다중 경로 T-DMB 환경에서의 신호검출 성능 분석 연구

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Performance of Signal Detection for T-DMB System in Multipath Environments

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요 약

본 논문에서 다중 경로 T-DMB 환경에서 신호검출 알고리즘을 적용하여 성능을 분석하였다. 가우시안, Rayleigh, COST 207 채널을 각각 적용하여 다중 환경에서 다양한 파라미터를 변화시켜 연구하였다. 최종 실험결과는 주파수 유무에 따라 비트화로 정의하여 비교 분석하였으며, 검출하기 위한 신호는 T-DMB 표준을 참고하여 생성하였다. 실험에 있어서 적용된 신호검출 기법은 에너지 검출 기법을 적용하였으며, 생성 신호의 길이에 따라 실험을 하였다. 실험결과로써는 다중 환경에 따른 다양한 결과값을 얻을 수 있었으며, 뿐만 아니라 신호 길이에 따른 성능 분석을 할 수 있었다. 신호의 길이가 증가할수록 검출시간이 길어져 성능과 비례함을 확인할 수 있었다. 우리는 이번 신호검출 실험을 실제 T-DMB 환경에서 적용할 수 있도록 연구를 하였다.

Key Words : COST 207, energy detection, multipath, spectrum sensing, T-DMB.

ABSTRACT

In this paper, we analyzed performance of signal detection for terrestrial digital multimedia broadcasting (T-DMB) system in various channel environments that applied gaussian, Rayleigh and COST 207 environments that estimate response of real channel state. In order to detect the signal, a signal detection scheme based on energy detection is employed. We generated T-DMB signals so that estimate properly simulation result. For evaluating the signal detection performance, detection probability is derived. We consider two kinds of detection segment, which are three segments and five segments. And we compare the system performances in accordance with the detection segment. From simulation results, it is confirmed that the performance of signal detection is raised as increase the number of segments. The result of this paper can be applied to implement signal detection of broadcasting system.

Ⅰ. Introduction

Future broadcasting systems go digital and ubiquitous. In case of fixed broadcast networks, there are North American advanced television systems committee (ATSC), European terrestrial digital video broadcasting (DVB-T) and Japanese terrestrial integrated services digital broadcasting (ISDB-T) standards. Otherwise, in case of mobile broadcast networks, a variety of systems has been developed such as terrestrial digital multimedia broadcasting (T-DMB), DVB-H. The latest trend of broadcasting systems are not fixed broadcasting and low definition but high mobility and high definition multimedia information reception. Furthermore, full duplex transmission location positioning and relay station for high frequency efficiency are at issue because of broadcasting and telecommunication convergence technology [1].

In T-DMB system, we applied that one of the cognitive radio (CR) scheme is signal detection based on signal energy to improve an efficiency of spectrum resource utilization in radio spectrum currently allocated to the T-DMB systems. In this paper, we propose and implement the signal detection based on energy detection method for T-DMB signals. System performance is evaluated in term

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of a detection probability. Also, we consider three channel environments which are Gaussian, Rayleigh, COST 207, respectively.

The rest of this paper is organized as follows. In Section II, we briefly described T-DMB technique. The COST 207 channel considered in this paper is illustrated in Section III. In Section IV, the signal detection method based on energy detection is presented. In Section V, we analyze the system performance. Finally, concluding remarks are given in Section VI.

Ⅱ. T-DMB Technique

T-DMB is made for transmission on very high frequency (VHF: 174~216MHz) for analog television broadcasting. It is upgrades of the old DAB system with multimedia data service. Thus T-DMB provides high quality audio and video, data service and DAB service as well. In Korea, anybody with T-DMB mobile phone can use T-DMB service as well as DAB audio and video service. Both T-DMB and EUREKA-147 DAB have incorporated the transmission frame. Fig. 1 shows the format of the T-DMB frame. The frame is formed by the time juxtaposition of Synchronization channel, fast information channel (FIC) and main service channel (MSC). Each channel receives the data from the several sources and the transmission frames of each channel are formed by the data. The format and length of transmission frame are varied by transmission modes.

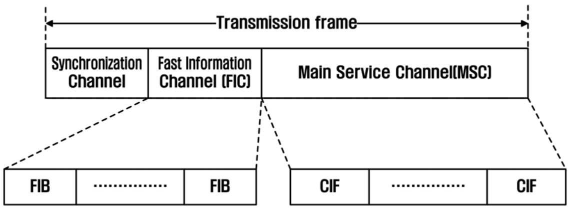

Fig. 1. Frame structure of T-DMB.

Fast information block (FIB) and common interleaved frame (CIF) are to provide independent data transmission mode for FIC and MSC. The general property of transmission frame is that CIF is a set of four groups, and each groups consists 12 FIB. For example, the first CIF consist the first three FIBs and the second CIF consists the next three FIBs. Each transmission frame is divided into a sequence of orthogonal frequency division multiplexing (OFDM) symbols. The number of OFDM symbols in a frame is varied by transmission modes. In case of T-DMB, synchronization channel has one symbol, fast information channel has 3 symbols and main service channel has 72 symbols respectively. Table 1 shows the parameters for T-DMB system.

Table 1. Definition of the parameters for T-DMB

Parameters		value
L	OFDM symbols	76
K	Transmitted carriers	1536 (2048)
T_F	The transmission frame duration	196,608T
T_{Null}	The Null symbol duration	2,656T
T_S	The duration of OFDM symbols	2,552T
T_U	The inverse of the carrier spacing	2,048T (1 ms)
△	The duration of the guard interval	504T (~246 us)

The first OFDM symbol of the transmission frame shall be the null symbol of duration T_{mall}. The rest of the frame consist OFDM symbols with the length of T_s. Each of OFDM symbols consist of a set of equally spaced carriers, with a carrier spacing equal to $1/T_u$. The main signal is given by [2].

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{m=-\infty}^{+\infty} \sum_{l=0}^{L} \sum_{k=-K/2}^{K/2} Z_{m,l,k} \cdot g_{k,l}(t - mT_F - T_{Null} - (l-1)T_s \right\}$$

$$g_{k,l}(t) = \begin{cases} 0 & for\, l = 0 \\ e^{j2\pi k(t-\Delta)/T_U} \cdot rect(t/T_S) & for\, l = 1,2,\cdots,L \end{cases} \tag{1}$$

$$T_S = T_U + \Delta.$$

From function (1) and Table 1, the length of main signal of T-DMB per frame can be evaluated as function (2).

The length of transmission frame (2)
=76symbols ×(2,048+504(GI))=193,952 bit/frame

This signals pass through the transmit block as shown Fig. 2. In T-DMB transmitter, Audio and video signal are coded by using MPEG-4 type with outstanding compression efficiency. They are transmitted through Orthogonal Frequency Division Multiplexing (OFDM).

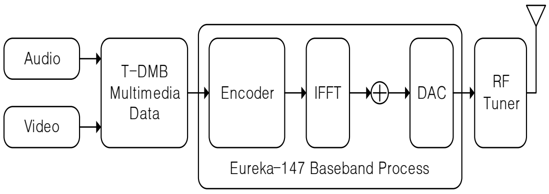

Fig. 2. Block diagram of T-DMB system.

Advanced T-DMB receiver is represented by function (3).

$$\hat{H}(n,k)=\frac{Y(n,k)}{{}_{\gamma HP}X_{HP}(n,k)+{}_{\gamma LP}X_{LP}(n,k)} \tag{3}$$

where n is n-th OFDM symbol, k is k-th sub-carrier, $\hat{H}$ IS estimated channel, $\hat{Y}$ is receiver signal, X is estimated transmitted signal and γ is weighting factor. To increase the accuracy of channel estimated value $\hat{H}$ in Advanced T-DMB, we use different weighting values for HP and LP symbol decision, time/frequency domain averaging and channel estimation weighting value for soft decision viterbi decoder input signal. The frequency domain average is given by

$$\hat{H}(n,k)=\frac{1}{2W+1}\sum_{w=-W}^{W}\hat{H}((n,k+w)_N). \tag{4}$$

where W is windoe size of moving average filter. The time domain average is given by

$$\hat{H}(n,k)=\beta\hat{H}(n,k)+(1-\beta)\hat{H}(n-1,k) \tag{5}$$

where β is forgetting factor. And the soft decision viterbi decoder input $\widehat{X_{LP}}(n,k)$ is given by

$$\widehat{X_{LP}}(n,k)=\hat{H}(n,k)^2\widetilde{X_{LP}}(n,k). \tag{6}$$

Ⅲ. COST 207 TU6 Channel

The technical specification for COST 207 [3] presents the equipment and techniques used to measure the channel characteristics over typical bandwidth of 10 MHz to 20 MHz at near 900 MHz. Adaptation of the COST 207 profiles to mobile DVB-T reception was done by the Motivate project [4]. Especially, we dealt with a typical urban reception case. The feature of typical urban (TU6) is made of 6 paths having wide dispersion in delay relatively strong power. This TU6 profile parameters are given in Table 2.

Table 2. Typical urban (TU6) profile constitution.

Tap Number	Delay (us)	Power (dB)	Doppler
1	0.0	-3	Rayleigh
2	0.2	0	Rayleigh
3	0.5	-2	Rayleigh
4	1.6	-6	Rayleigh
5	2.3	-8	Rayleigh
6	5.0	-10	Rayleigh

Until a given Doppler limit, the receivers are able to perform sufficient channel equalization to demodulate the signal. Then, when the Doppler further increases, the recovery performance decreases until a point where no demodulation remains possible [5].

Ⅳ. Signal detection method

The energy detection scheme is one of signal detection scheme in CR system and is feature detection. We applied fast Fourier transform (FFT) based on energy detection of signal bandwidth. This scheme performs the signal measurements and determines the unoccupied channel by predefined threshold value. T-DMB signal received pass through frequency shift filter process and filtering the low-pass filter of bandwidth 40kHz. The filter bandwidth should be large enough to accommodate any unknown frequency offsets.

Filtered T-DMB signal is down-sampled and finally take FFT process [6]. FFT based on signal detection process is presented by Fig. 3. The condition to detect T-DMB signal is that noise floor value is -174 dBm/Hz and whole noise figure of receiver from noise figure (NF) of low noise amplifier (LNA), coupling loss and radio frequency (RF) switch loss is assumed by 8dB. In receiver, we taken power density function (PDF) of noise

$$\begin{aligned}\overline{N}&=N_0+NF\\&=-166dBm/Hz\end{aligned} \tag{7}$$

and average power of included noise in 6MHz bandwidth of T-DMB is calculated

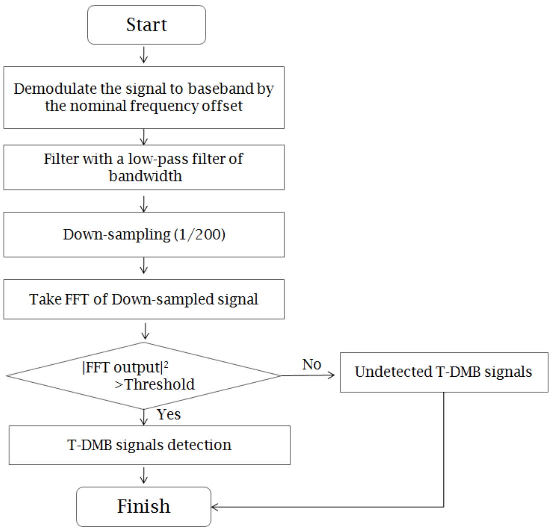

Fig. 3. Flow chart of Signal detection process.

$$\overline{P_{Noise}} = -166 + 10\log(6 \times 10^6) \approx -98\,dBm \tag{8}$$

However, the signal power of signals is presented by 116dBm. So, we calculated signal to noise in case of the spectrum presence in frequency band.

$$SNR = -116 - (-98.22) = -17.78\,dB \tag{9}$$

From this result, the T-DMB signal power lower about 18 dB than noise power. Therefore, performance has to satisfy T-DMB required condition when SNR value is under 18 dBm

V. Simulation

We considered various fading channel environments which are AWGN, Rayleigh, COST 207. The COST 207 channel defined that channel response value is implemented in real environment as described Section VI.

We analyzed the system performance in accordance with applied channel. The threshold value applied to detect T-DMB signal is determined by using constant the false alarm rate (CFAR) algorithm [7].

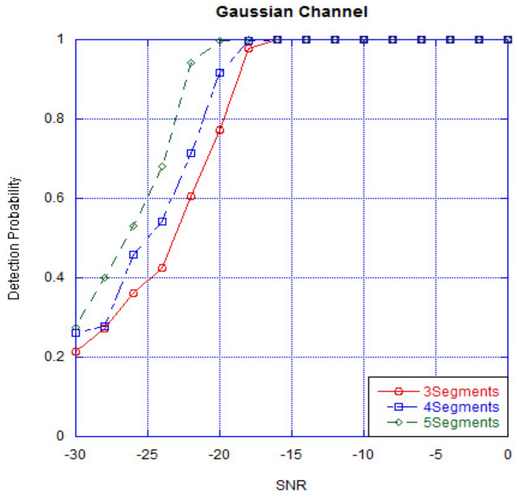

Fig. 4. Detection performance – AWGN environment.

In case of AWGN channel, the detection performance is increased as the number of data segments increases and the 90% value of detection probability can be got when SNR value is -23dB, -20dB and -18dB, separately. However, when apply Rayleigh channel, the performance of detection probability is about - 18dB, -15dB and -14dB.

Through the result between Gaussian channel and Rayleigh channel, we confirmed that channel state has an effect on detection performance and detection probability is improved as data segments increase. Finally, we implemented case of COST 207 channel which are closely alike. In case of COST 207 channel, detection performance is presented by Fig 6. This result shows that detection performance is increased in accordance with increasing the number of data segments.

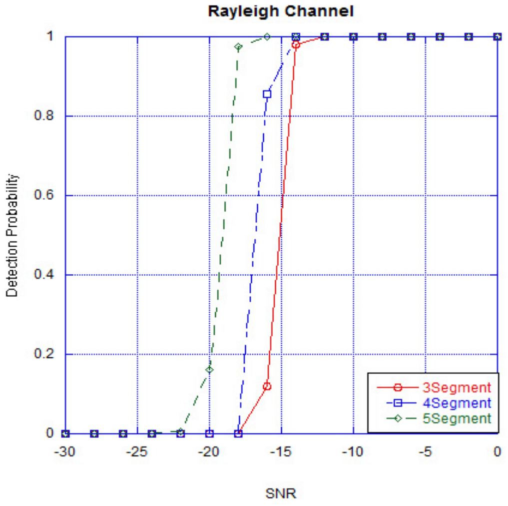

Fig. 5. Detection performance – Rayleigh environment.

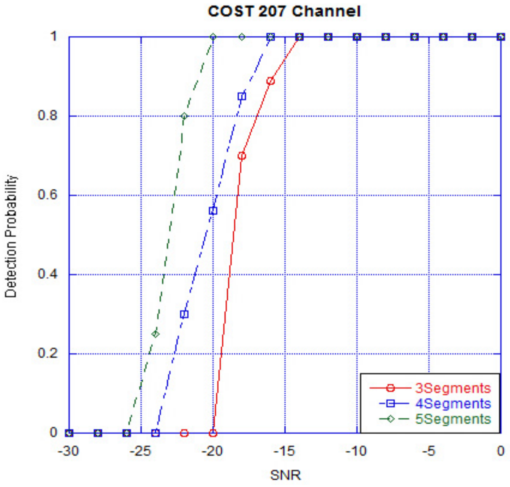

Fig. 6. Detection performance – COST 207 environment.

The detection probability exceeds 90% when SNR value is -21dB, -18dB and -16dB. We analyzed that this result data was better than Rayleigh case and was worse than Gaussian case. The detection probability according to data segments is similar.

Fig 7 is presented by comparison for detection performance among applied channels. This figure is based on 5 segments of T-DMB signal. The system performance in accordance with channel is best when apply Gaussian channel. We confirmed that the COST 207 channel performance has a value close the result of Gaussian case when SNR is 90%.

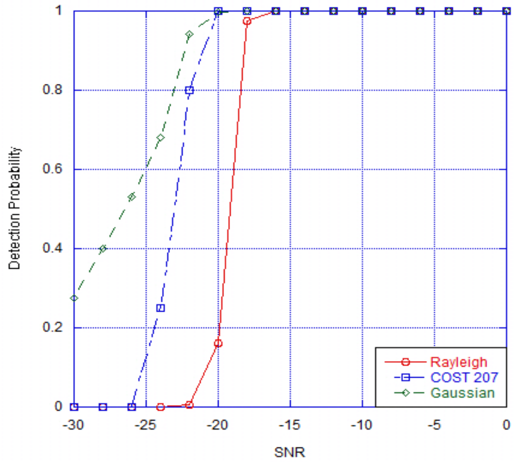

Fig. 7. Comparison of the detection performance for different environments.

VI. Conclusions

In this paper, we proposed the signal detection method based on energy detection for T-DMB signals and estimated system performance in term of detection probability. Before the simulation process, we generated the signal by using the reference documents of T-DMB standard and determined threshold by using the CFAR algorithm. In simulation, we analyzed performance of detection probability in accordance with channel and data segments. The performance of detection probability was the best among other channels applied. It was also demonstrated that detection performance was improved according to increasing the data segments.

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