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Adaptive Equalization of Fractionally Spaced Equalizer Based on Activity Detection and Tap Decoupling

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Abstract: - In this paper, we presents an adaptive equalization of fractionally spaced equalizer based on activity detection and tap decoupling. Fractionally-Spaced equalizer (FSE) with Activity Detection improves the stability, steady-state error performance and convergence rate of the system. Implementation of the FSE technique provide alternative to linear equalization. The objective of the FS equalizer is to minimize the bit error rate of the data due to the disturbances of noise and intersymbol interference phenomenon on the channel of the digital communication system. Results indicates that FSE with activity detection showed considerable improvement in convergence rate over the fractionally spaced without activity detection. Finally, convergence rate indicate that this FSE technique perform the equalization task with great accuracy and with less time consumption.

***Keywords: -* fractionally spaced equalizer, Activity detection, tap coupling, maximum likelihood sequence estimation.**

I. INTRODUCTION

As the communication speed is increasing rapidly over the years. Long haul transmission in digital communications usually consists of several keys area to ensure the data transfer is error-free. Equalization is considered to be a powerful technique to cope with channel distortions in high speed data transmissions [1]-[3]. Decision feedback equalization is considered to be a powerful technique to cope with channel distortions in high speed data transmissions [1]. Over the last three decades, the use of Decision feedback equalizer (DFE) has been reported in digital communication applications to mitigate ISI [2]. DFE provides a good compromise between performance and complexity, delivering a much better performance than a linear equalizer at a much lower complexity than that of the optimum detector the maximum likelihood sequence estimation (MLSE)[4]-[5]. An efficient equalization scheme is based on a decision feedback equalizer (DFE). The DFE is well known for its simple structure, which provides satisfactory trade off between cost effectiveness and performance. Channel-estimation-based techniques represent a powerful equalization method. The basic principle is to first estimate the channel between the transmitter and the receiver from a known training sequence, so that this estimate is further used to compute the optimal DFE filters [5]-[8]. The computed tap coefficients are then uploaded to the equalizer taps, and can be updated afterwards from blind channel estimates obtained from the equalized data stream [9]. In this paper, we present an adaptive equalization of fractionally spaced equalizer based on activity detection and tap decoupling. Fractionally-Spaced equalizer (FSE) with Activity Detection improves the stability, steady-state error performance and convergence rate of the system. Implementation of the FSE technique provide alternative to linear equalization. The objective of the FS equalizer is to minimize the bit error rate of the data due to the disturbances of noise and inter symbol interference phenomenon on the channel of the digital communication system. The rest of the paper is organized as follows: Section II defines the basic of fractionally spaced equalizer in detail. In Section III, activity detection is presented with the mathematical equations. Section IV explains the activity detection with tap coupling. In Section V, shows simulation results based activity detection and activity detection with tap coupling is presented. Finally, a conclusion is put forward.

II. FRACTIONALLY-SPACED EQUALIZER (FSE)

Conventional equalizers have tap spacing's that are spaced with respect to the symbol rate. It is known that an optimum receiver corrupted by Gaussian noise would have a matched filter sampled periodically at the symbol rate of the message and that the matched filter must be matched to the channel and corrupted signal prior to the equalizer. Since the channel response is usually unknown, the optimum matched filter must be adaptively estimated. A suboptimal result would cause degradation in performance and sensitivity to timing error from the sampling of the output. A solution to the above is the implementation of the Fractionally Spaced Equalizer (FSE) [8], which is based on sampling the incoming signal at least as fast as the Nyquist rate. Fractionally-spaced equalizers have taps that are spaced closer than conventional adaptive equalizers, and with a sufficient number of taps, it is almost independent of the channel delay distortion. It means that the equalizer can negate the channel distortion without enhancing the noise. Although FSE requires increased complexity to implement, its

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ability to effectively compensate for an extremely wide range of delay distortion is a major feature that surpasses the complexity draw back. The FSE technique is a highly desirable application since it minimizes noise enhancement. With appropriately chosen tap spacing's; the FSE can be configured as the excellent feed forward filter [10]. Tap-Spacing Selection: The tap-spacing of the FSE must be close enough to sample the incoming signal as fast as the Nyquist rate. If the transmitted signal consists of pulses having a raised cosine spectrum with a roll-off factor β, then the signal spectrum extends upto (1 + β)/Ts [11]. and so, the sampling rate must be set to at least:

$$Fs = (1 + \beta)/2Ts \qquad (1)$$

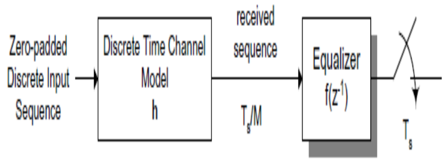

Fig. 1 a Discrete time version of the channel with a FSE

The structure of the FSE in the discrete domain is shown in fig 1. Assuming the channel has an impulse-response of length $(L_h - 1)$ T_s, the discrete-time representation of the channel will have a length $(L_h - 1)M$.

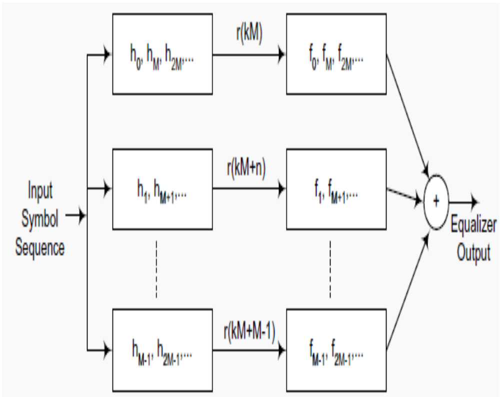

Fig. 2 A Multichannel representation of the FSE

Let h be the $(L_h - 1)$ M-vector representing the discrete time channel. The input pulse sequence u(n) at a rate T_s is zero-padded with M zeros in-between samples to set the sampling rate to M/T_s and the output signal from the FSE is sampled at a rate T_s (i.e, decimated). Let f be the vector representing the fractionally-spaced equalizer tap coefficients. Because of the presence of these M zeros in-between samples, the convolution u * h * f can be easily represented as a multichannel, single-rate (i.e., $1/T_s$) structure, as shown in fig. 2.

III. ACTIVITY DETECTION

During high bit rate transmission in optical systems, the channel tends to have longer impulse responses. This will augment the periods of zero activity in the channel response. As the name suggests, the activity detection guidance technique is a method of detecting active taps in a communication channel [3]. By implementing a technique capable of detecting active taps in the channel, non-active taps can be excluded in the estimation of the channel response. This relieves the computational burden of the LMS algorithm [9] [10], as well as to give a better convergence rate and asymptotic performance. The detection of the 'active' taps of a time-invariant channel is governed by the equation:

$$C_{k,n} = \frac{\left(\frac{1}{N}\sum_{i=1}^{N} iu_i . y_{i-k+1}\right)^2}{\frac{1}{N}\sum_{i=1}^{N}(y_{i-k+1})^2} \qquad (2)$$

where i=time index, k=tap index, and N is the number of input samples. C_k is known as the activity measure. In order to determine a tap to be active, the value of the activity measure, C_k, must be above a certain threshold. This activity threshold is given by:

$$C_{k,n} > \sum_{i=1}^{N} \frac{(iu)^2 \log i}{i} \qquad (3)$$

The accuracy improves with increasing N. When a tap is detected as inactive, it will be excluded in the estimation of the active taps. Therefore, the computational burden of the adaptive algorithm is reduced. The criterion discussed above is based on a few assumptions:

1. The input signal, iu, bounded and wide sense stationary process
2. The noise disturbance, nn, is a wide sense stationary white process, which is uncorrelated with the input signal

The activity measure given by Eq. 2 requires the input signal to be uncorrelated over time. The active tap detection would not succeed if the input were colored because the correlation within the input signal would cause coupling amongst the output of the unknown channel taps.

IV. ACTIVITY DETECTION WITH TAP DECOUPLING

Modifications to the activity measure have to be made to reduce the tap coupling effect.

$$CC_K = \sum_{i=1}^{N} \frac{[(iu_i - hiu_i + \hat{h}_k \; y_{i-k+1}).(y_{i-k+1})]^2}{\sum_{i=1}^{N}(y_{i-k+1})^2} \qquad (4)$$

This modification would reduce the contribution of any adjacent active tap to the perceived activity of the actual tap being considered. Simulation results would prove later, in Chapter 4, that the addition of the Tap

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Decoupling method would give a better convergence rate and asymptotic performance.

V. SIMULATION RESULTS

This section will present the results of the simulations performed using Matlab. The channel has a total of 2 active taps and a total tap length of 7. The noise interference applied was a zero mean white Gaussian signal, with a variance of 0.1. The adaptation step size was set at 0.005. Fig. 3 shows the Equalization of fractional spaced equalizer with Activity Detection. Fig. 4 indicates the convergence performance of fractional spaced equalizer with Activity Detection. Fig.5 demonstrates the Activity Detection with fractional spaced equalizer. Fig. 6 shows the Equalization of fractional spaced equalizer with Activity Detection and tap decoupling. Fig. 7 indicates the convergence performance of fractional spaced equalizer with Activity Detection and tap decoupling. Fig.8 demonstrates the Activity Detection with fractional spaced equalizer with tap decoupling.

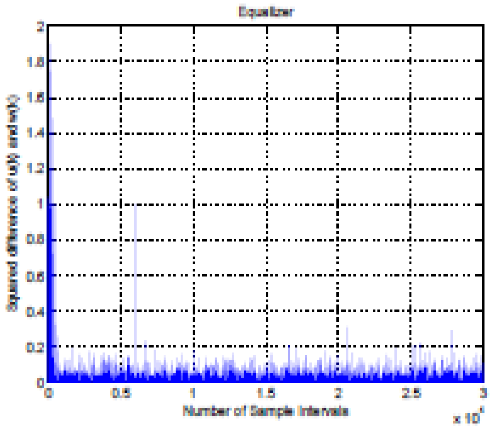

Fig. 3 Equalization of fractional spaced equalizer with Activity Detection

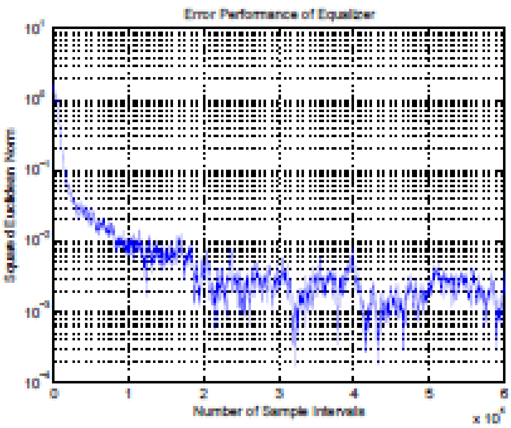

Fig. 4 convergence performance of fractional spaced equalizer with Activity Detection

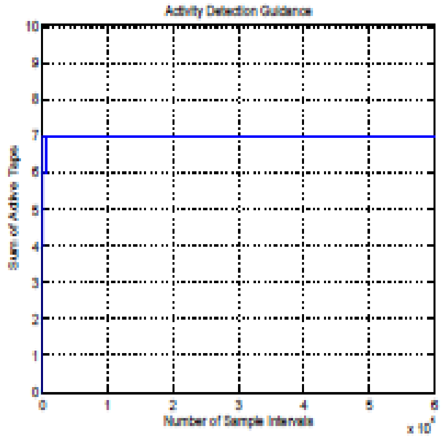

Fig.5 Activity Detection with fractional spaced equalizer

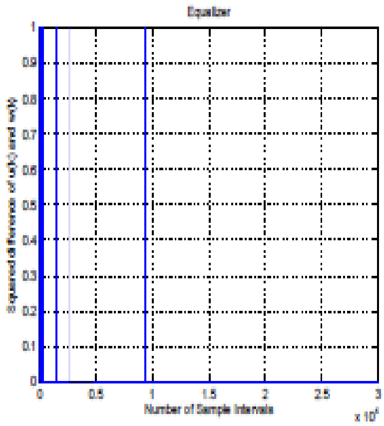

Fig. 6 Equalization of fractional spaced equalizer with Activity Detection and tap decoupling

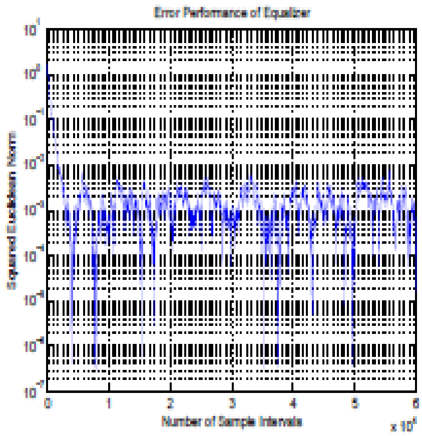

Fig. 7 convergence performance of fractional spaced equalizer with Activity Detection and tap decoupling

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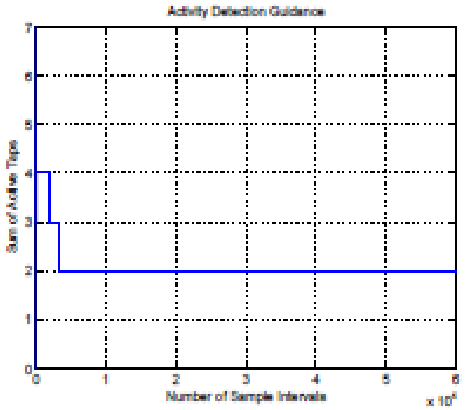

Fig.8 Activity Detection with fractional spaced equalizer with tap decoupling

VI. CONCLUSIONS

In this paper, we present an adaptive equalization of fractionally spaced equalizer based on activity detection and tap decoupling. Fractionally-Spaced equalizer (FSE) with The objective of the FS equalizer is to minimize the bit error rate of the data due to the disturbances of noise and inter symbol interference phenomenon on the channel of the digital communication system. Results indicates that FSE with activity detection showed considerable improvement in convergence rate over the fractionally spaced without activity detection.

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