Japan's Experiences for Digital Terrestrial TV Broadcasting

Part 2

Digital Terrestrial TV Broadcasting **(DTTB)**

Transmission Networks

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DiBEG JAPAN

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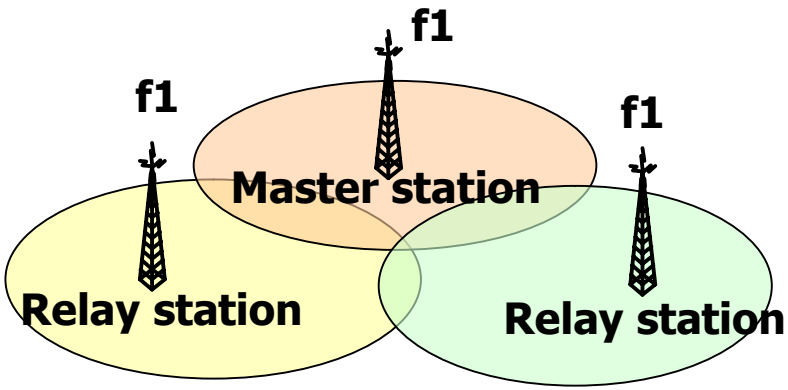
Part 2
Contents

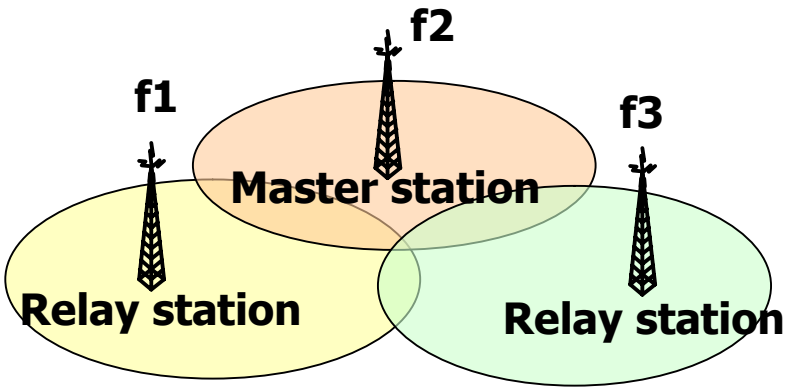
1. DTTB Transmission Network Design

1.1 Classification of DTTB Transmission Network

(1) Classification by transmitting frequency in Network



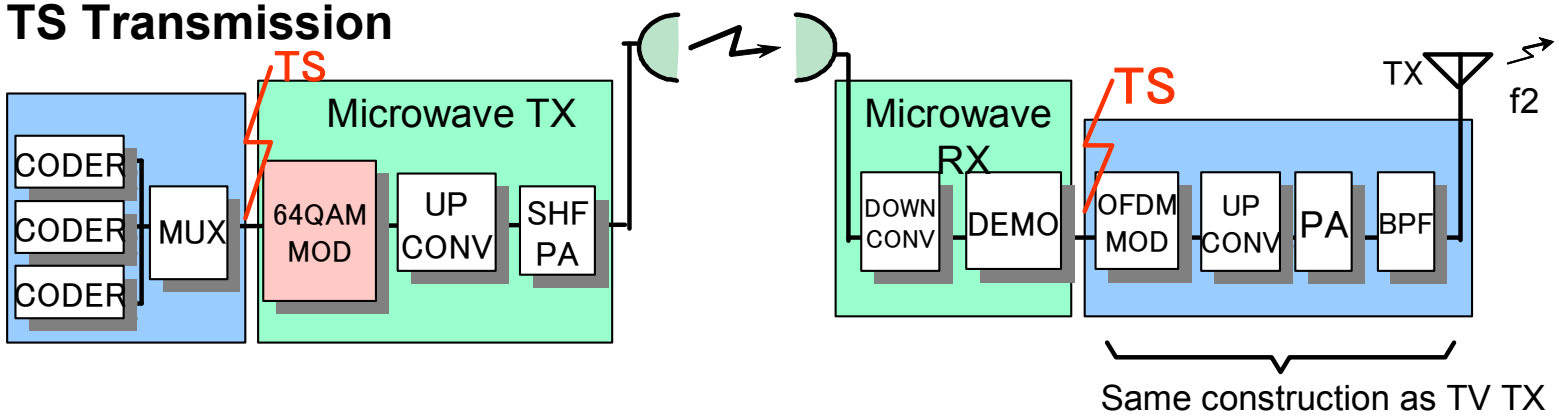
Single Frequency Network (SFN)



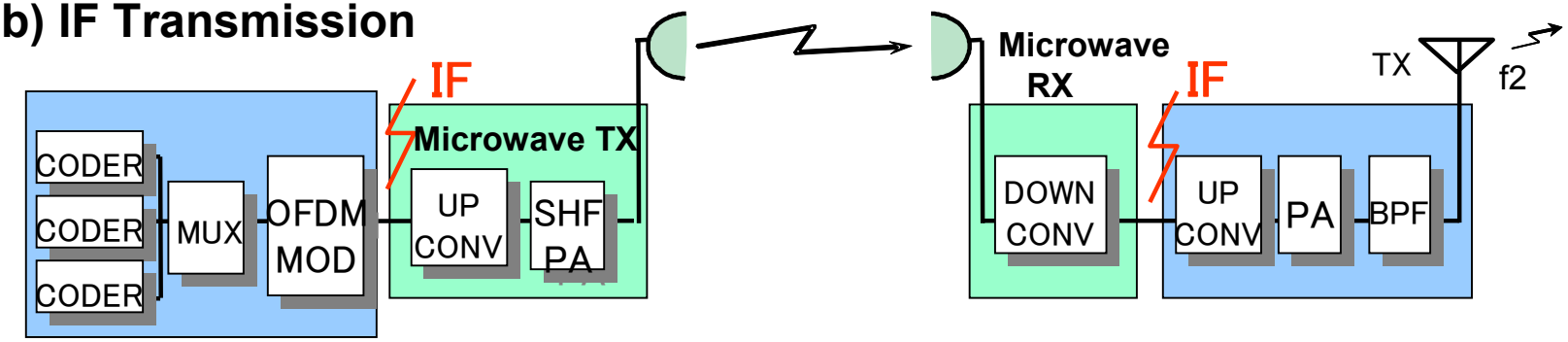
Multi Frequency Network (MFN)

(2) Classification by transmission measures in Network

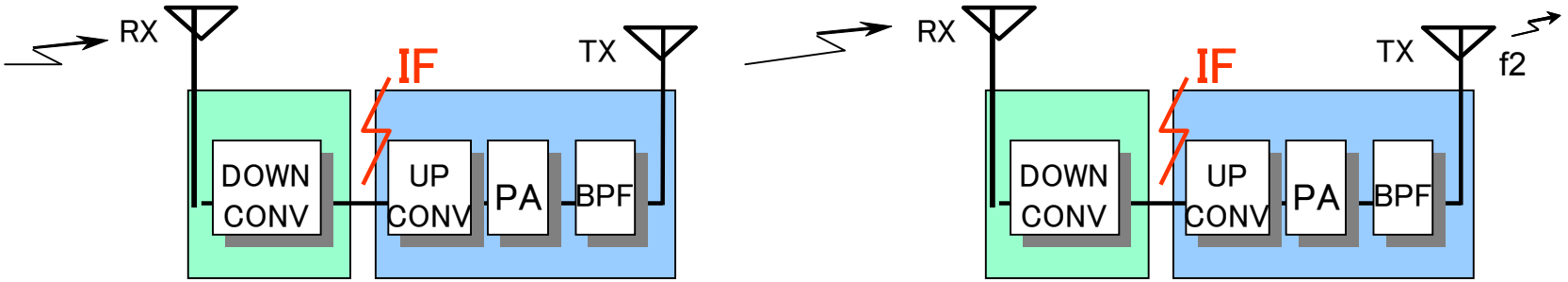
(a) TS Transmission



(b) IF Transmission



(c) Broadcast Wave Relay



Comparison of network system

Network type	Infra & maintenance cost	Signal quality	SFN timing adjustment	Save micro-wave frequency resource
TS transmission-microwave/fiber	**3**	**1**	**1**	**2**
IF transmission-micro wave/fiber	**2**	**2**	**1**	**2**
Broadcast- wave relay station	**1**	**3**	**2** (note1)	**1** (note2)

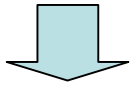
(note1) for Broadcast wave relay system, transmission the range of transmission timing is limited.

(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;

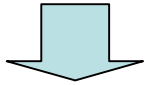
In digital transmission, threshold C/N is important. Under threshold C/N, receiver does not operate well. On the other hand, in analog system, under required C/N, only picture quality degrade. The C/N degradation is caused not only by thermal noise but also by another causes such as equipment degradation,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



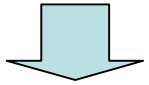
Check Network Model

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

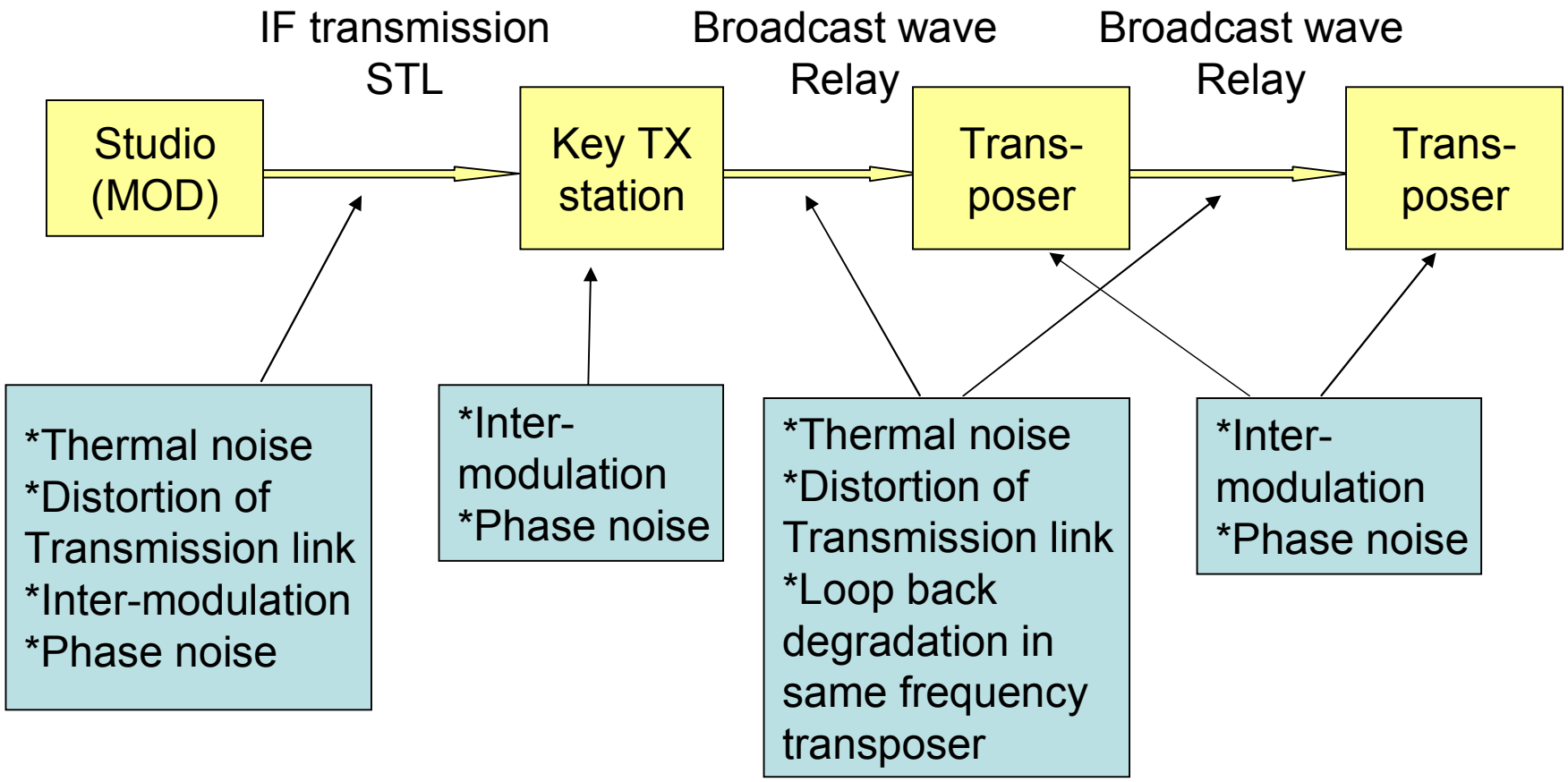
Equivalent C/N is degraded by equipment degradation, especially in multi-stage transmitter chain, these degradation are accumulated.

(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



(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, relation ship between number of stage and required C/N is shown below.

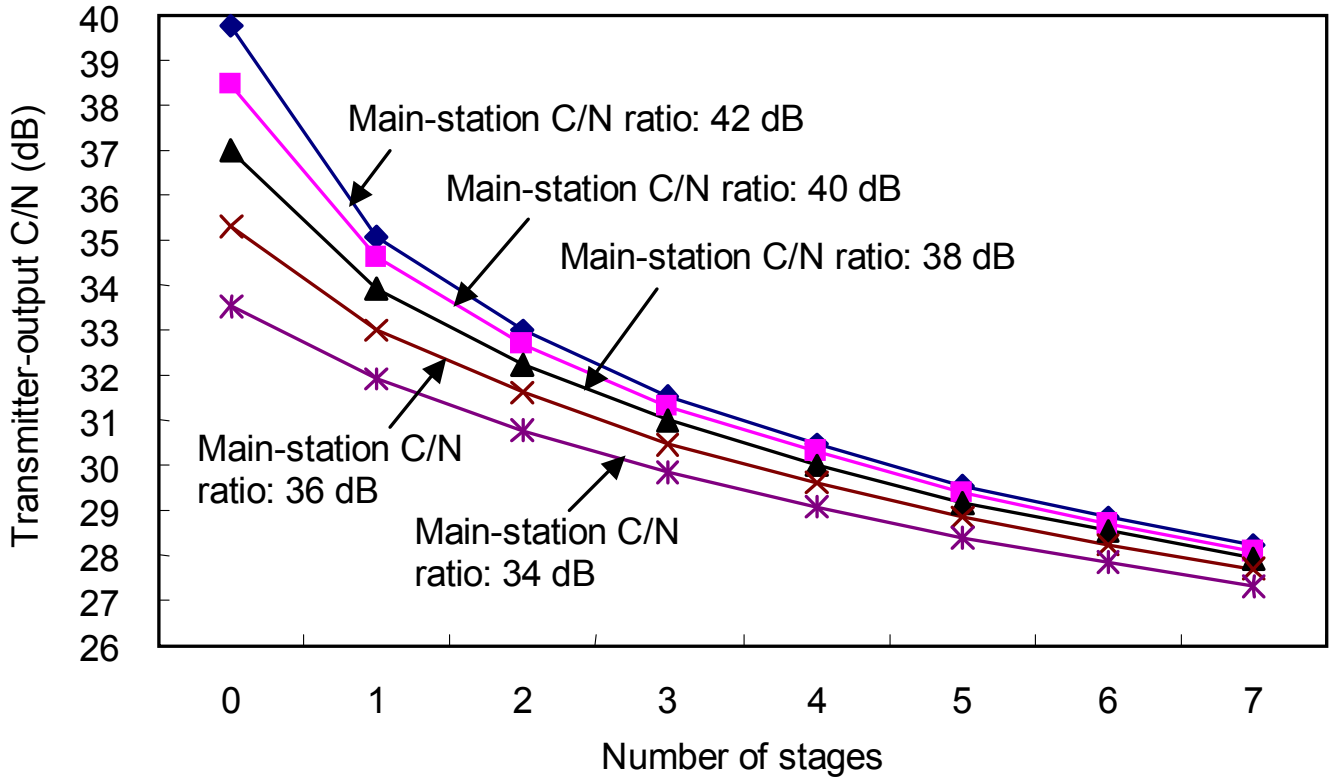


Fig. A3.4-2: Impact of Changes to the Equivalent C/N Ratio of the Main Station's Transmitter on the Transmitter-Output C/N Ratio

1.2 What's are key points of Network Design? (Continued)

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.

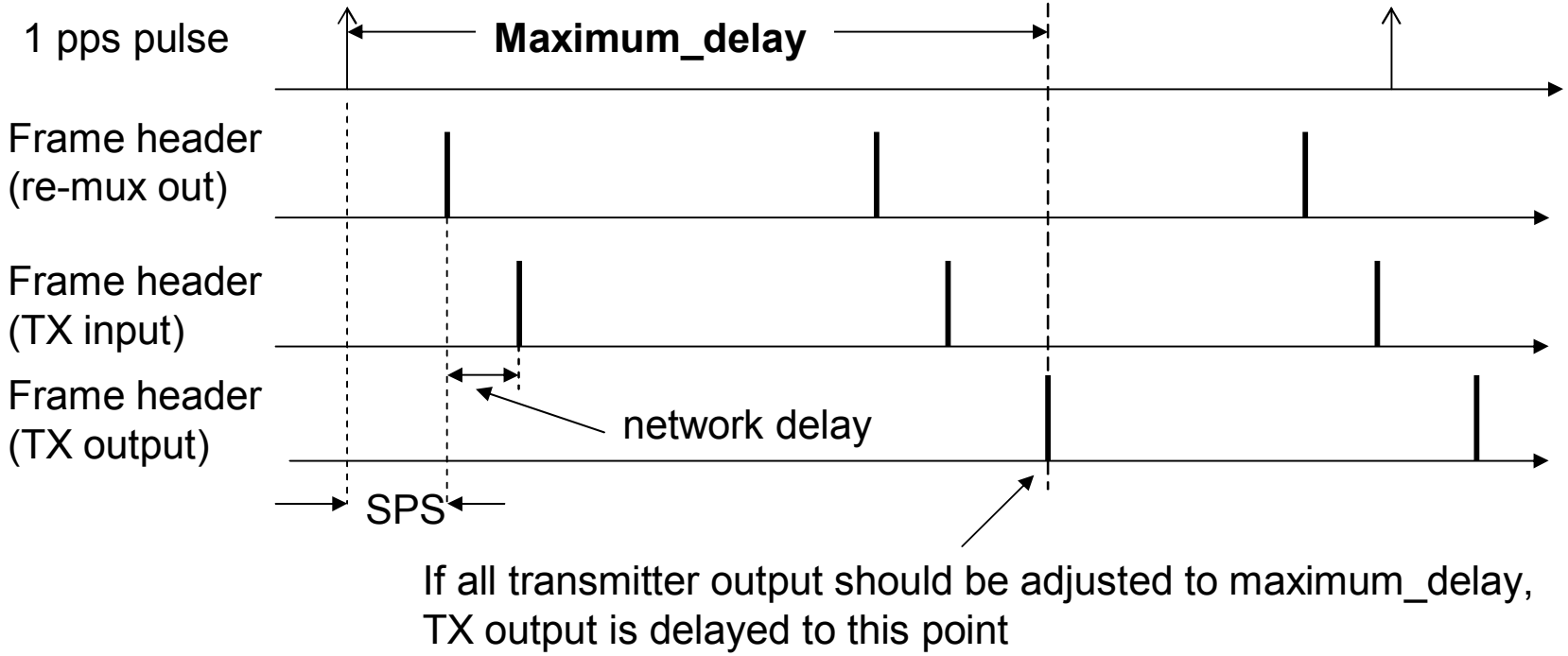
⇒ An Example is shown in Chapter 2.

(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.

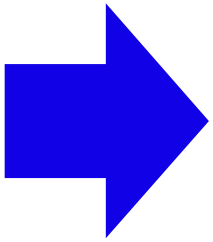
Example of Network_synchronization_information



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)***

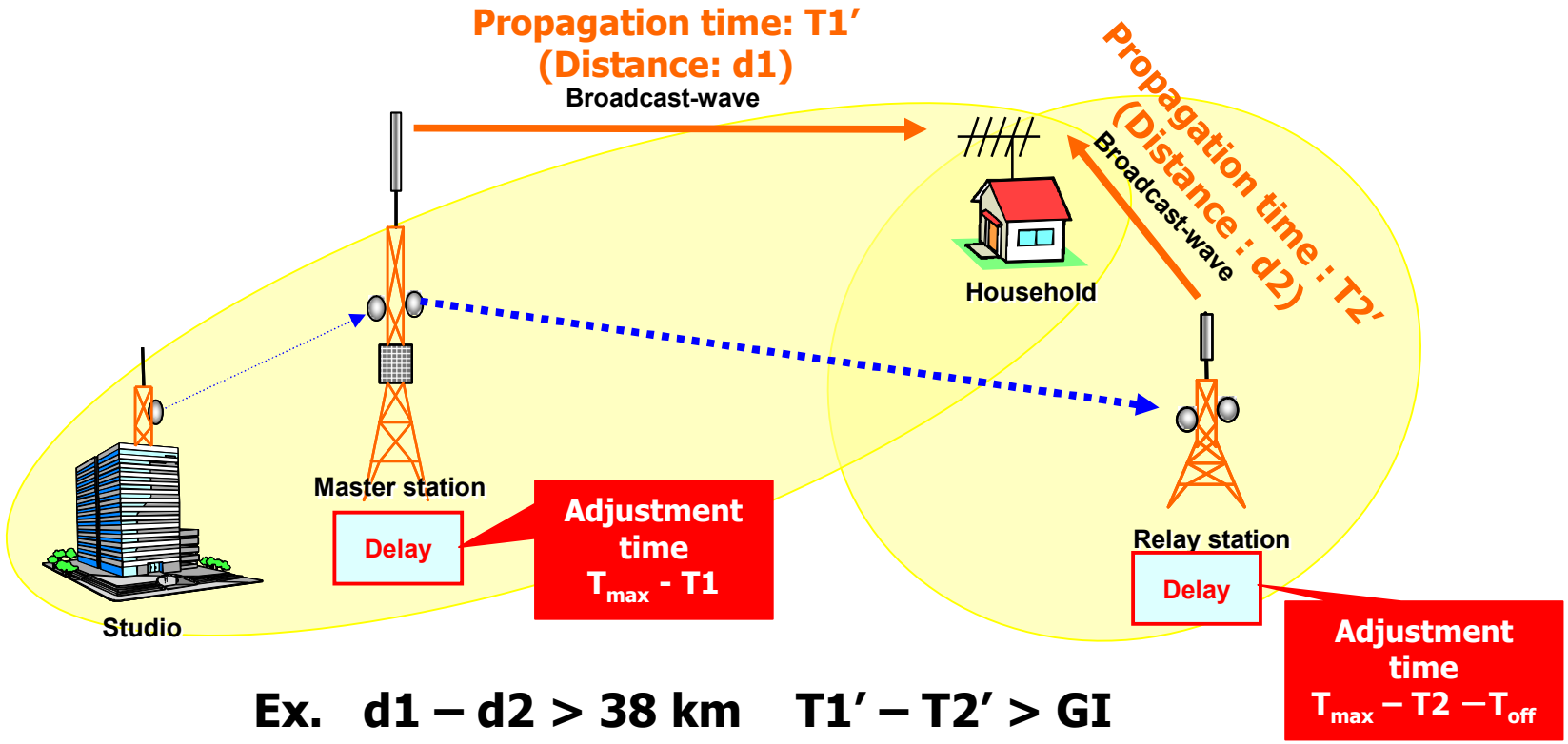
  Broadcast-wave emission timings of the broadcast stations are initially set at the maximum network delay.

- ***The Adjustment between broadcasting stations uses a relative delay .(fine-tuning)***

  A time offset is set at each broadcasting site, if necessary.

Fine Adjustment

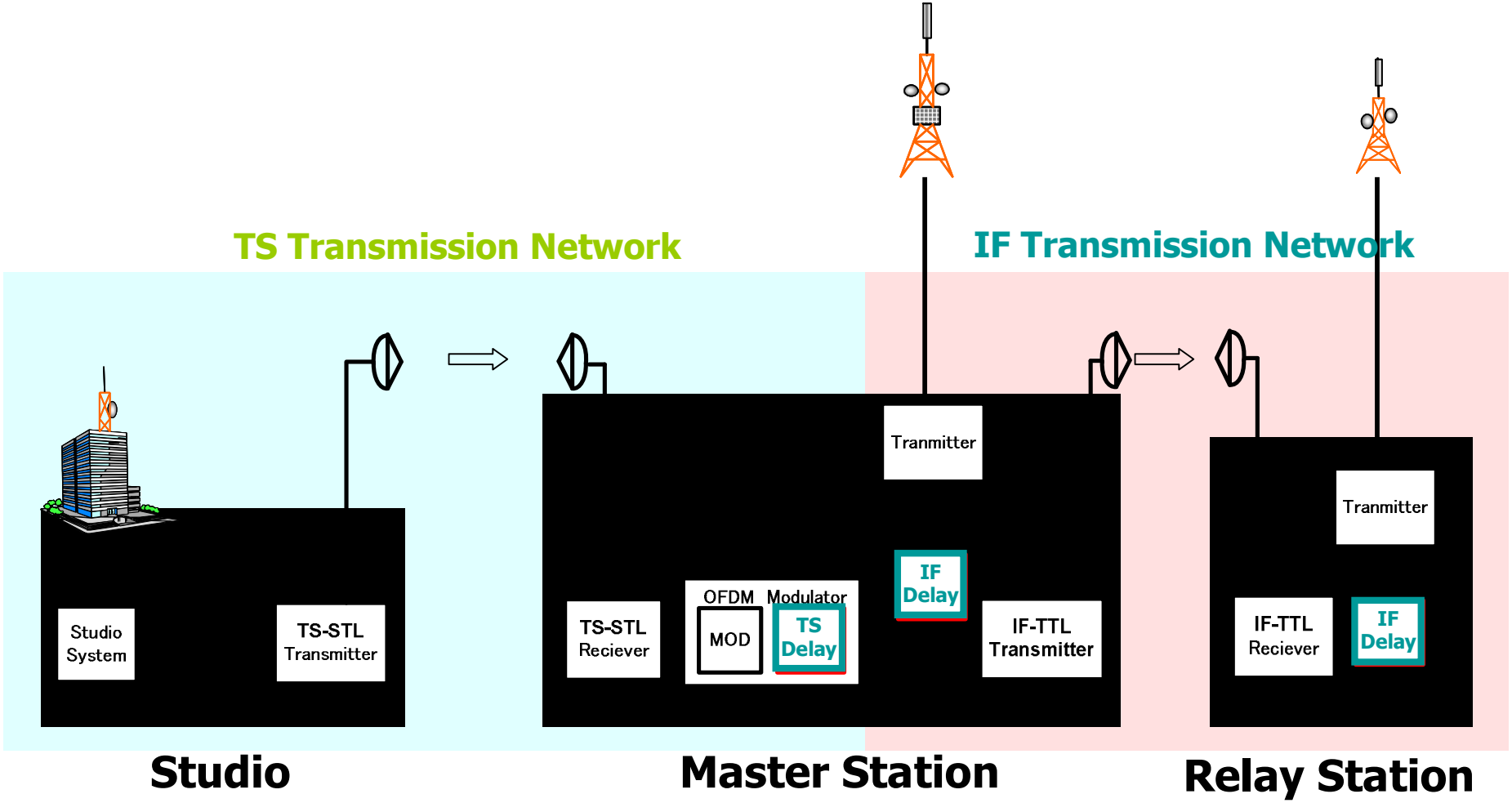
Adjust Relative Delay (Time offset : T_{off}) of Each Station



Ex. d1 – d2 > 38 km T1' – T2' > GI

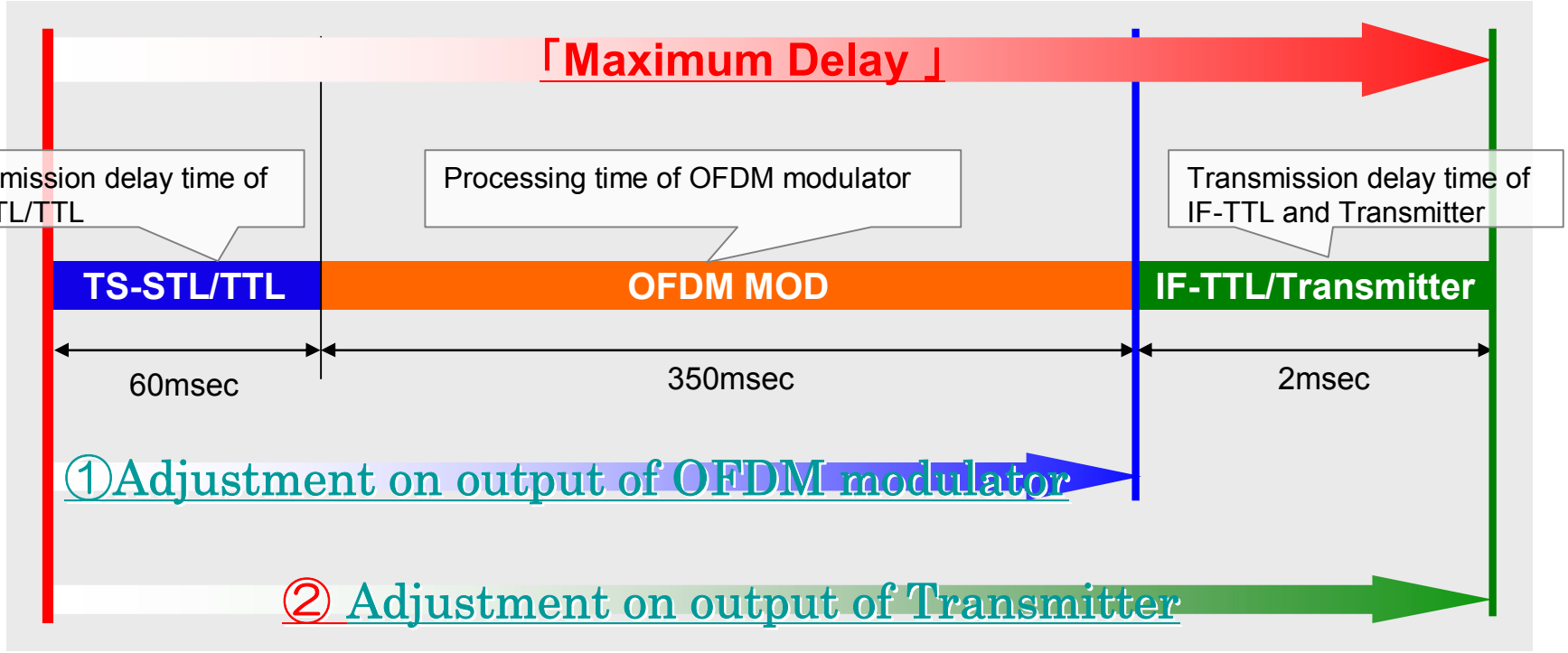
$T1' - (T2' + T_{off}) < GI$※

Adjustment System

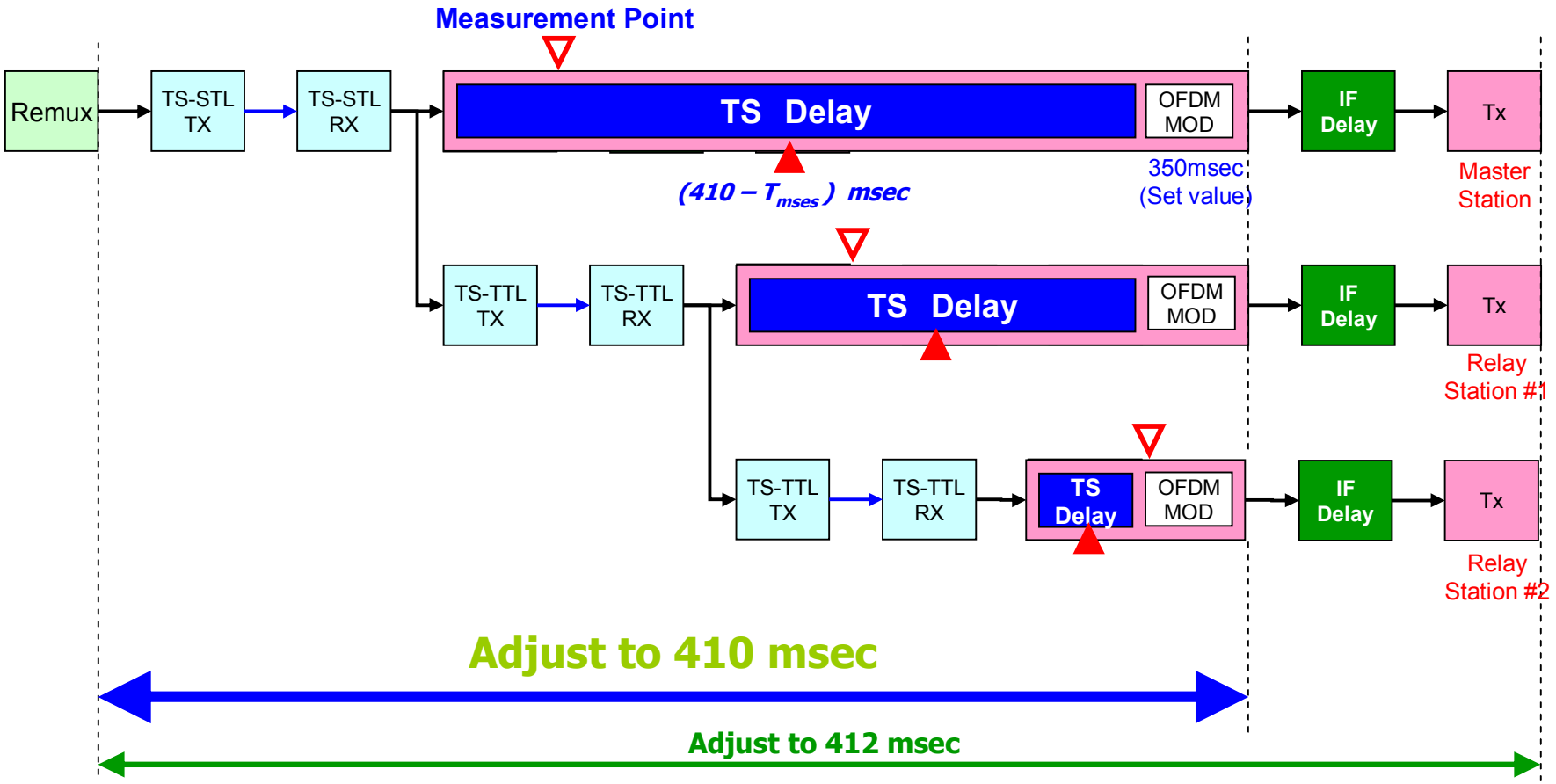


Maximum Delay

- ***Adjustment Point***
  - ***① Output of OFDM Modulator***
  - ***② Output of Transmitter***



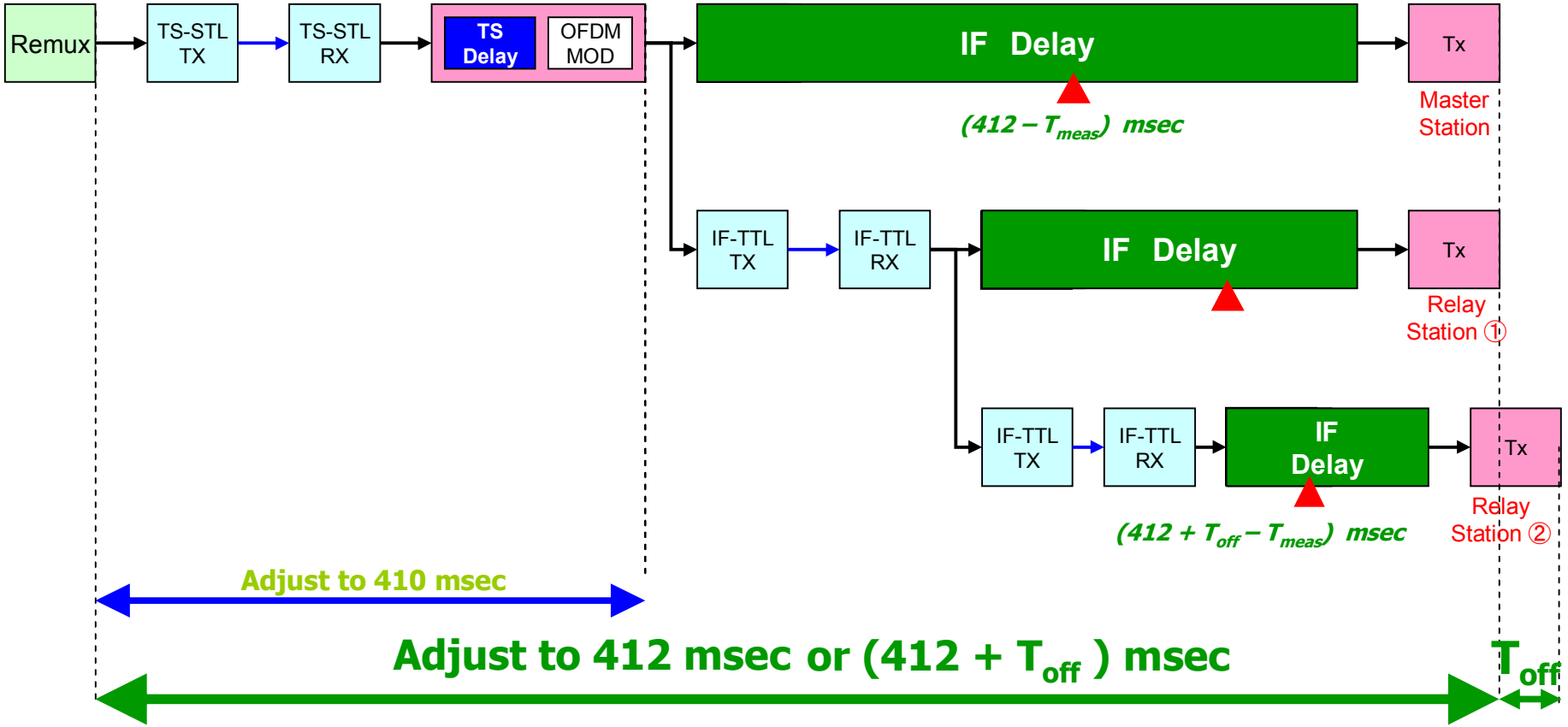
Adjusting the OFDM Modulator's Output



Adjustment time of "TS Delay"

410 msec – T_{meas}

Adjusting the Transmitter's Output



Adjustment time of "IF Delay"

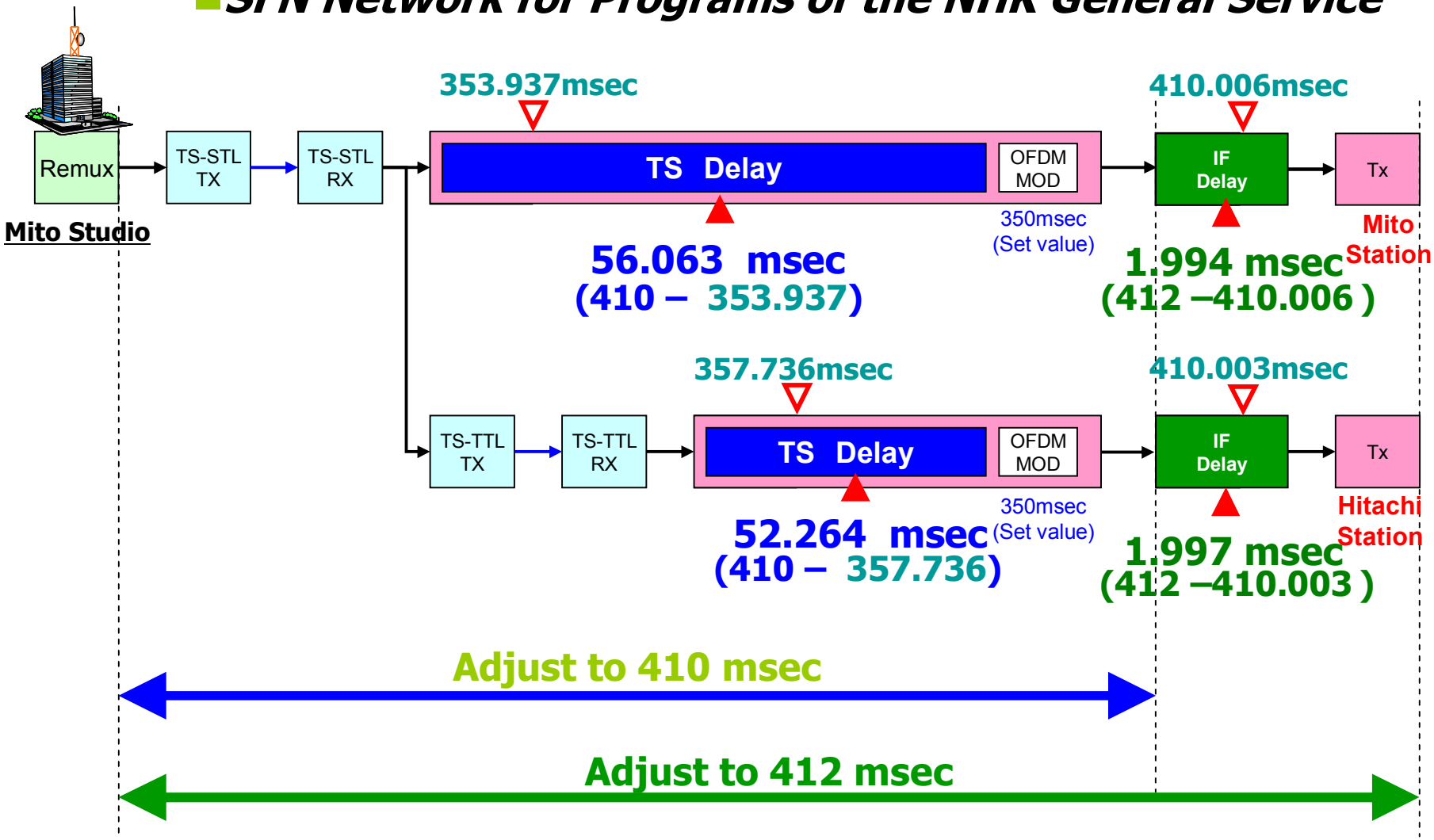
412 msec+ T_{off} – T_{meas}

The First Practical SFN (by TTL Network)

Transmission Engineering Center – Engineering Administration Department – NHK

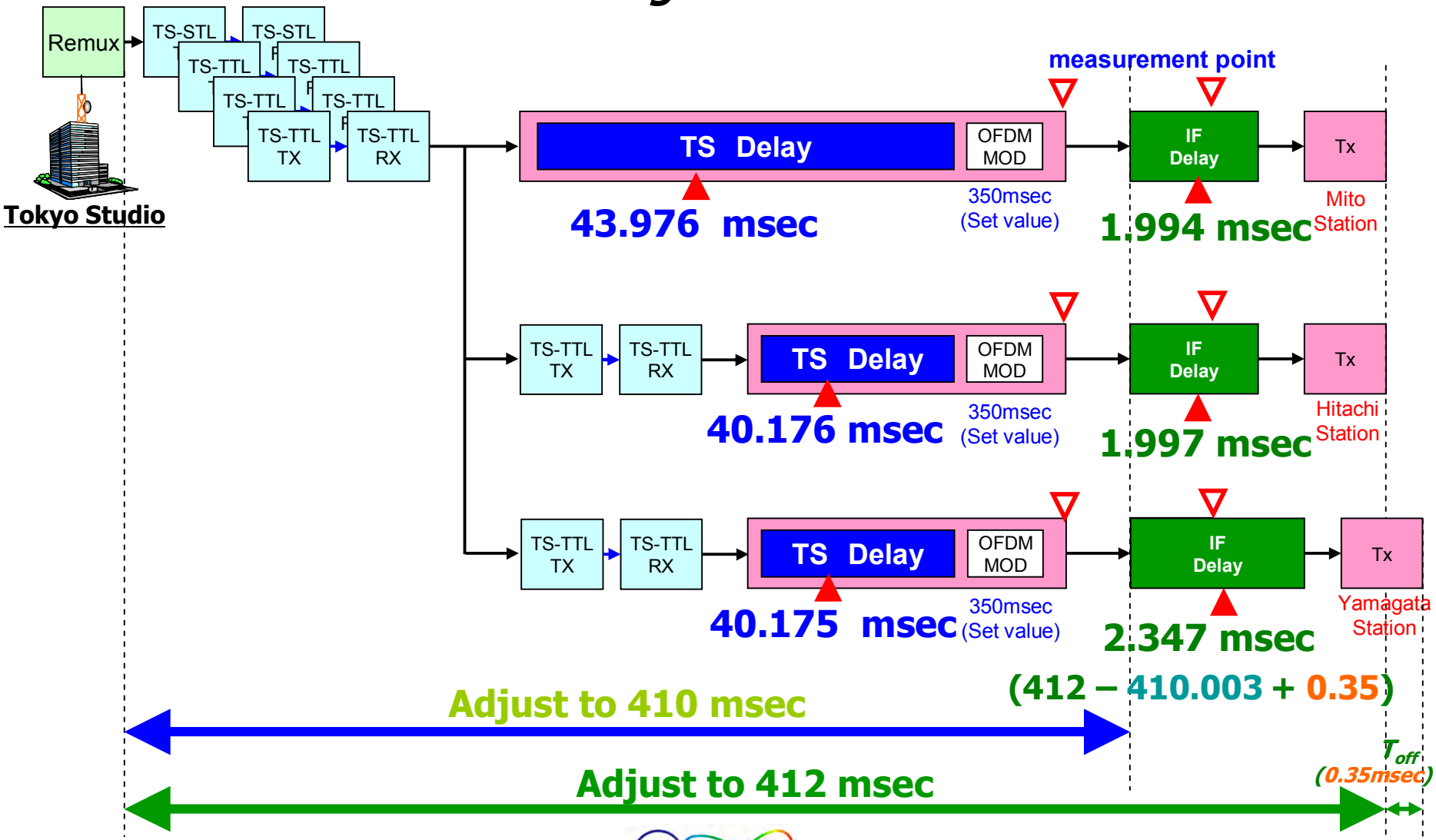
Adjusting the OFDM Modulator's Output

SFN Network for Programs of the NHK General Service



Adjusting the OFDM Modulator's Output

SFN Network for Programs of the NHK Educational Service



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 trans-poser

(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.

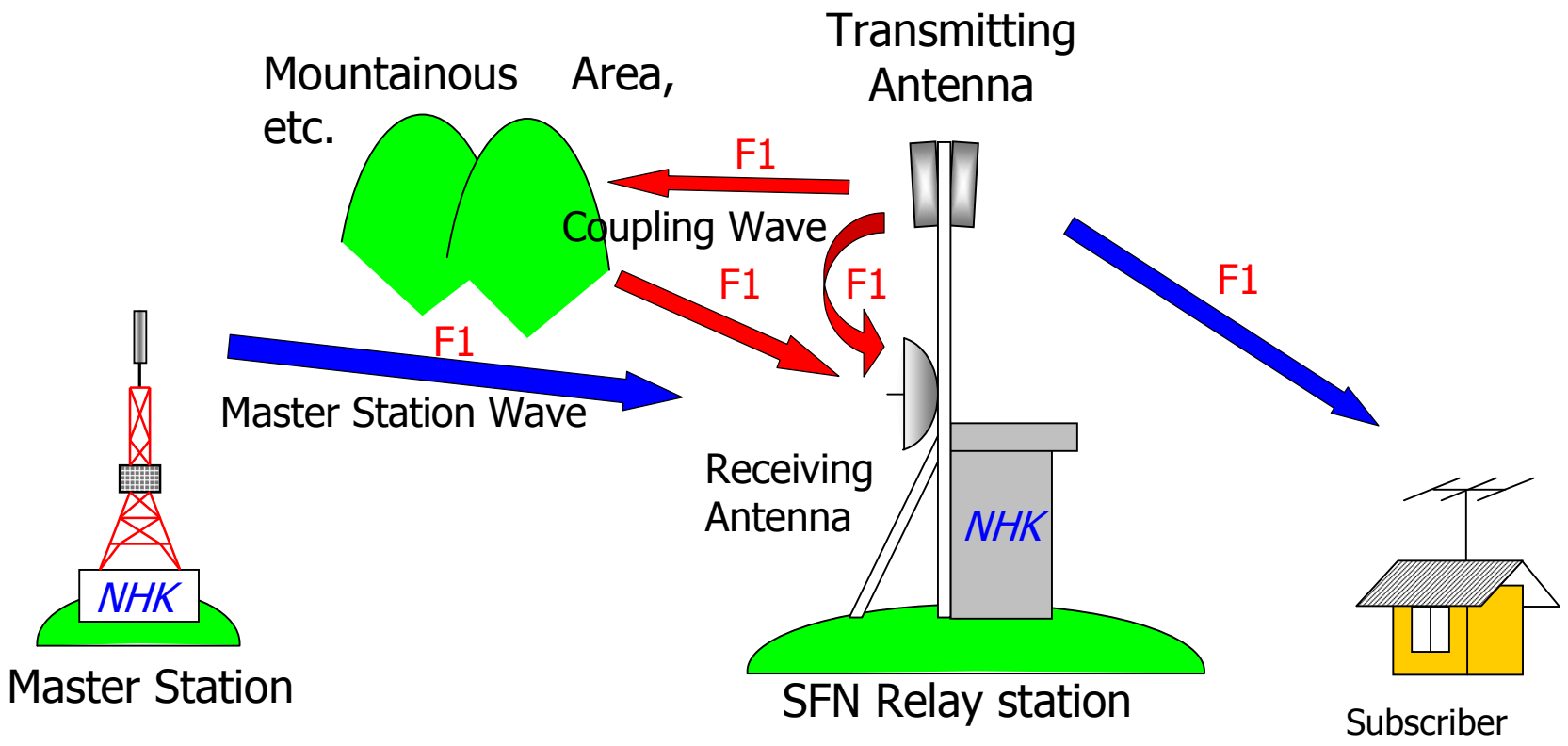
-Coupling loop interference(CLI) canceller; compensate the coupling loop between TX antenna and RX antenna in SFN

-Diversity receiving technology; Improve the degradation caused by fading. This technology is useful not only transmission network but also mobile reception.

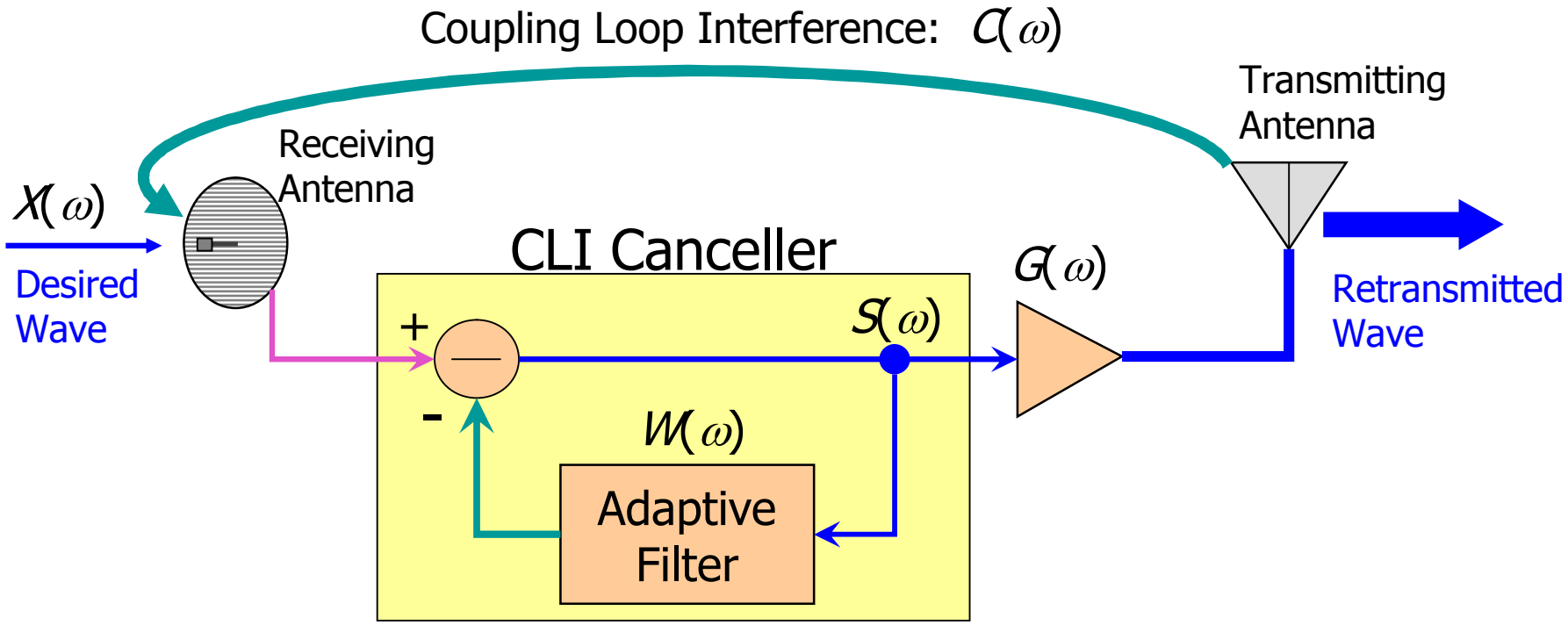
(1)Capling Loop Interference (CLI) Canceller

(note) Dedicated by NHK

Coupling Loop Interference at SFN Broadcast Wave Relay Stations



Principle of CLI Cancellation



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

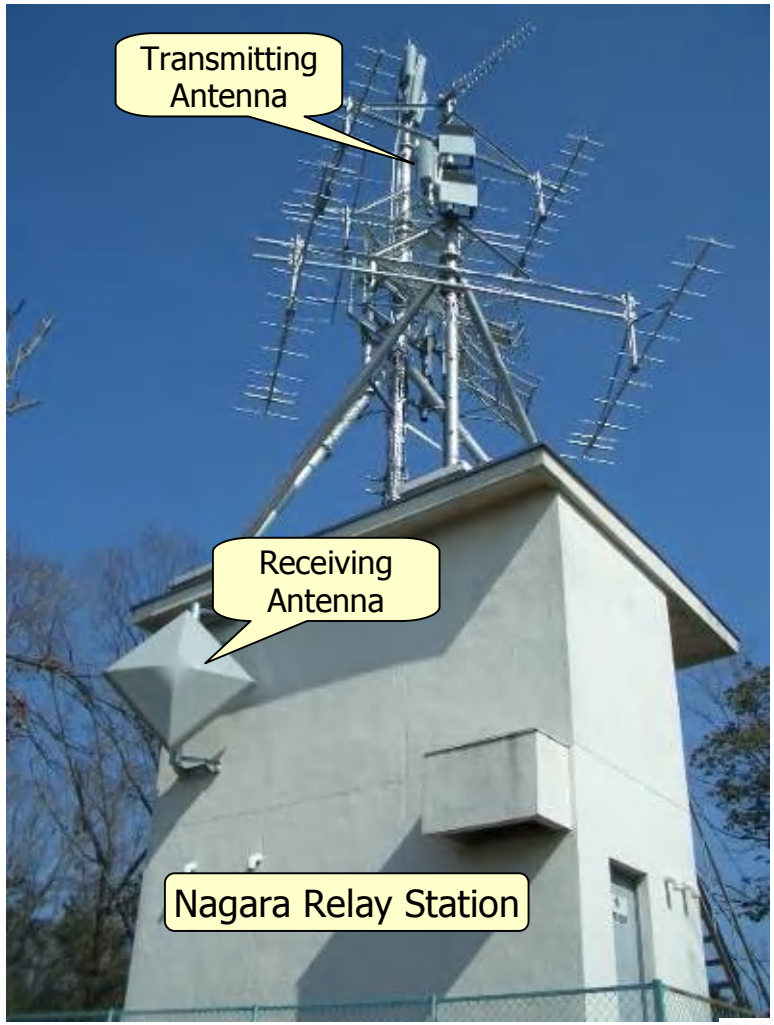
The error is solved as: $E(\omega) = C(\omega) \cdot G(\omega) - W(\omega)$

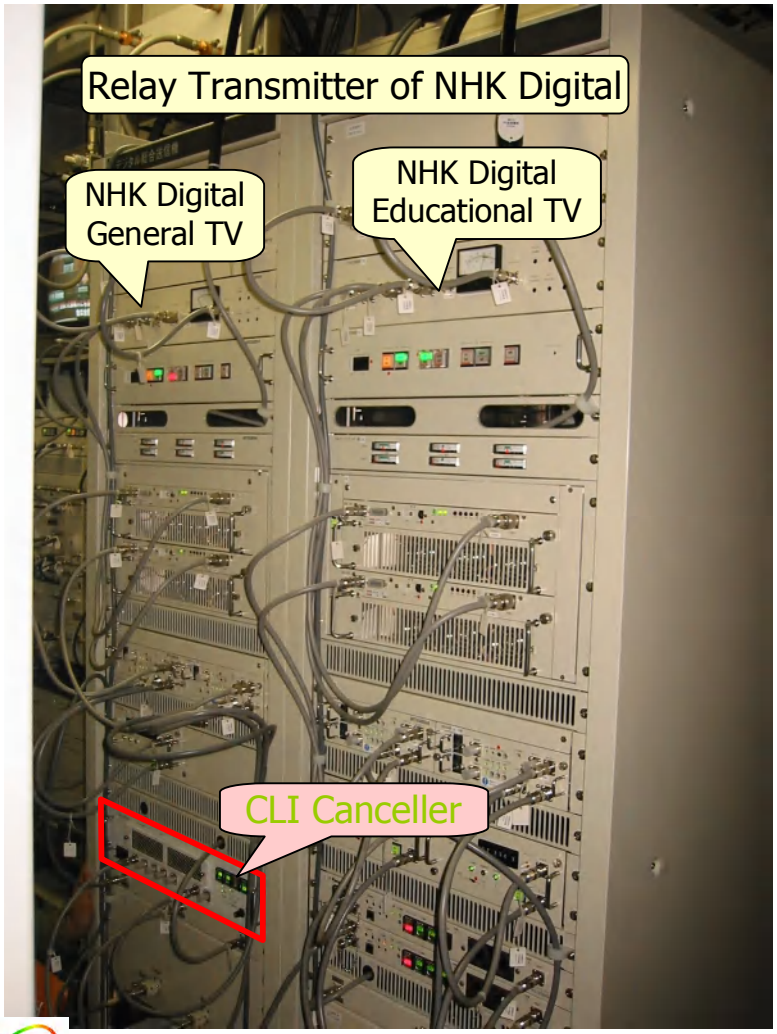
$$= 1 - \frac{X(\omega)}{S(\omega)} \quad \left(= 1 - \frac{1}{F(\omega)} \right)$$

The Practical SFN (by Broadcast Wave Relay Network)

Transmission Engineering Center – Engineering Administration Department – NHK

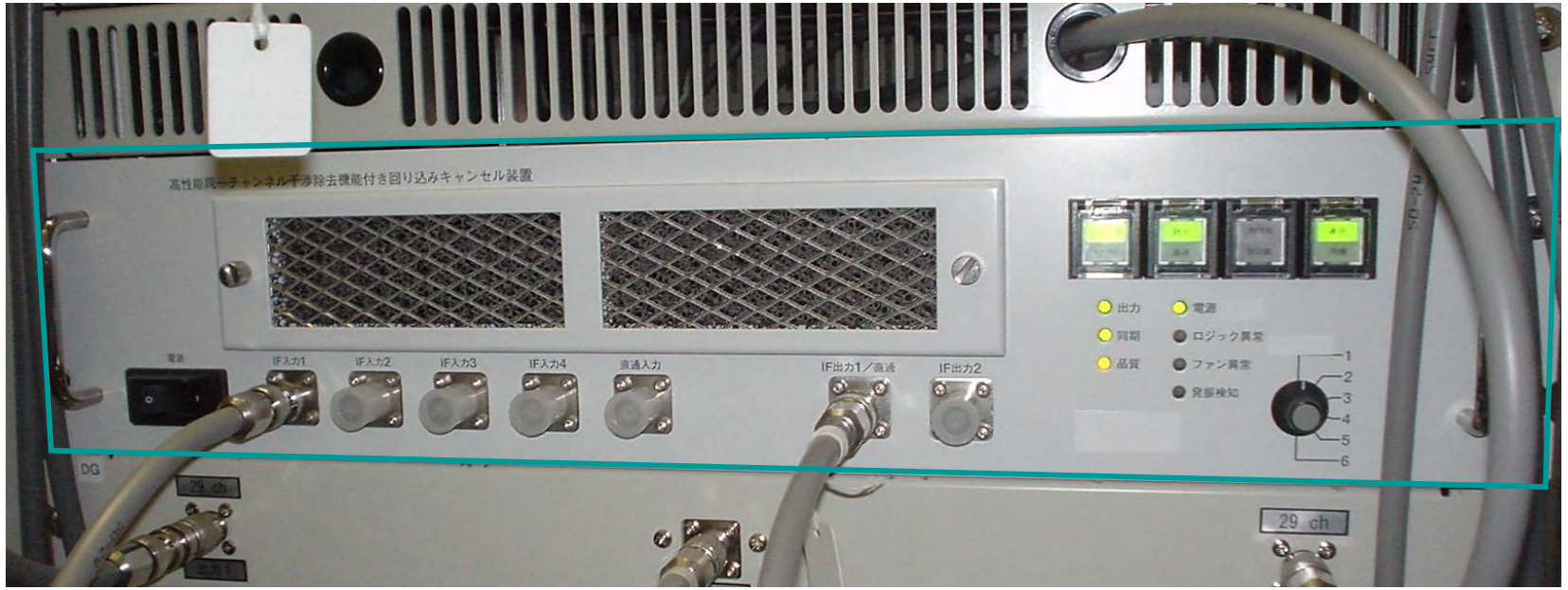
The SFN was Built in Nagara Relay Station



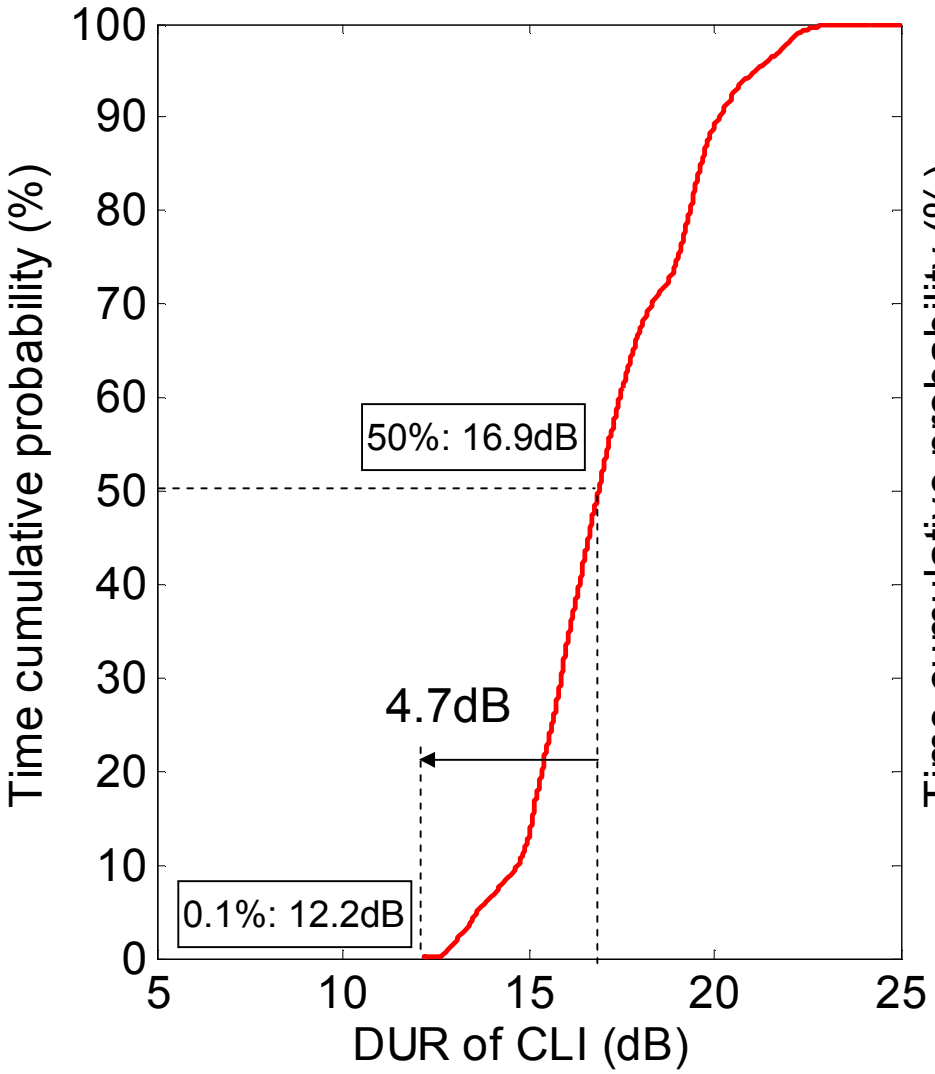


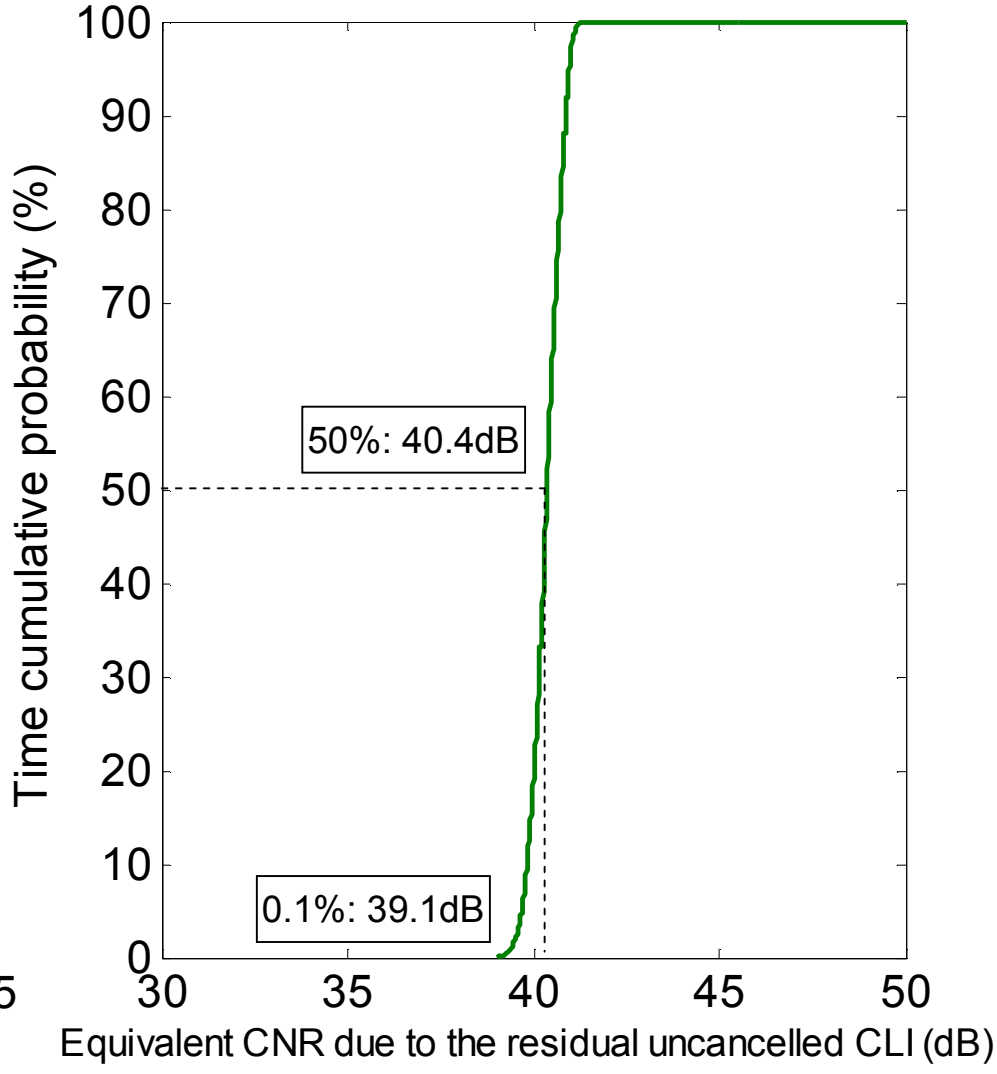
CLI Canceller in Practical Use

- The CLI canceller has been used for NHK Digital General at Nagara relay station.
  - 1st generation CLI canceller in practical use



Time Cumulative Probability

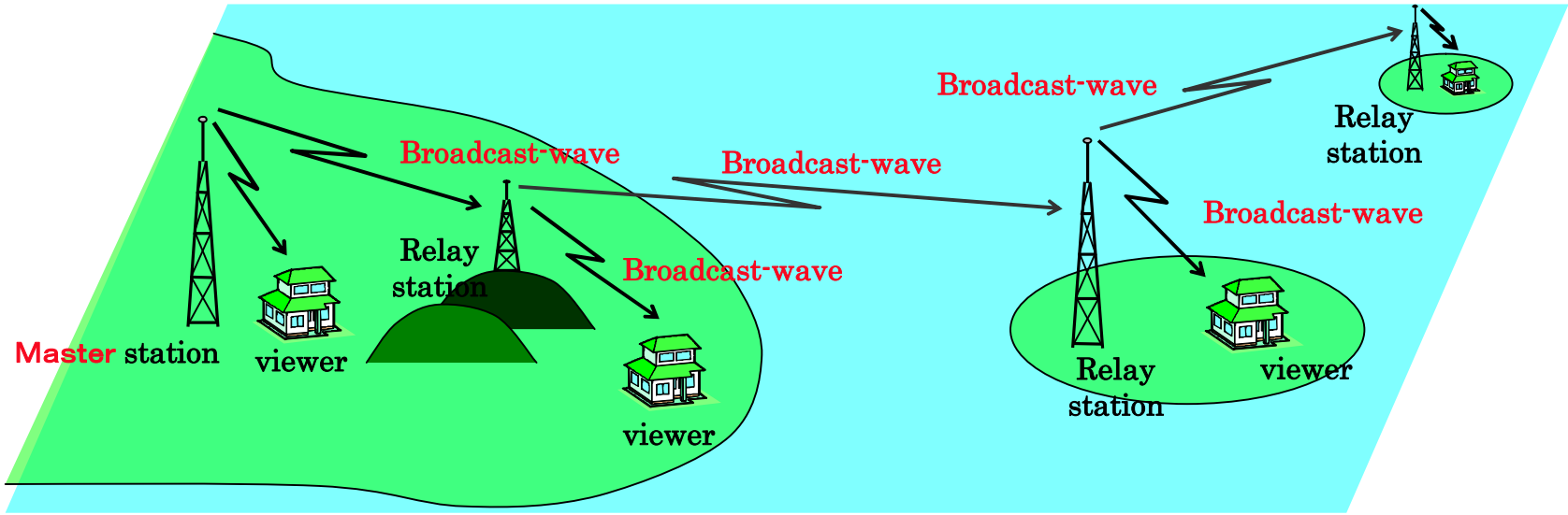




(2) Long Distance Broadcast Wave Relay Network with Diversity reception System

(note) This example is Dedicated by
Japan Radio Co. Ltd (JRC)

Broadcast-wave relay to isolated islets



Merit of broadcasting wave relay

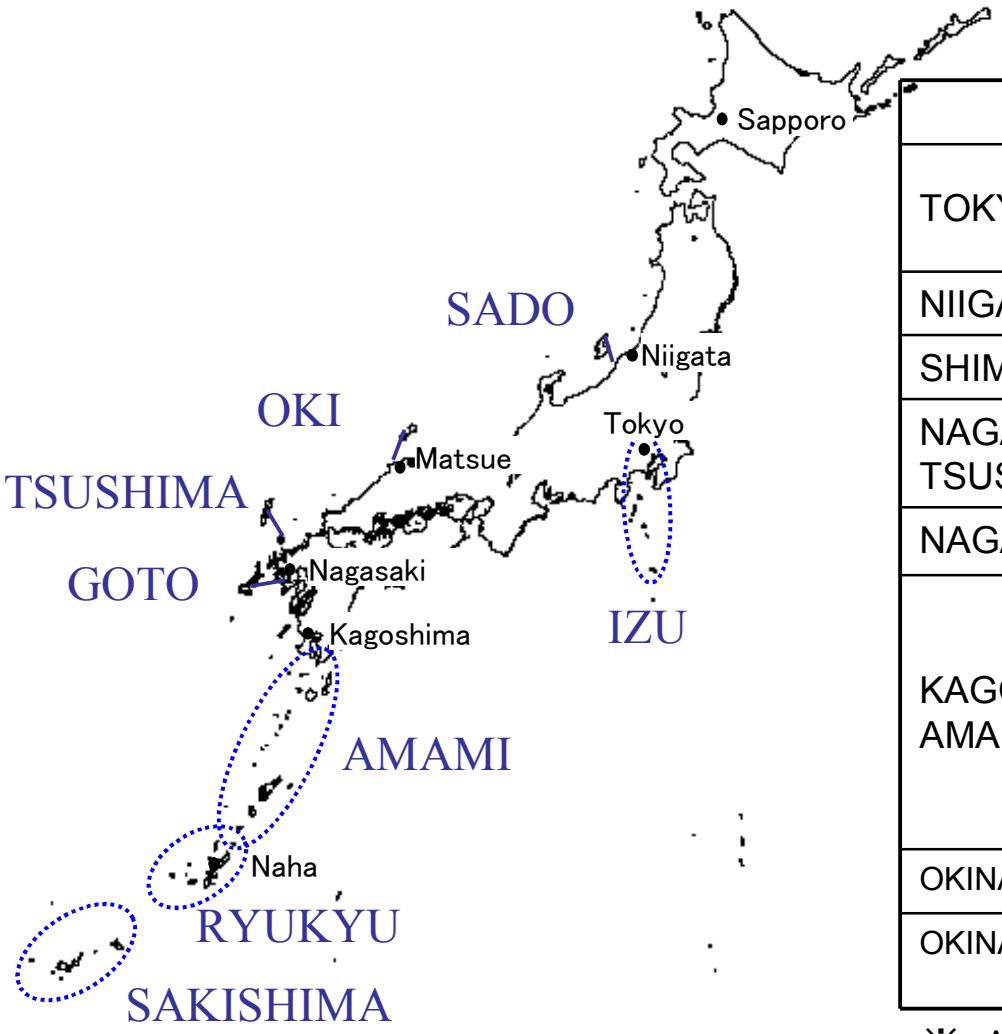
・Low cost ・・・dedicated links (TTL, OPTIC LINK) are unnecessary

・long distance relay・・・Broadcast-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



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

※ 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

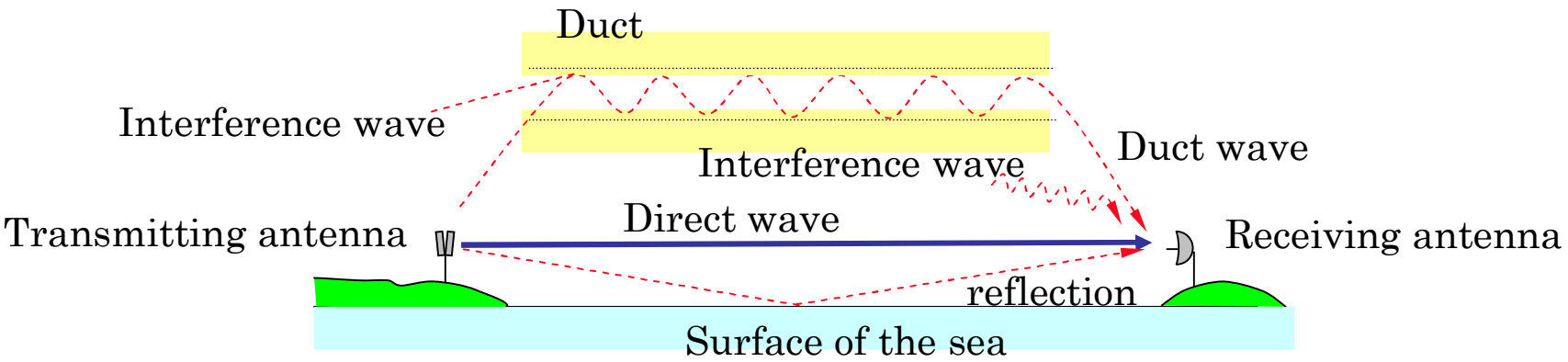
(1) Fading

The phenomenon that receiving level deteriorates temporarily.

Fading makes C / N of receiving signal bad and makes reception impossible.

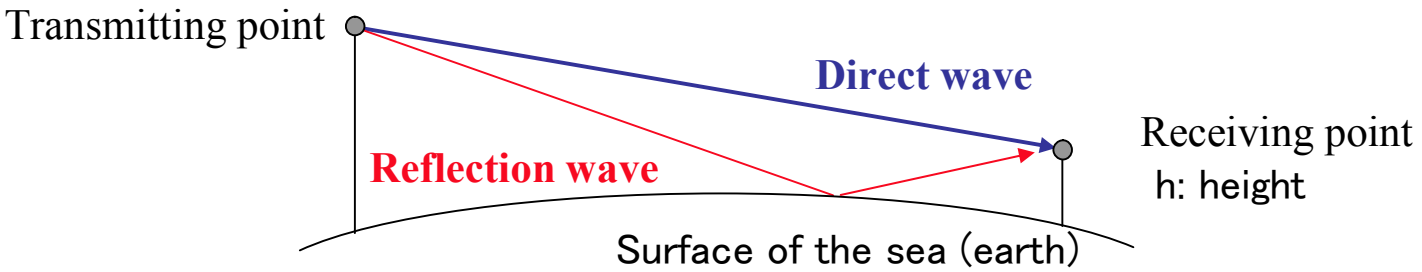
(2) Co-channel interference

Interference waves of same frequency make C / N of receiving signal bad.



Mechanism of fading

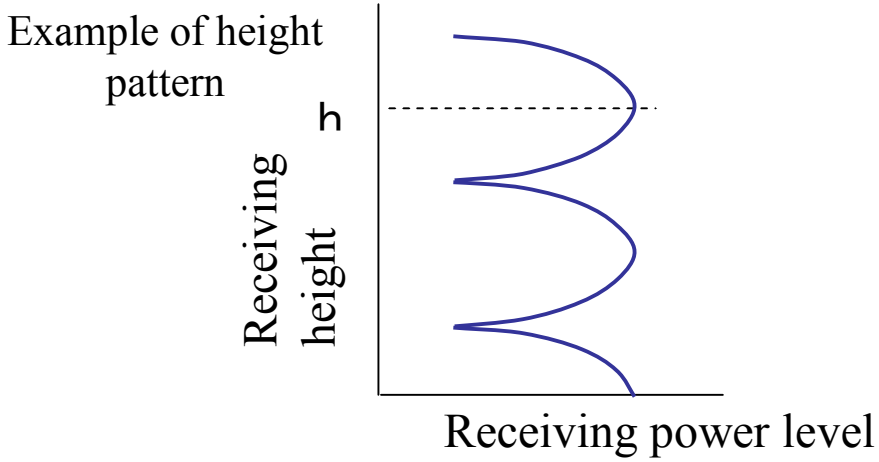
The receiving signal is mixture of direct wave and reflection wave.
Fading is the phenomenon that the phase change of these waves induce the receiving power level.



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

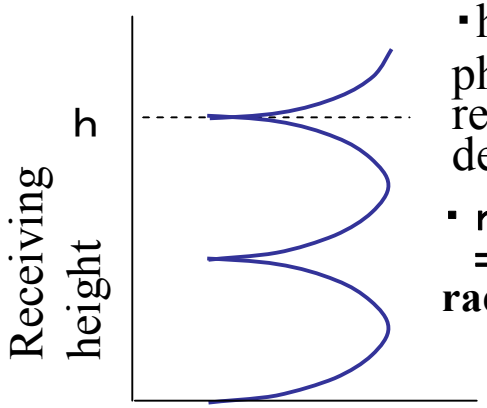
(a)K＝1．3

The power level is maximum at h



(b)K＝1．6

The power level is minimum at h



・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.

  ⇒ the receiving power drop becomes 3dB by SD reception.

- Actually there are many cases difficult to set 2antennas by half pitch physically. The antennas might be set in a shorter distance than the half pitch.

  ⇒ Some drop of receiving level must be permitted.

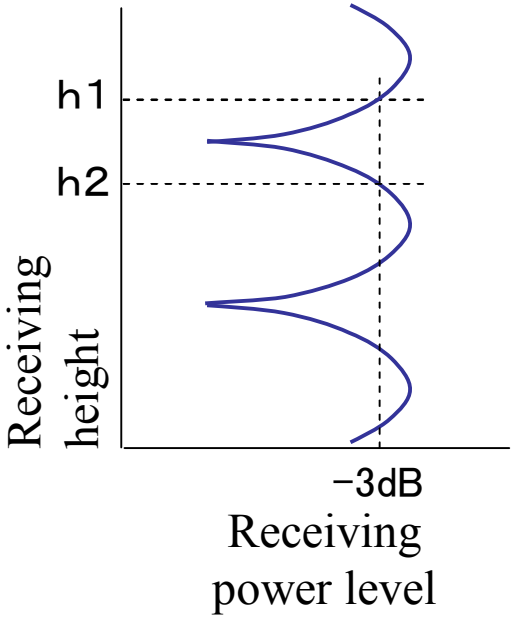
Relay distance and half pitch

Relay distance	Ideal antennas' distance (half pitch)
25km	13m
50km	28m
75km	50m
100km	95m
125km	260m

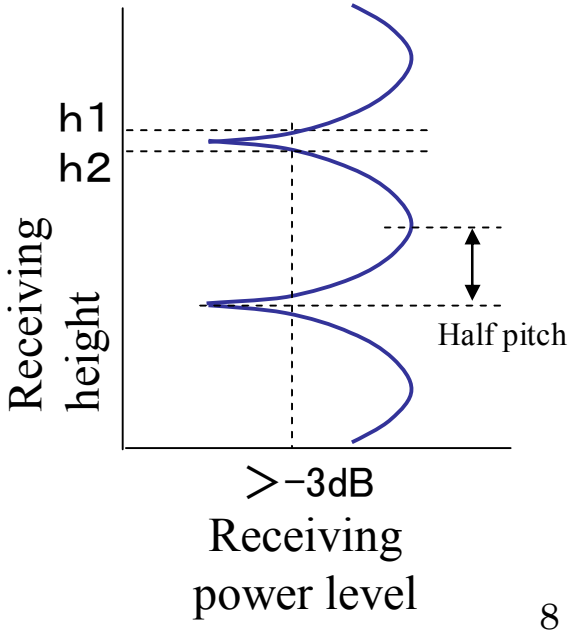
20ch(515MHz)
Antenna height from sea-level: 300m
K=4／3

2 antennas' distance:

(a) Half pitch



(b) Shorter than half pitch



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)

	Digital broadcasting （ISDB－T）	Analog broadcasting （NTSC）
Required C／N	20．1dB (64QAM、FEC:3/4)	30dB
Required receiving power level	－80．2dBm＋α (α : drop by multi-path)	－70．2dBm＋β (β : drop by multi-path)
Performance against multi-path	strong and no ghost	Weak and some ghost
	$\alpha < \beta$	
	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・Nf = −100.3dBm （Nf=6dB）

Actual example of SD reception

NAKANOSHIMA～NAZE

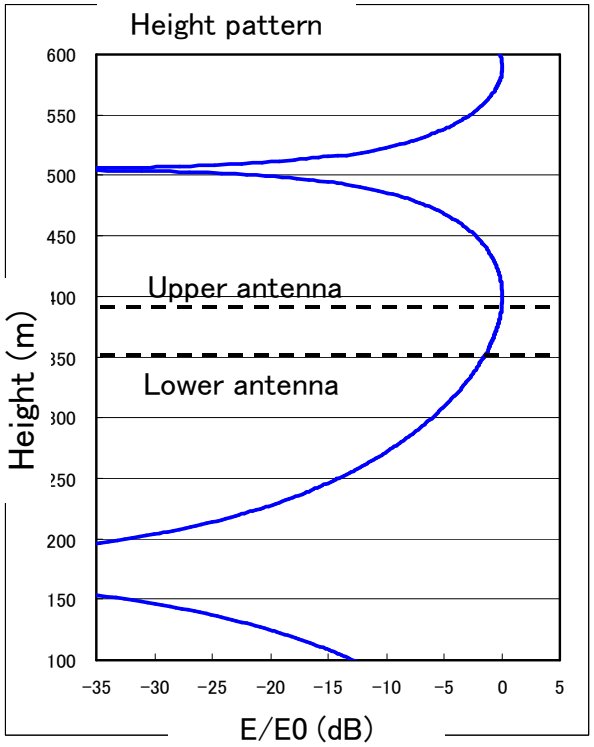
Test stations

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

Height pattern (calculation)

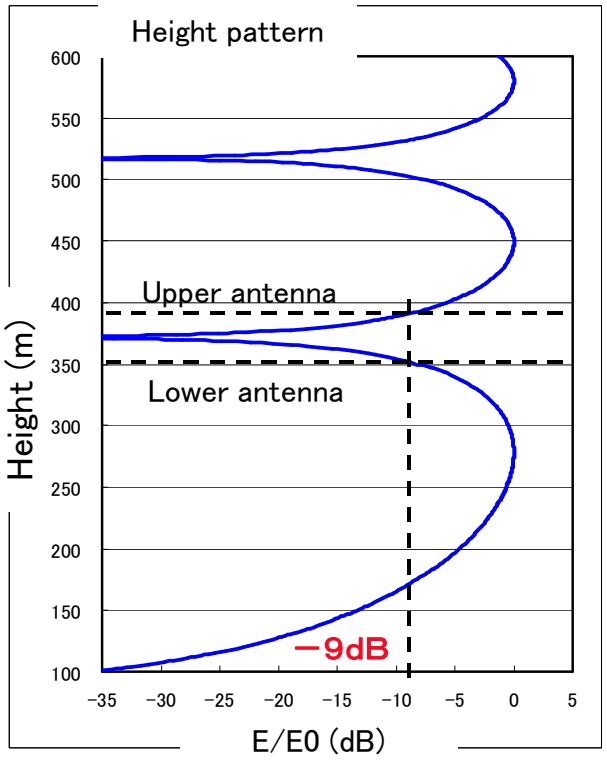
(a) normal state

K=4／3 (1. 33)



(b) fading

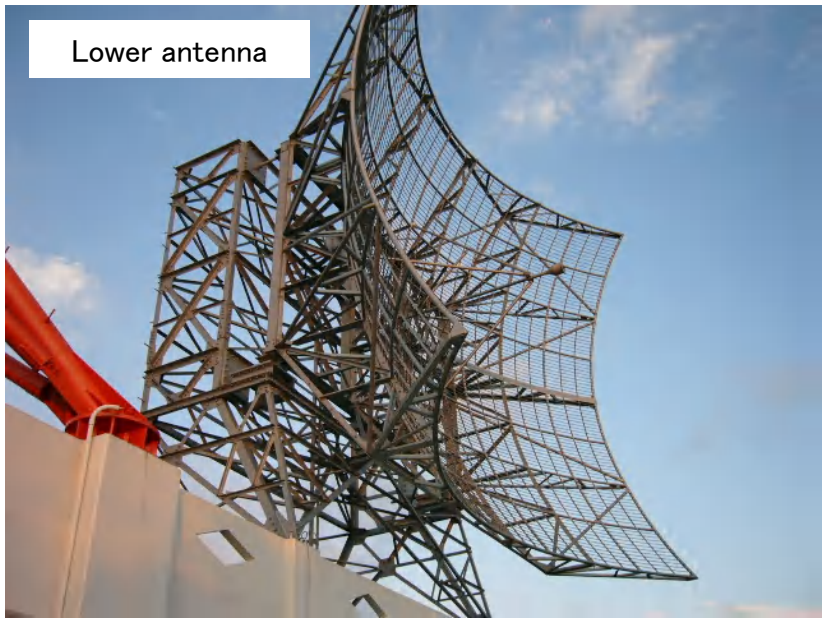
K=1. 65



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

Actual example of SD reception

Receiving antennas at NAZE station



Upper antenna

parabolic antenna 3mϕ

Lower antenna

parabolic antenna
10m×8m

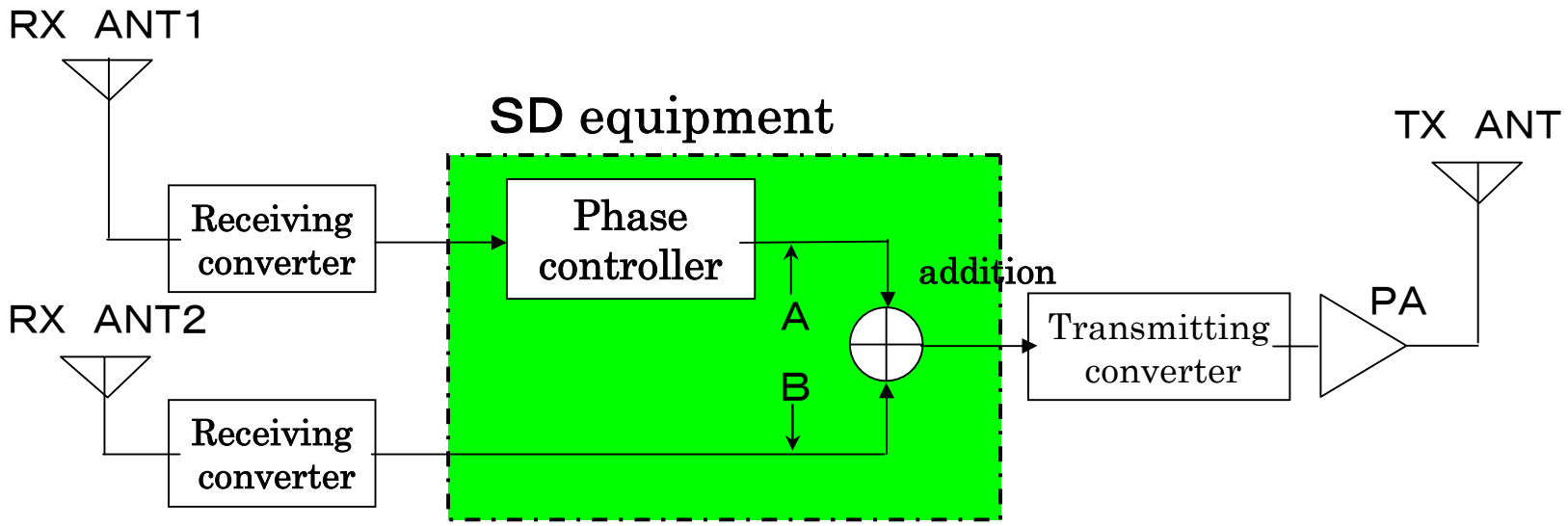
(gain32dB,beamwidth1.5deg.)

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.

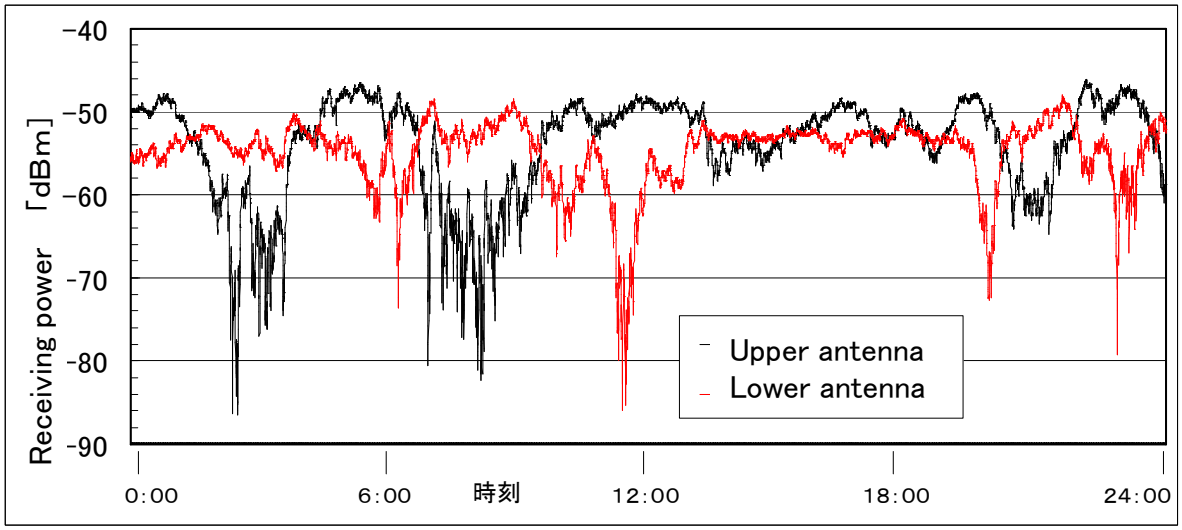
NAKANOSHIMA～NAZE SD reception test measured data

courtesy of
Minaminihon Broadcasting
Kagoshima Television Station
Kagoshima Broadcasting Corporation
Kagoshima Yomiuri Television
NHK

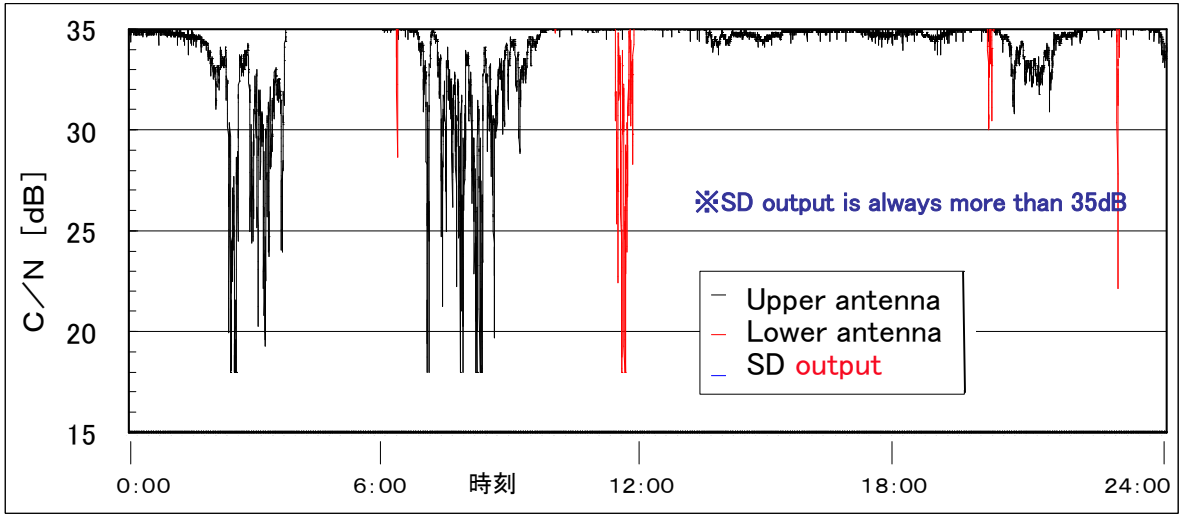
[SD equipment:IF band composite method]

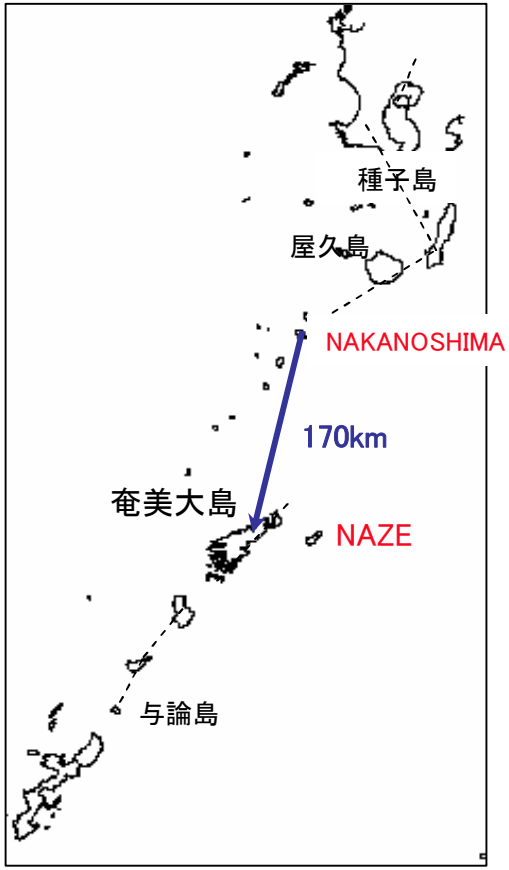
May 18, 2006　24 hours data

Receiving power



C／N





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)**

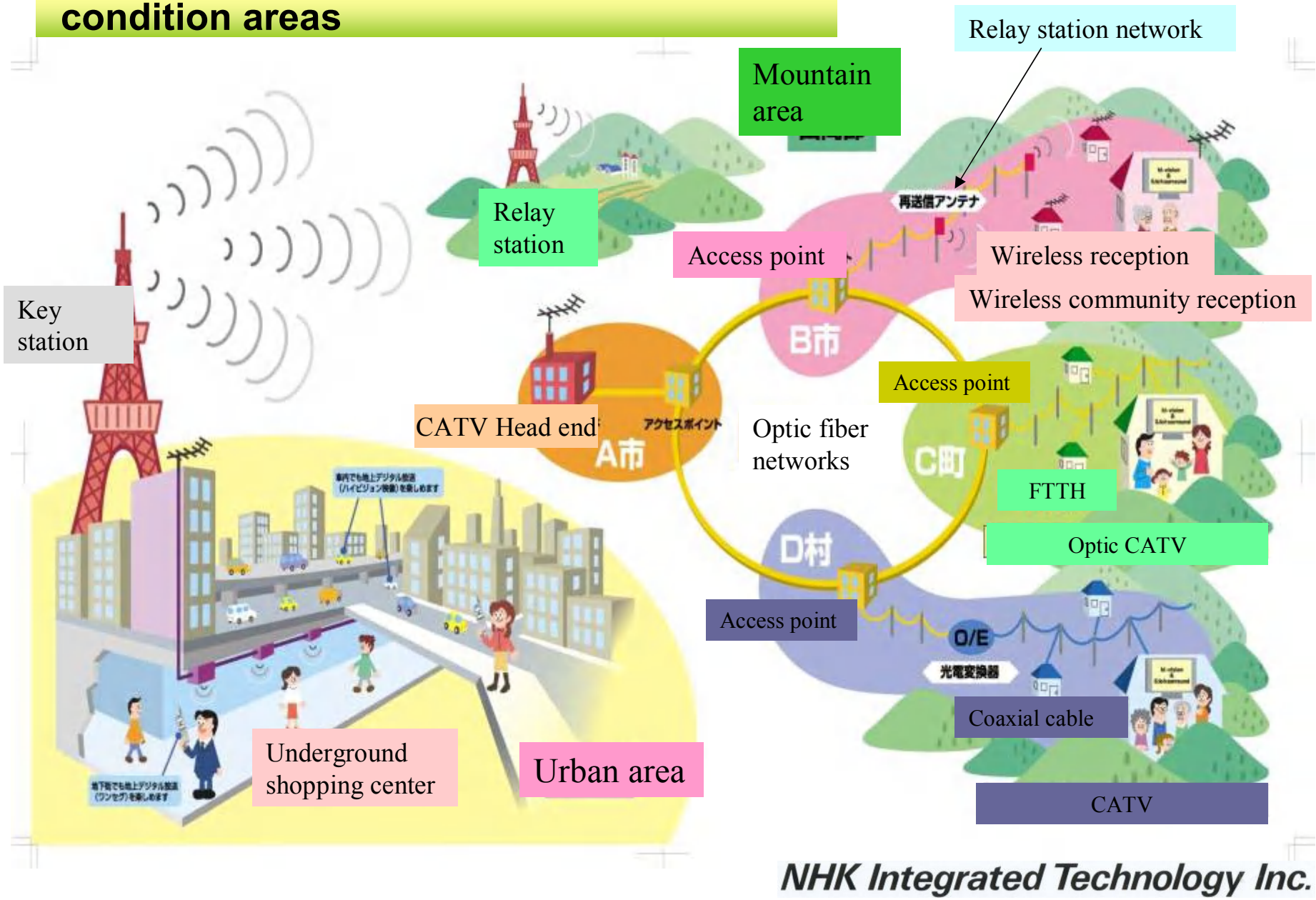
Information and communications council（01/08/2006）

Administrative role for utilization and promotion of terrestrial digital broadcasting　～3rd report～

Utilization of gap filler

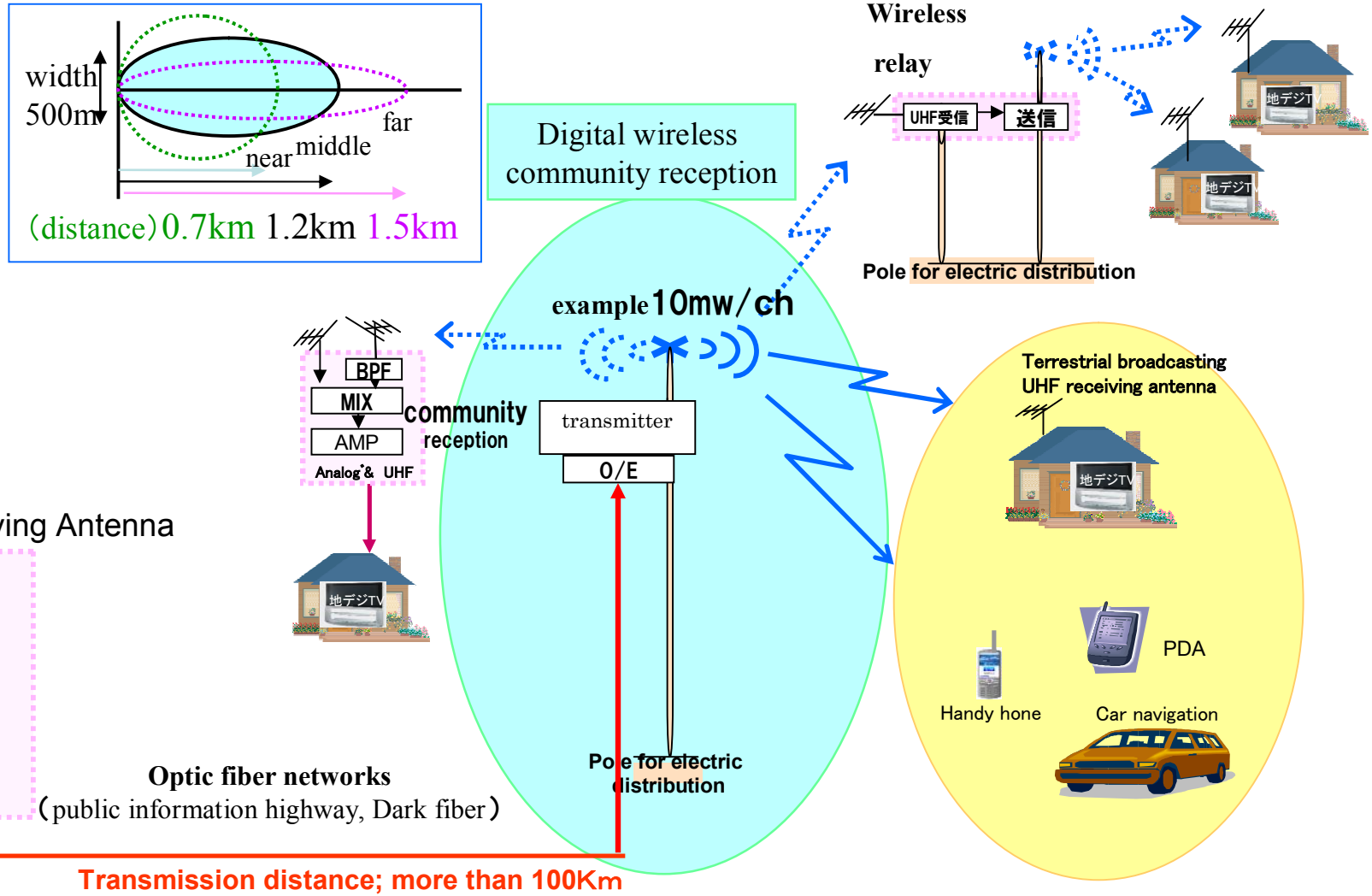
- deregulation of technical standards and qualifications is necessary
- gap filler is effective at area dotted with small villages
- gap filler by wireless should be examined in supporting remote areas as well as CATV by wire
- Portable reception service by gap filler is very effective against disasters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

Terrestrial broadcasting for bad reception condition areas



NHK Integrated Technology Inc.

Image of digital wireless community reception system



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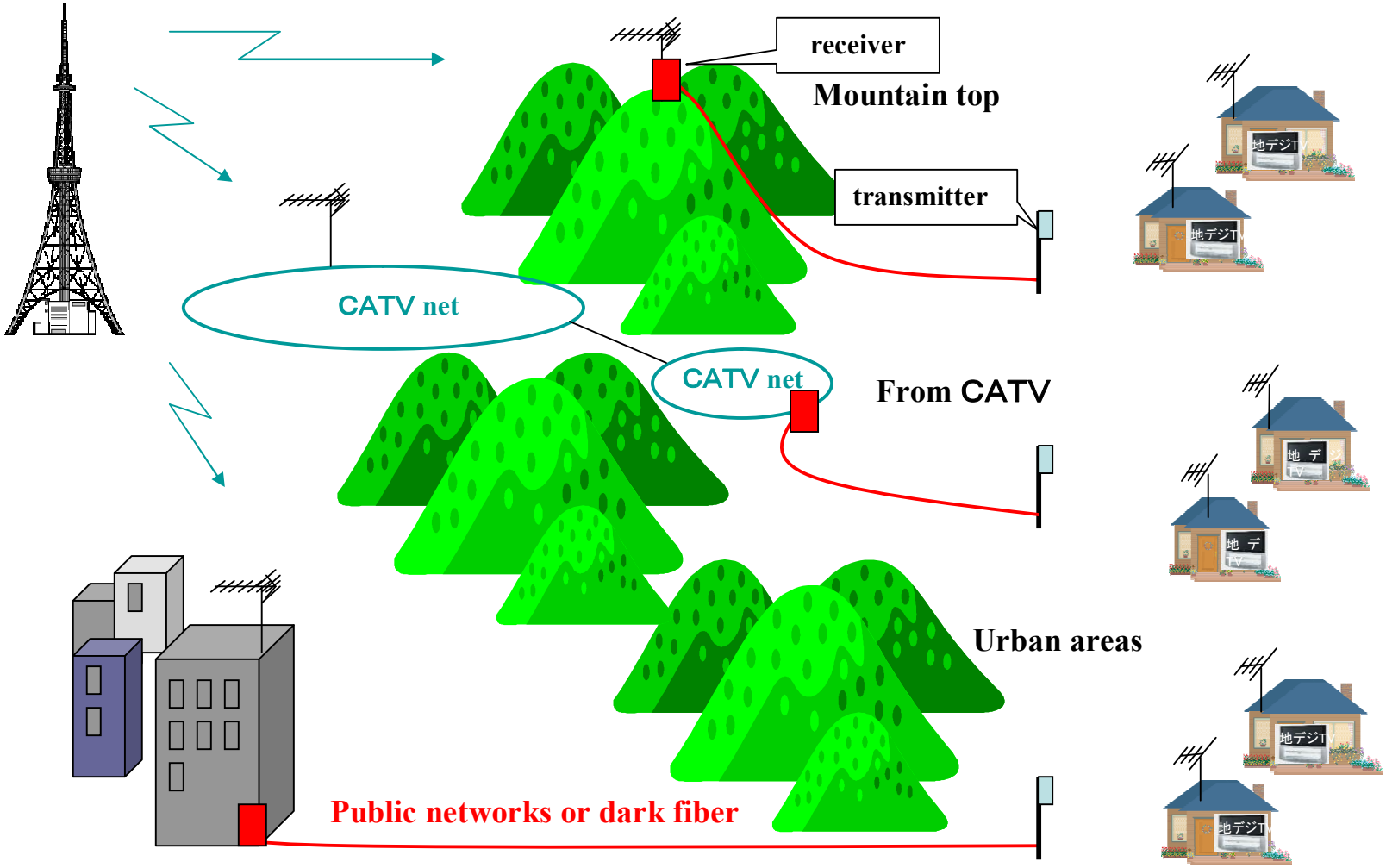
Receiver and transmitter of community reception antenna



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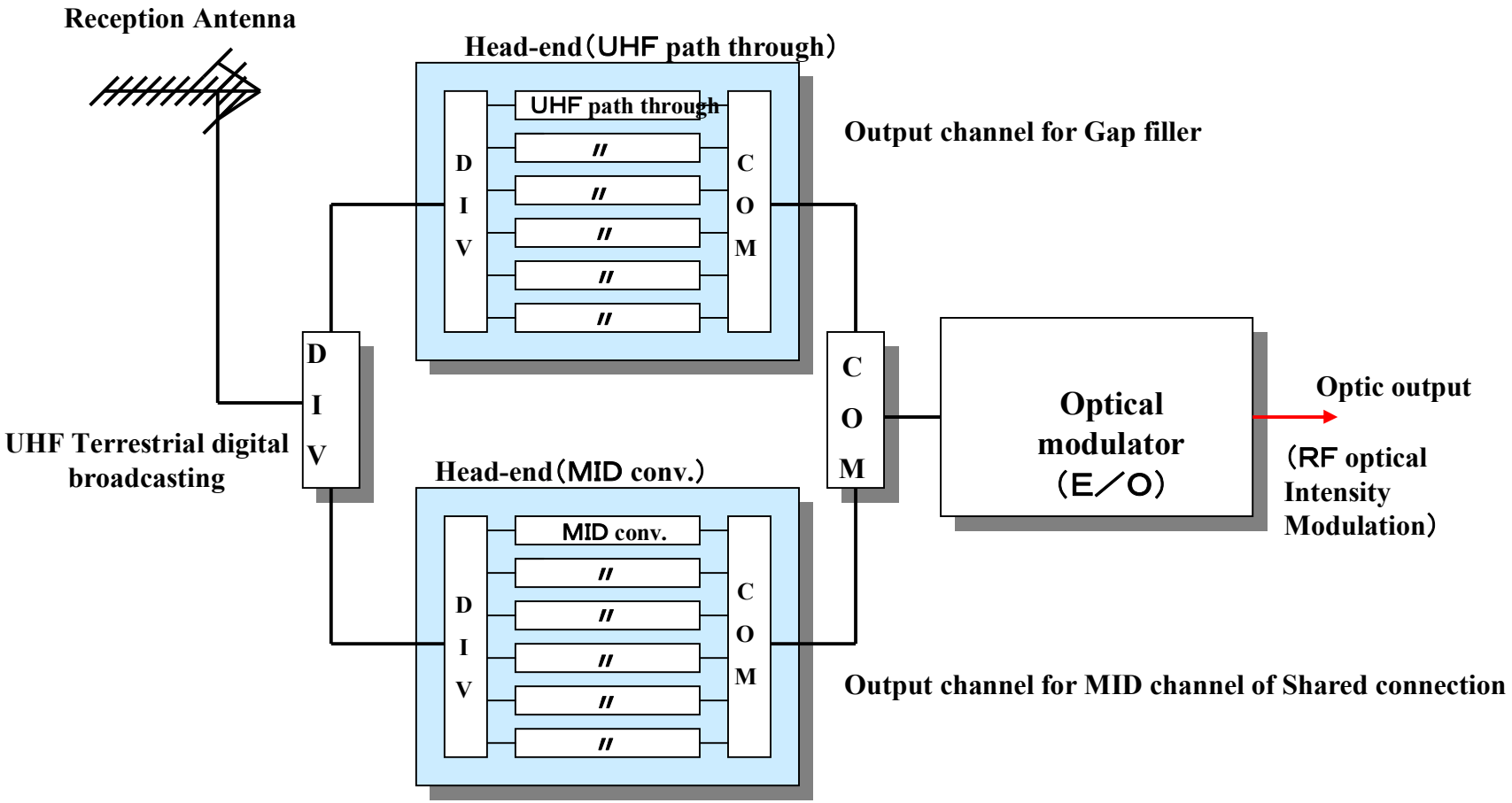
Receiver Portion of Community Antenna System

Example of Receiver for Gap filler and MID channel



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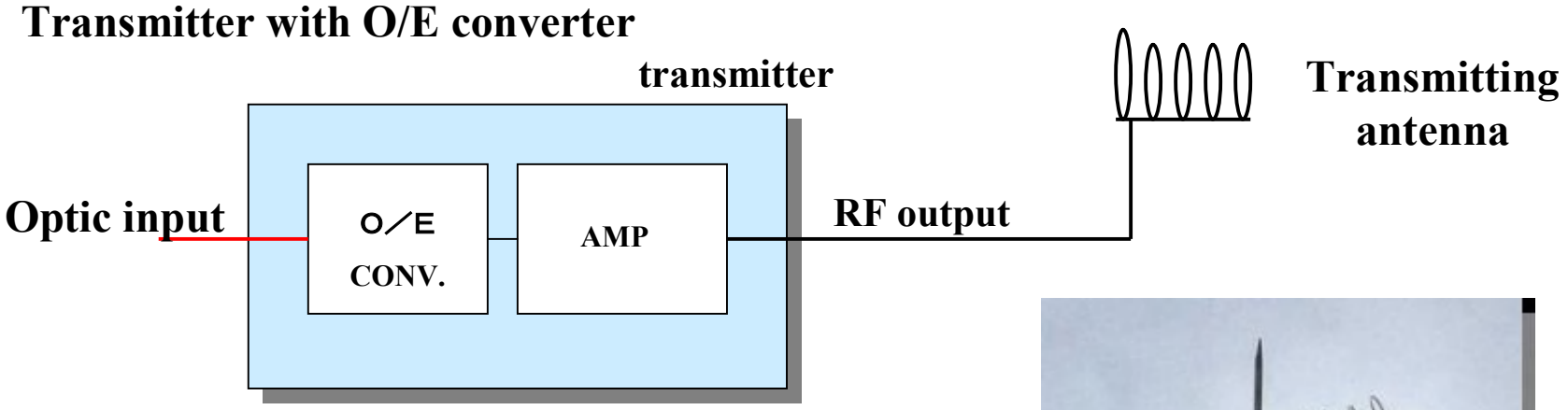
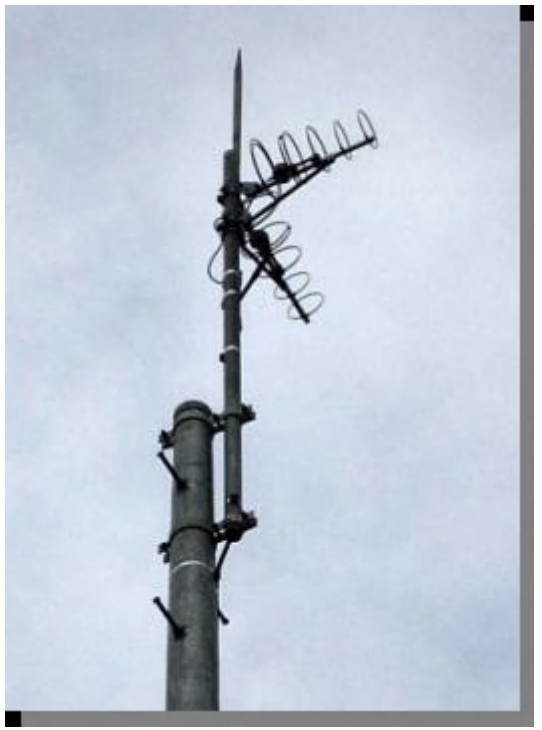
Re-transmitter Portion of Community Antenna System (Optical input type)



example



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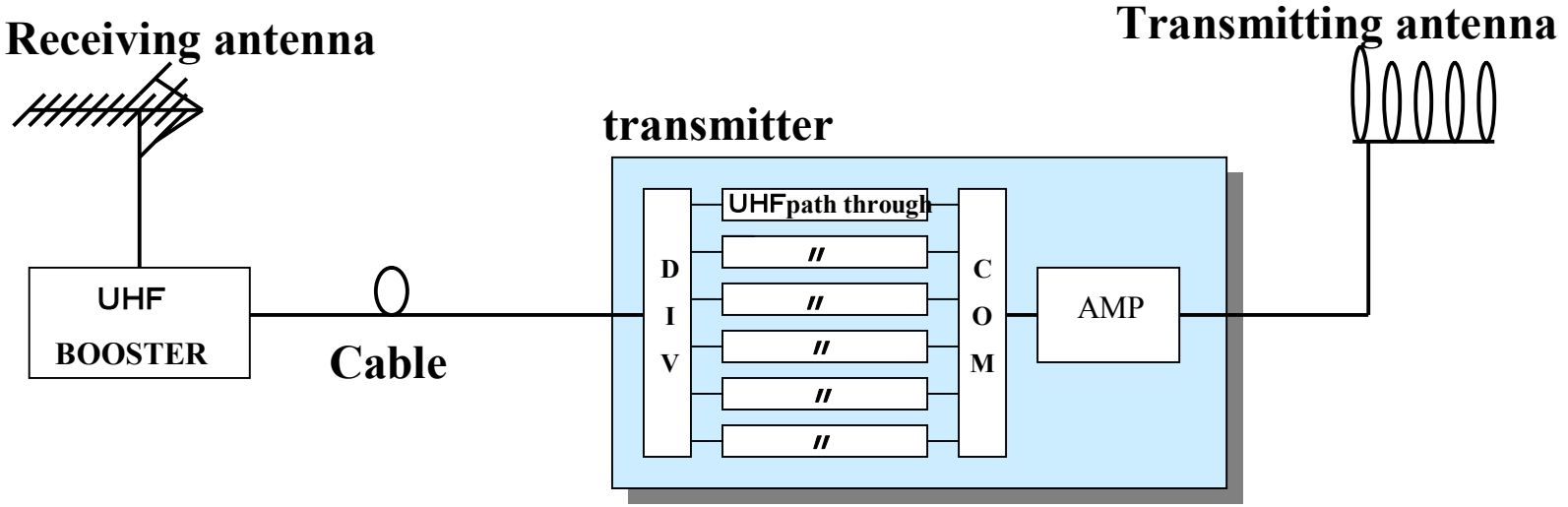
Re-transmitter Portion of Community Antenna System(Relay type)

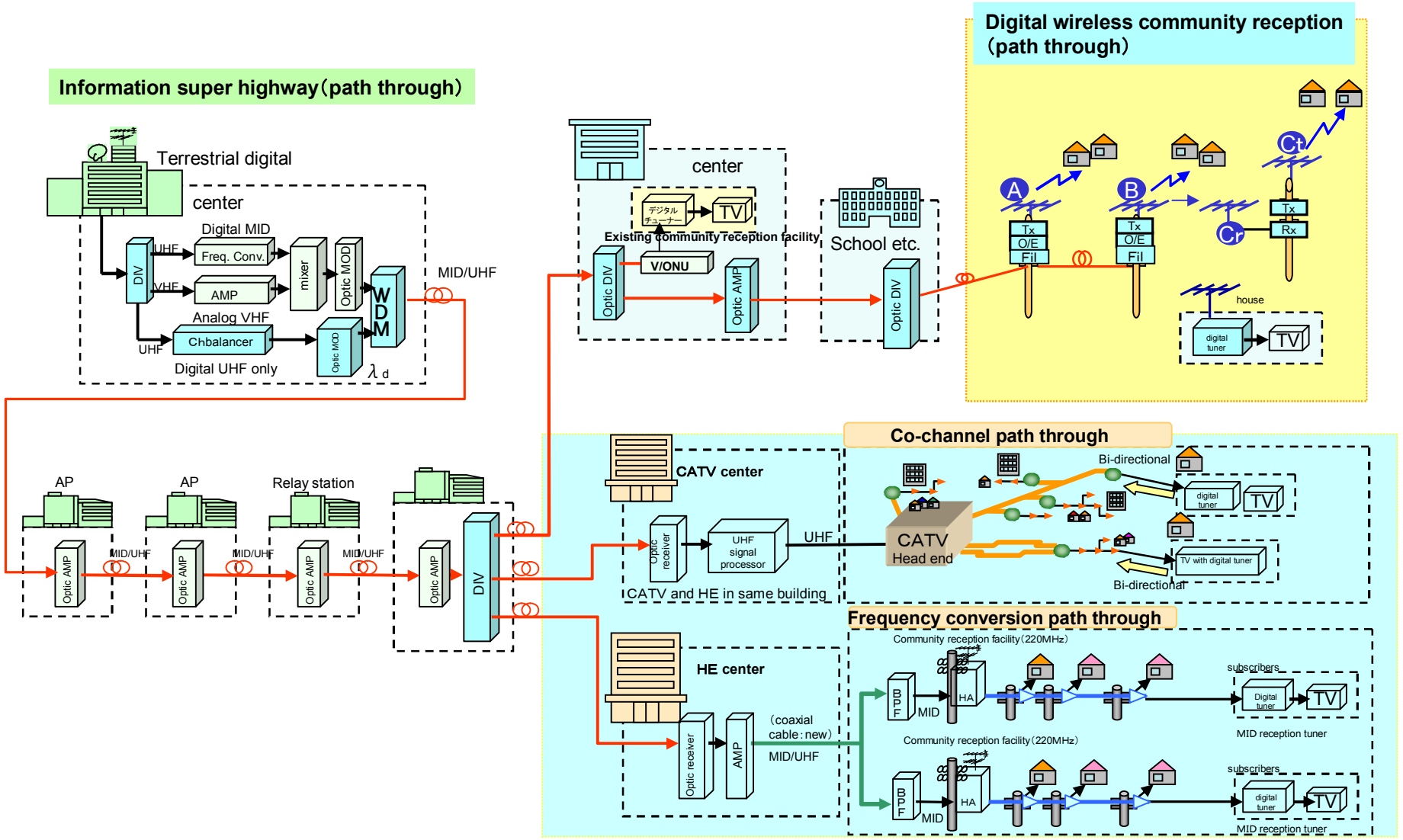


example

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



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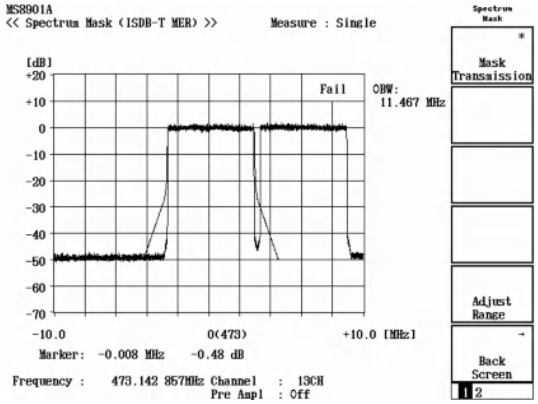
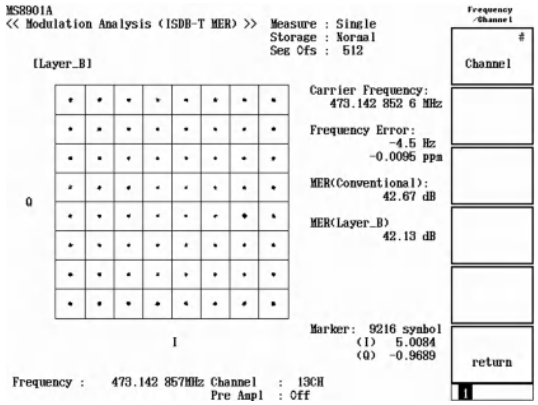
Transmitting power(experimental station)

Optic transmission about 40km without optic amplifier on the way

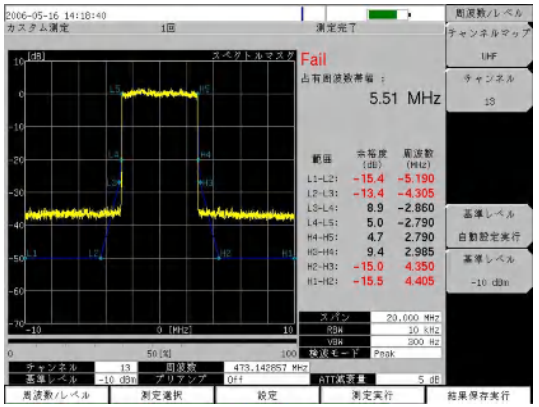
Transmitter output

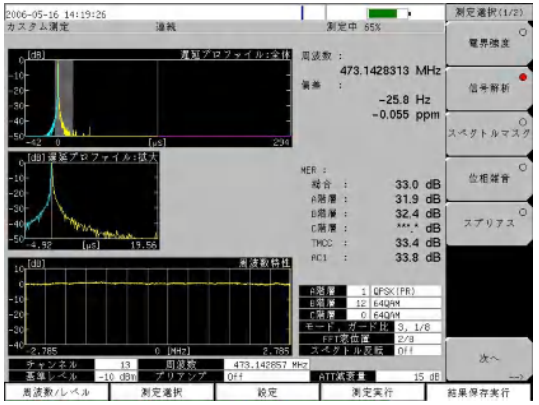




Optic transmission about 40km with 4 optic amplifier

Transmitter output





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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.

Re-transmitting antenna (Yaesu underground mall)

Yaesu underground mall

NHK Integrated Technology Inc.

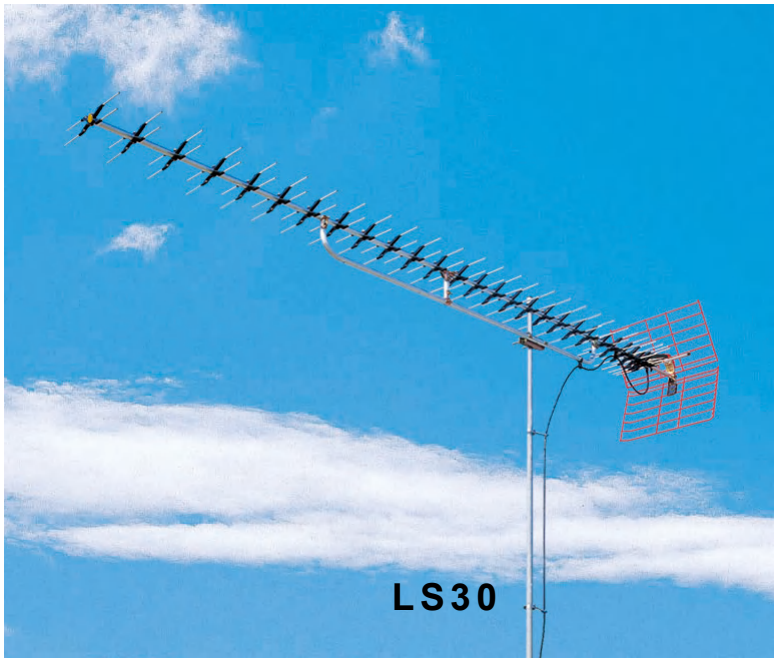
5. Examples of receiving Antenna for Fixed Reception

(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



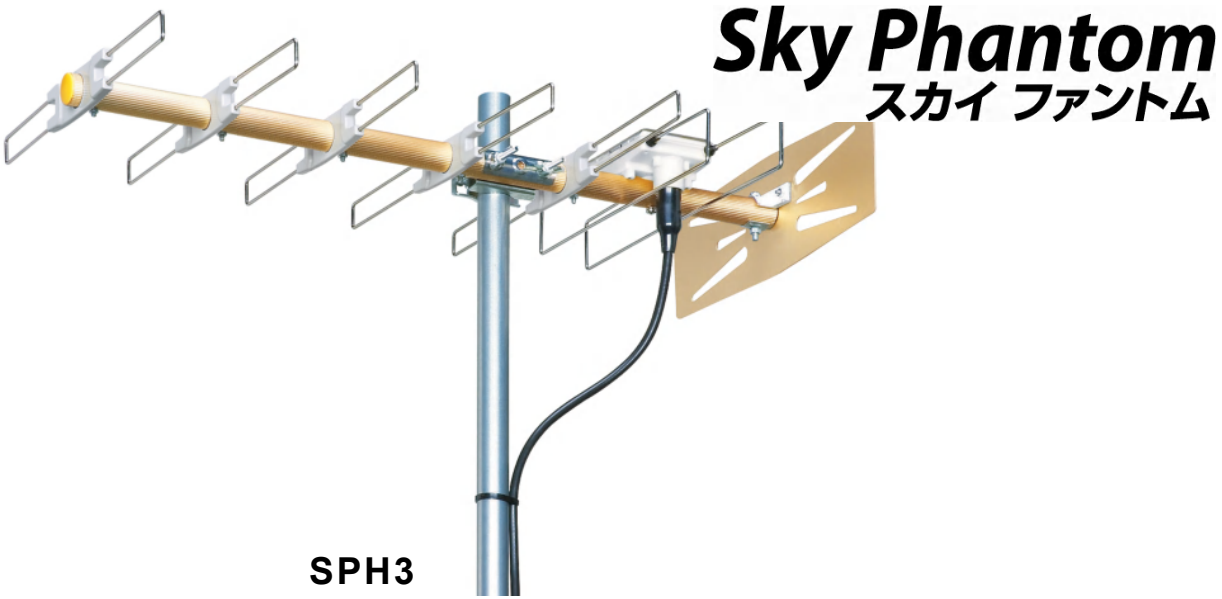
Model	GaindB)	VSWR	F/B ratio (dB)	Wind Surface Area (m^2)	Dimension (mm) L×W×H	Weight (kg)
LS14	8.4～14	1~2.5	17.5～ 32	0.16	1160×495×560	約2.3
LS20	8.9～15.7			0.21	1860×495×560	約2.7
LS30	10.7～17.4		19.8～30.7	0.31	3040×495×560	約3.7

MASPRO

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



SPH3

Model	Gain (dB)	VSWR	F/B ratio (dB)	Wind Surface Area (㎡)	Dimension (mm) L×W×H	Weight (kg)
SPH3	6～9	2.5以下	13～23	0.03	630×358×100	0.56

MASPRO

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.

Sky Crab
スカイ クラブ
（かに）

SC2

Model	Gain (dB)	VSWR	F/B ratio (dB)	Wind Surface Area (㎡)	Dimension (mm) L×W×H	Weight (kg)
SC2	4～5.5	1.1～2.2	9～27	0.07	131×330×205	約0.84

MASPRO

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.

TT2

King of Indoor

Top Ten

トップ テン（塔＝十, 10＝Ten）

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

MASPRO

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