Vol.2011-AVM-75 No.20
2011/12/16

A proposal for rapid diffusion of digital terrestrial broadcasting in foreign countries by ISDB-T technology

－Easy construction of broadcast infrastructure in non-electrified areas－

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Abstract This proposal relates to the effective use of "One seg" technology of ISDB-T for smooth diffusion of digital broadcasting in foreign countries in which several non-electrified areas remain. For an example, digital broadcast service will start as One-seg situation and move to the Full-seg service after power infrastructure will be available. The almost of transmission infrastructure can be re-used after transition.

Keyword ISDB-T, ISDB-Tsb, ISDB-Tmm, Segmented OFDM transmission, One-segment transmission,

1. forward

Terrestrial digital TV broadcasting started firstly in EU and U.S. in the late of 1990s. Next, a digitalization of TV broadcasting was adopted and promoted in many countries. On the other hand, the digitalization needs much cost not only for the diffusion of digital receiver but also for the construction of the digital transmitter infrastructure.

These cost problems are one of most important bottleneck to prevent a rapid diffusion of digital broadcasting. Because of these reasons, many countries which started a digital broadcasting service cannot finish an analog broadcasting service except a few countries, such as U.S., U.K, and Japan.

A broadcast transmission infrastructure will also require a electric power infrastructure for broadcasting transmitters in order to sustain a stable broadcast service.

Therefore, the developing of electric power infrastructure in non-electrified area is a rather important issue in developing countries and island countries.

In view of such situation, this report proposes an effective method to facilitate digital broadcasting infrastructure in such non-electrified areas by making use of ISDB-T transmission technology which was developed in Japan and adopted and now used in many countries.

2. Features of ISDB-T system and the possibility of low-power transmission

2.1 hierarchical transmission system of ISDB-T[1],[2]

Before explaining the details of the proposal, features of ISDB-T are explained briefly.

ISDB-T adopts "Band segmented OFDM transmission system" for hierarchical transmission

Figure 1 illustrates the image of the hierarchical transmission service based on "Segmented OFDM transmission.

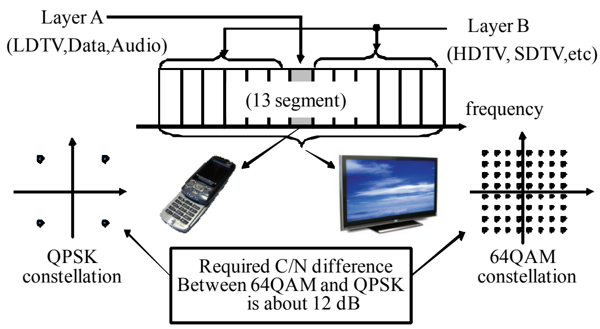


Figure 1 Image of hierarchical transmission of ISDB-T

This figure shows the case of "2 hierarchy service". Carriers of OFDM signal is grouped into segments in the frequency axis. The number of segments is 13 in case of ISDB-T. While a segment which is intended to be used for handheld reception service is usually modulated in QPSK, the other segments for fixed reception service are modulated in 64QAM.

In other words, carriers grouped for mobile reception take only 4 values in constellation, whereas other carriers take 64 values. In case of Figure 1, about 12 dB difference exists for required C/N between 2 hierarchies.

Number of hierarchy of ISDB-T is any of one(1), two(2) or three(3). In case of 2 hierarchy service, ISDB-T use the center segment for mobile and portable reception, the rest 12 for fixed reception.

The name "One-Seg" comes from abbreviation of "One-Segment", which is located in central position of the bandwidth and used to transmit TV service for mobile and portable terminals, which can be transmitted from a single transmitter. In contrast to the "One-Seg" service, the service for fixed TVs using the rest of the segments is called "Full-Seg" service as shown in Figure 1 above.

2.2 Relationship between transmission bandwidth and reception bandwidth[1],[4]

The relationship between transmission bandwidth and receiving bandwidth is investigated. As shown in Figure 2 below, theoretically, there are four cases between transmission bandwidth and reception bandwidth in segmented OFDM transmission system.

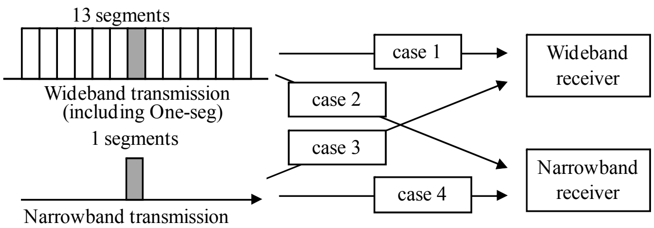


Figure 2 relationship of TX/RX bandwidth

Here "wideband" means a transmitter (or a receiver) transmits (receives) full of 13 segments; whereas narrowband means a transmitter (or a receiver) transmits (receives) only 1 segment.

While these 4 cases are theoretically possible, each cases in practical service are summarized in Table 1. Case 1 is most popular case used for fixed services, and Case 2 is ISDB-T One-Seg services.

Case 4 is 1 segment digital radio in Japan called ISDB-Tsb , in which transmitter transmits 1 segment or 3 segments carrying mainly audio programs. ISDB-Tsb allows placing the system next to each other in the frequency axis called "consecutive segment transmission system" so that multiple systems can be placed in the assigned frequency slot that is generally wider than bandwidth necessary for 1 system.

Table 1 Relationship of TX/RX bandwidth

Case	TX- BW	RX-BW	Service type
case 1	wide	wide	TV fixed reception
case 2	wide	narrow	Partial reception
case 3	narrow	wide	None (note)
case 4	narrow	narrow	digital radio/mobile multimedia

(note) possible in theory, but no actual services exist

3. Migration process from analog to digital broadcasting and its issues

Terrestrial digital TV broadcasting services in EU and U.S. began in the late 1990s and also in 2003 in Japan.

Now in 2011, these countries have completed the full transition to digital broadcasting.

Figure 3 shows the typical migration process from analog to digital broadcasting. The countries which have already completed this transition followed the transition process shown in Figure 3.

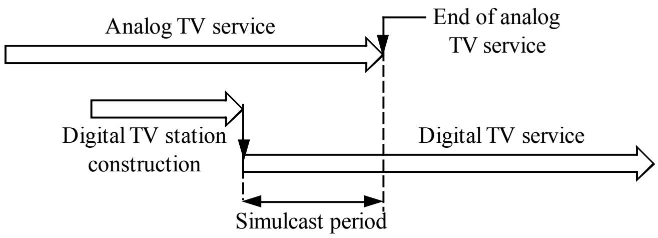


Figure 3 Typical migration process

Also, in a transition schedule, the coexistence period of a analog broadcast and a digital broadcast service(this period is so-called "simulcast period") is provided to continue the broadcast service.

During this migration process, digital broadcast transmitting stations are constructed and both analog broadcasting and digital broadcasting should operate in parallel during "simulcast period".

Therefore, for this migration process, it is necessary that the enough electric primary power should be provided for operation of these transmitters.

Countries, EU, U.S., Japan, these countries have already completed the digital transition, have enough power infrastructure even in rural areas, so, it is not necessary to develop a new power infrastructure for digitalization.

However, in developing countries and island countries, several non-electrified areas may remain in these countries, especially in mountain area and isolated small island. In these areas, it is necessary to develop the power infrastructure before starting the migration process.

The schedule delay of migration process in these non-electrified areas may affect the migration schedule of all over of this country.

In generally, it is considered that the most important issue of migration process is the diffusion of digital receiver. But, in developing countries and island countries, the developing of power infrastructure in non-electrified areas may also be the key issue for early diffusion of digital broadcasting service.

This report relates to solve these issues, and gives a solution for early developing of digital broadcasting infrastructure in these countries.

4. Proposed migration process

4.1 How to reduce a power dissipation of transmitter station

As described in section 3. , the key issue of which early developing of digital broadcast infrastructure in non-electrified area is " transmitter station need higher primary power".

For the early development of transmission infrastructure in poor power infrastructure areas, the best solution is to construct stand-alone type power generation station composed by solar panel and battery, this type power station needs neither any high power generator nor any power line network.

High power transmitter station needs very big size solar panel and big capacity battery, of course, needs much cost, so, this seems not to be a better solution. Therefore, the better solution is just to reduce a output power of broadcast transmitter, that is, low power transmission is desirable. Also it saves cost.

As described above, it is said, "reduction of transmission power is a key issue for rapid diffusion of digital broadcasting service into rural areas"

Two measures shown below are considered for the reduction of transmission power.

(a) Reduction of coverage area

It is possible to reduce a transmission power by reduction of coverage area. But, this measure has two big problems described below.

(i) Inability to secure the planed coverage area is a basic problem of channel planning

(ii) After constructed a power infrastructure, broadcast transmission power will be up to planed power level. But, if changes transmission power, a channel plan should be reviewed or changed to avoid a interference between adjacent transmitter stations.

(b) Reduction of transmission bandwidth

For another technique, "Reduction of transmission bandwidth" is possible solution. In this case, it is possible to reduce the transmission power without decreasing of coverage area. For an example, described in section 2. above, by making use of "One-segment transmission technology" it is possible to reduce a transmission power down to one thirteenth(1/13) without any change of transmission parameters(modulation index, error correction coding rate,etc) and coverage area.

As described above, (b) is the better solution.

4.2 Image of proposed transmission network

Figure 4 below shows an image of proposed transmission network of digital terrestrial broadcasting based on the solution (b) described in section 4.1.

Here, the digital broadcasting program is assumed to be delivered directly from a central broadcaster's station to transmitter stations of each area via satellite communication channel.

The delivered broadcasting program is two hierarchical transmission signal which is composed of 12 segments program and 1 segment program, both program contents are same.

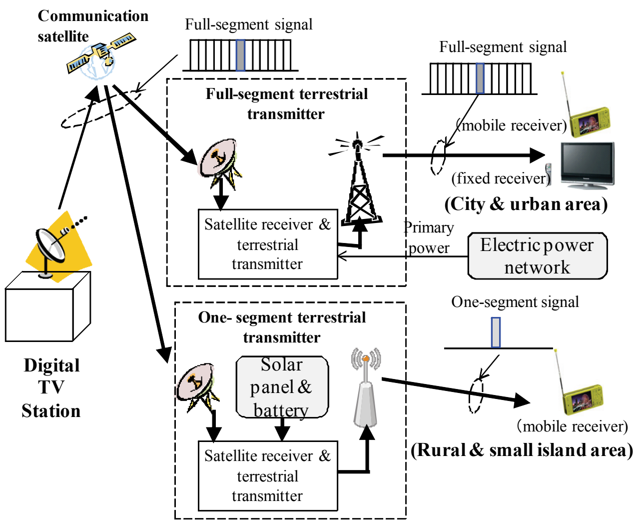


Figure 4 An image of proposed transmission network

"Full-segment terrestrial transmitter", indicated in Figure 4, demodulates a received signal and convert to a transport stream format, which is provided to a ISDB-T modulator. This modulated OFDM signal is amplified at a power amplifier and transmitted via UHF transmitting antenna.

"Full-segment terrestrial transmitter" is assumed to be a high power transmitter station, therefore, this type transmitter should be constructed in a region in which a enough power infrastructure has been developed.

While, "One-segment terrestrial transmitter", shown in Figure 4, extracts one-segment signal from a received signal by making use of PID filter, then converts to Transport Stream(TS) format which is provided to a ISDB-T modulator. A modulated OFDM signal is amplified at a power amplifier and transmitted via UHF transmitting antenna by same process of “Full-segments transmitter”..

The transmitted signal bandwidth of “One-segment transmitter” is just one thirteenth (1/13) of the bandwidth of Full-segment signal, therefore, the required output power of “One-segment transmitter is one thirteenth of the one of “Full-segment transmitter”

That means “One-segment transmitter” is possible to operate by small primary power. This significant reduction of transmission power enables “One-segment transmitter” operation by small electric power generation kit, composed of solar panel and battery. Therefore, ”One-segment transmitter” can be easily deployed even in non-electrified areas

As described, If a digital broadcasting network is structured by a mixture of “Full-segment transmitter” stations and “One-segment transmitter” stations, it is possible to rapid diffusion of digital broadcasting service in nationwide of country even though several non-electrified areas still remain.

4.3 Migration to Full segment transmitter

“One-segment transmitter” is a temporary situation for rapid diffusion of digital broadcasting service in non-electrified areas, therefore, this transmitter should be necessary to be changed to a “Full-segment transmitter” , which covers both HDTV fixed reception and One-seg mobile/portable reception illustrated in Figure 1, after power infrastructure becomes available.

Figure 5 shows the migration scenario.

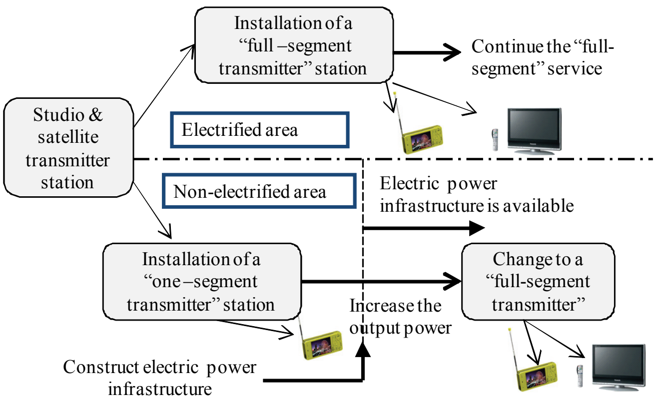


Figure 5 Migration scenario

The biggest issue of this transition is a legacy problem of equipments composed of “One-segment transmitter” station. But, all equipments can be utilized after transition to “Full-segment transmitter” by making the design of equipment to be considered for future use in Full segment operation stage.

Figure 6 shows a composition of “One-segment transmitter” station, and a scenario to change to “Full segment transmitter”

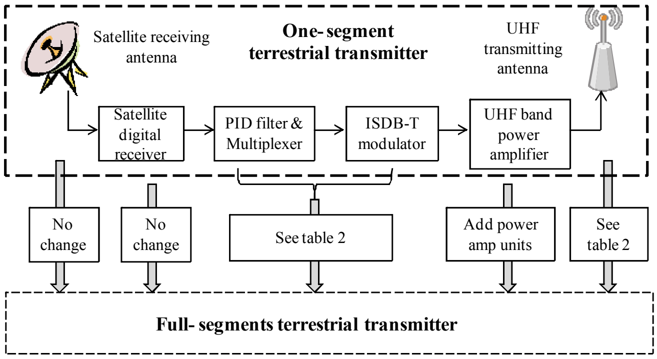


Figure 6 Composition of One-segment transmitter and migration process to Full-segment transmitter.

Table 2 shows the details of transition process of each equipment.

Table 2 Migration process of each equipment

Equipment	Change to “Full-segment transmitter” station	Remarks
Satellite receiving antenna	No change	
Satellite receiver	No change	
Multiplexer with PID filter	Not necessary to replace a hardware, but necessary to change parameters	
ISDB-T modulator	Same as above	
UHF band power amplifier	Expansion of power amplifier units	
UHF transmitting antenna	Not necessary except special case(note)	

(note)special case: frequency change, power rating change

When changing from One-segment transmitter to Full-segment transmitter, the broadcasting program which is filtered from a distributed program stream via satellite networks should be changed. Therefore, the operating parameters of PID filter and Multiplexer should be changed. According to the change of transmission signal from one-segment to full segment, operating parameters o ISDB-T modulator should be also changed. But, these situation change does not require a replacement of equipment.

For a power amplifier, the output power should be increased because of transmission bandwidth expansion. In generally, the increase of output power is achieved by expanding of power amplifier unit.

For satellite distribution network, it is no necessary to change both network configuration and hardware.

Needless to explain, One-seg receiver can be used after Full segment transition.

5. Other example...Local broadcasting network

In section 4, an example for national broadcasting transmission network is introduced. In this section, applications for local broadcasting network are shown.

Table 3 shows a classification of local broadcasting network based on the transmission link.

Table 3 classification of local broadcasting network[3]

network	Distribution signal format	Distribution link
TS relay network	Transport Stream signal	Digital communication Link(micro wave, fiber)
IF relay network	OFDM modulated RF signal	RF signal(micro wave , fiber)
Broadcast wave relay network	OFDM modulated RF signal	Use broadcast signal from former stage transmitter

In case of TS relay network, a distributed signal format is same as a signal of satellite link shown in Figure 4.

Then , the network composition is similar to an example illustrated in Figure 4. So the detail explanation can be skipped.

On the other hand, IF relay network and broadcast wave relay network are similar network system, because both networks use same signal format(OFDM modulated signal) for a distribution signal. The difference is that IF relay network uses micro-wave link or fiber link(RF), while, broadcast wave relay link uses broadcast signal which is transmitted from a former transmitter.

An example for broadcast wave relay network, which is composed of Full-segment relay stations and One-segment relay stations, is illustrated in Figure 7.

The selection of Full-segment station or One-segment station depends on the situation of power infrastructure where a relay station is constructed.

One-segment relay station can be also moved to a Full-segment relay station. Figure 8 below shows the composition of a broadcast wave relay station and transition process.

As shown in Figure 8, IF filter should be replaced for a transition to a Full-segment relay station.

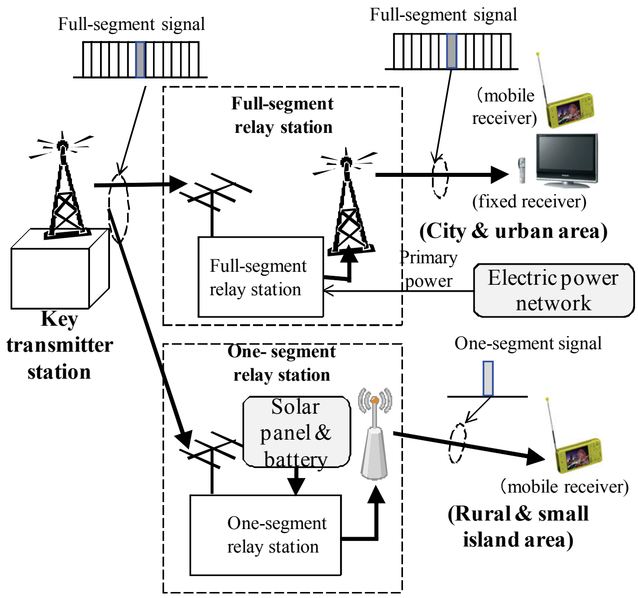


Figure 7 An image of proposed transmission network (Local broadcasting network)

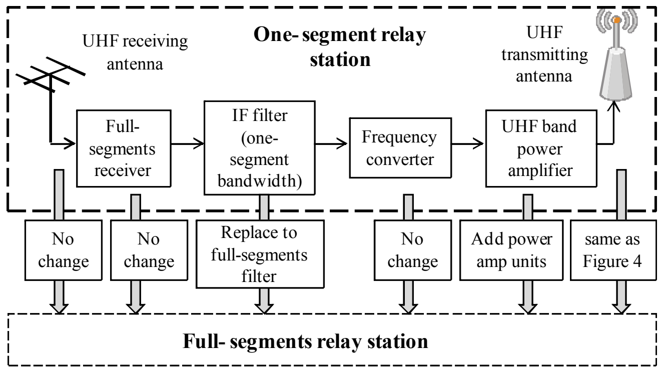


Figure 8 Composition of One-segment relay station and transition process

For power amplifier, RF circuit and transmitting antenna, transition process of these equipment is same as an example shown in Table 2.

6. Other example...transition to mobile multimedia broadcasting[4],[5]

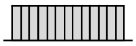
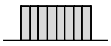
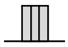
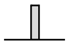
One-segment transmission of ISDB-T is the common standard of ISDB-T(digital TV) and ISB-Tsb (digital radio). In ISDB-Tsb standard, the consecutive transmission system is also defined to transmit plural channels by single transmitter. Therefore, any number of segment signal can be transmitted based on ISDB-T system(note).

(note)Experimental digital radio broadcasting was tested during 2003 to 2011 in Tokyo and Osaka in Japan by 8 segment consecutive transmission system. Also

Mobile multimedia broadcasting services, which also use both ISDB-T segmented OFDM transmission and consecutive transmission technologyies are planned to start within a couple of years in Japan.

Table 4 shows an example of the relationship between number of segment by consecutive transmission and required power ratio.

Table 4 relationship between required power and number of segment (consecutive transmission system)

Number of requested broadcast channels	Frequency spectrum (image)	Required transmitter power ratio
13		1
8		8/13
3		3/13
1		1/13

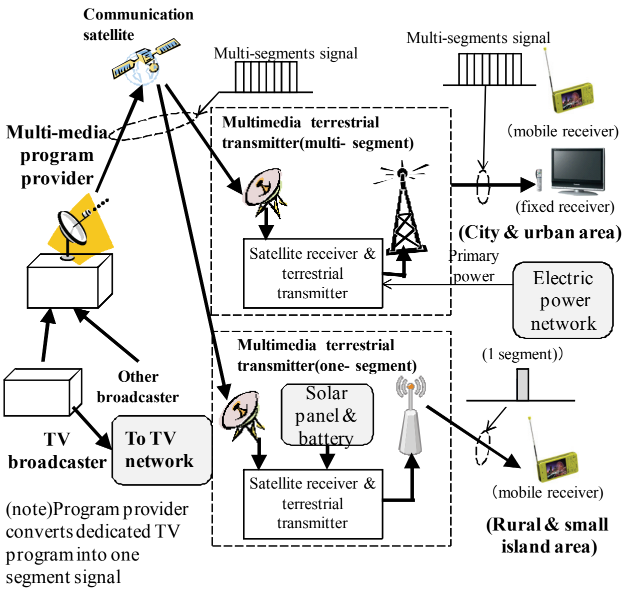


Figure 9 An example of Mobile multimedia network

Figure 9 above shows an example of national network of digital mobile multi-media broadcasting system based on the consecutive transmission technology.

An up-link station of multimedia broadcasting center gathers broadcast programs from each broadcasters, then multiplex these programs and distribute via communication satellite channel. Multimedia terrestrial transmitter stations receive a down-link signal in which multiple programs are combined.

According to a number of requested programs, each transmitter stations extract required programs , convert to a segment form ,multiplex- OFDM modulation, then on air. Figure 10 illustrates an example of the composition of multimedia terrestrial transmitter station.

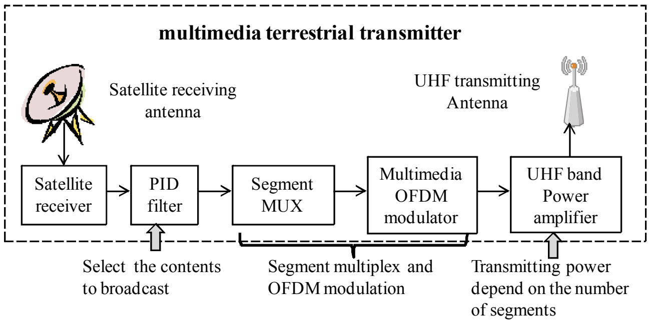


Figure 10 Composition of multimedia transmitter station

As described above, the transmitting power of each station depend on the number of segments. Therefore, in case of few segment broadcasting services, it is possible to operate a transmitter by solar panel and battery especially in rural area and small island.

7. conclusion

Several kinds of hybrid transmission network , which are composed of high power and low power transmitters, are effective measures for early diffusion of digital terrestrial broadcasting service. In addition, legacy problem does not exist for these networks.

In future, if some countries intend to adopt these networks configuration, It is necessary to make a details scenario for migration process, and carefully investigate a channel plan for both temporary and final situation, including assignment of NIT(Network Information Table) and its download measure.

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[5] ARIB STD-B46 Version 1.1; セグメント連結伝送方式による地上マルチメディア放送の伝送方式