CHAPTER-I

INTRODUCTION

Many remarkable achievements in the fields of control and communication have been possible mainly for the latest developments in digital technology. Advantageous features like efficient signal regeneration, the possibility of combining transmission and switching functions, the adequacy of a uniform format for different types of signals and miniaturisation and increased reliability of digital circuits due to I.C. technology make digital systems more desirable in both communication and control. While applying digital techniques, the problems of analog to digital and digital to analog conversions are becoming increasingly important. Most of the earlier digital systems design assumed that the quantization step is fine enough to neglect the undesirable effects of these conversion processes. But the demands for increased sophistication and accuracy in recent years make the designers realise the importance of these undesirable effects of quantisation noise and error. In the last few years appreciable researches have taken place in this area in the fields of picture processing, communication technology and control theory. As a result, instantaneous variable step size quantizers (Adaptive quantizers) have been widely discussed in the literatures.

Some of the adaptive quantization schemes are aimed at increasing the dynamic range rather than an inherent signal to noise ratio (SNR) advantage. Whereas other adaptive quantisation schemes are based on the improvement of the SNR.

When adaptive quantisers are used in radio communication and remote control systems, the information of the quantisation step sizes are also to be transmitted to the receiver along with the quantisation level information, thus increasing the channel requirement. An optimal method to predict the quantisation step size at the receiver has been presented in this thesis which improves the SNR and also the channel capacity.

The process of converting analog signals to digital signals is completed in two steps. First the signal is sampled and then it is quantised. Both of these operations introduce noise in the signal. Different methods to reduce these noise have been investigated to appreciable depth by different workers in the field. Review of these works are presented in Chapter-II. It was found that a heuristic controller using the digitisation techniques may be used to control the output of unknown plants. Some basic ideas about the same are also presented.

Adaptive quantisation is a quasi-uniform quantisation technique, employing more than one quantisation steps. In Chapter-III the basic concepts behind the prediction of the quantisation step sizes at the receiver is given. Prediction of the quantisation step size is based on the information received of the most recent quantisation level and the just previous quantisation level. Necessary algorithms for prediction are described in this chapter. By imposing restrictions on the slope conditions of the input samples, the effectiveness of the proposed technique is illustrated, using digital computer simulation, for first order Gauss-Markovian input samples

Results of simulation in Chapter-III show that given maximum absolute value of the ratio of adjacent sam it is always possible to choose a quantizer structure so the given prediction algorithm can be used to calculate t quantization step size for every quantization level recei the receiver. The first order Gauss-Markovian samples us the input, only approximately represent the speech or pic signal samples. Imposition of the restrictions on the sl conditions of these input samples may not approximate the speech or picture signals in all cases. Hence, to get ma SNR without the constraints on the slope, optimal method predicting the quantization step sizes is developed and d in Chapter-IV.

In view of obtaining quantizer performance whic remains acceptable over a reasonable range of signal stat an improved method of prediction of the quantization step is also described. Verification of this method for two d types of input distributions, with different quantizer st has been described in Chapter-IV. Results show that for as well as for Gamma distributed inputs, this method give better SNR than most of the existing other schemes for values of correlation factor 'C' and wordlength, W'.

An alternate method is to emulate the receiver transmitter and to send a control signal whenever it is r to correct the step size. Situations under which the con signal is to be transmitted is known either by the forwa estimation of the quantization step size (Scheme A), or by the backward estimation of the step size (Scheme B) as explained in Chapter-V. One of the levels from the set of unallowed levels $\{N_u\}$ is used as a control signal without using extra channel and it is transmitted through the same main stream of bits carrying the level information. Both the schemes have been simulated on a digital computer for first order Gauss-Markovian input which symbolises the ordinary speech and picture signals. Scheme A is found most suitable for smaller wordlengths and gives a better SNR than most of the existing schemes. Scheme B gives a good SNR only with higher wordlengths.

Another method for step size correction (Scheme C) has also been explained in the same Chapter-V, which is suitable for off line operation of the signal and gives a good SNR only for larger values of the wordlengths.

A simple heuristic controller using digital techniques is proposed in this thesis which controls an unknown plant in a suboptimal way and hence can replace the human controller in some situations like unmanned spaceships or nuclear reactors etc., where system parameters are not known precisely.

It uses an adaptive delta modulator and a 3 bit shift register as an error classifier which classifies the error voltage into one of the predecided classes. The decision making block of the controller takes a decision about the control law to be implemented, based on the information received from the error classifier at each sampling instant. The implementer implements the appropriate decision taken by the decision making block.

Performance of the heuristic controller with three different types of systems and for a step input have been verified and given in Chapter-VI. The results are quite satisfactory.

Study of this heuristic controller with two differer types of non-linear systems has also been made and given in Chapter-VII. Performance of a system with the heuristic controller for (i) random input and (ii) ramp input have also been illustrated in Chapter-VII.

Finally the results of the study are summarised and scope for future works discussed (in Chapter-VIII). It is hoped that these schemes will be useful in many practical systems.

First order Gauss-Markovian sequences being used in many simulation works presented in the thesis, a simple metho for generating the same was determined and is presented in Appendix-A.

The calculations were made on the basis of 10,000 samples. The procedure for the calculation of SNR for the adaptive quantiser of Chatterjee and Jain, has been explained in Appendix-B.