Seminar #7

Digital receiver

1th April , 2005

Digital Broadcasting Expert Group (DiBEG)

Yasuo TAKAHSII

(Toshiba)

In this section, digital receiver structure, contents of these elements, demodulator key technology, examples of product are introduced. Mobile and portable receiver are introduced in seminar #9
Contents

1. Configuration of digital receiver
   1.1 Basic configuration of digital receiver
   1.2 Specifications of tuner unit

2. Synchronization technology in digital receiver

3. Digital receiver system
   3-1 Function of digital receiver
   3-2 Configuration of digital receiver
   3-3 Outside view of digital receiver

4. Software of digital receiver
   4-1 Composition of software in digital receiver
   4-2 Version up of software
   4-3 Function of communication of digital receiver

5. LSI for digital receiver
   5-1 LSI system of digital receiver
   5-2 OFDM demodulator LSI
   5-3 MPEG decoder system LSI
   5-4 Back end video processing LSI
6. Recording and RMP in digital broadcasting
   6-1 digital recorder for broadcasting
   6-2 recording time of digital broadcasting
   6-3 specifications of IEEE1394
   6-4 copy control for digital broadcasting contents (RMP)

7. New type display

8. Example of products
1. Configuration of digital receiver

1.1 Basic configuration of digital receiver

1.2 Specifications of tuner unit
Basic configuration of the receiver (see B21, Fig. 2-1)
Basic configuration of DIRD (see B21, Fig. 2-2)
2. Specifications of tuning unit (quoted from ARIB STD-B21)

(1) Input
Impedance: 75 Ω
Received frequency: UHF ch 13-62
Center frequency: 473 + 1/7 MHz (ch 13), 479 + 1/7 MHz (ch 14), . . . , and 767 + 1/7 MHz (ch 62)

(2) First intermediate frequency
Center frequency: 57 MHz (frequency reversed)
Local oscillator frequency: At the upper side of the received frequency

(3) Synchronization range of the received frequency
Synchronization range of the received frequency: ±30 KHz or wider

(4) Synchronization range of the received clock
Synchronization range of the received clock: ±20 ppm or wider

(5) Tuning unit
Minimum input level: -75 dBm or lower (targeted value) (See Appendix 10.).
Maximum input level: -20 dBm or higher.
### Protection Ratios of the 13-segment receiver (see B21, Table 5-2)

<table>
<thead>
<tr>
<th>Undesired wave</th>
<th>Item</th>
<th>Protection Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog television</td>
<td>From the co-channel</td>
<td>18 dB or less</td>
</tr>
<tr>
<td></td>
<td>From the lower adjacent channel (undesired wave on the lower side)</td>
<td>-33 dB or less</td>
</tr>
<tr>
<td></td>
<td>From the upper adjacent channel (undesired wave on the upper side)</td>
<td>-35 dB or less</td>
</tr>
<tr>
<td>Digital television</td>
<td>From the co-channel</td>
<td>24 dB or less</td>
</tr>
<tr>
<td></td>
<td>From the lower adjacent channel (undesired wave on the lower side)</td>
<td>-26 dB or less</td>
</tr>
<tr>
<td></td>
<td>From the upper adjacent channel (undesired wave on the upper side)</td>
<td>-29 dB or less</td>
</tr>
</tbody>
</table>

(Note) The transmission parameters used for the measurement must be as follows: Mode 3, guard interval ratio of 1/8, no time interleaving, modulation of 64 QAM, and an inner-code of 7/8 (See the Appendix.)
2. Synchronization technology in digital terrestrial receiver

2.1 outline of digital terrestrial receiver

2.2 synchronization technology
Outline of digital receiver
(tuner and demodulator section)
2.2 Key Technology for RX Synchronization

*4-element synchronization is required

(1) Carrier Synchronization: AFC
(2) Clock Synchronization
(3) FFT window timing
(4) Frame Synchronization

For Item (1) through (3), new synchronization methods are proposed
Key Technology: RX Synchronization

Synchronization Sequence

*Carrier Sync
*Clock Sync
*Window Timing Sync

Frame Timing Sync

Utilize correlation method (new technology)

Detect the sync word (located on TMCC)
New Technology – Auto and Cross Correlation for guard interval

The waveform of guard interval is same as the one at end of symbol. Thus Auto-correlation between the guard interval and the end of symbol is high.
Key Technology: RX Synchronization

Tg  Ts

Ts delay

Auto-correlation function

Strong Correlation within this period

Time
Key Technology-RX Synchronization

Detect the Window Timing

D/C → FFT → Square Root Sum → Ts delay → Average → Auto-correlation

Ts

Auto-correlation Waveform
Key Technologies-RX Synchronization

AFC: frequency offset error detection

D/C  FFT

Cross correlation

Ts delay  average
Ts delay  average

\[ \tan^{-1}(S_{iq}/S_{ii}) \]

Frequency offset error
Key Technology-RX Synchronization

AFC: frequency offset error detection

Sii: cross correlation between I and delayed I

Siq: cross correlation between I and delayed Q

\[
\tan^{-1} \left( \frac{\text{Siq}}{\text{Sii}} \right)
\]

Normalized Frequency Offset

\[
\begin{array}{c}
\text{Normalized Frequency Offset} \\
\end{array}
\]

\[
\begin{array}{c}
\text{tan}^{-1} (\text{Siq/Sii}) \\
0 \\
\end{array}
\]

\[
\begin{array}{c}
-1.0 \\
0.0 \\
1.0 \\
2.0 \\
\end{array}
\]
Key Technology-RX Synchronization

Composition of OFDM Frame

- **TMCC carrier**
- **Continual Pilot signal**
- **Scattered Pilot Signal**

(time, frequency)
Key Technology-RX Synchronization

Composition of OFDM Frame

SP: scattered pilot signal; used for equalizing of information signal

AC&CP; used for the frequency offset detection and carrier reference

TMCC(note): Transmission and multiplex configuration control: used for the transmission status information and frame synchronization

(note)In DVB-T, called TPS (Transmission parameter signal)
Key Technologies-RX Synchronization

Detection of Frame Timing

Note: The Frame Sync Words are located on the top of TMCC carrier
Key Technologies-Error Control

Blockdiagram of FEC Encoder

Reed-Solomon Encoding → Energy Dispersal → Byte interleave → Viterbi Encoding → Bit Interleave

(Outer Code) → (Inner Code)

Carrier Modulation → Time Interleave → Frequency Interleave → OFDM Framing → To IFFT
3. Digital receiver system

3-1 Function of digital receiver
3-2 Configuration of digital receiver
3-3 Outside view of digital receiver
3-1 Basic function of digital receiver

<table>
<thead>
<tr>
<th>media</th>
<th>Reception style</th>
<th>Transmission system</th>
<th>decoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS-digital</td>
<td>fixed</td>
<td>8 PSK</td>
<td>MPEG2-video AAC-audio BML-data</td>
</tr>
<tr>
<td>CS-digital</td>
<td>fixed</td>
<td>QPSK</td>
<td>Same as above</td>
</tr>
<tr>
<td>Terrestrial-digital</td>
<td>Fixed (note)</td>
<td>OFDM</td>
<td>Same as above</td>
</tr>
<tr>
<td></td>
<td>handheld</td>
<td>OFDM (1segment)</td>
<td>H.264-video AAC-audio Simple BML-data</td>
</tr>
</tbody>
</table>

(note) mobile reception service is possible in fixed reception service
3-1 function of digital terrestrial TV receiver

(1) Receiving antenna; UHF 13-62 Ch (470-770MHz), 14 element Yagi-antenna (7dB/UHF 13Ch) or more performance is desirable
(2) Receiver tuner; minimum input level is as low as -75dBm

Required D/U against interference

<table>
<thead>
<tr>
<th>interference</th>
<th>item</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog TV</td>
<td>Co-channel</td>
<td>18dB&gt;</td>
</tr>
<tr>
<td></td>
<td>Lower-adjacent</td>
<td>-33dB&gt;</td>
</tr>
<tr>
<td></td>
<td>Upper-adjacent</td>
<td>-35dB&gt;</td>
</tr>
<tr>
<td>Digital TV</td>
<td>Co-channel</td>
<td>24dB&gt;</td>
</tr>
<tr>
<td></td>
<td>Lower-adjacent</td>
<td>-26dB&gt;</td>
</tr>
<tr>
<td></td>
<td>Upper-adjacent</td>
<td>-29dB&gt;</td>
</tr>
</tbody>
</table>
3-1 function of digital terrestrial TV receiver

(3) Signal processing at front end portion;
   A/D, Quad. Demodulation, frequency/time de-interleave,
   64QAM, Viterbi decoding, hierarchy division, de-
   interleave, TS recover, RS decoding

(4) TS(Transport stream) processing;
   Recover the section data and PES data from TS

(5) Audio signal processing;
   Decode AAC LC profile of MPEG-2. Decoding systems
   are mono, stereo and multi-channel(3/1, 3/2, 5/1 CH)
3-1 function of digital terrestrial TV receiver

(6) Video decoding processing;
Decode HL, H14, ML, LL of MPEG-2 main profile. The output format is either of 1125i, 750p, 525p, 525i format.
3-1 function of digital terrestrial TV receiver

(6) Video signal processing;
D type output terminal

<table>
<thead>
<tr>
<th>D terminal spec.</th>
<th>480i</th>
<th>480p</th>
<th>1080i</th>
<th>720p</th>
<th>1080p</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Y, Pr, Pb + control signal
3-1 function of digital terrestrial TV receiver

(7) Display of data broadcasting (graphic display)
    display pixel; 960 * 540 (half of 1920* 1080)

Motion picture plane → select → 1 - α → + → 1 - α
Still picture plane → select → α → + → α
Text/object plane → select → CLUT → α

CLUT; color look up table
α; blending factor
3-1 function of digital terrestrial TV receiver

(8) Function of bi-directional communication
   - communication by Ether-net (TCP/IP)

(9) Digital interface
   - IEEE1394 (DVHS, etc)
Example of digital receiver block diagram

- BS tuner → 8 PSK DEM.
- Terrestrial tuner → OFDM DEM.
- Terrestrial analog tuner
  - ADC, Ghost reduction → NTSC DEC.
- DVD/VTR
- System LSI
  - De-MUX
  - MPEG DEC.
  - Format Conv.
  - NTSC DEC.
  - MPU
- 256MbitDDR memory
- IEEE1394
- LAN
- iLINK Ether
- TEL
- Memory card
- BCAS card
- PDP/LCD display
  - VTR output
  - CRT display
  - audio
  - VTR output
  - Optical digital audio
3-2 composition of digital receiver

(1) Tuner block; 2 type of tuners, analog and digital
(2) Analog signal proc. block; Analog tuner input and external NTSC input is decoded and output as digital signal.
(3) System LSI; divide digital broadcasting stream processing, decode MPEG-2 video/audio decoding, format conversion, graphic processing, capture of NTSC, NTSC encoding, system control and data broadcasting processing by 32 bit on-chip RSIC processor
(4) input/output; IEEE 1394 terminal to DVHS, LAN connector, MODEM connector, slot of multi-memory card, optical output for digital audio.
(5) Back end processor; separate CRT and LCD/PDP signal processing circuits
3-3 digital TV LSI board

- BS tuner
- MPEG decoder LSI
- Terrestrial TV tuner
- 8 PSK
- OFDM
- Back end proc. for flat panel
3-3 Hi-vision TV for digital terrestrial TV broadcasting

32D4000

26L400, 32L4000, 42P4000
Price of Wide screen digital TV

In Japan, all type of wide screen digital TV sets have HDTV performance. For this reason, it seems to be slightly expensive, but in a couple of years, the price of digital TV with wide screen for HDTV become cheap rapidly. The target price is as much as 100 $/1 inch.

(note) in Japan, more than 50 % of program of digital TV should be HDTV, therefore, all types of wide screen digital receiver is compatible to HDTV display.
4. Software of digital receiver

4-1 composition of software in digital receiver
4-2 version up of software
4-3 function of communication of digital receiver
## 4-1 Software stack of digital receiver

<table>
<thead>
<tr>
<th>Upper middle-ware</th>
<th>Lower middle-ware</th>
<th>OS</th>
<th>Device driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH.Select</td>
<td>CA</td>
<td>Linux</td>
<td>TS</td>
</tr>
<tr>
<td>data</td>
<td>TS manage</td>
<td></td>
<td>MPEG</td>
</tr>
<tr>
<td>EPG</td>
<td>MPEG</td>
<td></td>
<td>Ether</td>
</tr>
<tr>
<td>schedule</td>
<td>comunication</td>
<td></td>
<td>VBI data</td>
</tr>
<tr>
<td>mode manage</td>
<td>iLINK file</td>
<td></td>
<td>1394</td>
</tr>
<tr>
<td>video manage</td>
<td></td>
<td></td>
<td>memory card</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>graphics</td>
</tr>
</tbody>
</table>

- **Application**
  - BML browser
  - user I/F
  - tele-text/ character input

- **Device driver**
  - TS
  - MPEG
  - Ether
  - VBI data
  - 1394
  - memory card
  - graphics

- **Graphic library**

- **OS**
  - Linux
4-1 Structure of BML browser
4-2 software version up

<table>
<thead>
<tr>
<th>method of down load</th>
<th>contents of soft ware</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) broadcast wave (auto)</td>
<td>improved software</td>
</tr>
<tr>
<td>(2) broadcast wave (any)</td>
<td>add function</td>
</tr>
<tr>
<td>(3) memory card</td>
<td>individual user</td>
</tr>
</tbody>
</table>

(1) mainly correct bug of software (mainly used)*
(2) up version of function (HTML)
(3) up version of function (TV set)
*version up automatically at stand by mode
4-2 software download

(1) Information is broadcasted through all channels such as service ID, schedule, receiver type which should be downloaded, etc.

(2) Receiver gets the download data during stand by mode.
   The download data is different for maker ID, type No., group No., and version No.

(3) Download data is transmitted through the engineering Ch of BS-3 for satellite media, and NHK general Ch and NHK educational Ch for terrestrial media.
4-3 communication function of digital receiver

- Data broadcast: The contents on the web servers related with the broadcast program can be displayed through TCP/IP communication. Text data is also transmitted by IP packet.
- Download function: Software can be downloaded not only through the broadcast channel but also through the internet.
- Home networking: Digital TV receiver can be connected with the DVD recorder by TCP/IP communication.
- Web browsing: By installing HTML browser into the digital TV, the internet Web browsing will be possible.
5. LSI for digital receiver

5-1 LSI system of digital receiver
5-2 OFDM demodulator LSI
5-3 MPEG decoder system LSI
5-4 back end video processing LSI
Example of digital receiver block diagram

BS tuner → 8 PSK DEM. → MPEG system LSI

Terrestrial tuner → Terrestrial analog tuner → ADC → Ghost reduction

Terrestrial analog tuner → OFDM DEM. → MPEG decode

MPEG decode → Format converter

Graphic proc. → MPU

IEEE1394 → LAN → Card I/F

iLINK → Ether → Memory card

video → PDP/LCD backend proc. → audio
5-2 OFDM demodulator
LSI (TC90A87FG)
5-2 Feature of OFDM Dem. LSI

- Compatible to all parameters defined in ARIB spec.
- Compatible to 13 segment, 3 segment and 1 segment transmission.
- Use wideband ADC. Possible to input 57 MHz IF signal directly.
- Equip the interference reduction circuit against analog TV signal interference.
- Equip the memory, decision circuit in LSI. Only crystal is required as a outside part.
- 2 type of package, 114 pins QFP and 13 mm square BGA.
5-3 MPEG decoder system LSI (TC81240TBG)

- TS Proc.
- SDRAM cont.
- MPEG video decode
- Video format proc.
- Graphic proc.
- Cont. proc.
- Audio Dec.
- TX49 core (64 bit RSIC)
- NTSC Enc.

Input: TS input, PCI, USB
Output: video, audio, analog video

64 bit DDR-SDRAM
5-3 Feature of MPEG decoder LSI

- Host MPU; 64 bit RISC (TX49 core), 230 MIPS processor
- TS processing; 3 input, 48 section filter/TS
- De-scrambler; MULTI-2, DMULTI2, DES/TDES , DVB
- Audio; AAC, AC3, MPEG1,2
- MPEG video decode; 2 CH HDTV decode
- Display plane; video 2, graphics 2, carsol/background 1
- Graphics; bitBLT, scaling, alpha blending
- Progressive scan conversion; motion adaptation, intra field, intra frame.
- Noise reduction; motion adaptation, frame recursive type
- Video encoder; NTSC/PSL/SECAM
- Number of gate; 2.7 M gate, BGA 648 pin
5-3 back end video processing LSI (TC90A94TBG)
5-4 Feature of Back End Video Processing LSI

- Input signal: TV signal (480i/p, 720p, 1080i) and PC signal (VGA, SVGA, XGA, UXGA PC)
- Output signal: Panel size of 853x480, 1024x768, 1280x768, 1366x768, 1920x1080
- Format conversion: Motion compensated i/p conversion (480i) and motion adaptive conversion (1080i)
- Scaling: Horizontal/Vertical 1/3-3 nonlinear
- Picture quality control: Horizontal/vertical enhancer, Black enhancer, gamma correction
- Noise reduction: Motion adaptive frame recursive type
- OSD: 128 colors, 256 alpha blending
- Number of transistor: 12.6M Transistor, Package: BGA480pin
6. Recording and RMP (note) in digital broadcasting
   (note) Right Management and Protection

6-1 digital recorder for broadcasting
6-2 recording time of digital broadcasting
6-3 specifications of IEEE1394
6-4 copy control for digital broadcasting contents (RMP)
6-1 Recorder for digital broadcasting

(1) digital VHS:
   digital record on VHS tape
   (via IEEE1394(iLINK))

(2) hard disk recorder
   (with tuner, via iLINK)

(3) next generation (blue laser) DVD
   23GB recording on DVD disk
### 6-2 recording time of recorder

<table>
<thead>
<tr>
<th>Media For recording</th>
<th>capacity</th>
<th>Recording time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BS(22Mbps)</td>
</tr>
<tr>
<td>D-VHS</td>
<td>60GB</td>
<td>6 hours</td>
</tr>
<tr>
<td>Hard disk</td>
<td>200GB</td>
<td>20 hours</td>
</tr>
<tr>
<td>DVD (red)*</td>
<td>4.7GB</td>
<td>28 minutes</td>
</tr>
<tr>
<td>DVD (blue)</td>
<td>23GB</td>
<td>2.3 hours</td>
</tr>
</tbody>
</table>

* in case of DVD (red), record after down conversion to 525i
6-3 IEEE1394 interface

(1) iso-chronus transmission

\[ \text{period } T \]

(2) Copy control by TCP system
- equipment authorization
- Key exchange
- transmit encryption data(M6)
- copy is controlled by CCI

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Copy free</td>
</tr>
<tr>
<td>10</td>
<td>Copy once</td>
</tr>
<tr>
<td>01</td>
<td>No more copy</td>
</tr>
<tr>
<td>11</td>
<td>Never copy</td>
</tr>
</tbody>
</table>
6-4 RMP application for digital broadcasting

(1) BS and terrestrial broadcasting;
even though free program, scrambled by BCAS. Apply copy once mode. Started April 2004.

(2) BCAS card;
provide to user within same carry box. The card does not provided to unauthorized equipment.

(3) Authorization for new type equipment;
according to application, check and give authorization Authorized; DTCP,CPRM, Bluray
For memory card, DTCP over IP, wireless LAN, future discussion
## Copy control for DVD

<table>
<thead>
<tr>
<th>format</th>
<th>CPRM</th>
<th>DVD-RAM</th>
<th>DVD-RW</th>
<th>DVD-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video format</td>
<td>invalid</td>
<td>-</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Video recording (VR) format</td>
<td>valid</td>
<td>OK</td>
<td>OK</td>
<td>-</td>
</tr>
</tbody>
</table>

CPRM; Copy Protection for Recordable Media
6-4 charge system by scramble for BS BCAS (Conditional Access System)

Video

- Transmitter
  - Scrambler (MULTI2 system)
    - Scramble key
      - Change every 1 second
    - Work key
      - Change every 1 month
    - User key
    - Secret personal key

- Broadcast wave (scrambled)

BS receiver

- Descrambler (MULTI2 decode)
  - Work key
  - Scramble key
  - CPU
  - Memory
  - User key

IC card
6-4 Composition of RMP in receiver

Even though free program, scrambled HDD recording is locally encrypted by common key of 56 bit or more (HDCP rule) (CPRM, Bluray)

Card id not provided to unauthorized receiver (enforcement)
7. New type display

7-1 Liquid crystal display
7-2 plasma display TV (PDP)
7-3 FED (Field Emission Device)
7-4 Feature of each display
7-5 Projection TV

In this section, wide screen and high definition flat displays are introduced, this device is indispensable for HDTV.
7. New type display

Plasma display TV

Liquid crystal display TV
7-1 Liquid crystal display

- Back light (white light)
- Polarization board
- Liquid crystal
- Glass electrode
- Color filter
- Voltage
- 300 thousand pixel
7-2 plasma display TV (PDP)

- Light
- Plasma
- Electrode
- Fluorescent substance
- Drive pulse
  - OFF
  - ON

SDTV: 300,000
HDTV: 1,000,000
7–3 FED (Field Emission Device)

electrode(+) electrode(-)

Fluorescent substance

board

same principle of cathode ray tube
## 7-4 feature of each display

<table>
<thead>
<tr>
<th>item</th>
<th>LCD</th>
<th>PDP</th>
<th>FED</th>
<th>remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average blightness</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>To save power consumption, PDP is not so good</td>
</tr>
<tr>
<td>Power consumption</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Motion picture performance</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>contrast</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blight position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Visual angle</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>Self lightning system is better</td>
</tr>
</tbody>
</table>

1; best, 2; better, 3; good, 4; not so good
7-5 Projection TV

40-60 inch

Projection TV

screen

mirror

LCD panel

Light source

40 cm
8. examples of products

In this section, mainly introduce the fixed reception type digital receiver. Mobile and handheld receiver will be introduced in seminar #9)
Rapid increase of DTTB Receiver Shipment

2.4 million receivers are in the market now
Digital TV Products

- Plasma
  - HITACHI
  - SONY
  - Panasonic

- PDP
  - Pioneer
  - Victor • JVC
  - SANYO
  - TOSHIBA
Digital TV Products

LCD

Panasonic

SONY

SHARP

TOSHIBA

Victor・JVC

SANYO

MITSUBISHI

HITACHI
More manufactures are entering the market!
94% of DTTB receivers are all-in-one DTTB receivers

- Equipped with digital terrestrial and satellite tuner
- Compatible with HDTV (1080i)
- Equipped with data broadcasting decoder
- Capability to connect network

Many models have internet web browsing function

In addition, more than 3 million of HDTV ready TVs (HDTV display without DTTB tuner) have already shipped.
Example of Internet TV

Portal Site

- Character Input Button
- Internet Button
- Operation Button
- Access to Favorite Site
Example of Internet Function

Internet Screen

One Screen Mode

Internet Screen

TV Mode

Two (TV + Internet) Screen Mode
Example of Internet TV

**EPG and T-navi Portal Site**

T-navi: dedicated sites for TV internet viewers
Example of Internet TV

T-navi Menu List

NEWS

Travel

Shopping

Panasonic
Example of Digital TV Product

1920x1080 full HDTV resolution LCD display

Digital HDTV recorder (HDD+DVD) with digital TV tuner
Example of Digital TV PC Product

EPG enables to record TV program to PC

PC with DTTB tuner card
Example of Product
(CATV Digital STB)

DTTB is broadcasted via CATV with 64QAM transmodulation.

1.0 million CATV digital STB are in the market (Dec. 2004)
END of seminar #7