# Unified Analysis on Performance Limits of Coded Multilevel DPSK in Rayleigh Fading Channels

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### Abstract

This paper analyzes performance limits of coded multilevel differential PSK (MDPSK) in frequency selective Rayleigh fading channels. It is assumed either that interleaving degree is large enough, or that there is a sufficient bandwidth for frequency hopping, to randomize the burst errors produced by fading. The channel cutoff rate of MDPSK is calculated based on the "Gaussian metric"; AWGN, co-channel interference and multipath channel delay spread are taken into account. For practical, reliable communications over cellular mobile radio systems employing coded MDPSK, the three optimal information bit rates that achieve

1)minimum required average signal energy per information bit-to-noise power spectral density ratio ($E_b/N_0$),

2)maximum tolerable rms delay spread $\tau_{rms}$, and

3)maximum spectrum efficiency

are determined from the channel cutoff rate. It is shown that without fading frequency selectivity, the optimal information bit rate (=information bits /MDPSK symbol) which minimizes the required average $E_b/N_0$ is around 0.25 information bits /symbol for 2DPSK, and 0.4 bits /symbol for other MDPSK schemes with $M \geqq 4$.

In frequency selective fading, the lower the rate of codes for error correction, the higher the channel symbol rate for a given information bit rate $1/T_b$, and the transmission performance becomes more sensitive to the fading frequency selectivity. It is shown that a larger $\tau_{rms}/T_b$ value can be tolerated with larger values of M. The optimal code rate for 32DPSK is around 0.3 (1.5 information bits /symbol), and the maximum $\tau_{rms}/T_b$ value is 1.5.

In co-channel interference environments, it is obvious that a larger error correction capability reduces required average signal-to-interference power ratio (SIR). Therefore, the same frequency can be used in closer cells when lower rate codes are used. This increases the system spectrum efficiency. However, the lower rate codes require larger transmission bandwidth, and this decreases the efficiency.

In the analysis of the spectrum efficiency of cellular mobile radio systems employing coded MDPSK, the service area is defined as the area in which practical, reliable communications are possible. It is shown that for a given channel bandwidth, the spectrum efficiencies are maximized when the information bit rate is around 0.5 information bits /symbol for 2DPSK, 1 bit /symbol for 4DPSK, and 1.4 bits /symbol for other MDPSK schemes. For a given information bit rate, spectrum efficiency is increased with larger M values. The optimal code rate for 32DPSK is around 0.3, and the maximal spectrum efficiency is 2.6 times as large as that for 1 bit-per-symbol coded 4DPSK.