Japan’s Experiences for Digital Terrestrial TV Broadcasting

Part 2

Digital Terrestrial TV Broadcasting (DTTB)
Transmission Networks

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DiBEG JAPAN
Yasuo TAKAHASHI (Toshiba)
Part 2
Contents

1. DTTB Transmission Network Design
   1.1 Kinds of DTTB transmission Network
   1.2 What’s are key points of Network Design?

2. Examples of SFN Transmission Network

3. Improvement of Signal Quality in Transmission Network

4. Examples of Small power Relay Stations (Gap Filler, etc)

5. Examples of Receiving Antenna for Fixed Reception
1. DTTB Transmission Network Design

1.1 Classification of DTTB Transmission Network

(1) Classification by transmitting frequency in Network

- Single Frequency Network (SFN)
- Multi Frequency Network (MFN)
(2) Classification by transmission measures in Network

(a) TS Transmission

(b) IF Transmission

(c) Broadcast Wave Relay

Same construction as TV TX
Comparison of network system

<table>
<thead>
<tr>
<th>Network type</th>
<th>Infra &amp; maintenance cost</th>
<th>Signal quality</th>
<th>SFN timing adjustment</th>
<th>Save micro-wave frequency resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS transmission-microwave/fiber</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>IF transmission-micro wave/fiber</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Broadcast- wave relay station</td>
<td>1</td>
<td>3</td>
<td>2 (note1)</td>
<td>1 (note2)</td>
</tr>
</tbody>
</table>

(note1) for Broadcast wave relay system, transmission the range of transmission timing is limited.

(note 2) Broadcast wave relay system dose not need micro wave frequency.
1.2 What’s are key points of Network Design?

1.2.1 Link budget;
In digital transmission, threshold C/N is important. Under threshold C/N, receiver does not operate well. On the other hand, in analog system, under required C/N, only picture quality degrade. The C/N degradation is caused not only by thermal noise but also by another causes such as equipment degradation, etc. Therefore, link budget is important especially for multi-stage transmission chain.

Check Network Model

In case of “IF Transmission model” and “Broadcast wave Relay Model”, signal degradations are accumulated

Check Network Configuration

(a) Transmission distance between relay station, (2) Number of Stage, etc

Check , (a) required signal quality of each stage, (b) required equipment degradation for each stage
Link budget parameters

(a) Transmission model

3 types are considered; TS transmission, IF transmission, broadcast relay station

(b) Propagation loss and fading margin

Fading margin is different according to propagation distance. See details ARIB STD-B31 reference A.3.2

(c) Equipment degradation and transmission distortion

Equivalent C/N is degraded by equipment degradation, especially in multi-stage transmitter chain, these degradation are accumulated.

(d) Number of transmitter stage

Degradation of each stage are accumulated, therefore, equivalent C/N of final stage should be considered in network design (as a reference, see ARIB STD-B31 A.3.2.4)

As examples, show (c) and (d) in next pages
causes of signal degradation in transmission network

*Thermal noise
*Distortion of Transmission link
*Inter-modulation
*Phase noise

(note) all these degradation are evaluated as END (Equivalent Noise Degradation) in transmission link budget
**Number of transmitter stage**

As explained before, equivalent noise degradation of each stage are accumulated. For this reason, equivalent C/N of final stage should be carefully checked, and decide number of transmitter stage and these required C/N. As an example, relationship between number of stage and required C/N is shown below.

![Graph showing the impact of changes to the equivalent C/N ratio of the main station's transmitter on the transmitter-output C/N ratio.](image)

**Fig. A3.4-2: Impact of Changes to the Equivalent C/N Ratio of the Main Station’s Transmitter on the Transmitter-Output C/N Ratio**
1.2.2 Network synchronization (SFN Network)

SFN technology is the feature of DTTB to save frequency resource. For SFN system, plural path should be within guard interval at receiving point. For this reason, the transmission timing of plural transmitter in same network should be managed to achieve SFN condition.

(1) Network synchronization system

3 types are explained in ARIB STD-B31 Appendix 5.2

(a) Complete synchronization system: not used in actual system

(b) Slave synchronization system: most popular

(c) Reference synchronization system: considering to use

(2) Information for Network synchronization control

In ISDB-T system, network_synchronization_information is multiplexed into broadcasting TS at RE-MUX. This information is useful not only for network synchronization but also for measure the transmission timing of each transmitter.

An Example is shown in Chapter 2.
(3) What is “IIP”?
IIP (ISDB-T Information Packet) is multi-plexed into Broadcast TS at Re-Multiplexer. Broadcasting network control informations are included in IIP, and are used for transmission network control at transmitter station. (see details ARIB STD-B31 Appendix 5.5)

Network_synchronization_information is useful for network synchronization. Details are shown in table 5-12, and table 5-13 of ARIB STD-B31 Appendix.

Example of Network_synchronization_information

![Diagram of Network_synchronization_information]

1 pps pulse

Frame header (re-mux out)

Frame header (TX input)

Frame header (TX output)

Maximum_delay

If all transmitter output should be adjusted to maximum_delay, TX output is delayed to this point.
2. Examples of SFN Transmission Network

SFN Construction with TTL Network (note)

(note) This example is dedicated by NHK
Delay Adjustment Method: Requirements

- The broadcasting network should be able to be expanded without interrupting the service.
- The delay adjustment should be easy.
Delay Adjustment Method

- Broadcast-waves are emitted at the same time from each station. (coarse-tuning)
  
  Broadcast-wave emission timings of the broadcast stations are initially set at the maximum network delay.

- The Adjustment between broadcasting stations uses a relative delay. (fine-tuning)
  
  A time offset is set at each broadcasting site, if necessary.
Fine Adjustment

Adjust Relative Delay (Time offset: $T_{off}$) of Each Station

Ex. $d_1 - d_2 > 38$ km  $T_1' - T_2' > GI$

$T_1' - (T_2' + T_{off}) < GI$\*
Adjustment System

TS Transmission Network

Master Station

Relay Station

Transmission Engineering Center – Engineering Administration Department – NHK
Maximum Delay

**Adjustment Point**

① *Output of OFDM Modulator*

② *Output of Transmitter*

Transmission delay time of TS-STL/TTL: 60msec

Processing time of OFDM modulator: 350msec

Transmission delay time of IF-TTL and Transmitter: 2msec

① *Adjustment on output of OFDM modulator*

② *Adjustment on output of Transmitter*
Adjusting the OFDM Modulator’s Output

Adjustment time of “TS Delay”

410 msec – \(T_{\text{meas}}\)

Transmission Engineering Center – Engineering Administration Department – NHK
Adjusting the Transmitter’s Output

Adjustment time of “IF Delay”

412 msec + \( T_{off} \) − \( T_{meas} \)
The First Practical SFN (by TTL Network)
Adjusting the OFDM Modulator’s Output

**SFN Network for Programs of the NHK General Service**

- **Remux** → **TS-STL TX** → **TS-STL RX** → **TS Delay** → **OFDM MOD** → **IF Delay** → **Tx**

**Mito Studio**
- 353.937 msec
- 56.063 msec (410 – 353.937)
- 357.736 msec (Set value)
- 52.264 msec (410 – 357.736)
- Adjust to 410 msec
- Adjust to 412 msec

**Hitachi Station**
- 410.006 msec
- 1.994 msec (412 – 410.006)
- 410.003 msec
- 1.997 msec (412 – 410.003)

Transmission Engineering Center – Engineering Administration Department – NHK
Adjusting the OFDM Modulator’s Output

SFN Network for Programs of the NHK Educational Service

- **Remux**
- **Tokyo Studio**
- **SFN Network for Programs of the NHK Educational Service**

Adjust to 410 msec

Adjust to 412 msec

- **Mito Station**
- **Hitachi Station**
- **Yamagata Station**

350 msec (Set value)

43.976 msec

40.176 msec

40.175 msec

1.994 msec

1.997 msec

2.347 msec

(412 – 410.003 + 0.35)

(0.35 msec)

Transmission Engineering Center – Engineering Administration Department – NHK
3. Improvement of Signal Quality in Transmission Network

As shown in Next page, there are many technologies for signal improvement which have been developed and now in practical use.

As examples, 2 cases are explained in this Conference

(1) Capling Loop Interference (CLI) Canceller
    (Dedicated by NHK)

(2) Long Distance Broadcast Wave Relay Network with Diversity reception System (Dedicated by JRC)
Examples of Signal Quality Improvement Technologies (These technologies have been developed and used in Practical System)

(1) Improvement of transmitter non-linear distortion
   - Feedback Pre-distortion correction technologies; adopted for high power transmitter
   - Feed forward type amplifier; mainly adopted for middle power multi-channel power amplifier used as transposer

(2) Improvement of phase noise in IF transmission micro-wave link

(3) Improvement of transmission distortion
   - Multi-path canceller; especially compensate the multi-path distortion on transmission link.
   - Coupling loop interference (CLI) canceller; compensate the coupling loop between TX antenna and RX antenna in SFN
   - Diversity receiving technology; Improve the degradation caused by fading. This technology is useful not only transmission network but also mobile reception.
(1) Capling Loop Interference (CLI) Canceller

(note) Dedicated by NHK
Coupling Loop Interference at SFN Broadcast Wave Relay Stations

Master Station Wave

Mountainous Area, etc.

Coupling Wave

F1

Transmitting Antenna

Receiving Antenna

SFN Relay station

Subscriber

Transmission Engineering Center – Engineering Administration Department – NHK
Principle of CLI Cancellation

Coupling Loop Interference: \( C(\omega) \)

Condition for cancelling: \( W(\omega) = C(\omega) \cdot G(\omega) \)

The error is solved as: \( E(\omega) = C(\omega) \cdot G(\omega) - W(\omega) \)

\[
E(\omega) = 1 - \left( \frac{X(\omega)}{S(\omega)} \right) = 1 - \left( \frac{1}{F(\omega)} \right)
\]
The Practical SFN
(by Broadcast Wave Relay Network)
The SFN was Built in Nagara Relay Station
The CLI canceller has been used for NHK Digital General at Nagara relay station.
- 1st generation CLI canceller in practical use
Equivalent CNR due to the residual uncancelled CLI (dB)

| T | i | m | e | c | u | m | u | l | a | t | i | v | e | p | r | o | b | i | l | i | t | y (\%)
| 50%: 16.9dB |
| 0.1%: 12.2dB |
| 4.7dB |

<table>
<thead>
<tr>
<th>DUR of CLI (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time Cumulative Probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
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<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
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<td>50</td>
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<td>60</td>
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<tr>
<td>70</td>
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<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

<table>
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<th>Time Cumulative Probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
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<td>10</td>
</tr>
<tr>
<td>20</td>
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<tr>
<td>30</td>
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<td>60</td>
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<tr>
<td>70</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

DUR of CLI (dB)

- 50%: 16.9dB
- 0.1%: 12.2dB

Equivalent CNR due to the residual uncancelled CLI (dB)

- 50%: 40.4dB
- 0.1%: 39.1dB

Time Cumulative Probability

Transmission Engineering Center – Engineering Administration Department – NHK
(2) Long Distance Broadcast Wave Relay Network with Diversity reception System

(note) This example is Dedicated by Japan Radio Co. Ltd (JRC)
Merit of broadcasting wave relay

- Low cost ••• dedicated links (TTL, OPTIC LINK) are unnecessary
- Long distance relay ••• Broadcasting wave transmits stably without precipitation reduction because of UHF band.

※ TTL (7GHz band) : max. transmission 50km

“Broadcasting wave relay” has the advantage for isolated islands
Broadcasting wave relay plans for isolated islands

<table>
<thead>
<tr>
<th>place</th>
<th>relay distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOKYO IZU</td>
<td>107km (TOKYO~OSHIMA)</td>
</tr>
<tr>
<td></td>
<td>153km (NIIJIMA~HACHIJOY)</td>
</tr>
<tr>
<td>NIIGATA SADO</td>
<td>60km (NIIGATA~RYOUTSU)</td>
</tr>
<tr>
<td>SHIMANE OKI</td>
<td>77km (MATSUE~SAIGO)</td>
</tr>
<tr>
<td>NAGASAKI TSUSHIMA</td>
<td>67km (GONOURA~IZUHARA)</td>
</tr>
<tr>
<td>NAGASAKI GOTO</td>
<td>102km (NAGASAKI~FUKUE)</td>
</tr>
<tr>
<td>KAGOSHIMA AMAMI ※</td>
<td>115km (MAKURAZAKI~MINAMITANE)</td>
</tr>
<tr>
<td></td>
<td>115km (MINAMITANE~NAKANOSHIMA)</td>
</tr>
<tr>
<td></td>
<td>170km (NAKANOSHIMA~NAZE)</td>
</tr>
<tr>
<td>OKINAWA RYUKYU</td>
<td>95km (NAHA~KUMEJIMA)</td>
</tr>
<tr>
<td>OKINAWA SAKISIMA</td>
<td>100km (SONAI~YONAKUNI)</td>
</tr>
</tbody>
</table>

※ AMAMI

9 relays including 6 over-sea ones

Total relay distance: about 600km
Problem of broadcast-wave relay to isolated islands

Receiving signal quality deteriorates in the long-distance transmission on the sea by fading or co-channel interference

(1) Fading
The phenomenon that receiving level deteriorates temporarily. Fading makes $C / N$ of receiving signal bad and makes reception impossible.

(2) Co-channel interference
Interference waves of same frequency make $C / N$ of receiving signal bad.
**Mechanism of fading**

The receiving signal is a mixture of direct wave and reflection wave. Fading is the phenomenon that the phase change of these waves induce the receiving power level.

The cause of "phase change" is "refractive index ($K$) change of the waves". After all, fading (power level change) occurs with "height pattern change".

(a) $K = 1.3$
- The power level is maximum at $h$

(b) $K = 1.6$
- The power level is minimum at $h$

Example of height pattern

- Height pattern phenomenon that the receiving power differs depending on the height.
- Refractive index $K$ = equivalent earth radius index (normal value: 1.3)
Space diversity reception (SD reception)

- The ideal distance between two antennas is half pitch.
  \[ \Rightarrow \] the receiving power drop becomes 3dB by SD reception.

- Actually there are many cases difficult to set 2 antennas by half pitch physically. The antennas might be set in a shorter distance than the half pitch.
  \[ \Rightarrow \] Some drop of receiving level must be permitted.

## Relay distance and half pitch

<table>
<thead>
<tr>
<th>Relay distance</th>
<th>Ideal antennas’ distance (half pitch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25km</td>
<td>13m</td>
</tr>
<tr>
<td>50km</td>
<td>28m</td>
</tr>
<tr>
<td>75km</td>
<td>50m</td>
</tr>
<tr>
<td>100km</td>
<td>95m</td>
</tr>
<tr>
<td>125km</td>
<td>260m</td>
</tr>
</tbody>
</table>

20ch (515MHz)
Antenna height from sea-level: 300m
\[ K = 4/3 \]

![Diagram](image)
Performance against fading

Merit of digital broadcasting (ISDB-T)
- OFDM and strong error correction
- Strong against multi-path and no deterioration of image quality by ghost
- Requirement of the receiving power level is low.

Digital broadcasting has wide permissible range against fading. SD reception is an easy measure against fading.

Comparison of digital broadcasting (ISDB-T) and analog broadcasting (NTSC)

<table>
<thead>
<tr>
<th>Required C/N</th>
<th>Digital broadcasting (ISDB-T)</th>
<th>Analog broadcasting (NTSC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required receiving power level</td>
<td>$-80. 2\text{dBm} + \alpha$ ($\alpha$: drop by multi-path)</td>
<td>$-70. 2\text{dBm} + \beta$ ($\beta$: drop by multi-path)</td>
</tr>
<tr>
<td>Performance against multi-path</td>
<td>strong and no ghost</td>
<td>Weak and some ghost</td>
</tr>
</tbody>
</table>

$\alpha < \beta$

If the required receiving power level is satisfied, the image quality is very high.

Even if the receiving level is high, there are some cases the image quality becomes very bad by ghost.

$kTB \cdot Nf = -100.3\text{dBm}$ (Nf=6dB)
Actual example of SD reception

NAKANOSHIMA~NAZE

Transmission distance 170km
Half pitch 143m
Antennas’ height difference 34m

Height pattern (calculation)

(a) normal state

K=4/3 (1.33)

(b) fading

K=1.65

The power level drop is about 9 dB in fading by SD reception
Actual example of SD reception

Receiving antennas at NAZE station

This test was sponsored by MIC and the antennas were borrowed from 4 commercial broadcaster in KAGOSHIMA prefecture.
Actual example of SD reception

For this example of field test, IF combining method is used

IF band combining method

[feature]
  • To consist the phase of A and B by phase controller and compose them.

  • The response is very quick and it can catch up fast fading also.
NAKANOSHIMA~NAZE SD reception test measured data

[SD equipment:IF band composite method]

May 18, 2006 24 hours data

- Upper antenna
- Lower antenna

※SD output is always more than 35dB
5. Examples of Small power Relay Stations (Gap Filler, etc)

In Japan, Digital Terrestrial TV service will be stopped by July, 2011. Therefore, magnification of the service area is important and urgent theme.

In 3rd Report of “Administrative role for utilization and promotion of terrestrial digital broadcasting,” following measures should be considered for bad receiving condition area to widen DTV service area.

**Basic rule:** by relay station of terrestrial broadcasting (digital CATV and community antenna system)

- complementary measures: *CATV, *Re-broadcast by IP multi-cast with optical fiber, *simulcast by satellite
- for remote area: *study of gap filler is necessary

(note) This example is dedicated by **NHK Integrated Technology Inc. (NHK ITEC)**
Administrative role for utilization and promotion of terrestrial digital broadcasting ~3rd report~

Utilization of gap filler

- deregulation of technical standards and qualifications is necessary
- gap filler is effective at area dotted with small villages
- gap filler by wireless should be examined in supporting remote areas as well as CATV by wire
- Portable reception service by gap filler is very effective against disasters
- new consensus of licensee and operator is necessary
Terrestrial broadcasting for bad reception condition areas

- Urban area
- Mountain area
- Relay station network

- Wireless reception
- Wireless community reception

- Access point
- CATV Head end
- Coaxial cable
- FTTH
- Optic CATV

Key station
Underground shopping center
Urban area

NHK Integrated Technology Inc.
Image of digital wireless community reception system

- Digital wireless community reception
- DTTB Receiving Antenna
- Optic fiber networks (public information highway, Dark fiber)
- Transmission distance; more than 100Km
- Wireless relay
- Terrestrial broadcasting UHF receiving antenna
- PDA
- Handy hone
- Car navigation

NHK Integrated Technology Inc.
Receiver and transmitter of community reception antenna

- **Mountain top**: Receiver
- **Urban areas**: Transmitter
- **Public networks or dark fiber**: From CATV

**CATV net**

*NHK Integrated Technology Inc.*
Receiver Portion of Community Antenna System

Example of Receiver for Gap filler and MID channel

Reception Antenna

UHF Terrestrial digital broadcasting

Head-end (UHF path through)

Head-end (MID conv.)

Optical modulator (E/O)

Optic output (RF optical Intensity Modulation)

Output channel for Gap filler

Output channel for MID channel of Shared connection

NHK Integrated Technology Inc.
Re-transmitter Portion of Community Antenna System (Optical input type)

Transmitter with O/E converter

Optic input

O/E CONV.

AMP

RF output

Transmitting antenna

example

NHK Integrated Technology Inc.
In general the receiving and transmitting channels are same (SFN), so the receiving antenna and transmitting one are apart for high isolation.
Test example of digital wireless community reception
Transmitting power (experimental station)

Optic transmission about 40km without optic amplifier on the way

Transmitter output

Optic transmission about 40km with 4 optic amplifier

Transmitter output
Field test of One-seg gap-filler for Underground

DTTB service for underground area (Underground mall and Subway) is also important theme not only for “Broadcasting service” but also “Disaster prevention” in Japan

Field test of re-transmitting service for underground has been held several area in Japan, following photo shows sight of Underground field test in Yaseu mall.
5. Examples of receiving Antenna for Fixed Reception

(note) This example is dedicated by MASPRO DENKHO Corp.
Super-High Performance Receiving Antenna

- High performance UHF antenna which adopts Stack Inductor and Wide Screen Reflector to reduce the multi-path interference of front direction and backside direction.
- Realize light but strong structure by adopting double boom structure composed by Aluminum boom and supporting boom

<table>
<thead>
<tr>
<th>Model</th>
<th>Gain (dB)</th>
<th>VSWR</th>
<th>F/B ratio (dB)</th>
<th>Wind Surface Area (m²)</th>
<th>Dimension (mm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS14</td>
<td>8.4~14</td>
<td>1~2.5</td>
<td>17.5~32</td>
<td>0.16</td>
<td>1160×495×560</td>
<td>約2.3</td>
</tr>
<tr>
<td>LS20</td>
<td>8.9~15.7</td>
<td></td>
<td></td>
<td>0.21</td>
<td>1860×495×560</td>
<td>約2.7</td>
</tr>
<tr>
<td>LS30</td>
<td>10.7~17.4</td>
<td></td>
<td>19.8~30.7</td>
<td>0.31</td>
<td>3040×495×560</td>
<td>約3.7</td>
</tr>
</tbody>
</table>
High Performance Receiving Antenna

- 7 element UHF all band receiving antenna, win a prize of JEITA “Digital Hi-vision (DH) mark”, which is best fitted for HDTV reception.
- Realize wideband high performances by adopting Maspro original technology of loop element inductor and beam dipole

<table>
<thead>
<tr>
<th>Model</th>
<th>Gain (dB)</th>
<th>VSWR</th>
<th>F/B ratio (dB)</th>
<th>Wind Surface Area (㎡)</th>
<th>Dimension (mm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPH3</td>
<td>6～9</td>
<td>2.5以下</td>
<td>13～23</td>
<td>0.03</td>
<td>630 × 358 × 100</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Simple Type Receiving Antenna (1)

- All band antenna best fitted for digital terrestrial broadcasting reception in strong field strength area. This antenna can be used both indoor and outdoor.
- Realize thin and compact size without the degradation of performance by adopting the folded type reflector.
- Realize the compatibility of light weight and high gain, by making use of vesicular type radiator.

<table>
<thead>
<tr>
<th>Model</th>
<th>Gain (dB)</th>
<th>VSWR</th>
<th>F/B ratio (dB)</th>
<th>Wind Surface Area (㎡)</th>
<th>Dimension (mm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC2</td>
<td>4 ~ 5.5</td>
<td>1.1 ~ 2.2</td>
<td>9 ~ 27</td>
<td>0.07</td>
<td>131 × 330 × 205</td>
<td>約0.84</td>
</tr>
</tbody>
</table>
Simple Type Receiving Antenna (2)

- All band antenna best fitted for digital terrestrial broadcasting reception in strong field strength area. This antenna can be used both indoor and outdoor.

- Realize high gain of 5 – 7 dB, this performance is highest level as a desk top type antenna, by making use of radiator which structure was accumulated to the top and bottom 2 step. This radiator is developed by Maspro.

<table>
<thead>
<tr>
<th>Model</th>
<th>Gain (dB)</th>
<th>VSWR</th>
<th>F/B ratio (dB)</th>
<th>Wind Surface Area (㎡)</th>
<th>Dimension (mm) L × W × H</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT2</td>
<td>5～7</td>
<td>1.1～2.2</td>
<td>3～10</td>
<td>0.07</td>
<td>616 × 111 × 90</td>
<td>約1.51</td>
</tr>
</tbody>
</table>
Summary

• As shown in this part, many technologies of transmission network has been developed and on practical use.

• In Japan, Analog Terrestrial TV service will be stopped by July, 2011, therefore, new measures should be required to expand the service area.

• From now, small power transmitter station network becomes main job in Japan, and another measures, such as IP distribution network, cable distribution, etc will be also used to extend the digital TV service area.
Obrigado

Thank you for your Attention!

Domo Arigato Gozaimashita

Digital Broadcasting Expert Group (DiBEG)

In ARIB (Association of Radio Industries and Business)

http://www.dibeg.org