ISDB-T technical seminar(2007)
in Brazil

Section 7

Implementation of Broadcaster

June, 2007

Digital Broadcasting Expert Group (DiBEG)
Japan
Yasuo TAKAHASHI
(Toshiba)

Preface

As described in forward section, to make up digital broadcasting system, broadcaster should consider and investigate the many theme for designing and constructing digital broadcasting infrastructure.

Theme of this section are as follows:

(1) Broadcaster system design and examples;

(2) Transmission network of DTTB

(3) Transmission network design for digital broadcasting

(4) New technologies for transmission network

(5) Examples of Transmitter and repeater

In this section, Japanese case is explained

Contents

1. Infrastructure of Broadcaster for digital broadcasting
1.1 What are difference?
1.2 What should be investigated / considered?
1.3 Master system design
1.4 Examples of master system/transmitter/antenna(in Japan)

2. Transmission network system for DTTB

3. Transmission network design for digital broadcasting
3.1 Link budget for transmission network chain
3.2 Network synchronization in SFN

4. New technology for transmission network
4.1 Degradation factors in transmission network
4.2 Examples of Improvement technology

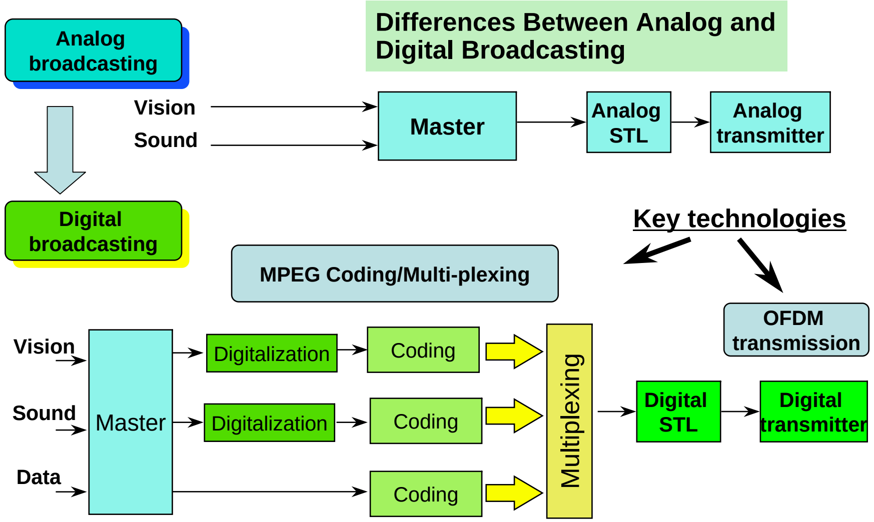
5. Examples of transmitter and repeater

1.Infrastructure of Broadcaster for digital broadcasting

1.1 What are difference?
1.2 What should be investigated / considered?
- Service and business solution
- **Business and Source of revenue**

1.3 Master system design
1.4 Examples of master system/transmitter/antenna(in Japan)

What are difference?



DiBEG

What should be investigated/ considered?

Service and Business solution

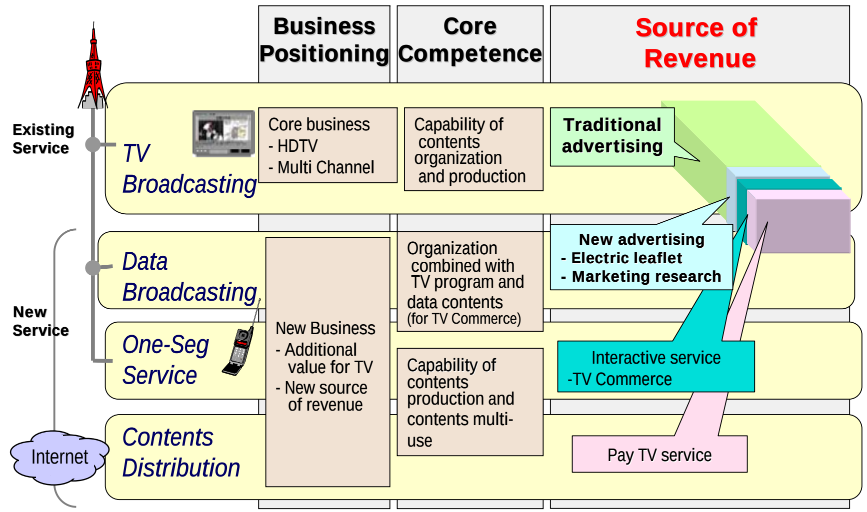
Service	*Analog Broadcasting*	*Digital Broadcasting*
･Number of Channel	Single Channel	Multi Channel
･Video Quality	Standard (SDTV)	+ High quality (HDTV)
･Communication	Casting	Interactive
･Target	Viewer	Customer
･Audience Action	Passive	Active
･Where	Home	Anywhere
		Fusion of Broadcast and Telecommunication
Business		
･Source of Revenue	Sponsor (Commercial station)	+ Subscriber, Industry
･Advertising Target	Mass	+ Segment, One to One
･Media	Broadcast	+ Interactive
･Potential	Low (Stability)	High

As shown above, broadcaster should consider from service/business aspect

DiBEG

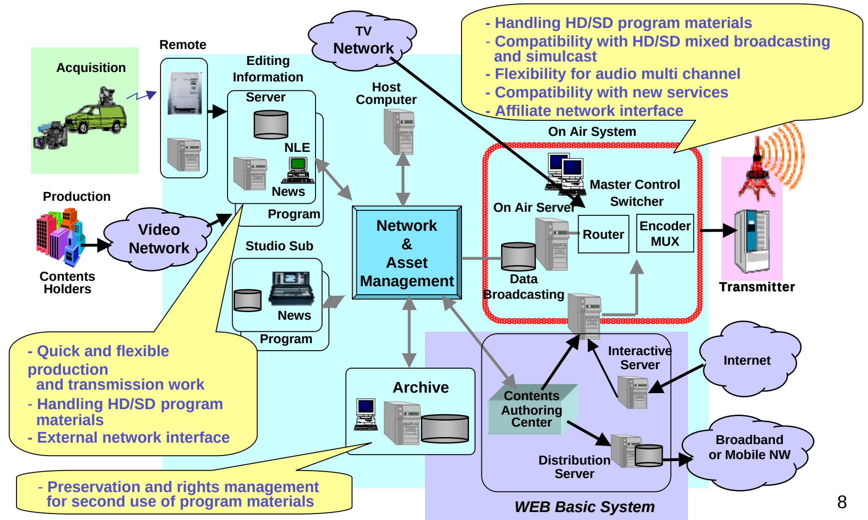
What should be investigated/ considered?

Business and Source of revenue



DiBEG

Requirements for Digital TV Station



DiBEG

1.3 Master system Design

For design digital master system, following parameters should be considered.

◆Video/Audio signal quality/ number of program; **HD? or Multi channel SD? or Mixture ?** ⇨ Number of Encoder, Switcher' type/size, etc

◆Hierarchical Transmission service; **Put One-seg service or not? Same program or not?** ⇨ Number/type of encoder, Switcher design, etc

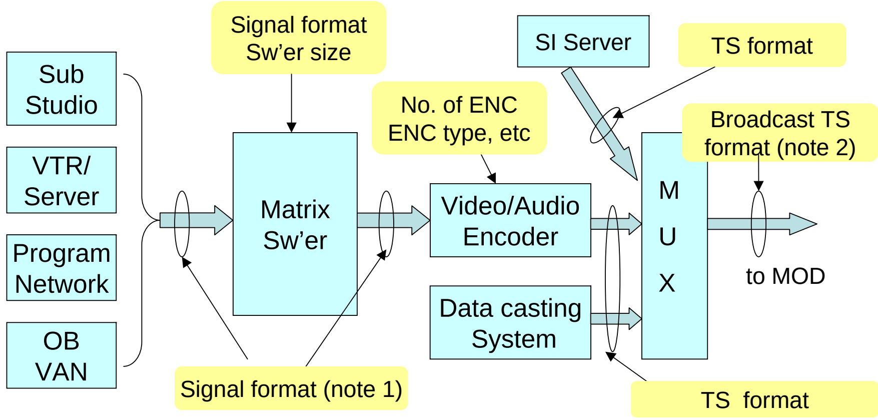
◆Middle ware Service; **What kinds of data casting? Program related data casting, independent data casting , both or any of one, or.**
⇨ Design of master data/control system, Authoring system, etc

◆Interactive Service; **What kinds of Interactive Service? Broadcaster itself? or collaborate with communication carrier?**
⇨ Business model design, Interactive system design, etc.

Most urgent and important themes are,
signal flow design ,and master control system design

⇨ **Example of Master system(Japan) is also shown.**

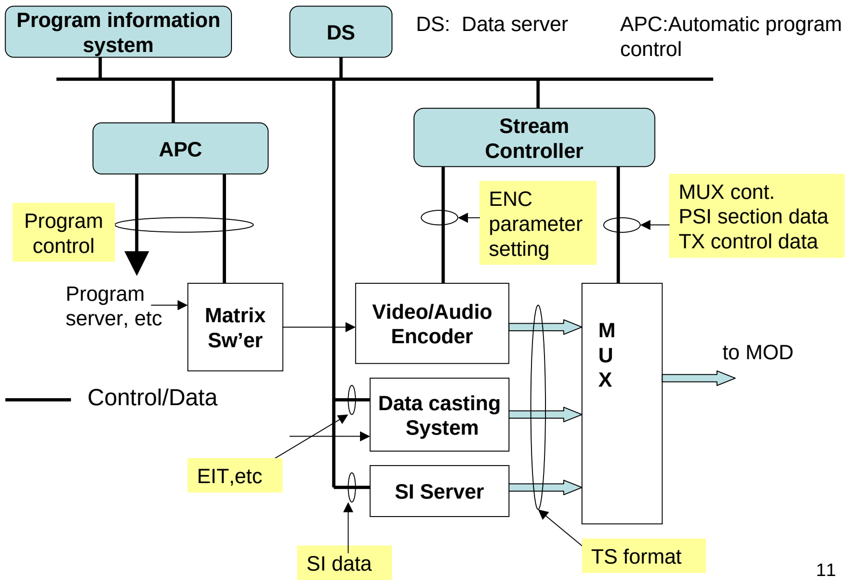
Signal flow of Digital Master



(note 1) Signal format of input/output of Sw'er depends on signal source,
If HD is main signal, digital format may be better.

(note 2) Transmission rate of Broadcast TS is constant rate,
in spite of different service

Example of Control/ data flow of Digital Master



TOSHIBA
Leading Innovation

Example of Master system(Japan)

Because of the difference TV broadcasting contents, operation system culture, etc . Brazilian system may not be same as Japanese system. But ,as a reference it may be useful. So, show example of Master system design in Japan

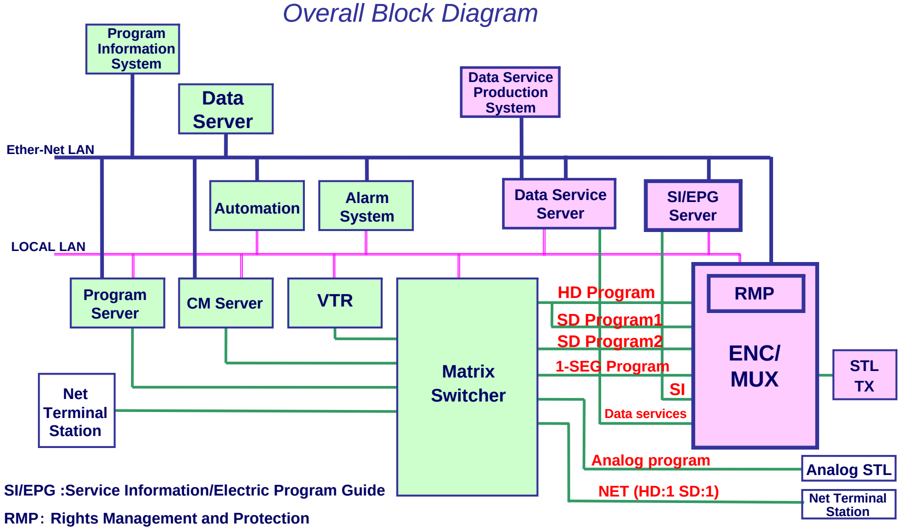
(1)Overview of Facilities
(2)Encoder／Multiplexer
(3)PSI/SI Flow Diagram

This document is dedicated by Toshiba

TOSHIBA
Leading Innovation

(1)Overview of Facilities

Overall Block Diagram



SI/EPG :Service Information/Electric Program Guide

RMP: Rights Management and Protection

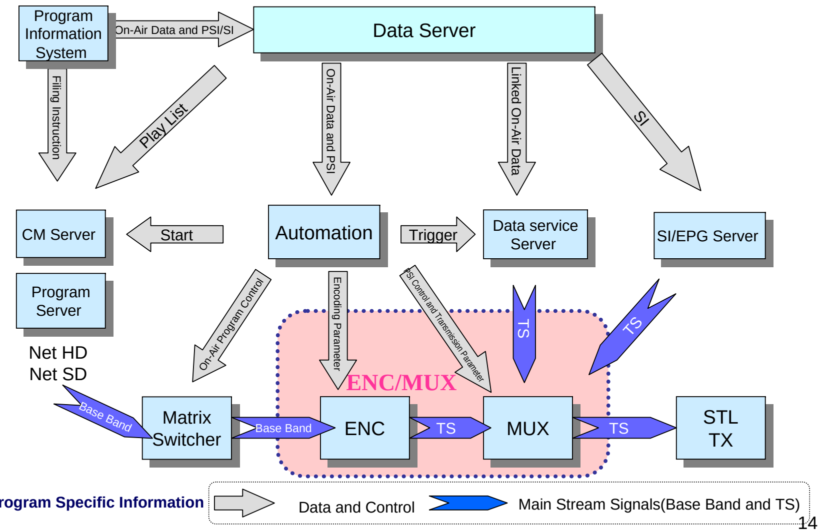
ENC/MUX: Encoder / Multiplexer

DiBEG

TOSHIBA
Leading Innovation

(1)Overview of Facilities

Data Flow/Signal Flow



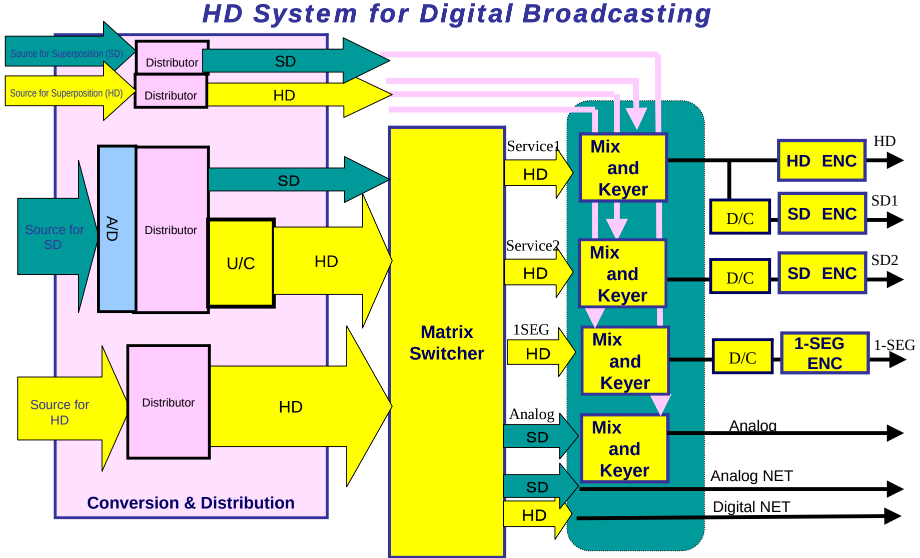
PSI :Program Specific Information

DiBEG

TOSHIBA
Leading Innovation

(1)Overview of Facilities

HD System for Digital Broadcasting

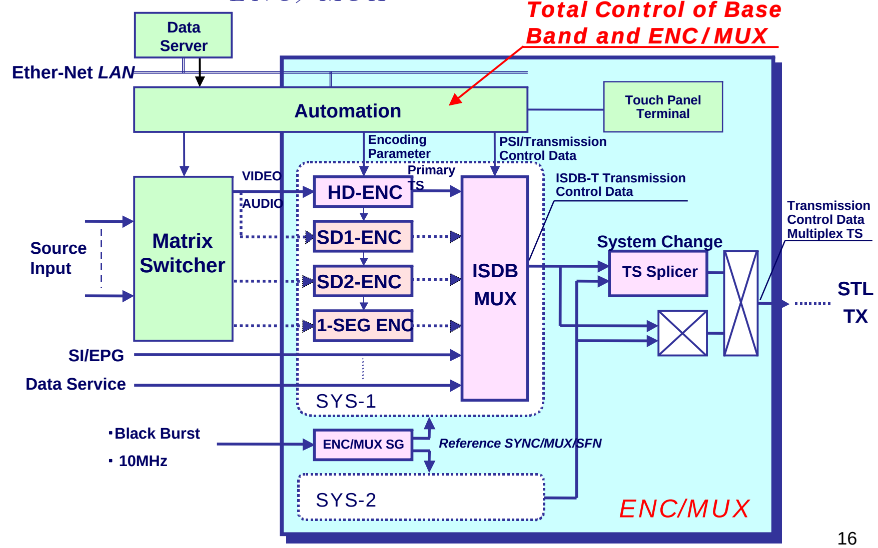


DiBEG

TOSHIBA
Leading Innovation

(2)Encoder／Multiplexer

ENC／MUX



DiBEG

TOSHIBA
Leading Innovation

(2)Encoder／Multiplexer

ENC / MUX (Encoder / Multiplexer)

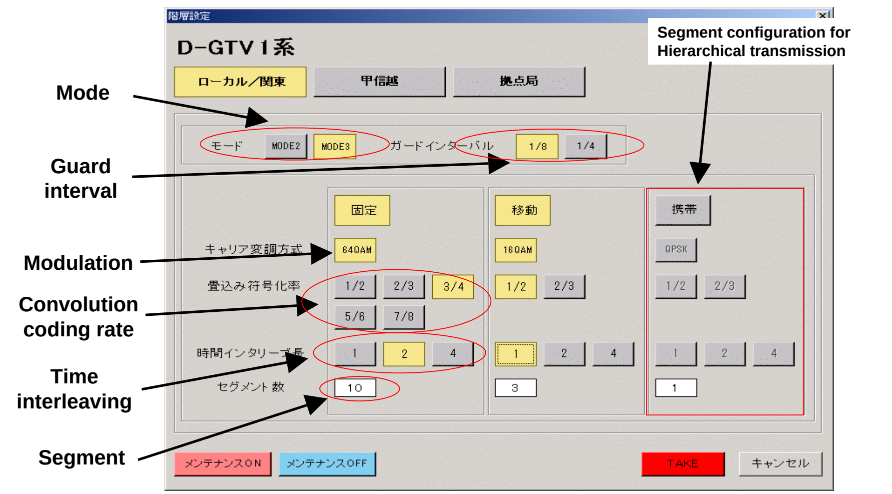
Automation	- Encoder control (video bit rate, picture angle, audio bit rate and audio mode) - MUX control (input port ON/OFF and PSI control)
E N C Encoder	- HD encoder (MPEG2 : MP@HL) - SD encoder (MPEG2 : MP@ML) - 1-SEG encoder (H.264 : BP@L1.2)
M U X Multiplexer	Digital terrestrial broadcasting format multiplexing (ARIB STD-B31 compliant)
T S splicer	- Seamless system switching (MPEG2) - Switching in full synchronous operation between the active and standby systems of encoders and multiplexers

DiBEG

TOSHIBA
Leading Innovation

For Reference

Example image of Stream Controller's display

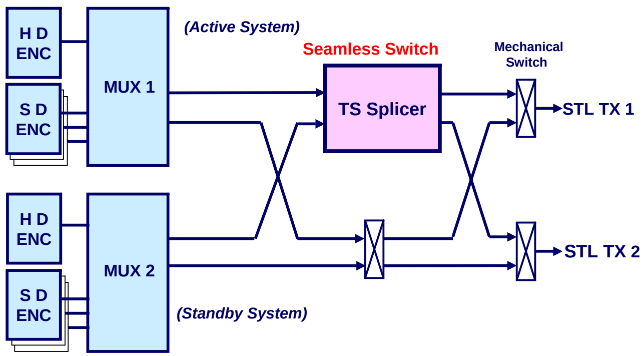


DiBEG

TOSHIBA
Leading Innovation

(2)Encoder／Multiplexer

Seamless Switching by TS Splicer



Switching between the active and standby systems by TS Splicer

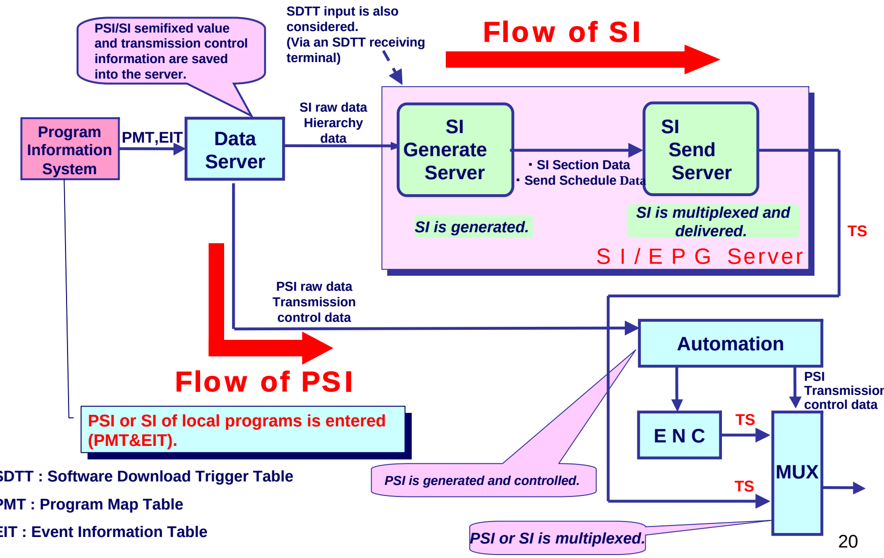
(1) Switching with no adverse effects on other channels even upon occurrence of a fault.

(2) Completely seamless system switching during maintenance.

DiBEG

TOSHIBA
Leading Innovation

(3)PSI/SI Flow Diagram



SDTT : Software Download Trigger Table

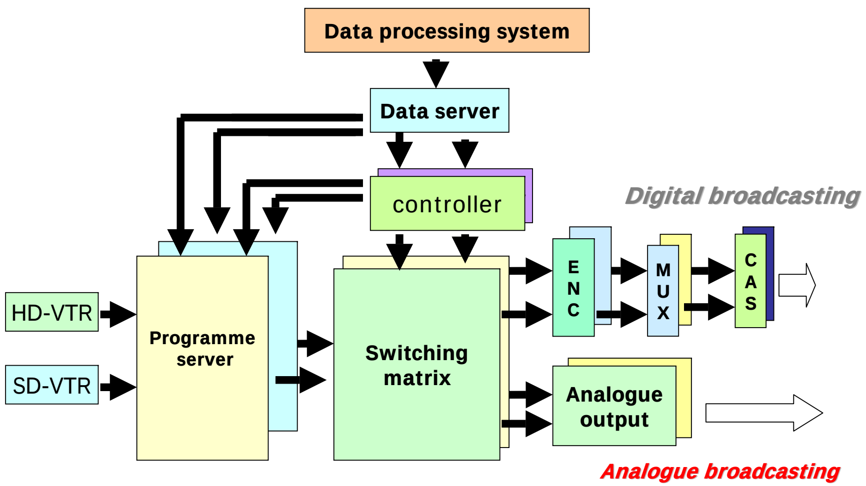
PMT : Program Map Table

EIT : Event Information Table

DiBEG

1.4 Example of Broadcaster Infrastructure

Master control system(TV Asahi)



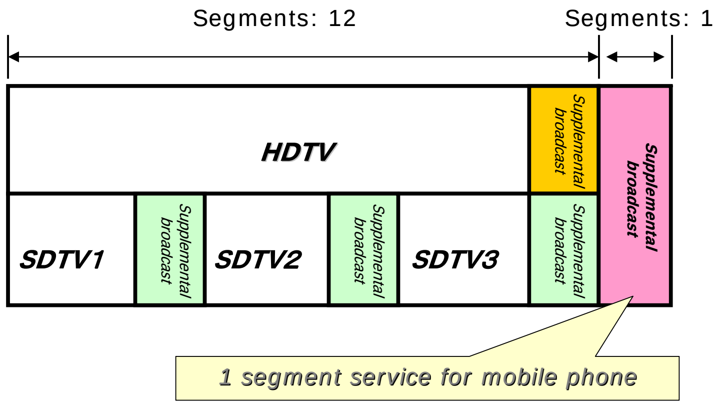
Master control system (2) (TV Asahi)

Characteristics of Master Control Switcher System

- **Massive and SD / HD Multi-format System**
  - **SD / HD router ; 256 x 128**
- **High Reliability**
  - **Triple redundant system**
  - **Input part ; Dual**
- **Scalability**
  - **Easy extension by addition of MK part**
  - **Software update by using Test part**
- **Efficient monitoring and operations**
  - **Integrated monitoring system**
  - **Multi-monitor, Touch panel**

Master control system (3) (TV Asahi)

Applications
(TV Asahi)



Digital transmission(Tokyo)

- *Transmitters and antennas for digital terrestrial television broadcasting installed at Tokyo Tower in 2003.*

STL

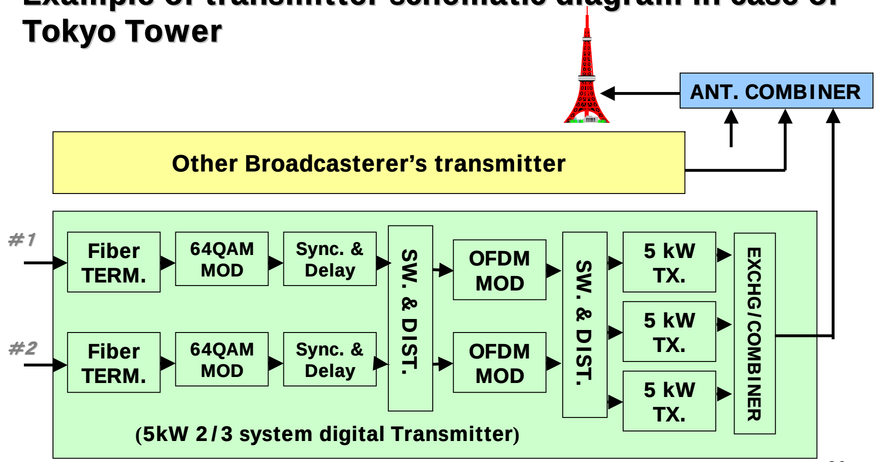
Optic fiber line x2

backup STL

Micro wave

Digital transmitter system(Tokyo)

Example of transmitter schematic diagram in case of Tokyo Tower



Digital Transmitter system(Tokyo)

- *Three 5kw transmitters for redundant operation.*
- *Output power is 10kW(Tokyo Area)*

TOSHIBA

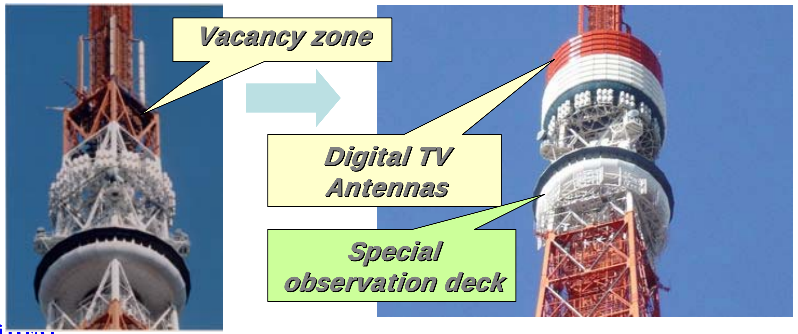
NEC

Antennas(1) (Tokyo)

A number of analog TV antennas were already mounted on the optimum position of Tokyo Tower .

Antennas(2) (Tokyo)

- ***Vacancy zone is around 250mH of Tokyo tower, There are no appropriate space except there. Digital antennas were designed , compact size, 6 meters in width and 12 meters in height.***



2. Transmission network system for DTTB

2.1 transmission network system for DTTB

(1) SFN? or MFN?

(a) To save frequency resource, SFN is better

(b) For wideband network for mobile service, SFN is better

(c) For SFN, network design and management should be done carefully compare to MFN (details are explained in chapter 3)

Note;

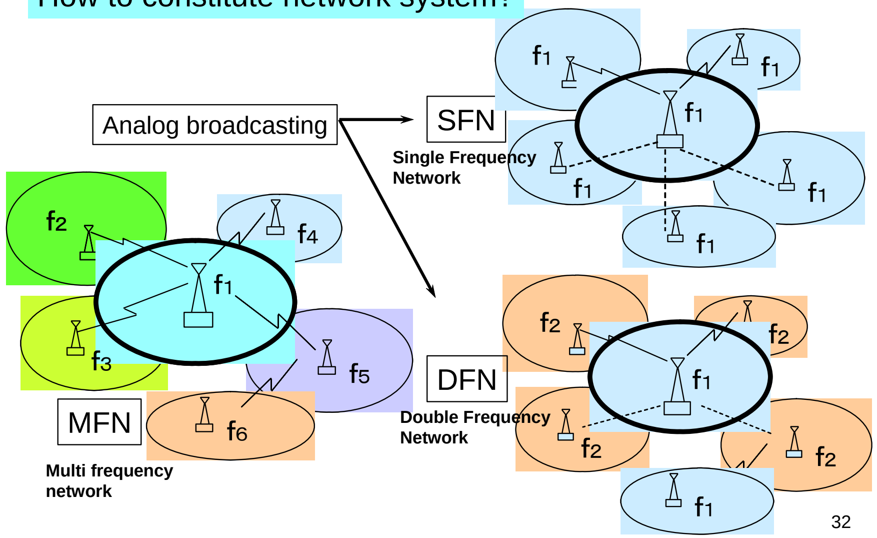
SFN; Single frequency network,

MFN; Multi Frequency Network, popular system for analog TV network

DFN; Double Frequency Network, special case of MFN.

Image of SFN/DFN/MFN

How to constitute network system?



2.1 transmission network system for DTTB

(2) Classification of network system

- **TS transmission** — **Micro-wave/fiber link**
- **IF transmission**
  - **Micro-wave/fiber link**
  - **Broadcast wave relay**

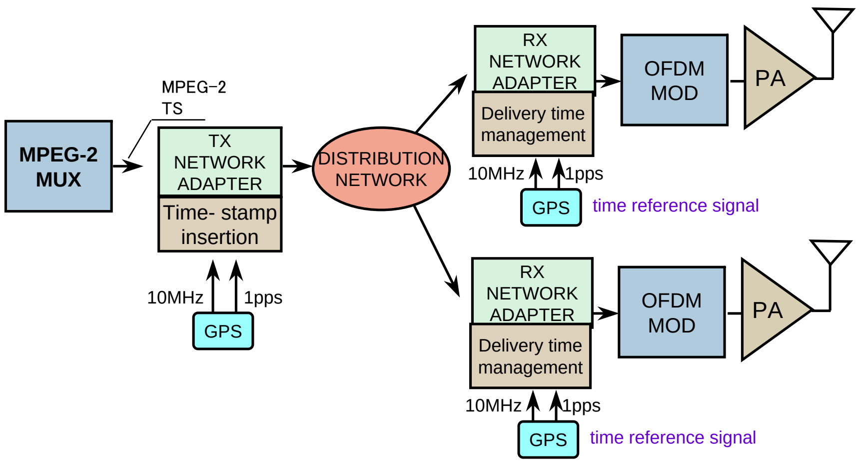
Comparison of network system

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)

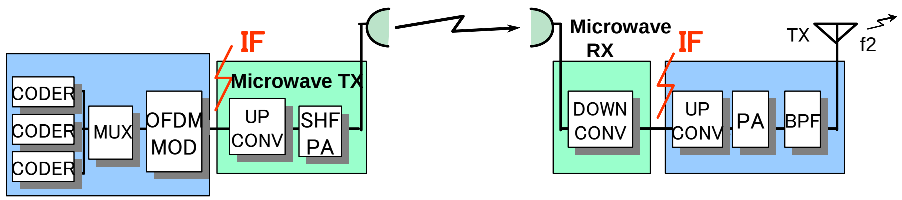
(note1) for Broadcast wave relay system, transmission the range of transmission timing is limited.

(note 2) Broadcast wave relay system dose not need micro wave frequency.

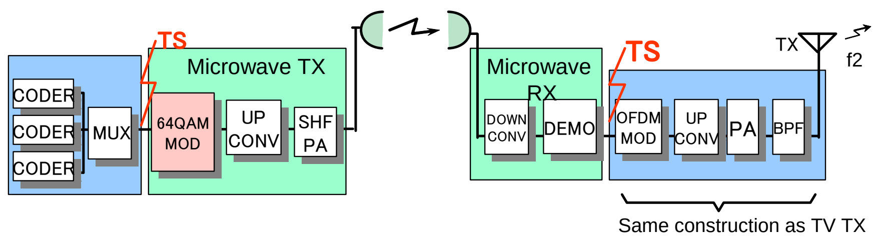
Image of Network timing adjustment by GPS



Example of IF transmission system by micro wave link



Example of TS transmission system
by micro wave link



DiBEG

3. Transmission network design for digital broadcasting

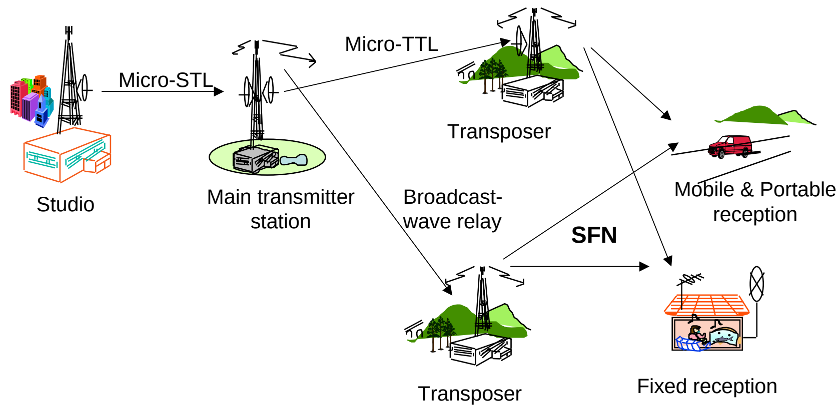
3.1 Link budget for transmission network chain

3.2 Network synchronization in SFN

DiBEG

DiBEG
Digital Broadcasting Experts Group

An Image of transmission network chain



DiBEG

Key points of transmission network for DTTB

For DTTB transmission network design, two important factor should be considered

(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.

(2) Network synchronization

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

DiBEG

3.1 Link budget for transmission network chain

Key Factor ;Equivalent C/N

Keep required Equivalent C/N ratio at the receiver front end

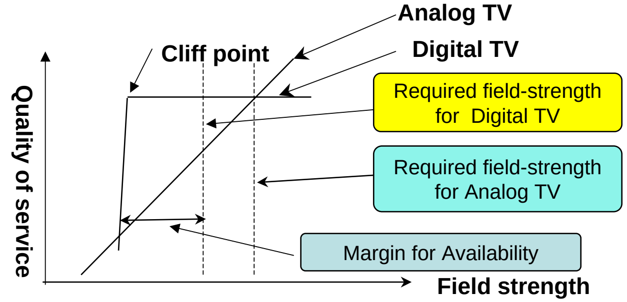
[1] In the digital system, "cliff effect" shall be considered

[2] Set the receiver model for link budget

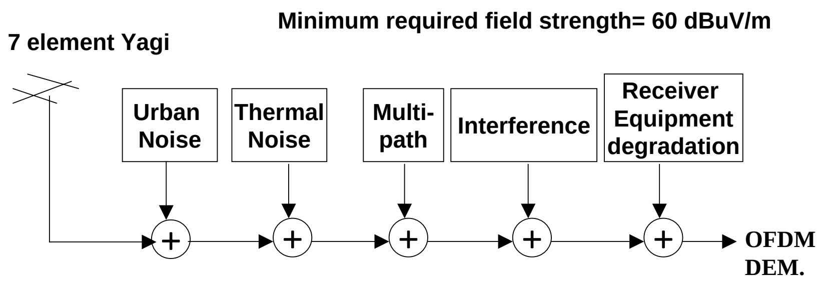
[3] Check link budget parameters

[1] "Cliff Effect"

In digital system, Quality of service is not proportional to input signal strength. At the lower level of cliff point, the fatal disturbances will happen, such as large block noise, moving picture frozen, and picture black out.



[2] Receiver model for link budget



(note) required C/N depends on transmission parameters

In Japan, considering most serious parameter set, 64QAM r=1/2, is base of link budget . In this case, equivalent C/N for receiver is as much as 28dB. (see details ARIB STD-B31 reference A.3.2.3

[3] Link budget parameters

(a) Transmitter 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

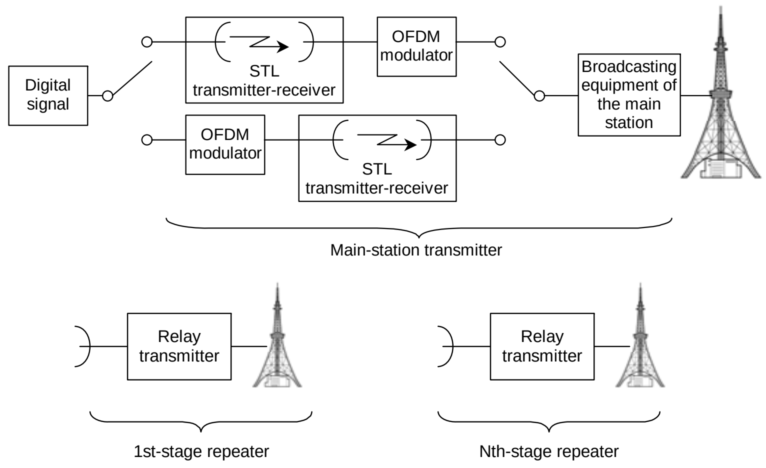
(c) Equipment degradation and transmission distortion

Equivalent C/N is degraded by equipment degradation, especially in multi-stage transmitter chain, these degradation are accumulated. See details next section 2.3

(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)

(a) Transmitter model



(b) Propagation loss and fading margin

-For design transmission network, at first, present analog network was surveyed (ARIB STD-B31 reference A.3.2.1 (1) table A3.2-1)

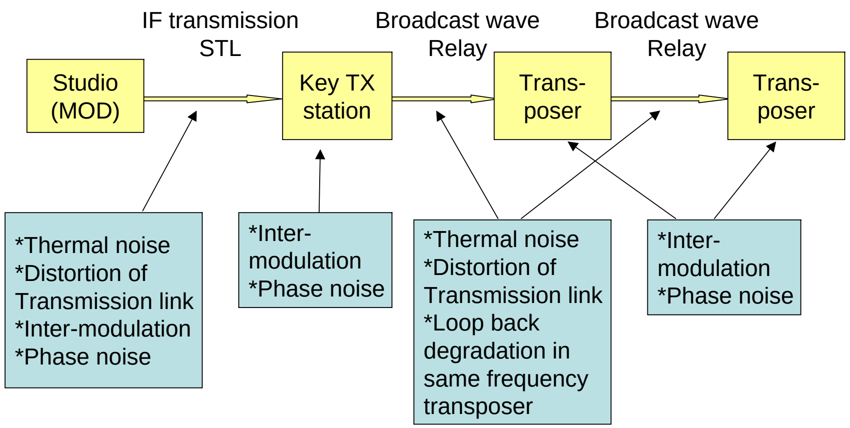
-assume the fading margin according to each stage-to-stage distance (value that includes 80% of all stations selected in (1)) under the assumption that 99.9% fading margin will be available.

Table A3.2-2: 99.9% Fading Margin Selected Based on a Stage-to-Stage Distance Acceptable for 80% of All Stations

Relay station	To 1st Stage	To 2nd Stage	To 3rd Stage	To 4th Stage	To 5th Stage	To 6th Stage	To 7th Stage
Stage-to-stage distance	52.5 km	25.1 km	23.1 km	16.3 km	23.7 km	9.5 km	5.8 km
Fading loss	13.1 dB	8.7 dB	8.4 dB	7.3 dB	8.5 dB	6.7 dB	4.1 dB

[3] causes of signal degradation in transmission network

(details will be explained in chapter 4. of seminar #8)



(note) all these degradation are evaluated as END (Equivalent Noise Degradation) in transmission link budget

(d) 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.

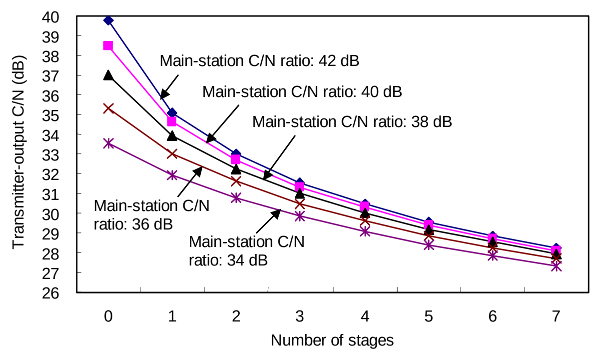


Fig. A3.4-2: Impact of Changes to the Equivalent C/N Ratio of the Main Station's Transmitter on the Transmitter-Output C/N Ratio

3.2 Network synchronization for SFN

(1) Network synchronization system

3 types of synchronization system 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

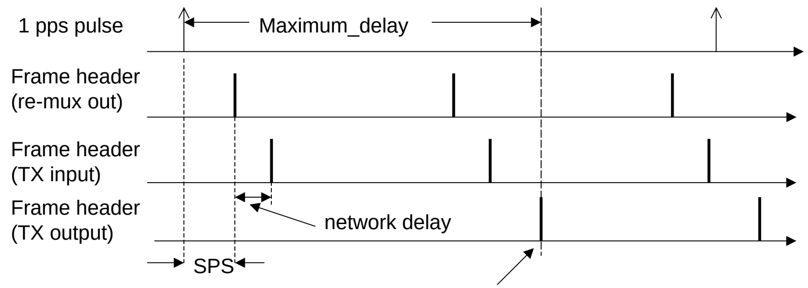
In ISDB-T system, network_synchronization_information is multi-plexed into broadcasting TS at RE-MUX. This information is useful not only for network synchronization but also for measure the transmission timing of each transmitter.

(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.

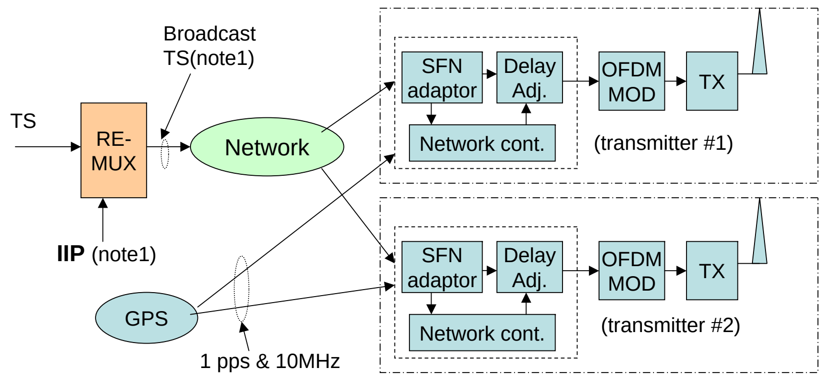
Example of Network_synchronization_information



If all transmitter output should be adjusted to maximum_delay, TX output is delayed to this point

Example of network synchronization by GPS

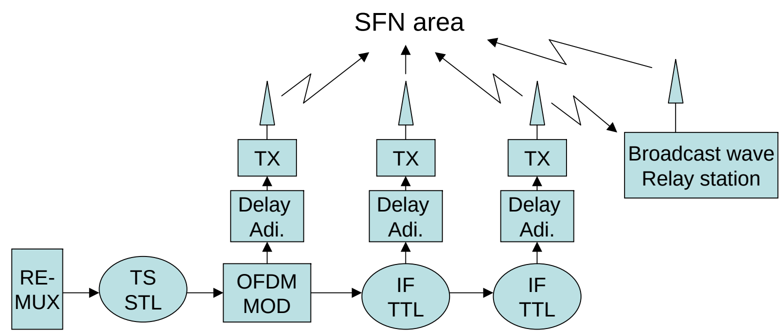
(TS transmission type)



(note 1) Broadcast TS; transport stream for broadcasting, OFDM framed.

IIP data is decode at SFN adaptor and measure the frame header timing then adjust signal delay.

Transmitting adjustment for transmitter chain



Each transmitter output timing is adjusted by “Delay Adi.”, but for broadcast wave transmitter , output timing adjustment is difficult. Therefore, signal delay of broadcast wave relay station should be considered in SFN design.

4. New technology for transmission network

4.1 Degradation factors in transmission network

4.2 Improvement technology

4.1 Degradation factors in transmission network

4.1.1 Classification of degradation

(a) Equipment degradation

(a) **Non-linear distortion**; non-linear of amplifier causes ICI (inter carrier interference between OFDM carriers.

(b) **Phase noise**; phase noise causes CPE(common phase error) and ICI. Especially critical for micro-wave IF transmission link.

(c) **Coupling loop interference (CLI);** CLI occurs in same frequency broadcast wave transposer, coupling from TX antenna to RX antenna

(b) Transmission distortion

(a) **Multi-path distortion**; Multi-path distortion causes frequency characteristics distortion , especially, long delay multi-path causes inter symbol interference(ISI)

(b) **fading**; fading is caused by transmission path variation.

4.2 Outline improvement technology

Many improvement technologies has been developed and on developing. Representative technologies are introduced here

(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

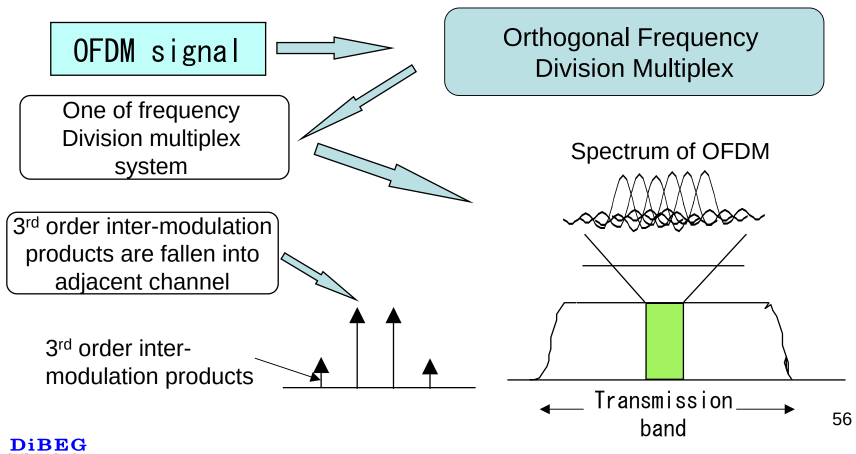
-Multi-path canceller; especially compensate the multi-path distortion on transmission link.

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

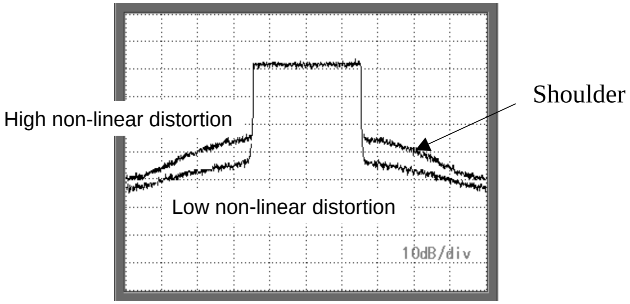
-**Diversity receiving technology**; Improve the degradation caused by fading. This technology is useful not only transmission network but also mobile reception.

(1) Non-linear distortion

In digital system Non-linear distortion of transmitter causes the inter-modulation products, and these products are fallen into the adjacent sub-channels. Therefore signal quality is degraded by the Inter-carrier interference.



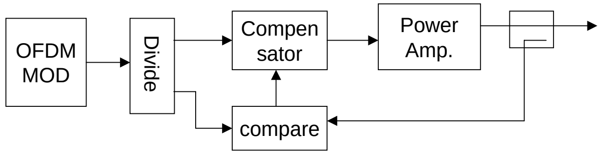
An example of output spectrum



The 3rd-order inter-modulation products appeared on the outside of signal bandwidth. These products are coaled "Shoulder", and used for measurement parameter of transmitter

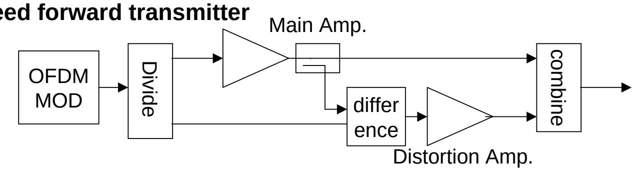
Examples

Feedback pre-distortion transmitter



This technology is used for high power transmitter. Inter-modulation level is decreased -45 dB or less.

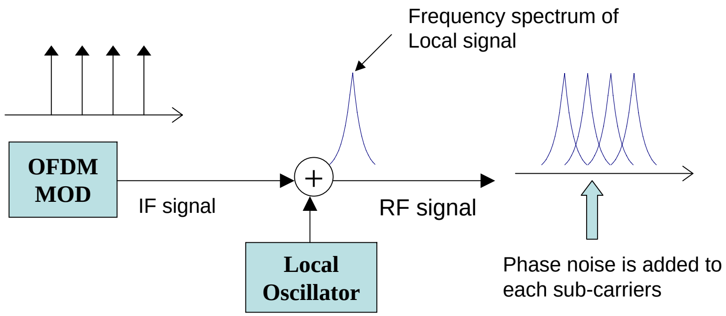
Feed forward transmitter



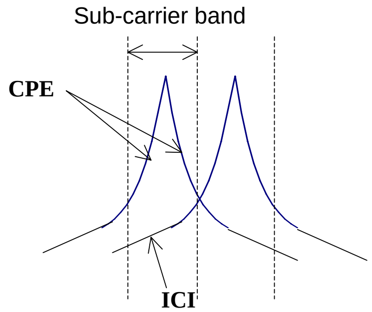
This technology is used for low to medium power transmitter. This type amplifier covers wideband, so used for multi channel amplifier. Inter-modulation level is decrease to -50 dB or less.

(2) Phase Noise

The phase noise is mainly generated from local oscillator, and is added to each sub-carriers of OFDM signal(See below)



The Influences of Phase Noise



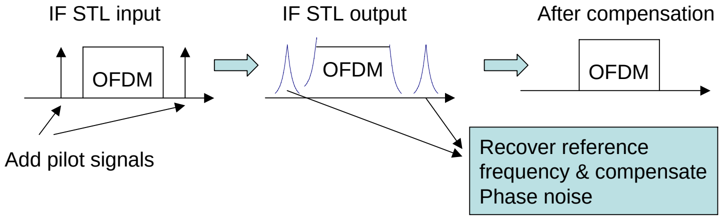
CPE: Common Phase Error. The in-band components of Phase Noise. This causes circular shift of signal constellation. As a result, causes the C/N degradation.

ICI: Inter-Carrier Interference. The out-band components of Phase Noise. This components behave as a thermal noise. As a result, causes the C/N degradation.

example

(1) Use high stable oscillator for local signal (ex. GPs controlled crystal oscillator)

(2) 2 pilot carrier transmission system for IF transmission micro-wave link



(3) Improvement of transmission distortion

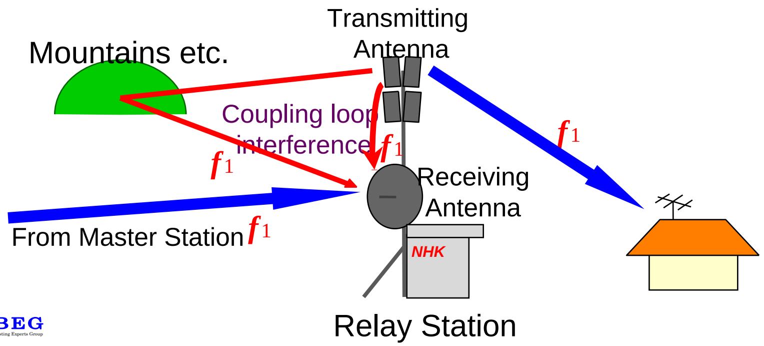
-Multi-path canceller; especially compensate the multi-path distortion on transmission link.

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

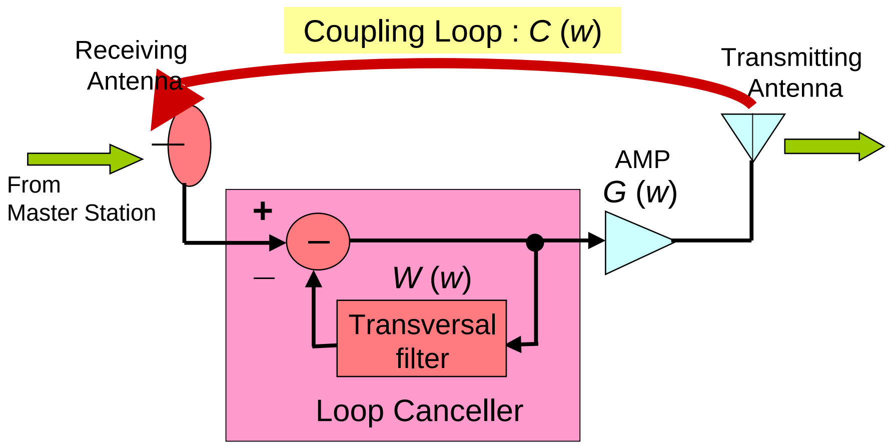
-**Diversity receiving technology**; Improve the degradation caused by fading. This technology is useful not only transmission network but also mobile reception.

What is CLI (coupling loop interference) ?

- Frequency of transmitting signal is the same as frequency of receiving signal.
- If the output of transmitting signal comes to the input receiving antenna, receiving signal is interfered. This is CLI.
- It is generally said that more than 90dB isolation is needed between transmitting antenna and receiving antenna.

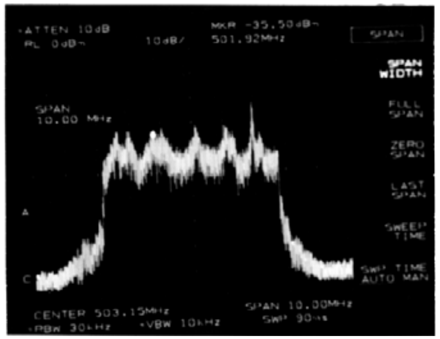


Principle of CLI canceller

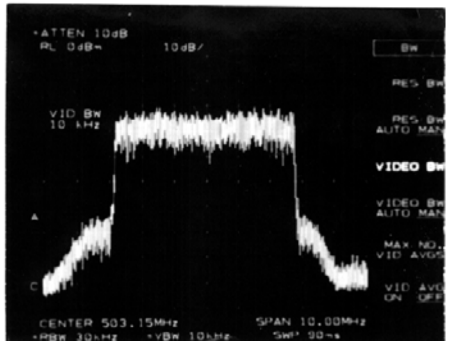


Condition for canceling : $W(w) = G(w)\,C(w)$

Effect of CLI canceller



Transmission signal
without CLI canceller



Transmission signal
with CLI canceller

Merits / demerits of SFN

- Merit of SFN
  - Frequency effective use (Frequency is limited)
- Demerits of SFN
  - CLI at broadcast-wave relay station
    - solve by CLI canceller
  - Appearance of long delay multipath
    - solve by guard interval of OFDM

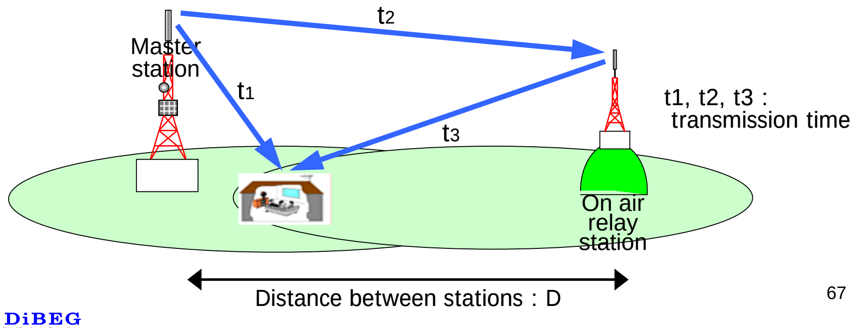
How about long delay multipath over guard interval

→ Long delay mutipath equalizer

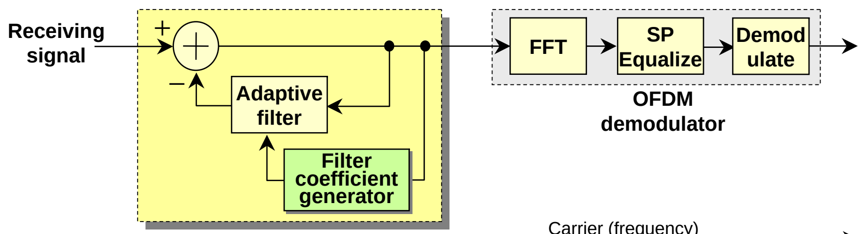
Long delay multipath situation

- Transmission time of desired signal : t_1
- Transmission time of delayed (undesired) signal : t_2+t_3
- Delay time of undesired signal $\tau_x = (t_2+t_3) - t_1$
- Guard Interval : τ_{GI} (for example τ_{GI} = 126 usec)
- Long delay multipath over guard interval $\tau_x > \tau_{GI}$
- IF D>37.8km, t_2>126usec, there is possibility to be $\tau_x > \tau_{GI}$

→ Development of long delay multipath equalizer is important.

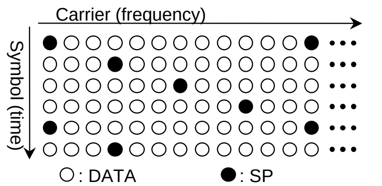


Receiver improvement
Principle of long delay mutipath equalizer



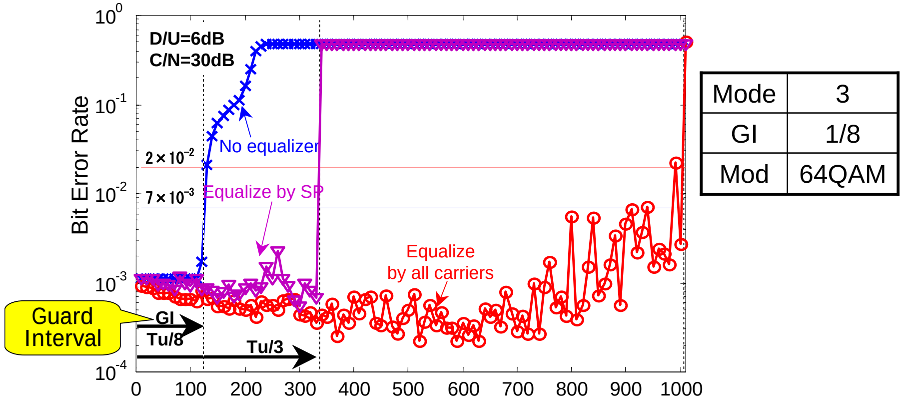
Equalizer adapted with long echo over guard interval
(Equalizer in time domain)

Update of filter coefficient ;
- SP : 4 symbol interval
- All carrier : 1 symbol



Distribution of Scattered Pilot symbol

Performance of long delay multipath equalizer

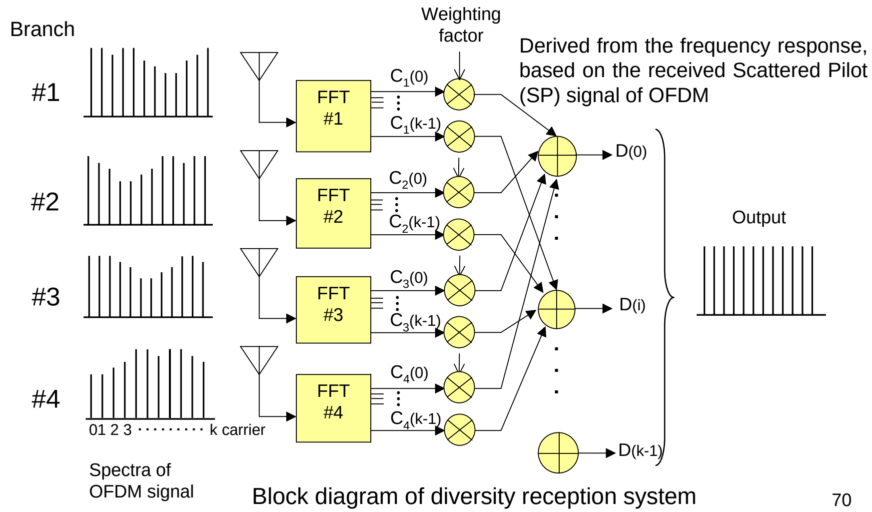


Mode	3
GI	1/8
Mod	64QAM

Useful symbol duration (Tu) : 1008usec

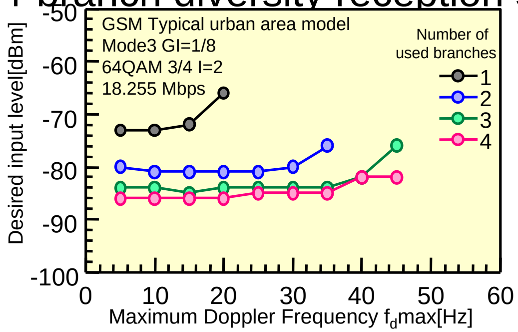
Guard interval (GI = Tu/8) : 126usec

Principle of 4-branch space diversity for OFDM signal under mobile reception



Block diagram of diversity reception system

Results of lab test on 4-branch diversity reception system



Number of Branch	$f_d$max	Velocity@19ch ($v = f_d max \times \lambda$)	Velocity@62ch ($v = f_d max \times \lambda$)	Desired input level (@ $f_d$max =20Hz)
1	20Hz	42 km/h	28 km/h	-66 dBm
2	35Hz	74 km/h	49 k	-81 dBm
3	45Hz	95 km/h	63 k	-84 dB
4	45Hz	95 km/h	63 km/h	-86 dBm

35km/h improved

20dB improved

5. Examples of Transmitter Equipment (Japan)

1. Main transmitter series;

   10kW (Tokyo), 3kW (Osaka, Nagoya), 1kW(other key station)

2. Relay station transmitter

   1W – 100W, SCPA, MCPA (note)

   (note) Multi channel Power amplifier

3. Microwave STL/TTL

DiBEG
Digital Broadcasting Experts Group

Examples of High Power Digital Transmitter (Toshiba)

10 kW digital Transmitter(2/3 type)

3 kW digital transmitter rack

1 kW digital transmitter rack

Output power series;

-10kW(2/3) type; for Kanto area
-3kW dual type; for Kansai and Chukyo
-1kW dual type; for medium cover area

Feature;

-Any of cooling type (water or air)
-Equipped high performance non-linear distortion compensator

Examples of Digital Transmitter (NEC)

Features

1) **Both liquid cooling / air cooling available**
2) **Compact size / Minimized footprint**
3) **Adaptive Digital Corrector to maintain optimal signal quality**
4) **Color LCD to monitor detailed parameters**

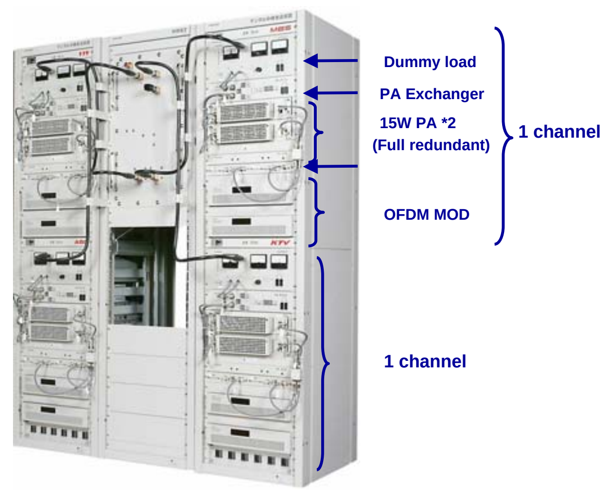
3kW Air Cooled
UHF Digital TV Transmitter
(in operation at Osaka & Nagoya stations)

10kW Water Cooled
UHF Digital TV Transmitter
(in operation at Tokyo station)

TOSHIBA
Leading Innovation >>>

100 W * 5 channel relay station transmitter (TS –TTL type)

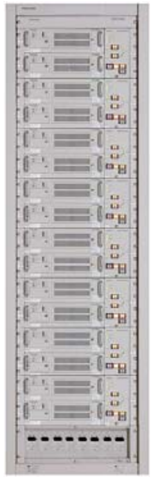
TOSHIBA
Leading Innovation >>>



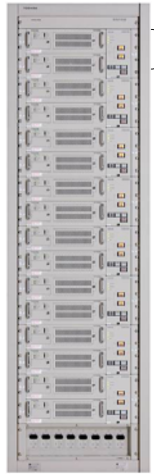
10 W * 4 channel relay station transmitter (TS –TTL type)

MCPA type relay station transmitter

(3channel * 3W)



8 channel transmitter



8 channel receiver

Compact size IF TTL Transmitter/Receiver

3 channel transmitter
(Full redundant)

(TX power; 1W or 2W)

3 channel receiver
(Full redundant)

(Single, or Space diversity)

TS-TTL transmitter/receiver

END of Seminar #7

Thank you for your attention