

ON OPTIMAL EQUALIZATION, ECHO-CANCELLATION AND CARRIER RECOVERY TECHNIQUES FOR DIGITAL COMMUNICATION


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DOCTOR OF PHILOSOPHY

by
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CERTIFICATE

This is to certify that the thesis entitled "On Optimal Equalization, Echo-Cancellation and Carrier Recovery Techniques for Digital Communication" being submitted by Sant Sharan Pathak for the award of the degree of Doctor of Philosophy to the Indian Institute of Technology, Delhi, is a record of the bonafide research work he has done, during the period from February 1979 to February 1984 under my supervision. The results obtained in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.


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TO

MY PARENTS

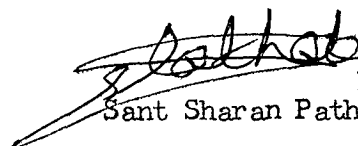
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21/3/84
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ABSTRACT

This thesis deals with some aspects of problems arising in digital communication receiver design. The specific problems taken up for study here pertain to design of optimum and/or sub-optimum receivers for digital communication in the presence of intersymbol interference, carrier phase jitter and interference from locally transmitted data along with Gaussian and non-Gaussian noise.

The problem of intersymbol interference with Gaussian noise is taken up first. A new state space model is proposed in which the transmitted data serves as a white noise input. Equalizer structures are then developed using the theory of white-noise input sequence estimation from the noise corrupted output of a linear system. This involves the use of smoothing techniques for estimating the input data. An important advantage of this approach of equalization is shown to be that the order of the required state space model can be significantly smaller than the length of the impulse response of the channel, thus resulting in savings in computations.

The problem of carrier recovery via a combination of decision-direction and optimum/nonlinear state estimation approaches is next formulated in a general setting involving arbitrary two-dimensional modulation schemes. A number of state space models along with their corresponding decision-directed observations are investigated from the points of view of their performance in the absence of

a-priori knowledge about the phase jitter being tracked. Some interesting new structures with fast and nearly optimal convergence properties are shown to emerge.

The possibility of combining the tasks of adaptive equalization, carrier recovery/phase jitter compensation, and echo signal cancellation based on a single global error criterion is examined next. It is shown that there are several alternatives for positioning the various components of the receiver in the global structure. A unified treatment of the various possible configurations is attempted here with a view to understand their relative advantages and disadvantages from the points of view of their steady state behaviour in the adaptive mode. In addition to proposing a new receiver-structure involving passband decision-feedback equalization and carrier recovery/phase compensation, an attempt is made here to put the subject of jointly adaptive systems in a proper perspective via extensive analysis and simulation studies.

Finally, the problem of mitigating intersymbol interference when associated with non-Gaussian noise is considered. A basic theory for this subject is developed by considering several approaches for the design of the locally-optimum receiver structures. A decision-feedback receiver, a composite-hypothesis testing MAP receiver and a maximum likelihood receiver are obtained. A Viterbi algorithm implementation of the maximum likelihood receiver is also suggested. The performance bounds for these nonlinear receivers are evaluated for some typical non-Gaussian noise distributions and channel impulse responses.

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