

# Abstract

## On Codes Over Asymmetric PSK and Multidimensional Uniform Signal Sets

The thesis consists of two parts: Part I deals with asymptotic achievable lower bounds on normalized rate of Euclidean space codes over uniform signal sets of any dimension and Part II deals with performance of Trellis and Block Coded Modulation (TCM and BCM) schemes on Rayleigh, Rician and shadowed Rician fading channels.

The Gilbert-Varshamov bound for codes designed for Hamming distance, over an alphabet of size  $q$ , is well known. Piret has obtained a similar lower bound for codes over symmetric PSK signal sets with Euclidean distance under consideration instead of Hamming distance. The Gilbert-Varshamov bounds for  $q = 2, 3$  and  $4$  are obtainable from Piret's bound for 2, 3 and 4-PSK signal sets and not for  $q \geq 5$ . A signal set is referred to be uniform if the Euclidean distance distribution is identical from any point of the signal set. In this thesis, we extend Piret's bound to codes over all uniform signal sets that includes, as a special case, codes over all signal sets matched to groups which, in turn, includes symmetric PSK signal set as a further subclass. The Gilbert-Varshamov bound for all values of  $q$  is shown to be obtainable by specializing the extended Piret's bound to simplex signal sets. The extended bound is used to study signal sets in two,

three and four dimensions that are matched to groups. It is shown that four-dimensional signal sets matched to binary tetrahedral, binary octahedral and binary icosahedral groups lead to better bounds than the signal sets matched to dicyclic group with the same number of signal points and comparable symmetric PSK signal sets. It is also shown that asymptotically good Hamming distance codes when used in multilevel construction of Euclidean space codes lead to asymptotically good Euclidean space codes.

In Part II of the thesis the results of the study of TCM and BCM schemes on fading channels are presented. It is well known that the code design criteria for Rayleigh fading channels, Rician fading channels with small parameter and shadowed Rician channels are to maximize the effective length as well as the minimum product distance of the code. In this thesis we use two different asymmetric 8-PSK signal sets in 4-state and 8-state rate  $2/3$  trellis-coded modulation (TCM) schemes and show performance gain over TCM schemes with symmetric 8-PSK constellations. The performance gain is due to the increase in the minimum product distance compared to that of best known TCM schemes of comparable states using symmetric 8-PSK signal sets while the effective length remains same. Simulation is performed over the Rayleigh, Rician and shadowed Rician fading channels to demonstrate the performance gain of the asymmetric 8-PSK TCM schemes over the symmetric 8-PSK TCM. The Underwater Acoustic (UWA) channel is modelled and the simulation results for the performance of TCM schemes over it are presented.

In the case of BCM schemes, the maximum effective length is obtained when Maximum Distance Separable (MDS) codes are used. The well-known MDS codes are Reed-Solomon

codes over finite fields using which, performance of BCM schemes over Rayleigh fading channels have been reported. We have used Reed-Solomon codes over elementary abelian groups and reported marginal improvements.