An Optimal ERP and Antenna HAAT Of 8-VSB for Digital Multimedia Broadcasting

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Abstract : It designs the general description of 8-VSB DTV transmission system will be installed and operated in future on the basis of NTSC TV transmission system in operation now.

First of all, it investigates a condition that can maintain optimum received field in case of ground wave broadcasting with analog NTSC and digital 8-VSB DTV. Also it calculates critical value of minimum field strength for receiving by using field strength calculation method of Longley-Rice.

The 8-VSB DTV transmission sets its goal in transmission of data with 19.39Mbps at high speed in order to be available of HDTV in the band of NTSC 6MHz. Accordingly, the optimum of field strength between transmission and receiving points most of all is important problem. So, 8-VSB DTV transmission should be enlarged or effective compared with NTSC service coverage. This study is to calculate the transmission power necessary in switching from NTSC VHF to DTV UHF and from NTSC UHF to DTV UHF for maintaining service coverage that NTSC is equal to 8-VSB DTV as a result of calculation.

1. Introduction

America started DTV from Nov. 1998 using ATSC(Advanced Television System Committee) Korean government announced the plan to change that main broadcasting would start in the Metropolitan area from 2000 via pilot broadcasting in 2001. In 2000, three major TV networks test-broadcasted DTV transmission and many studies have been researched. They are planning to assign DTV channel and change into DTV in order to ensure the same service coverage as the NTSC(National Television System Committee) TV district until 2010.

This study examined the history of analogue NTSC and ground wave TV using digital 8-VSB and the theory of conditions necessary for transmission output to receive.

As for analogue and digital TV broadcasting, it examines the condition of optimum reception with Longley-Rice calculation method on a basis of FCC rules Sections 73.623 and 74.704 for the prediction of radio path located on transmitter and receive points and receive field changed by radio path.[1][2][3]

2. Comparison with NTSC TV power and 8-VSB DTV power

2.1 Transmission power

DTV designs transmission power on a basis of required field strength and calculates as effective radiated power because it uses average power.[4][5]

NTSC type TV signal marks as Peak of Sync and the relations with average power is the same as formula (1).

$$\text{NTSC avg} = \text{NTSC peak} - 5.2\text{dB} \quad (1)$$

The formula (1) is available when TV transmitter is usually operated, that is, when video signal uses APL(Average Picture Level). If video signal is Blanking Level, The -2.2 dB should be applied instead of -5.2 dB. formula (2), (3) and (4) relate to peak power.

$$\text{DTVpeak} = \text{DTVavg} + 6.3\text{dB} \quad (2)$$

If NTSCavg is equal to DTVavg, formula (3) is as follows.

$$\text{DTVavg} = \text{NTSCpeak} - 5.2\text{dB} \quad (3)$$

If NTSCpeak is equal to DTVpeak, formula (4) is as follows.

$$\text{NTSCpeak} = \text{DTVavg} + 6.3\text{dB} \quad (4)$$

2.2 Determination factor of coverage area

The transmitter's coverage is based of ERP, HAAT(Height Above Average Terrain) of antenna and channel frequency in a condition without interference signal.

The criterion that the coverage region determines is a function about HAAT, ERP and Frequency as field strength on the receive point. It is impossible for us to calculate correct field strength and it cannot help calculating approximately with statistical data having several experiments.

FCC uses NTSC F(50, 50) and DTV F(50, 90) wave curve. F(L, T) draws coverage circle centered on transmitter antenna and it means the region that screen shows well in above L% on a position and above T% on the times.[6]

F(50, 50) is used in the calculation of service area of NTSC. F(50, 90) is applied to DTV. The normal receive is available only when the receiver of DTV signal maintains stabilized field of time. As for the reason why DTV uses 90% of time, DTV guarantees definition equal to the definition received from transmitting station when it

satisfies BER($3*10^{-6}$), TOV(Threshold of Visuality) condition, or SER($1.9*10^{-4}$) on the boundary of coverage. But Cliff Effect, did not recognize it, shows only when below TOV.

There arises differences of definition by the strength of received field in NTSC and S/N required to the received condition of medium level is 28.5dB. Generally, the received grades mark as City Grade, Grade A and Grade B and the criteria of field by channels is the same as Table 1. When it designs dimension of DTV transmission system maintaining an equal broadcasting service area, Grade B should be based for calculating the broadcasting area of NTSC.

Table 1. The range of NTSC field strength in FCC

C H	Frequency Band (MHz)	City Grade (dB u)	Grade A (dBu)	Grade B (dBu)
2~6	54~88	74	68	47
7~13	174~216	77	71	56
14~69	470~806	80	74	64

3. Analysis and examination about test network

3.1 ERP and antenna HAAT

ERP of NTSC TV and DTV system is calculated from loss by transmitter power and RF Filtering, feeder loss and antenna gain and it is the same as formula (5).

$$\text{ERP(kw)} = \text{Transmitter power(kw)} \times \text{Feeder ficiency} \times \text{Antenna gain} \quad (5)$$

ERP indicated as a decibel(dB) is the same as formula (6).

$$\text{ERP(dBk)} = \text{Transmitter power(dBk)} + \text{Feeder loss (-dB)} + \text{Antenna gain(dBd)} \quad (6)$$

The dBk is an algebraical unit on a basis of 1kW for calculating transmission power and effective radiated power algebraically and it is the same as formula (7).

$$\text{P(dBk)} = 10\log \text{Transmission power(kw)} \quad (7)$$

The antenna HAAT means the average height above sea of topography and it is used of showing the degree of transmission antenna position how many heights located from the average height of object area higher and it is the same as formula (8).

$$\text{HAAT} = h1 + h2 - h3 \quad (8)$$

Here, h1 : a transmitting tower height (m)
h2 : a transmitting place altitude (m)
h3: an average height 3.2~16km range from a transmitting place

3.2 General description design of DTV transmission System

It designs the dimension of DTV transmission system with the equal service area comparing with special channel on air with NTSC.

3.2.1 Examination of NTSC system

ERP is the same as formula (9) when the channel is 4(66~72MHz) and transmission power is 10kw(Visual Peak Power), 10.0dBk presented as dBk, and the length of feeder 3 1/8 Heliax cable(-0.35dB/100m) is 100m and the antenna is nondirectional 2-Dipole(+4.7dB) and the other loss is 0.3dB.

$$\text{ERP(dBk)} = 10.0 + 4.7 - 0.35 - 0.3 = 14.0 \quad (9)$$

The transmitter rated power is 25.40kw in 14.05dBk. If HAAT is computed, it is calculated as 790m by the formula (8).

3.2.2 Calculation of NTSC service area

Service coverage is 88km when the transmission rated power is 25.4kw in the Fig. 1, NTSC F(50,50) coverage and ERP(CH2~6)

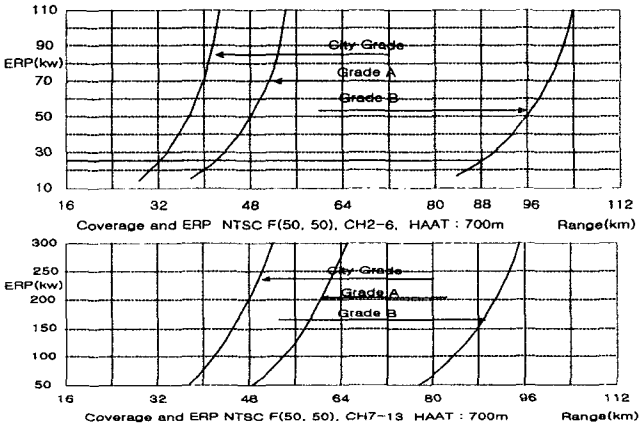

Fig 1. NTSC F(50,50) Coverage and ERP(CH2~13)

3.2.3 Calculation of DTV transmission ERP with a service area equal to NTSC broadcasting

In Fig. 2, it has 220kw in drawing a vertical line about 88km of service area limit length and in moving it left in a cross with 43dBu(critical value of electrical strength in DTV) curve and then in reading ERP scale. But it should be decreased of ERP about 2.32dB(43-40.68) because the minimum received field of CH-34 is 40.68dBu.

It brings a result value when it calculates ERP as a proportional value. ERP is 220kw(23.42dBk) when field strength is 43dBu and 128.8kw(21.1dBk) when 40.68dBu. The necessary ERP is 128.8kw(129kw).

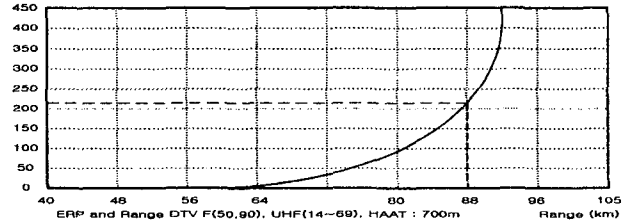

Fig 2. DTV F(50,50) Coverage and ERP(CH14~69)

3.2.4 DTV Transmitter rated Power(TPO) by ERP

Transmitter rated power of digital TV according to effect-ive radiated power is calculated by formula (10) and formula (11)

$$21.1\text{dBk}=\text{TPO}+11.7-0.35-0.4 \quad (10)$$

$$\text{TPO}=21.1-11.7+0.35+0.4=10.15(\text{dBk}) \quad (11)$$

Here, it is the same as 10.15(dBk)=10.35kw(≒10kw).

3.2.5 Calculation of DTV transmitter peak power and size of NTSC transmitter

The transmitter peak power of digital TV is the same as formula (12)

$$10\text{kw avg}\times 4.27=42.7\text{kw peak} \quad (12)$$

The size of this transmitter is equal to 42.7kw class of NTSC

3.3 Switching NTSC TV to DTV(CH36)

It calculates resources of transmission facilities required assuming that the transmitting station transmits as NTSC VHF CH4 is assigned of DTV UHF CH34.

It calculates resources of transmission facilities required assuming that the transmitting station transmits as NTSC UHF CH24 on the air is assigned of DTV UHF CH36.

The transmitter having channel with 24(530~536MHz) and transmission power with 30kw(Visual Peak Power) is 14.77dBk when it presents as dB. The feeder is 6 1/8 Heliax(-0.52dB/100m) and the length is 100m. It is used of 2Dipole (+11dB) antenna. And the other loss is calculated as -0.2dB.

3.3.1 Calculation of ERP and computation of HAAT

The value is the same as formula (13) in the calculation of ERP.

$$\text{ERP(dBk)} = 14.77+11-0.52-0.2=25.05\text{dBk}$$
$$25.05\text{dBk}\ (=319.9\ \text{kw}) \fallingdotseq 320\text{kw} \quad (13)$$

The HAAT of antenna is equal to NTSC and it is calculated as 790m by the formula (8).

3.3.2 Calculation of service area of NTSC

It confirms that the minimum received field becomes 63dB[64–20log (615/533)=62.80] and the service coverage becomes 67km as the figure 4.

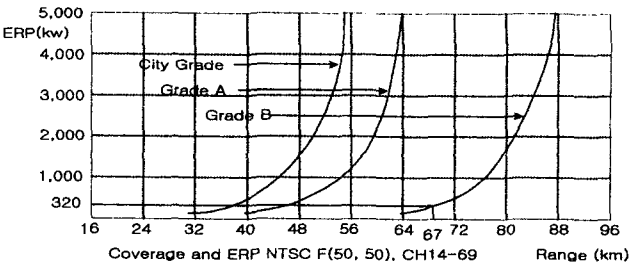

Fig 3. NTSC F(50,50) Coverage and ERP

3.3.3 General description of DTV transmission system

The antenna HAAT is 790m according to the formula (8). The 3 1/8″ Heliax(-0.806dB/100m) cable is used in the feeder. And the antenna is Slot(+10.3dB) when the length is 100m. Also it assumes that the other loss is 0.4dB.

3.3.4 Calculation of DTV transmission ERP with service area equl to NTSC broadcasting

ERP transmission power that can maintain 40dBu at 67km range is calculated from the figure 4.

The transmitter power is 10kw(10dBk) when the received field strength is 43dBu(DTV received field strength critical value considering margin). And the transmitter power becomes 6.16kw (7.9dBk) when the received field strength is 40.9dBu. Accordingly, the minimum received electric field of CH36 is calculated as 40.9dBu[41-20log(612/605).

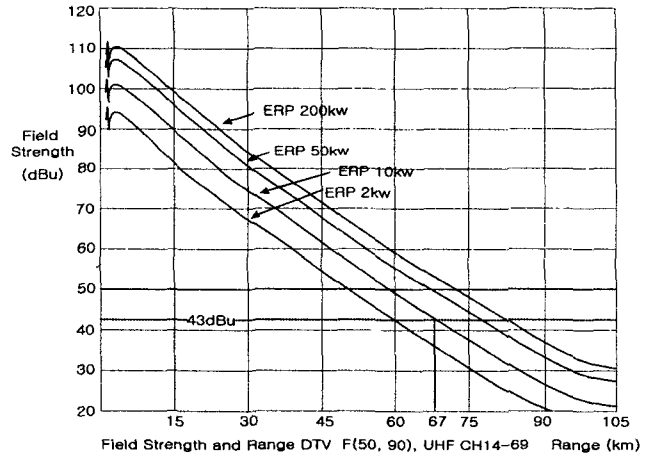

Fig 4. DTV F(50,50) Electric Strength and Length(CH14~69)

The result of calculating DTV transmitter rated Power(TPO) is the same as the formula (14).

$$7.9\text{dBk} = \text{TPO} + 10.3 - 0.806 - 0.4$$
$$\text{TPO} = 7.9 - 10.3 + 0.806 + 0.4 = -1.194\ (\text{dBk}) \quad (14)$$

The value is -1.194(dBk) (759w). It is deemed about 1kw transmitter.

3.4 General description design of DTV transmission system

It designs the general description of DTV transmission system necessary to maintain broadcasting service area equal to NTSC transmission system.

3.4.1 Antenna HAAT and maximum ERP

In the 6th report by FCC, it assigns the antenna's height, DTV and ERP for each DTV allocation. As for this allocation, it provides DTV service to topography equal to service right now by NTSC transmitting station. FCC determines minimum effective radiated power(ERP) of DTV as 1kw in VHF-L(CH2~6), 3.2kw in VHF-CH(CH7~13) and 50kw in UHF(CH14~69).

The relations with antenna HAAT of CH14~59 and maximum effective ERP is the same as the formula (15).

$$ERP_{MAX}=84.57-17.08\log10(HAAT) \quad (15)$$

With maintaining service coverage of NTSC, the rated power of transmitter and transmitter ERP by frequency band is the same as the table 2 when antenna HAAT is 690m(700) and it considers antenna gain, feeder loss and the other loss.

Table 2. Frequency Band and ERP

CH	Frequency Band (MHz)	ERP(kw)	TPO(kw)
2~6	54~88	74	2.04
7~13	174~216	77	2.57
14~69	470~806	80	3.86

3.5 Analysis of results

For the service coverage production according to the speci-fication of transmission system in NTSC TV and DTV, it was assumed that DTV channel is assigned, corresponding to NTSC and the specification of required DTV transmission system was formed.

4. Conclusion

The specification of DTV transmission system required to maintain broadcasting service coverage, which is equal to NTSC TV transmission system, was designed

By examined result, when NTSC VHF channel was changed into DTV UHF band, transmission output of about four times was required. On the other hand, when NTSC UHF is changed into DTV UHF band, significantly less transmission output (about 1/7) is required.

As a result of the test of ground wave three TV networks, the service coverage of DTV was similar to NTSC method in most distance.

It suggests that is effective to heighten transmitter output to operate of to build a transmission antenna for receiving a signal. But it is not desirable to heighten transmission output because NTSC and DTV should exist together in digital TV transmission.

References

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F(50,50) curves 73.699
Field strength contours 73.683
Prediction of coverage 73.684
Power and antenna height requirements 73.614