Cutoff Rate and Outage Probability Performance Comparisons Between DVB-T and DMB-T Systems Under Mobile Multipath Channels

Zi-Wei Zheng, Zhi-Xing Yang, Chang-Yong Pan, and Yi-Sheng Zhu, *Senior Member, IEEE*

***Abstract*—As an effective technique for combating multipath fading and for high-bit-rate transmission over wireless channels, orthogonal frequency-division multiplexing (OFDM) is extensively used in modern terrestrial digital television broadcasting systems to support high performance bandwidth-efficient multimedia services. Cutoff rate and outage probability are two important criterions to evaluate the performances of a practical communication system in radio engineering. In this paper, the cutoff rate and outage probability performances are compared between two important terrestrial digital television broadcasting systems, the cyclic prefix OFDM based DVB-T system and the time domain synchronous OFDM based DMB-T system, under different mobile multipath channel conditions. The DVB-T system and the DMB-T system are summarily introduced. The cutoff rate and outage probability expressions are developed, and simulation results are given for both the DVB-T system and the DMB-T system.**

***Index Terms*—Cutoff rate, orthogonal frequency-division multiplexing, outage probability, terrestrial digital television broadcasting.**

I. INTRODUCTION

TO FACE the challenge of the high data throughput requirements for modern communications, extensive researches have been paid to broadband modulation. Spread spectrum (SS) and multi-carrier modulation are two major broadband modulation techniques [1]–[3]. Orthogonal frequency-division multiplexing (OFDM) technique, a specific multi-carrier modulation, has emerged as a popular technique to combat ISI (Inter-Symbol Interference) channels. ISI is avoided by inserting the interval guard. The effect of selective fading is overcome by using simple channel equalization and FEC (forward error correction) techniques [4].

OFDM is extensively used in broadcasting domain, such as the Digital Video Broadcasting for Terrestrial Television (DVB-T) proposed as the European digital television standard [5], and the Terrestrial Digital Multimedia/Television Broadcasting DMB-T [6] proposed by Tsinghua University for the digital television terrestrial broadcasting standard of the People's Republic of China.

When delay spread is longer than the length of guard intervals, the performance of OFDM is lower sharply [7], [8]. To cope with the long multipath propagation in the digital television terrestrial broadcasting, long guard intervals may be introduced with the cost of lower effective data rate, or long OFDM symbol can be use to save the data rate but at the expense of implementation complexity and long decoding delay. Therefore, the length of the guard intervals and the length of the OFDM symbol must be selected tradeoff between system performance and the practical implementation complexity.

In DVB-T, the cyclic prefix (CP) technique, as guard intervals, is introduced to cope with multipath signals. Furthermore, DVB-T sends a large amount of training symbols (more than 10% of the data symbols) in order to facilitate the synchronization and channel estimation [5]. Thus cause losses in the channel throughput.

However, in DMB-T, instead of CPs, time domain synchronous OFDM (TDS-OFDM) inserts pseudo noise (PN) sequences as the guard intervals, which also serve as the training symbols [6]. After removing the PN sequences at the receiver, TDS-OFDM is equivalent to the zero-padded OFDM (ZP-OFDM) [9]. In [9], Muquet *et al.* proposed a low complexity equalizer for ZP-OFDM, compared ZP-OFDM and CP-OFDM, and numerically showed that ZP-OFDM with the equalizer outperformed CP-OFDM in terms of bit error rates, both in coded and uncoded cases. The reasonable time domain combination of the guard intervals and the training symbols can not only reduce transmission overhead and provide a better channel spectral efficiency performance, but also provide good channel estimation and tracking performances.

Cutoff rate and outage probability are two important criterions for designers to evaluate the performances of a practical communication system in radio engineering [1]–[4]. The wireless broadcasting channel is multipath fading. In the following, we will compare the cutoff rate and outage probability performances between the two important terrestrial digital television broadcasting systems, the cyclic prefix OFDM based DVB-T system and the time domain synchronous OFDM based DMB-T system under different mobile multipath fading channel conditions.

This paper is organized as follows. In Section II, the structures of the cyclic prefix OFDM based DVB-T system and the time domain synchronous OFDM based DMB-T system are discussed in brief. In Section III, the cutoff rate and the outage probability are expressed analytically for the DVB-T system and the DMB-T system. In Section IV, the cutoff rate and the outage probability performances are compared between the practical DVB-T systems and the practical DMB-T systems under different mobile multipath fading channel conditions. In Section V, conclusions are drawn.

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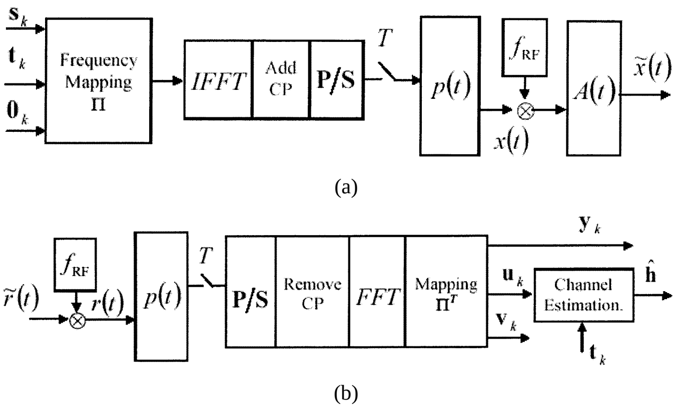

Fig. 1. (a) Transmitter and (b) receiver for DVB-T.

II. DVB-T System and DMB-T System

A. The DVB-T System

The transmitter and receiver structure of DVB-T is shown as in Fig. 1. In the DVB-T system, there are two kinds of training pilots: *continual training pilots*, which are located at fix carrier indexes, and *scattered training pilots*, which are put in quincunx in the spectrum. The continual training pilots, with cyclic prefix, and the scattered training pilots are used for frame synchronization, frequency synchronization, time synchronization, channel estimation, transmission mode identification, also used to follow the phase noise [5], [10].

Consider the kth block of information symbols with length N, including the unknown data symbols $\mathbf{s}(k)$ with length N_s, the known training pilot symbols $\mathbf{t}(k)$ with length N_t, and the stuffing symbols $\mathbf{0}$ with length $N - N_s - N_t$.

The vectors of the unknown data symbols, the known training pilot symbols, the stuffing symbols in the kth block, respectively, can be expressed as

$$\mathbf{s}(k) = [s_0(k), s_1(k), \ldots, s_{N_s-1}(k)]^T \tag{1}$$

$$\mathbf{t}(k) = [t_0(k), t_1(k), \ldots, t_{N_t-1}(k)]^T \tag{2}$$

$$\mathbf{0} = [0, 0, \ldots, 0]^T (N - N_s - N_t) \times 1 \tag{3}$$

At the transmitter, the N-point IDFT $N \times N$ matrix $\mathbf{F}'$ partitions the channel into N sub-carriers as other multi-carrier communication systems [4]. The mapping matrix $\mathbf{\Pi}(k)$ maps information symbols $\mathbf{s}(k)$, $\mathbf{t}(k)$ and $\mathbf{0}$ to the corresponding sub-carriers. The cyclic prefixes of length N_{cp} are added to each IDFT information symbols block. Parallel to serial (P/S) conversion, discrete to analog (D/A) conversion with sampling period T, and lowpass filtering with $p(t) = (1\sqrt{T})\mathrm{sinc}(t/T)$, are performed to the IDFT information symbols blocks. Then, the generated continuous-time complex baseband waveform $s(t)$ are up-converted to RF frequency and sent to the channel.

At the receiver, the local oscillator down-converts and transforms the RF signals to baseband. Then, the baseband signals are passing through a lowpass filter $p(t)$, an analog to discrete (A/D) converter with sampling period T, a serial to parallel (S/P) converter, an inter-block-interference (IBI) remover, the unit norm DFT $\mathbf{F}$ and the reverse mapping $\mathbf{\Pi}(k)^T$ operators.

The composite channel is defined as $h(t) = p(t) * g(t) * p(t)$, where $*$ denotes a linear convolution, where $g(t)$ represents the channel propagation characteristics and has long impulse response for terrestrial digital television broadcasting systems. Because $g(t)$ has a finite duration, and $p(t)$ goes to zero fast when $|t|$ goes to infinite, as in other multi-carrier communication systems [4], we assume that $h(t)$ has a finite duration $(n_0 T, n_1 T)$, where n_0 and n_1 are positive integers. The discrete channel impulse response is

$$h_n = h((n - n_0)T) \text{ for } 0 \le n \le L = n_0 + n_1 \tag{4}$$

where $L \le N_{cp}$ (assume there is no inter-block interference (IBI)). For mobile reception, h_n is time varying.

The input output relation of the CP-OFDM based DVB-T system can be expressed as

$$\begin{bmatrix} \mathbf{y}(k) \\ \mathbf{u}(k) \\ \mathbf{v}(k) \end{bmatrix} = \mathbf{\Pi}(k)^T \mathbf{D}(k) \mathbf{\Pi}(k) \begin{bmatrix} \mathbf{s}(k) \\ \mathbf{t}(k) \\ \mathbf{0} \end{bmatrix} + \mathbf{w}(k) \tag{5}$$

$$\mathbf{D}(k) = \mathrm{diag}(d_0(k), d_1(k), \ldots, d_{N-1}(k)) \tag{6}$$

$$\begin{aligned} \mathbf{d}(k) &\triangleq [d_0(k), d_1(k), \ldots, d_{N-1}(k)]^T \\ &= \sqrt{N}\mathbf{F} \begin{bmatrix} \mathbf{h}(k) \\ \mathbf{0}_{(N-L-1)\times 1} \end{bmatrix} \end{aligned} \tag{7}$$

where $\mathrm{diag}(\cdot)$ means the diagonal operation; $\mathbf{y}(k)$, $\mathbf{u}(k)$, $\mathbf{v}(k)$ are the outputs corresponding to $\mathbf{s}(k)$, $\mathbf{t}(k)$, $\mathbf{0}$ respectively; $\mathbf{h}(k) = [h_0(k), h_1(k), \ldots, h_L(k)]^T$ is the channel impulse response vector, $\mathbf{w}(k)$ is the noise term with complex Gaussian distribution $CN(0, \mathbf{I}_N)$. The outputs $\{\mathbf{u}(0), \mathbf{u}_1, \ldots \mathbf{u}(k)\}$ corresponding to the *continual training pilots* or *scattered training pilots*, with cyclic prefix, are used for frame synchronization, frequency synchronization, time synchronization, channel estimation, transmission mode identification, and also used to follow the phase noise. The estimated channel impulse response is used for channel equalization and detection. The equalized data signals are fed into the decision devices, which determine the nearest constellation points, thus result in the hard decision data symbols [5], [8].

B. The DMB-T System

The transmitter and receiver structure of DMB-T is shown as in Fig. 2. (The segments of encoder, symbol mapping, the demodulator and decoder are not included.).

At the transmitter side, each 3780 of the mapping symbols are grouped into one OFDM data frame body. Data information symbols $\mathbf{s}(k) = [s_0, (k) s_1(k), \ldots s_{N_s-1}(k)]^T$ $(N_s = 3780)$ are assigned to every specific OFDM data frame body by the inverse fast Fourier transform (IFFT) block [11]. A 378-symbol PN sequence $\mathbf{t}(k) = [t_k, t_1(k) \ldots t_{N_s-1}(k)]^T$ $(N_t = 378)$ is inserted for synchronization and channel distortion evaluation in front of each OFDM data frame body. A square root raised cosine (SRRC) pulse shaping is performed to limit the transmitted signals to 8MHz bandwidth before they are up-converted and power amplified and transmitted over the channel.

At the receiver side, the received signals are down-converted, SRRC pulse shaping, sampled. Then, the samples are fed in parallel to the synchronizer, the channel estimator, and the fast Fourier transform (FFT) block, respectively. In each signal

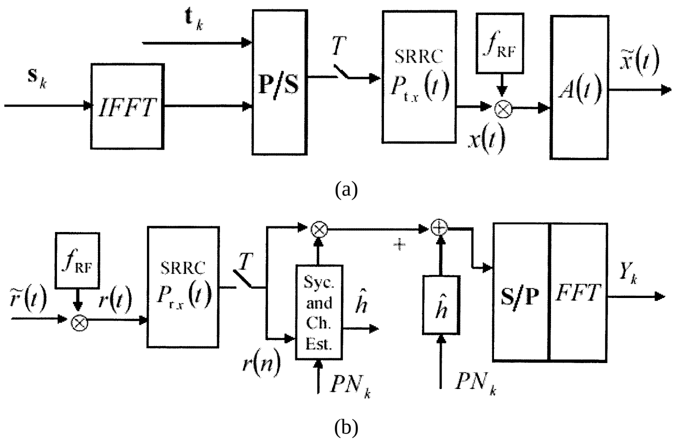

Fig. 2. (a) Transmitter and (b) receiver for DMB-T.

frame, a known PN sequence is inserted as the frame header. With the PN sequence, a windowed averaging modified scheme of [9] is used for time and frequency synchronization. Also, the PN sequence is used as the channel sounding signal. For each signal frame, a channel impulse response can be obtained by correlating the received PN sequence with the local PN sequence.

If the channel model is slow-fading channel, the channel characteristics are assumed to be approximately constant for at least one signal frame. If the PN sequence inserted in theframe header is expressed as PN_k, it will pass through approximately the same SRRC filters and channel. At the receiver side, it is convolved with the known PN_k and results

$$\begin{aligned} R_{PN_k} &= FFT(PN_k \otimes P_{tx}(t)) \otimes h(t) \otimes P_{rx}(t) \otimes PN_k \\ &= FFT(PN_k \otimes PN_k) \\ &\quad \cdot FFT(P_{tx}(t)) \cdot FFT(h(t)) \cdot FFT(P_{rx}(t)) \\ &= FFT(PN_k \otimes PN_k) \cdot H_k(f) \end{aligned} \tag{8}$$

In an idea case, the fast Fourier transform of the PN correlation, $FFT(PN_k \otimes PN_k)$, is known. By convolving the received PN sounding sequence with the known PN, we can derive the channel response function $H(f)$.

If the channel model is fast-fading channel, Doppler frequency is high, the channel characteristics are variable from time to time, and so, the channel variation between two successive OFDM frame intervals becomes nonnegligible. To reduce the performance degradation caused by Doppler effect, the time correlation characteristic of channel between two successive OFDM frame intervals is considered [4]. So, the current estimated channel frequency response weighted by averaging with the post-estimated channel frequency response in next frame PN period is used as the channel response function in current frame OFDM body.

Such obtained channel impulse response is processed by windowing and zero-padding to form a 3780-symbol FFT time domain block. The FFT time domain block is transformed to FFT frequency domain block to obtain the channel frequency response of the current OFDM data frame body. For each sub-carrier of the frequency domain, there is a one-tap filter calculating the magnitude and phase values.

III. Cutoff Rate and Outage Probability Expression

The lowpass equivalent model of a channel with L multipath components has a generic form of [1]

$$h(t) \sum_{l=1}^{L} a_i e^{j\varphi_l} \delta(t - \tau_l) \tag{9}$$

where a_l, φ_l, τ_l, and L, respectively denotes, the amplitude, the phase, the delay of the lth multipath propagated signal path, and the number of propagated signal paths. In the Annex B of DVB-T standard [5], the values of these parameters are given for fixed reception and portable reception. However, for mobile reception, these parameters are time varying, moreover, a maximal Doppler spread of f_d will occur, so, in the simulations of this paper, these parameters are randomly generated with time according to the long impulse response channel propagation characteristics for terrestrial digital television broadcasting systems under different maximum Doppler frequencies.

The frequency domain response of (9) can be expressed as

$$H(f) = \sum_{l=1}^{L} h_l e^{j(\varphi_l - 2\pi f \tau_l)} \tag{10}$$

The power density spectrum function of (10) is [3]

$$\begin{aligned} |H(f)|^2 = \sum_{i=1}^{L} h_i^2 + \sum_{i=1}^{L} \sum_{j=1; i \neq j}^{L} h_i h_j \\ \times \cos[2\pi(\tau_i - \tau_j) f + (\varphi_i - \varphi_j)] \end{aligned} \tag{11}$$

The distribution function of (11) is

$$p_x(x) = \frac{1}{\left\{ d\pi \sqrt{1 - \left[\frac{(x-c)}{d}\right]^2} \right\}}, c - d \leq x \leq c + d \tag{12}$$

where $c = \sum_{i=1}^{L} h_i^2$, $d = \sum_{i=1}^{L} \sum_{j=1; i \neq j}^{L} h_i h_j$.

While capacity is a theoretical limit for infinite block length codes and zero error probability, the cutoff rate gives a bound for finite block length and error probability. The cutoff rate is useful because of the cutoff rate theorem, which states that there exist $(n,k)_q$ block codes, with code-word error probability P_{error} after maximum likelihood decoding being upper bounded by $P_{\text{error}} < 2^{-n(R_0 - R_b)}$, provided the binary code rate $R_b := (k/n) \cdot \log_2(q)$ is less than the cutoff rate [13]

$$R_0 = -\log_2 \left(\int_C \left(\sum_{s \in M} \frac{1}{q} \sqrt{p(y \mid s)} \right)^2 dy \right) \tag{13}$$

where M, with $|M| = q$, is the set of code symbols (input alphabet) and $p(y \mid s)$ is the probability density function of the received signal y given the transmitted code symbol s.

TABLE I
CONFIGURATION PARAMETERS OF DVB-T AND DMB-T FOR SIMULATIONS

	DVB-T 2K (1)	DVB-T 8K (2)	DMB-T (3)	DVB-T 2K (4)	DVB-T 8K (5)	DMB-T (6)	DVB-T 2K (7)	DVB-T 8K (8)	DMB-T (9)
Subcarrier Number For Data N_s	1529	6116	3780	1529	6116	3780	1529	6116	3780
Subcarrier Number For Training N_t	176	701	378	176	701	378	176	701	378
Total Subcarrier Number N	2048	8192	3780	2048	8192	3780	2048	8192	3780
Sampling Period T (μs)	0.1094	0.1094	0.1323	0.1094	0.1094	0.1323	0.1094	0.1094	0.1323
Bandwidth f_B (MHz)	7.61	7.61	7.56	7.61	7.61	7.56	7.61	7.61	7.56
N_{cp}/N	1/32	1/32	0	1/32	1/32	0	1/32	1/32	0
Inner Coding	rate 2/3 punctured convolution code	rate 2/3 punctured convolution code	rate 2/3 trellis code	rate 3/4 punctured convolution code	rate 3/4 punctured convolution code	rate 3/4 trellis code	rate 1/2 punctured convolution code	rate 1/2 punctured convolution code	rate 1/2 trellis code
Modulation	64QAM	64QAM	64QAM	16QAM	16QAM	16QAM	QPSK	QPSK	QPSK

For flat fading channels, the cutoff rate of a coded communication system can be expressed as [14]

$$R_0 = -\log_2 \left\{ \frac{1}{Q^2} \sum_{i=1}^{Q} \sum_{j=1}^{Q} \mathrm{E}\left[\exp\left(-\frac{\chi^2}{4N_0} |s_i - s_j|^2 \right) \right] \right\} \tag{14}$$

where Q is the signal dot number in the signal constellation, χ is a random variable according to the distribution of the magnitude of the normalized channel, $E[\cdot]$ denotes expectation, N_0 is the noise power spectral density, $|s_i - s_j|^2$ is the Euclidean distance between any symbol pair s_i, s_j.

Since both the DVB-T system and the DMB-T system are applied OFDM as their modulation modes, OFDM transforms a broadband frequency selective multipath fading channel into a set of parallel narrowband flat fading channels [4], (14) can be used to calculate the cutoff rate of either the DVB-T system or the DMB-T system.

From (10)–(12), by some calculations, we can get

$$\begin{aligned} &\mathrm{E}\left[\exp\left(-\frac{\chi^2}{4N_0} |s_i - s_j|^2 \right) \right] \\ &\quad = E[\exp(-\gamma |H(f)|^2 g_{i,j})] \\ &\quad = \frac{1}{d\pi} \int_{c-d}^{c+d} e^{-x\gamma g_{i,j}} \frac{1}{\sqrt{1 - \left(\frac{x-c}{d}\right)^2}} dx \\ &\quad = \frac{1}{\pi} \int_{-1}^{1} e^{-(c+d\xi)\gamma g_{i,j}} \frac{1}{\sqrt{1-\xi^2}} d\xi \\ &\quad = e^{-c\gamma g_{i,j}} \left[\frac{1}{\pi} \int_{-1}^{1} e^{-d\xi\gamma g_{i,j}} \times \frac{1}{\sqrt{1-\xi^2}} d\xi \right] \\ &\quad = e^{-c\gamma g_{i,j}} I_0(d\gamma g_{i,j}) \end{aligned} \tag{15}$$

TABLE II
6-PATH HILLY TERRAIN CHANNEL PARAMETERS OF SIMULATIONS

Path	Delay (μs)	Power (dB)
1	0	0
2	0.1	−1.5
3	0.3	−4.5
4	0.5	−7.5
5	15	−8.0
6	17.2	−17.7

where $\gamma = E_s/N_0$ denotes the signal-to-noise ratio of the receiver, E_s is the mean symbol energy at the receiver, $I_0(\cdot)$ denotes the modified zero-order Bessel function of the first kind, $g_{i,j} = |s_i - s_j|^2/4E_s$.

Then, (14) can be re-expressed as

$$R_0 = -\log_2 \left\{ \frac{1}{Q^2} \sum_{i=1}^{Q} \sum_{j=1}^{Q} e^{-crg_{i,j}} I_0(drg_{i,j}) \right\} \tag{16}$$

From (14) and (16), we can see that cutoff rate R_0 is jointly influenced by of the channel fading conditions (parameter c, d), coding gain (parameter $g_{i,j}$), frame structure (parameter γ).

Considered sampling period, training pilots, cyclic prefix of the frame structure, the signal-to-noise ratio of the effective symbols at the receiver $\gamma_u = E_u/N_0$ can be expressed as

$$\gamma_u = \left\{ \frac{(nn_s)}{[T(n + n_{cp})(n_s + n_t)]} \right\} \cdot \gamma \tag{17}$$

where n_s, T, n, n_t, n_{cp}, respectively denotes, the number of effective symbols, the sampling period, the number of sub-carriers, the number of training pilots, the number of cyclic prefix.

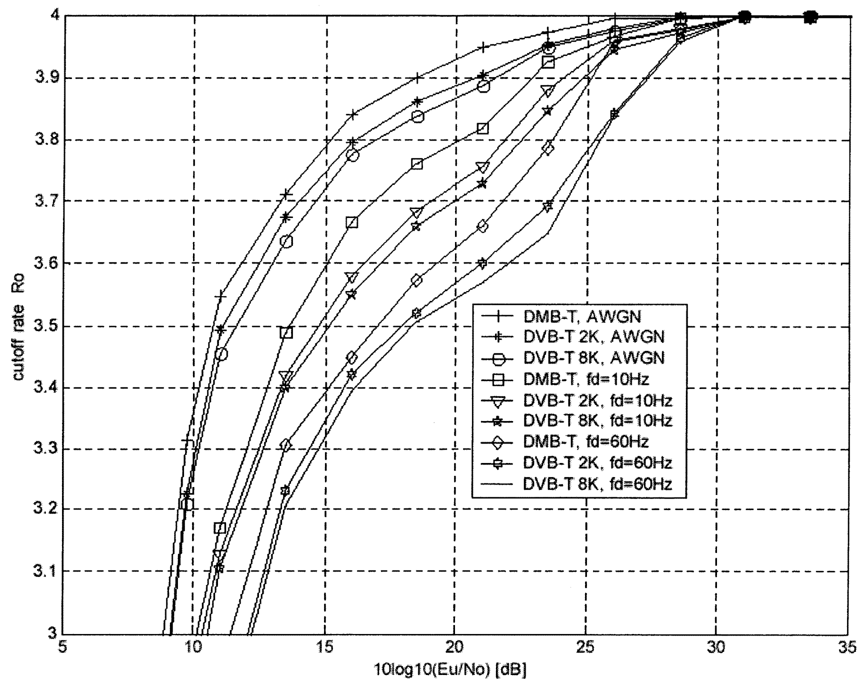

Fig. 3. Cutoff rate vs. signal-to-noise ratio of the effective symbols performances of practical systems (1), (2), (3) in Table I under different multipath mobile channels.

$E_u = \{(nn_s)/[T(n+n_{cp})(n_s+n_t)]\} \cdot E_s$ is the mean symbol energy of the effective symbols.

Thus, we have

$$g_{i,j} = \left\{ \frac{[T(n+n_{cp})(n_s+n_t)]}{(nn_s)} \right\} \cdot \frac{|s_i - s_j|^2}{4E_u} \quad (18)$$

$$\gamma = \frac{\gamma_u}{\left\{ \frac{(nn_s)}{[T(n+n_{cp})(n_s+n_t)]} \right\}} \quad (19)$$

In a fading radio channel, it is likely that a transmitted signal will suffer deep fades that can lead to a complete loss of the signal or outage of the signal. Outage probability is defined as the probability that the end-to-end signal-to-noise ratio *SNR* falls below a predetermined protection ratio SNR_{pre}, and the outage probability is a measure of the quality of the transmission in a mobile radio channel [15]. According to the cutoff rate definition and the outage probability definition [1]–[4], [13]–[15], the outage probability $P_{\rm out}$ corresponding to an expected transmission rate R_d can be defined as the error probability when the system transmit the data symbols at such expected transmission rate R_d, it also equals to the critical probability when the cutoff rate R_0 is less than the expected transmission rate R_d to ensure that no error occurs, and can be expressed as

$$P_{\rm out} = \{(R_0 < R_d) \mid R_d\} \quad (20)$$

The expected transmission rate R_d depends on the modulation mode. When QPSK modulation mode is utilized, then

$$R_d = 2R_c \quad (21)$$

When 16QAM modulation mode is utilized, then

$$R_d = 4R_c \quad (22)$$

When 64QAM modulation mode is utilized, then

$$R_d = 6R_c \quad (23)$$

where R_c is the coding rate of the system.

So, the outage probability $P_{\rm out}$ is jointly influenced by of the channel fading conditions, the coding gain, the frame structure, and the modulation mode.

IV. Simulation Performance Comparison

Nine practical systems as shown in Table I are used for simulations. The simulation channels are the AWGN channel, the 6-path typical hilly terrain channels with parameters randomly generated from COST 207 specifications [16] as illustrated in Table II, under different maximal Doppler frequencies, $f_d = 10$ Hz, which corresponds to receiver velocity of 12.5 to 23 km/h in the TV UHF band (@470…862 MHz), and, which corresponds to receiver velocity of 75 to 138 km/h in the TV UHF band (@470…862 MHz). The system cutoff rate and the system outage probability performances are evaluated by the Monte Carlo method.

The cutoff rate vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (1), the 8 K mode DVB-T system (2), and the DMB-T system (3) under different multipath mobile channel conditions are shown in Fig. 3.

The cutoff rate vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (4), the 8 K mode DVB-T system (5), and the DMB-T system (6) under different multipath mobile channel conditions are shown in Fig. 4.

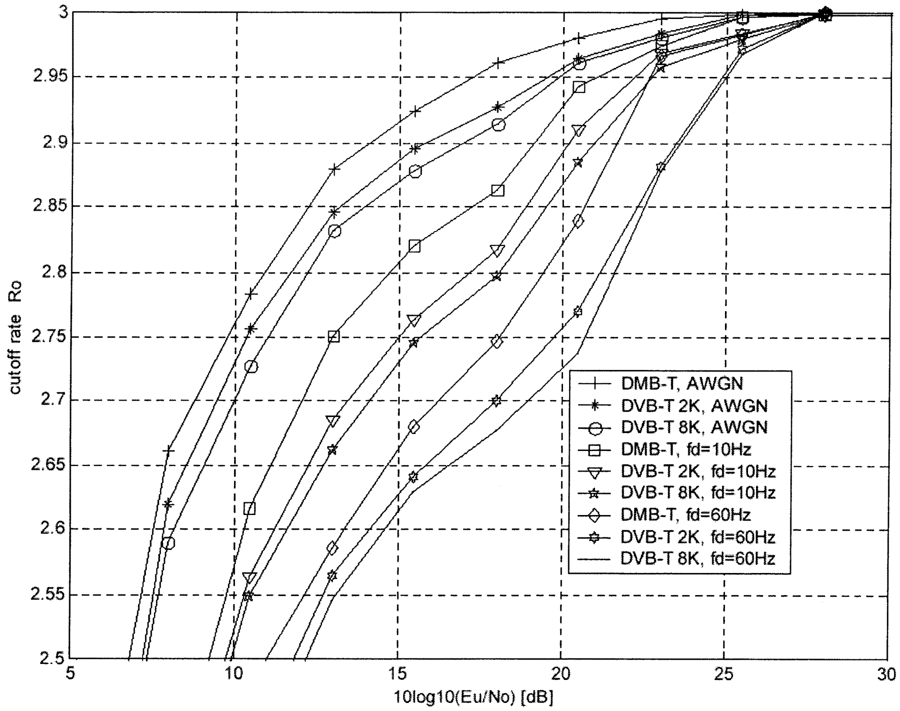

Fig. 4. Cutoff rate vs. signal-to-noise ratio of the effective symbols performances of practical systems (4), (5), (6) in Table I under different multipath mobile channels.

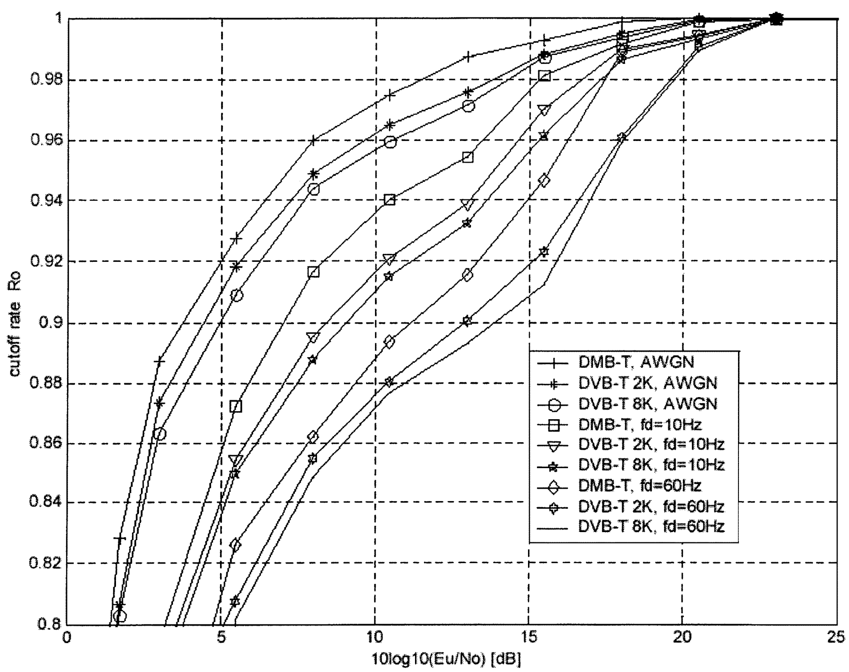

Fig. 5. Cutoff rate vs. signal-to-noise ratio of the effective symbols performances of practical systems (7), (8), (9) in Table I under different multipath mobile channels.

The cutoff rate vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (7), the 8 K mode DVB-T system (8), and the DMB-T system (9) under different multipath mobile channel conditions are shown in Fig. 5.

The outage probability vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (1), the 8 K mode DVB-T system (2), and the DMB-T system (3) under different multipath mobile channel conditions are shown in Fig. 6.

The outage probability vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (4), the 8 K mode DVB-T system (5), and the DMB-T system (6) under different multipath mobile channel conditions are shown in Fig. 7.

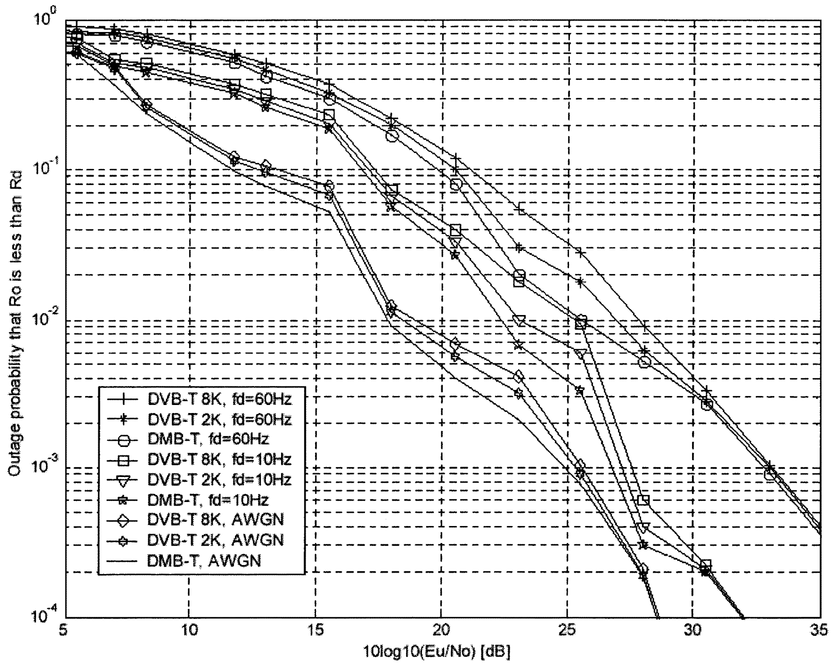

Fig. 6. Outage probability vs. signal-to-noise ratio of the effective symbols performances of practical systems (1), (2), (3) in Table I under different multipath mobile channels.

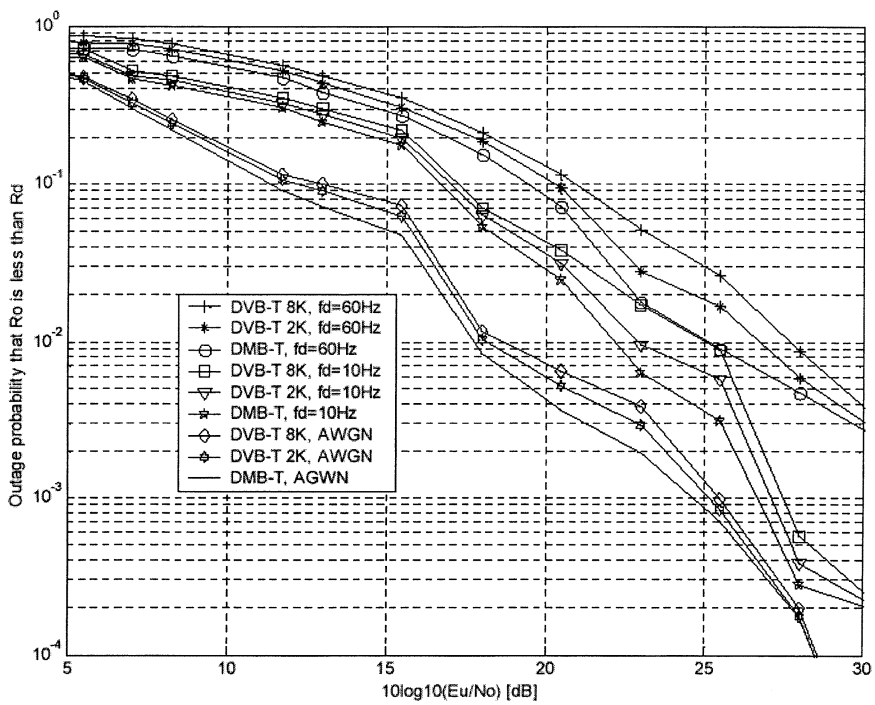

Fig. 7. Outage probability vs. signal-to-noise ratio of the effective symbols performances of practical systems (4), (5), (6) in Table I under different multipath mobile channels.

The outage probability vs. signal-to-noise ratio of the effective symbols performances of the 2 K mode DVB-T system (7), the 8 K mode DVB-T system (8), and the DMB-T system (9) under different multipath mobile channel conditions are shown in Fig. 8.

From Figs. 3–5 we can see that the DMB-T systems (3), (6), (9), has better cutoff rate performances than the 2 K mode DVB-T systems (1), (4), (7), and the 8 K mode DVB-T systems (2), (5), (8), under different multipath mobile channel conditions.

From Figs. 6–8 we can see that the DMB-T systems (3), (6), (9), has better outage probability performances than the 2 K mode DVB-T systems (1), (4), (7), and the 8 K mode DVB-T systems (2), (5), (8), under different multipath mobile channel conditions.

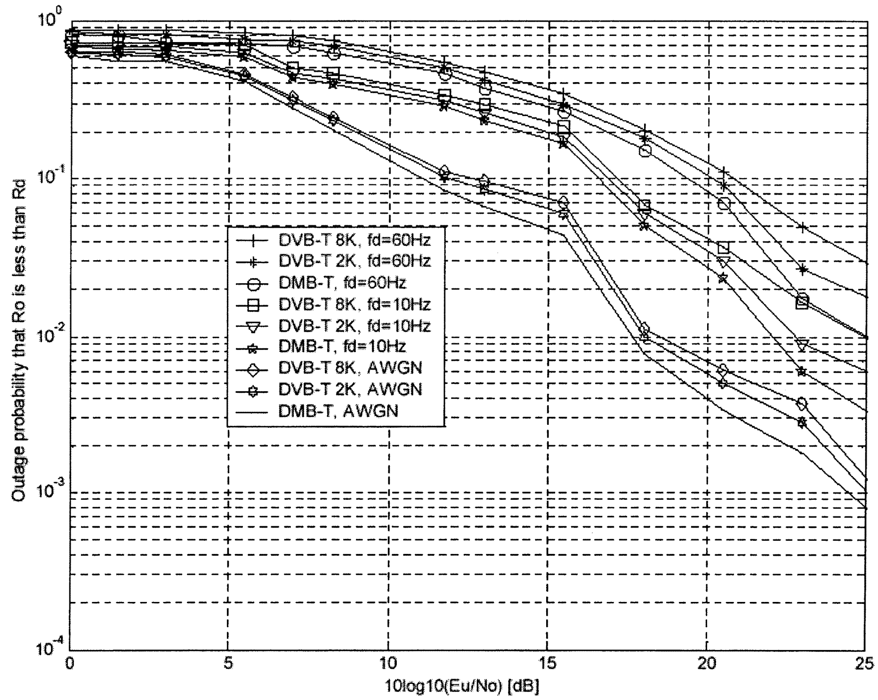

Fig. 8. Outage probability vs. signal-to-noise ratio of the effective symbols performances of practical systems (7), (8), (9) in Table I under different multipath mobile channels.

V. Conclusions

In this paper, we derive the expression of the cutoff rate and the outage probability suitable for the DVB-T system and the DMB-T system, and compare cutoff rate and the outage probability performances between these two practical systems under different multipath mobile channel conditions. Simulation studies show that the practical DMB-T systems have not only better cutoff rate performances but also better outage probability performances than both the practical 2 K mode DVB-T systems and the practical 8 K mode DVB-T systems.

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