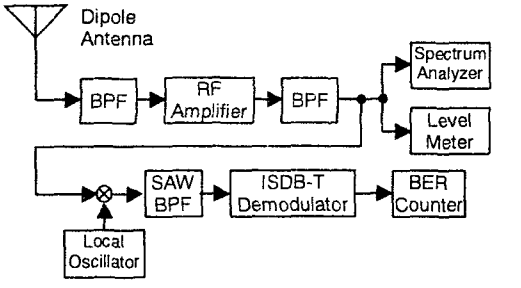


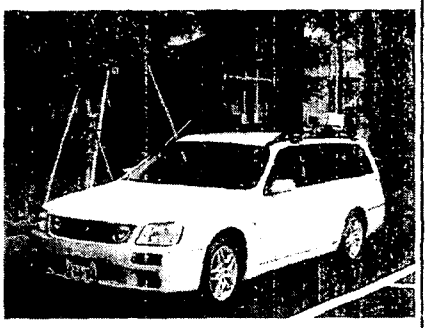
Tokyo Tower

- Mounted on Tokyo Tower
- Specifications

Antenna height	247.5 m
Frequency	190.0 MHz (VHF 7ch)
Transmitter power	100 W
ERP	800 W
Polarization	Linear-Vertical

Measuring equipment





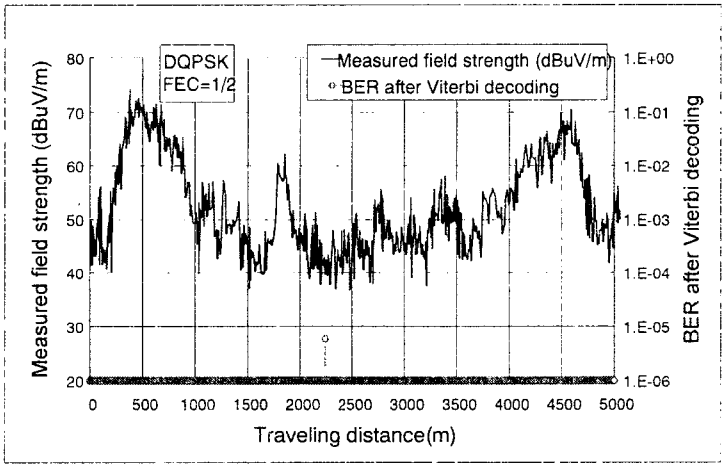
- Measurements
  - Field strength
  - BER (bit error rate)
  - Positions of measuring points (by GPS)
- Above items were measured every one second

Wide-area mobile reception trials

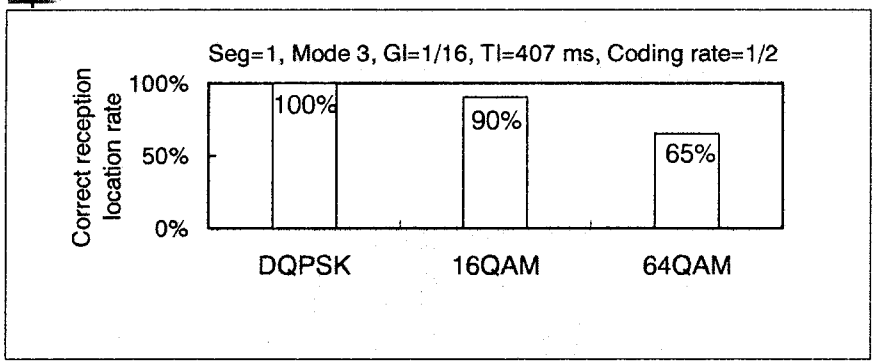
- *Purpose of the trials*
  - To investigate mobile reception characteristics
    - over highways and main arterial roads
  - To compare transmission parameters
    - modulation, coding rate, time-interleaving
  - To get required field strength of the system

Mode	Guard Interval Ratio	Time-interleave	Carrier Modulation	Error Correction	Information Bit Rate
3	1/16	407 ms	DQPSK	1/2 + RS	330.42
3	1/16	407 ms	16QAM	1/2 + RS	660.84

Measured field strength and BER along by the measured route

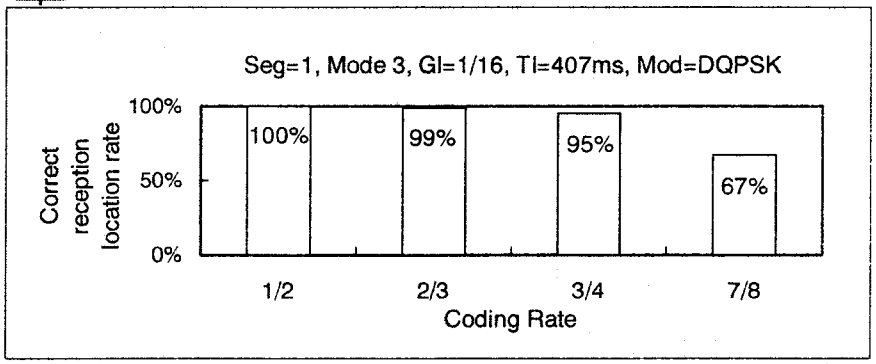


Comparison of modulation methods



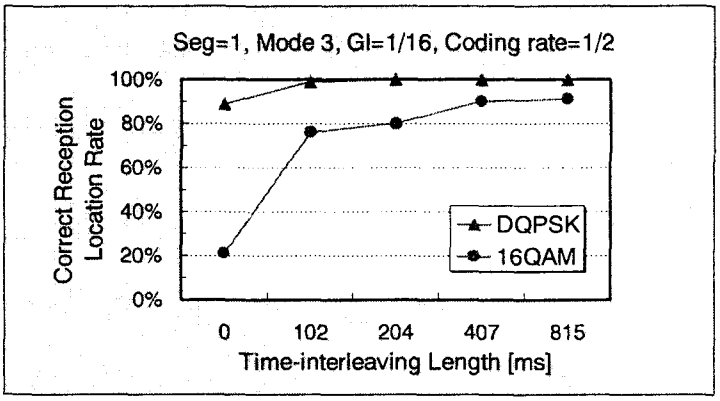
- DQPSK : best performance for mobile reception
- 16QAM : not as good as DQPSK
  - Transmission data rate for 16QAM is twice that for DQPSK
- 64QAM : mobile reception seems difficult

Comparison of FEC coding rates



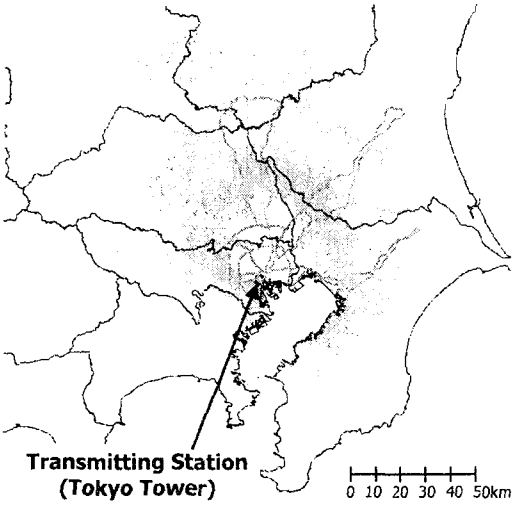
- Coding rate of 1/2 is the most robust against interference in mobile reception
- Performance of 2/3 is similar to those of 1/2

Effect of time-interleaving



- Time-interleaving length
  - 100 ms: sufficient for DQPSK
  - 400 ms: required for 16QAM

Wide-area mobile reception trial
Experimental Result (DQPSK)



DQPSK 1/2+RS

Error free

Error occurred

Field strength (calculated)

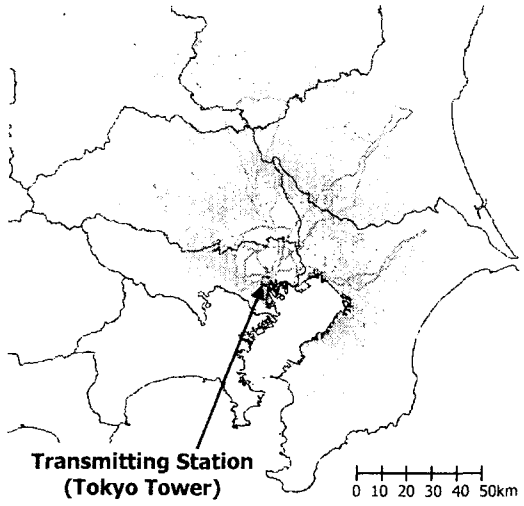
> 70 dBμV/m

> 60 dBμV/m

> 50 dBμV/m

Correct receiving :
about 60 km radius

Wide-area mobile reception trial
Experimental Result (16QAM)

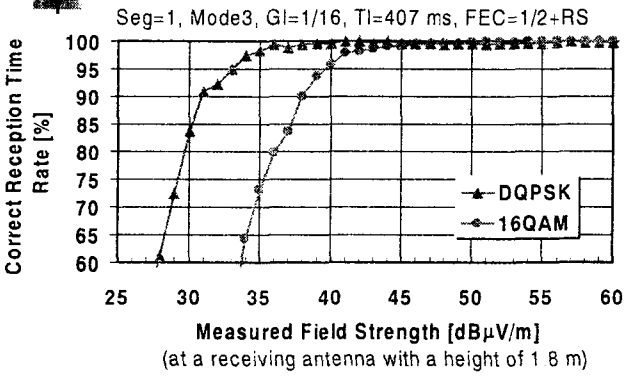


16QAM 1/2+RS
- Error free
- Error occurred

Field strength (calculated)
- > 70 dBμV/m
- > 60 dBμV/m
- > 50 dBμV/m

Correct receiving :
about 40 km radius

Wide-area mobile reception trials



Correct reception time rate	99%
DQPSK	38 dBμV/m
16QAM	44 dBμV/m

- Correct reception time rate =

$$\frac{\text{(Number of the measured samples with BER = 0)}}{\text{(Number of samples)}}$$

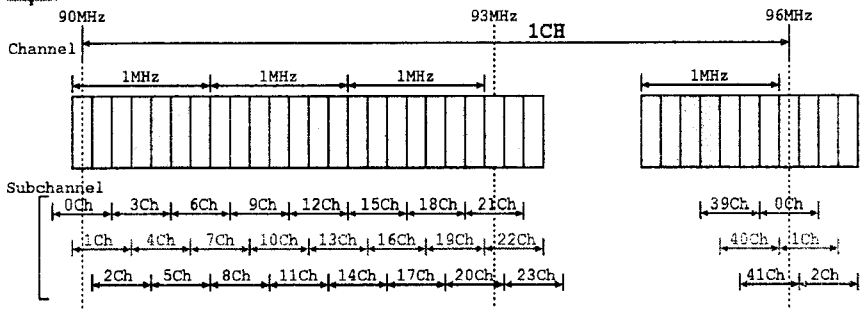
Proportion of samples measured in a 1-second interval

Wide-area mobile reception trials

- Fading margins

	Required correct reception time rate	Example: **99** %	
	Modulation	DQPSK	16QAM
(3)	Required C/N under Gaussian noise environment (Lab. Test)	6.5 dB	10.9 dB
(4)	Field strength requirement	38 dBμV/m	44 dBμV/m
(10)	Receiver input carrier terminal voltage	20.6 dBμV	26.6 dBμV
(16)	Receiver input noise terminal voltage	2.5 dBμV	
(17)	Required C/N for mobile reception ((10) – (16))	18.1 dB	24.1 dB
(18)	Fading margin ((17) – (3))	**11.6** dB	**13.2** dB

Channel allocation considered in Japan



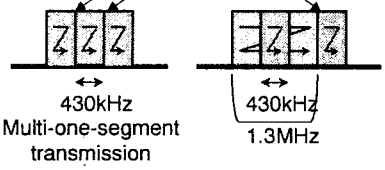
- Channel bandwidth = 6 MHz
- Segment bandwidth = 6/14 MHz = 3/7 MHz = 429 kHz
- Number of sub-channels in a channel = 42 (0 - 41 ch)
- Sub-channel separation 1/7 MHz =143 kHz
- Japan adopts 1/7 MHz offset sub-channel allocation
  1-1, 1-4, 1-7, ... , 1-40 sub-channel

Connected transmission

Connected transmission

Synchronize transmission

No guard-band



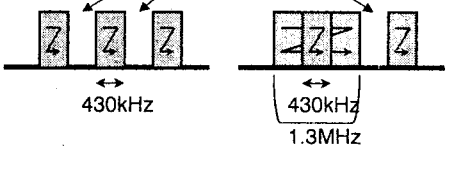
430kHz
Multi-one-segment transmission

430kHz
1.3MHz

Non-connected transmission

Non-synchronize transmission

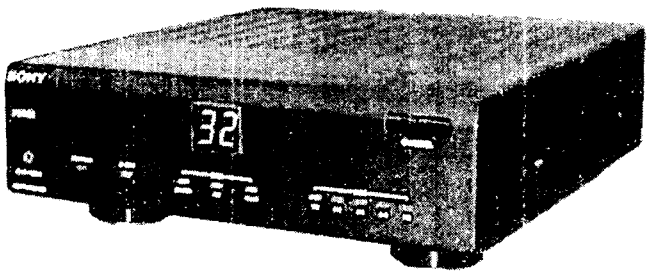
Guard-band needed



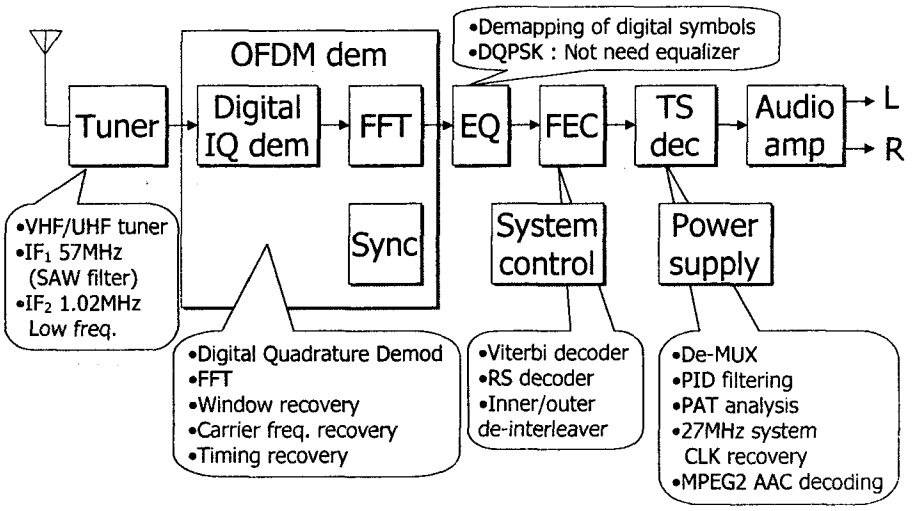
430kHz

430kHz
1.3MHz

Prototype receiver



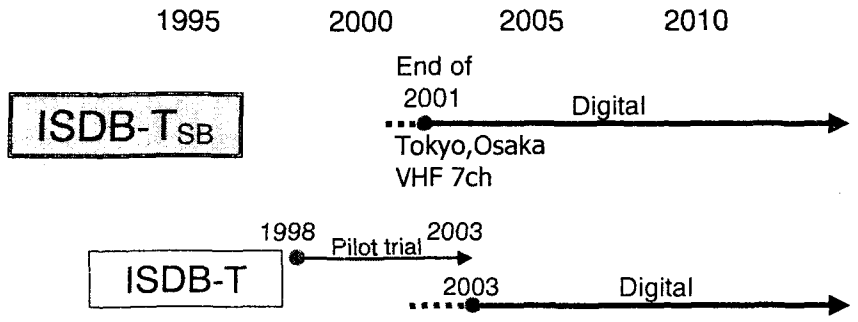
Functional block diagram of the prototype receiver



Service examples (1 segment)

Parameter	DQPSK 1/2	16QAM 1/2
Reception	Mobile	Mobile
TS rate	330 kbps	660 kbps
Services	2 Audio programs (CD quality stereo) Data (traffic, news)	3 Audio programs (CD quality stereo) Still picture Data (traffic, news)

Schedule of ISDB-T_{SB} service



ITU-R Recommendations

- ISDB-T_{SB}
  - BS.1114[-2] : approved at SG6, Sep.2000
  - ITU-R recommends DAB and ISDB-T_{SB} for terrestrial digital sound broadcasting system
- ISDB-T
  - BT.1306-1 (Oct.2000)

Conclusions

- ISDB-T_{SB} system
  - has commonality with ISDB-T (MPEG-2 base)
  - was approved at the SG6 meeting,Sep.2000 (BS.1114-[2])
- Field trials
  - Required field strength
    - DQPSK,1/2 : 38dBμV/m, 16QAM,1/2 : 44dBμV/m
  - Required fading margins
    - DQPSK,1/2 : 11.6 dB, 16QAM,1/2 : 13.2 dB
- Prototype receiver and services
- At the end of 2001, DSB will start in Japan.