A 4-State Asymmetric 8-PSK TCM Scheme for Rayleigh Fading Channels

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Abstract — **We use an asymmetric 8-PSK signal set in a 4-state rate 2/3 TCM scheme to show performance gain over TCM schemes with symmetric constellations. Simulation performed over the Rayleigh fading channel is reported.**

I. Introduction

The code design criteria for Rayleigh fading channels are, (i) maximize the effective length of the code L, and (ii) maximize the smallest product of the squared distances, $d_p^2(L)$, along effective length L error events.

4-State rate 2/3 symmetric 8-PSK TCM schemes have been studied in connnection with use in Rayleigh and shadowed mobile radio channels [1] [2]. Fig. 1(a) shows the symmetric 8-PSK signal set with relevant distances marked. In this paper we show that following the design rules of [2] the 8-PSK signal set with asymmetry as shown in Fig. 1(b) increases the value of $d_p^2(2)$ over the best possible using symmetric 8-PSK. The increase depends on the value of asymmetry θ (see Fig. 1(b)) and the maximum value achievable is 4 which is attained for an angle $\pi/12$. Moreover, the free Euclidean distance also improves marginally compared to Jamali and Le-Ngoc.

II. Code Design for Asymmetric 8-PSK

In the best known 4-state symmetric 8-PSK TCM scheme [2] the $d_p^2(2)$ is achieved by the combination

$$\delta_3^2 \delta_0^2 = 2.344 E_s^2. \quad (1)$$

By observing the state transitions it is noticed that the δ_0^2 term in (1) appears only in one of the following ways:

$$s_5 s_6 \quad or \quad s_1 s_2.$$

Introduction of asymmetry as shown in Fig. 1(b) increases the distance among these pairs. This is the key to the improvement of $d_p^2(L)$.

Table 1 summarizes the performance of known 4-state symmetric 8-PSK and APSK schemes.

	U [3]	WL [1]	JN [2]	APSK Fig.1(b)
L	1	2	2	2
$d_p^2(L)$	$4E_s$	$1.172E_s^2$	$2.344E_s^2$	$4E_s^2$
d_{free}^2	$4E_s$	$2.586E_s$	$3.172E_s$	$3.268E_s$

Table 1: Comparison of 4-state rate 2/3 8-PSK schemes

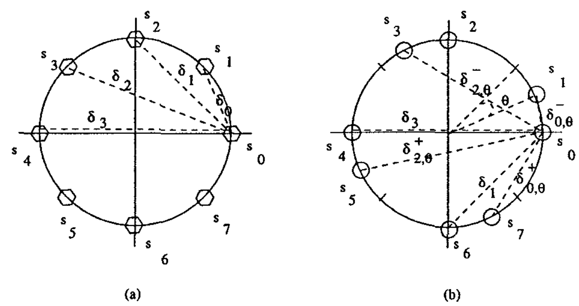

Fig. 1: (a) Symmetric 8-PSK with distances marked (b) Asymmetric 8-PSK signal set with angle of asymmetry θ

Fig. 2 shows simulation results for Wilson and Leung code (WL), Jamali and LeNgoc code (JN) and the code of this paper (15deg) along with the uncoded QPSK. The asymmetric TCM scheme shows improvement over JN by about 0.4 dB around the bit error probability 10^{-5}.

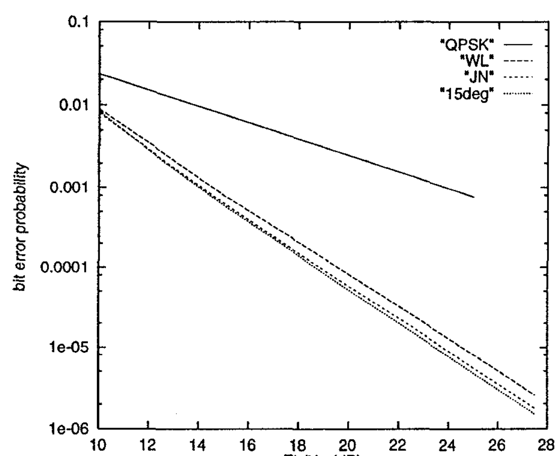

Fig. 2: Bit error rate performance over a Rayleigh fading channel with perfect CSI

References

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