بسم الله الرحمن الرحيم

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Menoufia University
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Department of Electrical Communications Engineering

Adaptive Techniques For Performance Improvement Of Communication Systems For Coded Data

By

Eng. Hala Farid Abed EL-Daim
(B.Sc., Electrical Communications Engineering)
May 1995

A master thesis submitted in partial fulfillment of the requirements for the M.Sc. degree, Communications Engineering
Faculty of Electronic Engineering, Menoufia University
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Abstract

The research in this thesis has been concerned with studying in-service error-monitoring techniques at a repeater and a receiver using line codes for digital transmission systems. Pattern violation detection (PVD) and digital sum variation (DSV) techniques have been applied at repeaters. On the other hand, illegal and disparity techniques have been applied at the receiver.

Pattern violation detection (PVD) technique is based on detecting invalid code sequences (pattern violations) within the data stream, which correspond to the code symbols. By detecting these pattern violations, it is a straightforward matter to detect single errors in a received signal. The analysis of PVD technique has been introduced in the thesis, also the probabilities of detecting these patterns have been computed.

DSV technique involves an extension of the idea of disparity of single symbol rather than a word. The technique has been evaluated through the computer simulation. The simulation has been considered with additive white Gaussian noise channel. The performance of the technique has been measured by calculating efficiency of error detection, detected violation rate, and injected error rate for most practical line codes at different values of signal to noise ratio. The optimum line codes, from the efficiency viewpoint, have been obtained as follows.

The optimum line codes, from the point of view of efficiency.

Family	1B2B	3B4B	5B6B	4B3T
Optimum code	AMI(2)	3B4B(1)	5B6B(1)	4B3T

Illegal and disparity techniques have been applied at the receiver. The first technique was based on the fact that if the received coded word don't appear in the coding map, then, it is considered illegal word. The presence of one or more bit errors at unknown locations in a word makes the whole word unusable. On the other hand, the second technique depends on the appearance of two consecutive nonzero disparity words, which have the same polarity and are detected as an error.

We have discussed the two techniques over additive white Gaussian noise through a computer simulation program for the most practical line codes. The obtained simulation results of detected word errors rate (DWER) and efficiency of error detection (η) have showed that the two techniques have the same performance of the system at very low SNR (<-5dB), but as the SNR becomes greater than –5 dB the disparity technique gives better performance.

The principle of decoding the received code word has been based on constructing the decoding map for each line code. Based on minimizing error multiplication technique, we have constructed the decoding maps for different line codes. The error extension factor can be generally determined as the ratio between bit error rate at the output of the decoder to transmission (injected) bit error rate. To estimate the error extension factor, the computer simulation model has been carried out over AWGN channel for most practical line codes. Our results indicated that, from the viewpoint of error extension factor, AMI(1) is the best code in 1B2B family, 5B6B(2) is the most favorite code in 5B6B family, and FOMOT is the best code in 4B3Tfamily. Finally, we present the design curves that are very important for a practical design of digital communication systems. From these curves, error extension factor can be estimated if the transmission error rate and data statistics are given.

Contents

CHAPTER 1

Introduction

Any communication channel, whether it is a data link, microwave link, telephone network or storage channel such as magnetic tape or disc, will be subjected to the presence of noise. The form that noise may take will vary from channel to channel. Interference from nearby channels in the form of crosstalk, which attempts to disrupt communications, is example of source of noise. Regardless of what form the noise signal takes, it will ultimately have an adverse effect on the performance of communication system. In the presence of various types of noise, distortion and interference, the output of the communication channel is an estimate of the originally transmitted data (channel input), since the transmitter has little control over the source of the noise signal. The only alternative is to attempt to protect the transmitted data in order to minimize the effect of corruption, and to increase the accuracy of the estimate made at the receiver. The level of the protection required to the data to be transmitted, may be achieved by choosing an appropriate modulation technique, this in itself may not necessarily be sufficient to ensure that the probability of error be sufficiently low. The use of error detecting or error correcting codes can often ensure some desired degree of protection against error. The choice of method of protection will be dependent on the source of the original message, and the types of noise present in the communication channel. Considering the source of the message to be sent, if the message is repeatable, and there are no time constraints to prohibit the re-transmission of a message, then detecting the occurrence of an error or errors may well be sufficient. Thus the performance of a digital transmission system is accessed by the continuous monitoring of transmission errors and so it is essential that the used code has an error detecting capability. CCITT recommendation [1] exist for 2,8,34 and 140 Mbit /s, where two specified thresholds exit for the decoded binary error rate namely:

1. 10^{-3} indicating that the performance is below acceptable standards and urgent attention is required.
2. 10^{-6} (10^{-5} for 2 M bit/s) indicating that the performance is deteriorating-early warning monitor.

The operating system employed is to monitor the digital section performance. By measuring the error rate and if the performance falls below the accepted standard the digital section is removed from the service and modified.

This thesis represents a trial to surpass the progress in one of the fastest growing communication services in the world – error detection techniques. In this chapter, types of noise in digital communication systems are introduced in section 1.1. Classification of coding in communication systems is presented in section 1.2. Classification of line codes schemes is the main subject of section 1.3. In addition, the main objectives of this thesis are indicated in section 1.4. Finally, section 1.5 illustrates the organization of the thesis.

1.1 Types of Noise in Digital Communication Systems

The degree to which it is possible to communicate reliable signals between different locations is determined by the capability of the receiver to distinguish between the various possible messages that might have been sent by the transmitter. One thing that limits this capability to distinguish between possible messages is noise. The noise may come from many sources and takes many forms. For purpose of analysis, it is convenient to group noises into certain broad categories that can be described by appropriate sets of parameters. Generally, four broad categories of noise can be distinguished in a digital communication channel as follows:

1. Gaussian noise.
2. Impulse noise.
3. Intersymbol interference noise.
4. Jitter noise.

The first category, Gaussian noise, had been our chief concern in designing and evaluating modulators and demodulators for data transmission. Sources of Gaussian noise include thermal noise in the transmitting and receiving equipment, thermal noise in the channel, and radiation picked up by the receiving antenna [2]. The thermal noise is produced by the random motion of electrons in the conducting media. A noise signal having a flat power spectral density over a wide range of frequencies is called white noise by the analogy to white light. The power spectral density of white noise is denoted by $N_0/2$ watt/Hz. The factor 2 is included to indicate that its power spectral is a two-sided. The probability density function of the Gaussian noise is given by [3]

$$p(n) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(n-N_0)^2}{2\sigma^2}} \tag{1.1}$$

Where, σ is the root mean square of the noise voltage (standard deviation). A good model for noise occurring in many electrical communication systems is provided by zero-mean Gaussian noise, since the noise is essentially the sum of large number of random contributions from individual electrons.

The transmission errors introduced by white Gaussian noise are such that the occurrence of error during a particular signaling interval does not affect the performance of the system during the subsequent signaling interval. Thus, the transmission errors due to white Gaussian noise are referred to as random errors. The probability that any digital symbol is received in error depends on the amount of noise present in the channel in relation to the signal level, that is, on the signal to noise ratio (SNR). To specify the relative amounts of signal and noise, the absolute value of SNR is defined as [4]

$$SNR = \frac{mean\ square\ value\ of\ the\ signal\ voltage\ (S)}{mean\ square\ value\ of\ the\ noise\ voltage\ (N)} \tag{1.2}$$

For the data transmission system described in the thesis, S is assumed to be one-half and