Analysis of Threshold-Based Selection Diversity Receivers

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***Abstract*—Selection diversity (SD) represents an attractive solution in various wireless communication scenarios, since it offers relatively low complexity and improved performance. However, in many practical situations the continuously monitoring of all the available diversity paths, which is mandatory in SD schemes, adds unnecessary overhead to the systems. In this paper, in order to alleviate this complexity, a new threshold-based SD (t-SD) receiver is proposed. In particular, in t-SD, the current path is used as long as its signal to noise ratio is above a predefined threshold, otherwise the receiver becomes a pure SD. For this new concept we present an analytical framework for important statistical metrics accompanied by a complexity analysis. Various numerical evaluated results illustrate that the proposed scheme outperforms other well known schemes in terms of the performance and complexity trade off.**

***Index Terms*—Performance and complexity trade off, selection diversity, switching threshold, threshold-based (hybrid) reception.**

I. Introduction

Recent wireless communication systems should efficiently support the increase of the wireless communication demands. However, these systems are subject to various propagation phenomena, including multipath fading and shadowing, that can seriously degrade their performance. One of the simplest and yet most efficient techniques to mitigate the deleterious effects of the fading, and thus improve their performance, is to use diversity at the receiver side. In the context of low complexity diversity methods, several approaches have been proposed in the past including selection diversity (SD), switch-and-stay combining (SSC) and switch and examine combining (SEC) [1]. The last scheme has been designed to bridge the gap between SD, which provides the best performance, and the least complicated SSC, which however gives the poorer performance. Nevertheless, since SEC does not take full advantage of the available path estimates, its performance is closer to the SSC one.

In [2], an alternative approach to SEC was proposed, with improved performance and a relatively small increase in complexity. More specifically, the conventional SEC receiver seeks to use an acceptable diversity path by examining as many paths as necessary. If no acceptable diversity path is available, it uses the last examined antenna path or switches back to the first path for the next transmission slot [3]. In the latter case since all available diversity paths have been anyway examined, a more preferred alternative would be to use the strongest one among all these unacceptable paths. This was the initial idea for the switch-and-examine combining with postselection (SECps) scheme proposed in [2]. In the same work, it was also shown that the receiver can deliver much better performance than the conventional SEC scheme at the expense of a slight increase in hardware complexity. The same diversity reception technique was also studied in [4], assuming dual-branch reception and correlated but non identical distributed Nakagami-m fading. Recently, this type of reception was also employed in a diversity-combining system that utilizes transmit antenna selection (TAS) [5]. It was shown that the combined TAS/SECps is able to achieve similar average output signal to noise ratio (SNR) and bit error rate (BER) performance as compared with TAS/SD, when the predetermined SNR threshold is optimized, while it requires a significant lower number of channel estimates. However, in several communication scenarios the performance gap between SD and SECps, is considered to be high, especially for cases where the switching threshold is relatively low.

In this paper, in order to further improve the SECps performance, we propose a new threshold based (hybrid) SD scheme, termed threshold-SD (t-SD). In particular the receiver uses the current path as long as its SNR is above the predefined threshold. Whenever the SNR of the selected path falls below the threshold, it selects the diversity path that provides the largest instantaneous SNR. In other words, instead of continuously examining if any of the diversity path exceeds the threshold, the receiver directly selects the best one. As a consequence, the receiver's performance clearly improves, as compared to SEC and SECps, and thus approximates more closely the corresponding one of SD. In addition, it is shown that the induced system complexity, in terms of the average number of path estimations (ANPE) as well as the switching probability (SP), are kept relatively low.

The rest of the paper is organized as follows. Section II contains the mode of operation of the t-SD scheme as well as important statistical metrics of its output SNR, such as the moments generating function (MGF) and the moments. In Section III, the performance analysis of t-SD is performed in terms of the outage probability (OP), average BER (ABER), average output SNR (ASNR) and average channel capacity. In the same section, a complexity analysis, in terms of the ANPE and the SP is also included. Section IV presents some numerical results and Section V includes concluding remarks.

II. Mode of Operation of the Proposed Scheme

We consider the downlink of a communication system with one transmit and L receive antennas. In the proposed

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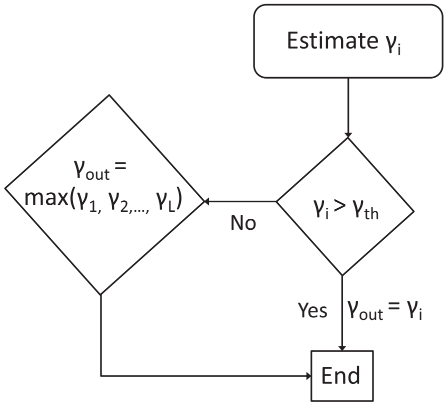


Fig. 1. The mode of operation of the proposed scheme (t-SD).

scheme, in every time slot the receiver examines if the received instantaneous SNR of the path that was selected in the previous time slot (lets say γ_i with $i \in \{1, 2, \ldots, L\}$) exceeds a predefined threshold $\gamma_{\rm th}$. If that path exceeds the threshold, the receiver stays there, otherwise it switches to the path with the highest SNR, as shown in Fig. 1. Note that (i) a single (branch) receiver is used when the SNR of the tagged diversity path is above the threshold (i.e., $\gamma_i \geq \gamma_{\rm th}$) and (ii) L-branch SD is used when $\gamma_i < \gamma_{\rm th}$. From the mode of operation of t-SD, the cumulative distribution function (CDF) of the instantaneous output SNR, $\gamma_{\rm out}$, can be expressed as

$$F_{\gamma_{\rm out}}(\gamma) = \begin{cases} \Pr[\gamma_{\rm th} \leq \gamma_i < \gamma] + \Pr[\gamma_i < \gamma_{\rm th}] \\ \times \left\{ \Pr\left[\gamma_{\rm th} \leq \max\limits_{j \in \{1,\cdots,L\}, \gamma_j \neq \gamma_i} \{\gamma_1, \gamma_2, \cdots, \gamma_j\} < \gamma \right] \right. \\ \left. + \Pr\left[\max\limits_{j \in \{1,\cdots,L\}, \gamma_j \neq \gamma_i} \{\gamma_1, \gamma_2, \cdots, \gamma_j\} < \gamma_{\rm th} \right] \right\}, & \gamma \geq \gamma_{\rm th} \\ \Pr\left[\max\{\gamma_1, \gamma_2, \cdots, \gamma_L\} < \gamma\right], & \gamma < \gamma_{\rm th} \end{cases} \tag{1}$$

Assuming independent and identically distributed (i.i.d.) fading conditions[1] across the paths, we can rewrite (1) as

$$F_{\gamma_{\rm out}}(\gamma) = \begin{cases} F_{\gamma_i}(\gamma) - F_{\gamma_i}(\gamma_{\rm th}) + F_{\gamma_i}(\gamma_{\rm th}) F_{\gamma_i}(\gamma)^{L-1}, & \gamma \geq \gamma_{\rm th} \\ F_{\gamma_i}(\gamma)^L, & \gamma < \gamma_{\rm th}. \end{cases} \tag{2}$$

The corresponding expression for the probability density function (PDF) is

$$f_{\gamma_{\rm out}}(\gamma) = \begin{cases} f_{\gamma_i}(\gamma) + (L-1) F_{\gamma_i}(\gamma_{\rm th}) f_{\gamma_i}(\gamma) \\ \quad \times F_{\gamma_i}(\gamma)^{L-2}, & \gamma \geq \gamma_{\rm th} \\ L f_{\gamma_i}(\gamma) F_{\gamma_i}(\gamma)^{L-1}, & \gamma < \gamma_{\rm th}. \end{cases} \tag{3}$$

The previous general expressions apply to any fading scenario. Here, we will focus on the Rayleigh multipath fading model, which typically agrees very well with experimental data for mobile systems where no line-of-sight path exists between the transmitter and receiver antennas [1]. In this case the instantaneous SNR at the input of the receivers has the exponential PDF of the form

$$f_{\gamma_i}(\gamma) = \frac{1}{\overline{\gamma}_i} \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right) \tag{4}$$

where $\overline{\gamma}_i$ denotes the average input SNR. The corresponding expression for the CDF of γ_i is given by

$$F_{\gamma_i}(\gamma) = 1 - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right). \tag{5}$$

Therefore, substituting (5) in (2) yields the following closed-form expression for the CDF of $\gamma_{\rm out}$

$$F_{\gamma_{\rm out}}(\gamma) = \begin{cases} \exp\left(-\frac{\gamma_{\rm th}}{\overline{\gamma}_i}\right) - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right) + \left[1 - \exp\left(-\frac{\gamma_{\rm th}}{\overline{\gamma}_i}\right)\right] \\ \quad \times \left[1 - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right)\right]^{L-1}, & \gamma \geq \gamma_{\rm th} \\ \left[1 - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right)\right]^L, & \gamma < \gamma_{\rm th}. \end{cases} \tag{6}$$

The corresponding PDF expression is given by

$$f_{\gamma_{\rm out}}(\gamma) = \begin{cases} \frac{1}{\overline{\gamma}_i} \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right) + \left[1 - \exp\left(-\frac{\gamma_{\rm th}}{\overline{\gamma}_i}\right)\right] \frac{(L-1)}{\overline{\gamma}_i} \\ \times \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right) \left[1 - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right)\right]^{L-2}, & \gamma \geq \gamma_{\rm th} \\ \frac{L}{\overline{\gamma}_i} \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right) \left[1 - \exp\left(-\frac{\gamma}{\overline{\gamma}_i}\right)\right]^{L-1}, & \gamma < \gamma_{\rm th}. \end{cases} \tag{7}$$

A. Moments Generating Function

Substituting (7) in the definition of the MGF, i.e., $M_{\gamma_{\rm out}}(s) = E\langle \exp(-s\gamma_{\rm out}) \rangle$, with $E\langle \cdot \rangle$ denoting expectation, and using [6, eq. (3.310)] yields the following expression for the MGF of $\gamma_{\rm out}$

$$\begin{aligned} M_{\gamma_{\rm out}}(s) = & \sum_{j=0}^{L-1} \binom{L-1}{j} (-1)^j L \frac{1 - \exp\left[-\frac{\gamma_{\rm th}(1+j+s\overline{\gamma}_i)}{\overline{\gamma}_i}\right]}{1+j+s\overline{\gamma}_i} \\ & + \frac{\exp\left[-\gamma_{\rm th}\left(\frac{s\overline{\gamma}_i+1}{\overline{\gamma}_i}\right)\right]}{1+s\overline{\gamma}_i} + F_{\gamma_i}(\gamma_{\rm th})(L-1) \\ & \times \sum_{j=0}^{L-2} \binom{L-2}{j} (-1)^j \frac{\exp\left[-\frac{\gamma_{\rm th}(1+j+s\overline{\gamma}_i)}{\overline{\gamma}_i}\right]}{1+j+s\overline{\gamma}_i}. \end{aligned} \tag{8}$$

B. Moments

The nth order moment of $\gamma_{\rm out}$ can be evaluated by substituting (7) in the definition of the moments, i.e., $\mu_{\gamma_{\rm out}}(n) = E\langle \gamma_{\rm out}^n \rangle$. Then, using [6, eqs. 8.350/1 and 8.350/2], the following closed-form expression is obtained

$$\begin{aligned} \mu_{\gamma_{\rm out}}(n) = & \sum_{j=0}^{L-1} \binom{L-1}{j} (-1)^j \frac{L}{\overline{\gamma}_i} \frac{\gamma\left(n+1, \frac{j+1}{\overline{\gamma}_i}\gamma_{\rm th}\right)}{\left[(j+1)/\overline{\gamma}_i\right]^{n+1}} \\ & + \frac{\Gamma\left(n+1, \frac{\gamma_{\rm th}}{\overline{\gamma}_i}\right)}{\left(1/\overline{\gamma}_i\right)^n} + \frac{L-1}{\overline{\gamma}_i} \sum_{i=0}^{L-2} \binom{L-2}{j} \\ & \times F_{\gamma_i}(\gamma_{\rm th})(-1)^j \frac{\Gamma\left(n+1, \frac{j+1}{\overline{\gamma}_i}\gamma_{\rm th}\right)}{\left[(j+1)/\overline{\gamma}_i\right]^{n+1}} \end{aligned} \tag{9}$$

where $\gamma(\cdot,\cdot)$ and $\Gamma(\cdot,\cdot)$ denote the lower and the upper incomplete gamma functions [6, eqs. (8.350/1 and 8.350/2)], respectively.

[1] Due to space limitations, the non i.i.d. case, which corresponds to more realistic network conditions, is not included in this version.

III. Performance Analysis

In this section, using the previously derived expressions for the PDF, CDF, MGF and moments of the output SNR, various performance evaluation criteria will be presented. More specifically, the performance is studied using the OP, the ABER, the ASNR and the average channel capacity, while a complexity analysis is also included.

A. Outage Probability

OP is defined as the probability that the SNR falls below a predetermined threshold $\gamma_{\rm T}$ and is given by $P_{\rm out} = F_{\gamma_{\rm out}}(\gamma_{\rm T})$.
High SNR approximation: In order to clearly understand important system-design parameters, we focus here on the high SNR regime. This approach help us to quantify the amount of performance variations, which are due to the fading effects as well as to the receiver's architecture. At high SNR the exponential CDF can be closely approximated by $F_{\gamma_i}(\gamma) \approx \frac{\gamma}{\overline{\gamma}_i}$ [7]. Based on this approximated expression the CDF of $\gamma_{\rm out}$ can be written as

$$F_{\gamma_{\rm out}}(\gamma) \approx \begin{cases} \frac{\gamma}{\overline{\gamma}_i} - \frac{\gamma_{\rm th}}{\overline{\gamma}_i} + \frac{\gamma_{\rm th}}{\overline{\gamma}_i}\left(\frac{\gamma}{\overline{\gamma}_i}\right)^{L-1}, & \gamma \geq \gamma_{\rm th} \\ \left(\frac{\gamma}{\overline{\gamma}_i}\right)^{L}, & \gamma < \gamma_{\rm th}. \end{cases} \tag{10}$$

B. Average Bit Error Rate

Using the previously derived MGF expression in (8) and following the MGF-based approach, the ABER can be readily evaluated for a variety of modulation schemes [1]. More specifically, the ABER can be calculated: *i)* directly for non-coherent differential binary phase shift keying (DBPSK), that is $P_{\rm be}^{DBPSK} = 0.5 M_{\gamma_{\rm out}}(1)$; and *ii)* via numerical integration for Gray encoded M-PSK, that is $P_{\rm be}^{M-PSK} = \frac{1}{\pi \log_2 M} \int_0^{\pi-\pi/M} M_{\gamma_{\rm out}}\left[\frac{\log_2 M \sin^2(\pi/M)}{\sin^2\phi}\right] d\phi$.
High SNR approximation: Considering higher values of the average input SNR and based on (10), yields the following simplified expression for the PDF of the output SNR

$$f_{\gamma_{\rm out}}(\gamma) \approx \begin{cases} \frac{1}{\overline{\gamma}_i} + \frac{\gamma_{\rm th}(L-1)}{\overline{\gamma}_i^2}\left(\frac{\gamma}{\overline{\gamma}_i}\right)^{L-2}, & \gamma \geq \gamma_{\rm th} \\ \frac{L}{\overline{\gamma}_i}\left(\frac{\gamma}{\overline{\gamma}_i}\right)^{L-1}, & \gamma < \gamma_{\rm th}. \end{cases} \tag{11}$$

Substituting (11) in the definition of the MGF and using [6, eq. (8.350/2)], yields the following simplified expression of (8)

$$\begin{aligned} M_{\gamma_{\rm out}}(s) \approx \frac{\exp(-s\,\gamma_{\rm th})}{s\overline{\gamma}_i} + \left(\frac{1}{s\overline{\gamma}_i}\right)^L [L\Gamma(L) \\ -L\Gamma(L, s\,\gamma_{\rm th}) + s\,\gamma_{\rm th}(L-1)\Gamma(L-1, s\,\gamma_{\rm th})]. \end{aligned} \tag{12}$$

C. Average Output SNR

The ASNR is an important performance indicator that is tightly related to the performance metrics of a system, such as the BER and the asymptotic spectral efficiency. ASNR can be directly evaluated by setting $n = 1$ in (9).

D. Ergodic Capacity

Ergodic capacity is an essential metric to measure the maximum achievable transmission bit rate under which errors are recoverable from a Shannon's perspective. Substituting (7) in the definition of the capacity, i.e., $C_{\gamma_{\rm out}} = E\langle \log_2(1+\gamma_{\rm out})\rangle$, making an integration by parts and using [6, eqs. (3.352/1) and 4.337/2], the following closed form expression can be derived

$$\begin{aligned} C_{\gamma_{\rm out}} = \sum_{j=0}^{L-1} \binom{L-1}{j} (-1)^j \frac{L}{\overline{\gamma}_i} \mathcal{F}\left(\frac{j+1}{\overline{\gamma}_i}\right) + \frac{1}{\overline{\gamma}_i}\mathcal{G}\left(\frac{1}{\overline{\gamma}_i}\right) \\ + F_{\gamma}(\gamma_{\rm th}) \frac{L-1}{\overline{\gamma}_i} \sum_{j=0}^{L-2} \binom{L-2}{j} (-1)^j \mathcal{G}\left(\frac{j+1}{\overline{\gamma}_i}\right) \end{aligned} \tag{13}$$

where

$$\mathcal{G}(x) = \frac{\exp(-x\,\gamma_{\rm th}) \log_2(1+\gamma_{\rm th})}{x} - \frac{\exp(x)}{x \ln(2)} {\rm Ei}(-x\,\gamma_{\rm th} - x)$$

$$\begin{aligned} \mathcal{F}(x) = \frac{\exp(x)}{x\ln(2)} [{\rm Ei}(-x\,\gamma_{\rm th} - x) - {\rm Ei}(-x)] \\ - \frac{\exp(-x\,\gamma_{\rm th}) \log_2(1+\gamma_{\rm th})}{x} \end{aligned}$$

with ${\rm Ei}(\cdot)$ denoting the exponential integral function [6, eq. (8.211/1)].

E. Complexity

The complexity of the proposed scheme will be investigated by employing the ANPE and the SP in a guard period as a quantification of the power savings [2], [8].

1) Average Number of Path Estimations: The system complexity increases as the ANPE increases, due to the important amount of information that must be exchanged for performing various operations, e.g., channel estimations [9]. From the mode of operation, the ANPE, $N_{\rm out}$, is given by

$$N_{\rm out} = \pi_1 + L\pi_L \tag{14}$$

where π_j denotes the probability that exactly j diversity paths are estimated. Thus, it is obvious that $\pi_L = F_{\gamma_i}(\gamma_{\rm th})$ and $\pi_1 = 1 - F_{\gamma_i}(\gamma_{\rm th})$, simplifying (14) to

$$N_{\rm out} = 1 + (L-1)F_{\gamma_i}(\gamma_{\rm th}). \tag{15}$$

2) Switching Probability: SP is an important performance measure that is very useful in practical scenarios. In particular switching between branches not only consumes power, but also reduces the data throughput in a transmit-switched diversity configuration as well as leads to inaccurate phase estimates [10], [11]. It is obvious that the receiver makes a switch if and only if $\gamma_i < \gamma_{\rm th}$ and $\gamma_j > \gamma_i$ for at least one $j \in \{1, 2, \ldots, L\}$ and $j \neq i$. For i.i.d. fading, following a similar approach as the one used in [2], the SP, $P_{\rm out}^s$, can be also expressed as

$$P_{\rm out}^s = F_{\gamma_i}(\gamma_{\rm th}) \left[1 - \frac{1}{L} F_{\gamma_i}(\gamma_{\rm th})^{L-1}\right]. \tag{16}$$

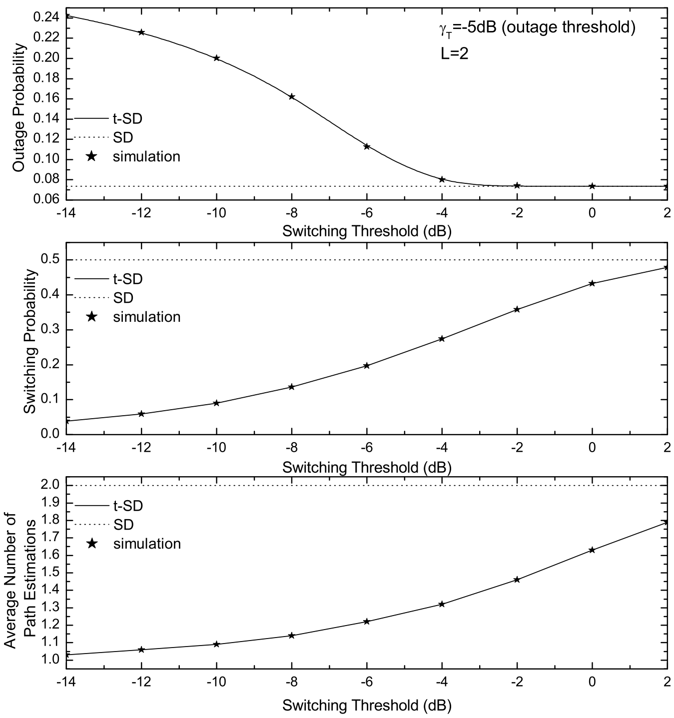


Fig. 2. Outage probability, average number of path estimations and switching probability of SD and t-SD as a function of $\gamma_{\rm th}$.

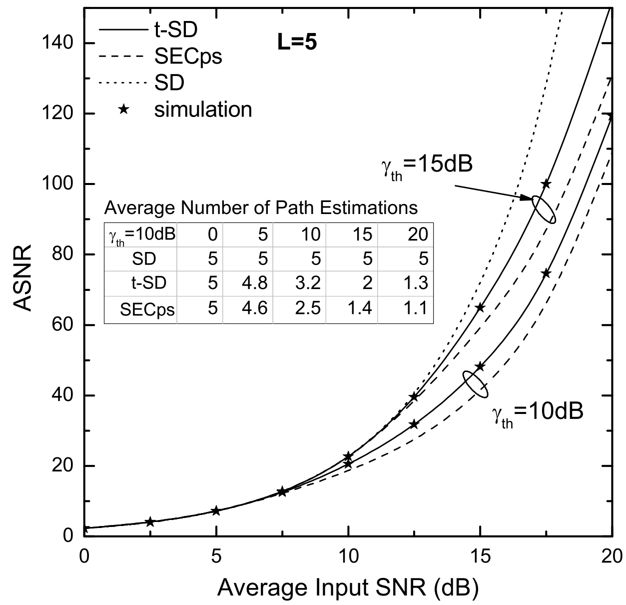


Fig. 3. ASNR and average number of path estimations of SD, SECps and t-SD as a function of $\overline{\gamma}_i$.

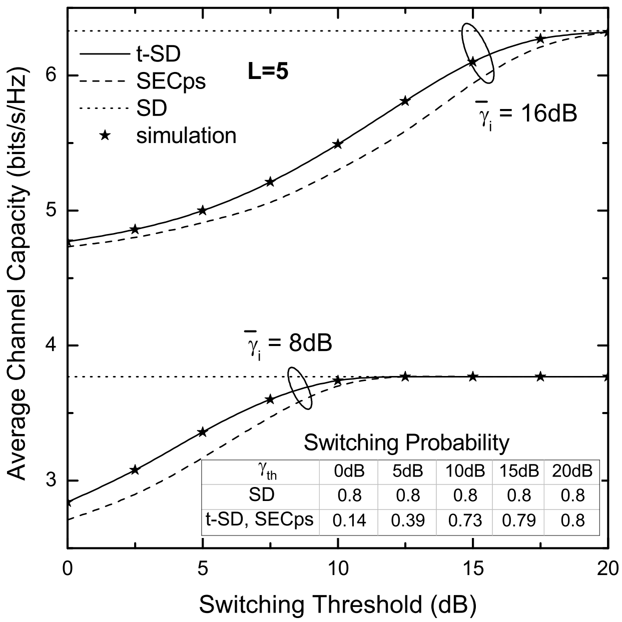
IV. Numerical Results

In this section, various numerical performance evaluation results will be presented in terms of the OP, ABER, ASNR and the average capacity criteria. Additionally, for comparison purposes, the corresponding performances of other diversity techniques are also examined, with the ANPE as well as the SP also taken into consideration. In Fig. 2, the OPs of dual-branch SD and t-SD receivers are plotted as a function of the switching threshold, $\gamma_{\rm th}$, assuming normalized outage threshold, $\gamma_T/\overline{\gamma}_i = 5$dB. In the same figure the SP, $P^s_{\rm out}$, and the ANPE, $N_{\rm out}$, are also included. It is depicted that for higher values of $\gamma_{\rm th}$, the OP of t-SD becomes almost equal to the corresponding one of SD. However, for these high values of $\gamma_{\rm th}$, $N_{\rm out}$ as well as $P^s_{\rm out}$ of t-SD are considerably lower as compared with the corresponding ones of SD. Thus, non negligible energy savings can be achieved without any important loss in performance. In Fig. 3, considering $L = 5$ diversity branches, the ASNRs of SD, SECps and t-SD are plotted as a function of the average input SNR, $\overline{\gamma}_i$, and for various values of $\gamma_{\rm th}$. It is depicted that for lower values of $\overline{\gamma}_i$, the ASNR performances are equal, while a performance gap appears when $\overline{\gamma}_i > \gamma_{\rm th}$, with SD having always the best performance and SECps the worst. In the same figure, assuming also $L = 5$ and $\gamma_{\rm th} = 10$dB, a table containing $N_{\rm out}$ of the previously tested diversity schemes, is also included. Comparing the figure and table results, it is obvious that in terms of ASNR, t-SD provides an intermediate performance to the ones offered by SD an SECps. Additionally, for the same parameters, the $N_{\rm out}$ of t-SD is much lower than that of SD and quite close to the one required by SECps, especially for higher values of $\overline{\gamma}_i$.

In Fig. 4, the average channel capacity performances of SD, SECps and t-SD are plotted as a function of the switching threshold, $\gamma_{\rm th}$, for various values of the average input SNR, $\overline{\gamma}_i$. It is shown in this figure that t-SD has always better performance as compared to SECps, while it approaches the performance of SD for higher values of $\gamma_{\rm th}$. In the same figure, assuming $\overline{\gamma}_i = 8$dB, a table containing the SP of the three diversity methods under consideration is also included. Comparing SD with t-SD, it is interesting to note that with a relatively small cost on the average capacity performance, e.g., $\simeq 10\%$ for $\gamma_{\rm th} = 5$dB, the switching probability of t-SD is $\simeq 50\%$ less as compared to that of SD. Therefore, in this figure it also verified that as far as the performance and complexity trade off is concerned, t-SD represents an excellent compromise, as compared to SD and SECps. This tradeoff analysis is more clearly presented in Fig. 5. In this figure assuming DBPSK, $\overline{\gamma}_i = 12$dB, $\gamma_{\rm th} = 8$dB, the minimum ABER, $P_{\rm be}$, is evaluated for the three diversity receivers under consideration, assuming that a constraint, $N_{\rm c}$, on the ANPE exists, i.e.,

$$\begin{aligned} &\text{minimize } P_{\rm be} \\ &\text{subject to } N_{\rm out} \le N_{\rm c}. \end{aligned} \tag{17}$$

Setting constraints on the number of path estimations is expected to considerable decrease the system complexity as well as increase the effective throughpout performance via the decrease of feedback information that should be exchanged between the transmitter and the receiver, e.g., [12]–[14]. Therefore, in this figure the minimum $P_{\rm be}$ is illustrated for various values of diversity branches, L, and constraints on the ANPE, $N_{\rm c}$. It is depicted that $P_{\rm be}$ decreases as L increases,



γ_{th}	0dB	5dB	10dB	15dB	20dB
SD	0.8	0.8	0.8	0.8	0.8
t-SD, SECps	0.14	0.39	0.73	0.79	0.8

Fig. 4. Average channel capacity and switching probability of SD, SECps and t-SD as a function of $\gamma_{\rm th}$.

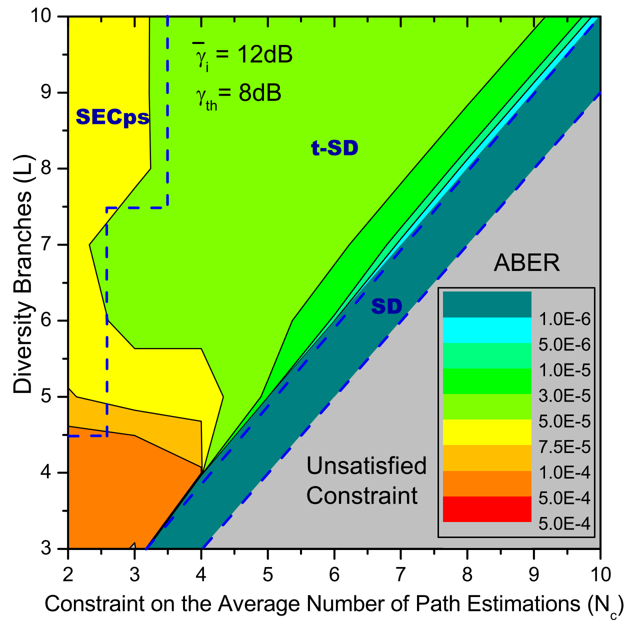


Fig. 5. ABER performance and complexity trade off analysis for various values of L and N_c.

as expected. Moreover, it is interesting to note that most cases the minimum $P_{\rm be}$, satisfying the constraints, is provided with t-SD reception, whilst SD is better when no path estimations constraints exist and SECps in cases where the constraints are very tight. For comparison purposes, computer simulation performance results are also included in Figs. 2-4, verifying in all cases the validity of the proposed theoretical approach.

V. Conclusions

In this paper a new threshold based SD receiver (t-SD) is proposed for reducing the complexity that the conventional SD receiver induces to the system, without considerable affecting the performance. For this new scheme, important statistical metrics have been derived in closed form including PDF, CDF, MGF and moments. In addition the performance of t-SD has been evaluated and compared with the corresponding ones of conventional SD and SECps, using well known performance criteria, namely OP, ABER ASNR and average channel capacity. It is depicted that in many cases t-SD, outperforms SD and SECps in terms of the performances and complexity trade off. Further research attempts, not included in this conference version, have shown that the performance gap between t-SD and SECps increases when non i.i.d. fading conditions have been considered.

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