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A NEW ADAPTIVE TECHNIQUE FOR TRANSMITTER PRE-EMPHASIS AND RECEIVER EQUALIZATION IN A HIGH-SPEED BACKPLANE ENVIRONMENT

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***Abstract.*- In this paper, a new adaptive equalization technique of a multi-gigabit channel is proposed. This approach calculates the voltages probability density functions of the received signal; and based on the spread of the PDF curves, weights of FIR filters are updated. The algorithm was tested in a Tyco XAUI-FR4 backplane.**

1. INTRODUCTION

Data transmission through backplanes is facing a number of challenges as conventional backplanes are not keeping pace with the improvements of multi-gigabit serial data traffic; and are becoming critical bottleneck in computer systems [1],[2],[3]. These backplanes are found in a variety of consumer electronic products such as notebook and desktop computers, as well as video game playstations. The channel transfer function of a backplane varies significantly at high frequencies, due to discontinuities in the signal path that causes losses and reflections, therefore, providing serious challenge to data transmission rates of 5 GHz and up [2]. To overcome these problems, the most common approach is equalization. For example, transmitter equalization is very useful approach when dealing with inter-symbol interference (ISI) but it is not as useful when dealing with reflections. Therefore, in configuration-dependent reflections [1], transmitter equalization along with decision feedback receiver equalization (DFE) are effectively used (see Fig. 1).

In systems with equalization, pre-emphasis, based on FIR filters, is performed to boost high frequency signal content on the transmitter side and the decision feedback equalization, along with a linear feed-forward equalizer, is used to combat reflections in the receiver (see Figure 1). The FIR pre-emphasis and receiver filters coefficients are first optimized using the LMS algorithm [4]. Then the coefficient updates are communicated back to the far-end transmitter where they are applied. These coefficients are continually updated, to allow for correction of the impairments of the packages, connectors, and backplane traces; and other problems such as power-supply drift, component aging, and temperature variations. Instead of continuously updating the coefficients, even when the channel conditions are good as suggested by Stonick *et. al.* [1], in this paper, we propose a new adaptive equalization technique that updates the FIR filter coefficients only when the signal integrity degrades. This degradation is detected when the voltage probability density functions of the received signal have wider spread than a targeted value. This new algorithm was tested in a Tyco XAUI FR4 backplane with two daughter cards [5].

2. TRANSMITTER PRE-EMPHASIS AND RECEIVER EQUALIZATION

Figure 1 shows the configuration of a transmitter pre-emphasis and receiver equalization of backplane transceiver. The entire setup consists of transmitter daughter card, connector, backplane channel, another connector and a receiver daughter card.

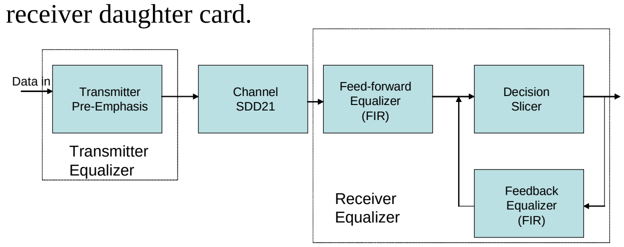
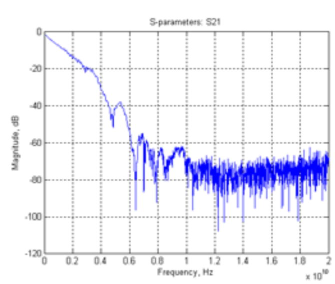


Figure 1 Block diagram of backplane channel

For this paper, the channel transfer function used is from the Tyco XAUI-FR4 backplane (SDD21 see Figure 1), and it is represented by its measured differential S_{21} parameter, which is shown in Figure 2a. The measured S_{21} transfer function, which is generally given over a range of high frequencies, is linearly interpolated without phase unwrapping for lower frequencies till zero Hz. The magnitude and phase at DC is extrapolated using polyfit as specified by IEEE 802.3ap task force [6]. The pulse response (Figure 2b) for this backplane is obtained by applying an inverse FFT to the transfer function and convolving it with a bit pulse.



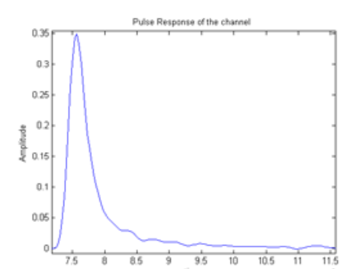


Figure 2 a) Transfer function b) Pulse response of the channel

The transmitter FIR filter coefficients are optimized using the LMS algorithm using a convergence engine [4]. The improvement in the eye diagram, due to a 5-tap transmitter pre-emphasis filter can be seen from Figures 3a and 3b. The receiver equalizer consists of a feed-forward and a decision feedback equalizer (DFE) filters (Figure 1). The feed-forward filter is also optimized using the LMS algorithm. The receiver eye diagram with feed-forward is shown in Figure 4a. The DFE filter coefficients are calculated using a technique implemented in Stateye version 3 [5]. In this Stateye methodology, the cursor points are first extracted and then the DFE coefficients are calculated.

3. A NEW ADAPTIVE TECHNIQUE

In order to maintain signal integrity, the adaptive equalization scheme updates the FIR coefficients continuously because the channel may experience on-chip and board level temperature and other variations. However, continuously running the LMS algorithm for all FIR filters, even when the channel conditions are good, is time consuming and waste of power resources. Therefore, in this paper we calculate the voltage PDF for the entire range of the eye at the sample point, and use the spread of this PDF curve as the criterion to change the filter weights; if the desired criterion is satisfied then the filter weights are retained, thus there is no use of the LMS engine. It is important to point out that computing the PDF is less time consuming than running the LMS algorithm for all the three FIR filters involved, in fact in our MATLAB simulations the PDF time calculations is about 1/3 of the LMS convergence time. For the Tyco XAUI-FR4 backplane setup, the width of the PDF curves, around the sample point, were found to be 0.18277 and 0.2609 V after simulating the entire equalization circuit. Then, the desired spread is set slightly above the larger of the above two values, in this case at 0.27 V. Using this threshold, Figures 3b, 4a and 4b shows the results of running this algorithm. Note that the LMS convergence engine is run only when the PDF spacing is greater than 0.27V.

4. CONCLUSIONS

In this paper, a new adaptive technique was presented, which ensures the performance and required eye characteristics with reduced computations; as we update the coefficients for the three different FIR filters involved only when needed, thus saving computing and power resources. Simulation results show that calculating the PDF is approximately 3 times faster than continuously running the LMS engine. This reduces computing time and saves power resources for high speed backplanes commonly found in notebook, desktop computers and video game playstations.

5. REFERENCES

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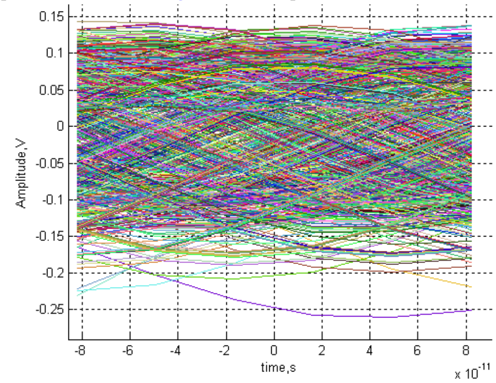

Figure 3a Eye diagram without equalization

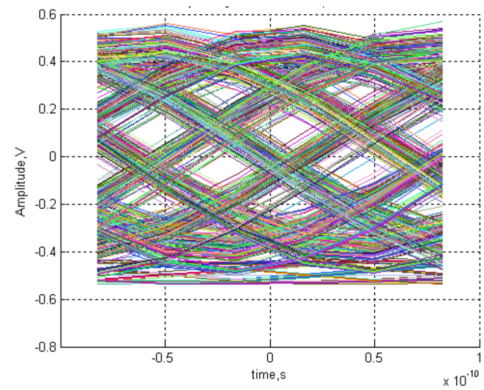

Figure 3b Eye diagram after transmitter pre-emphasis

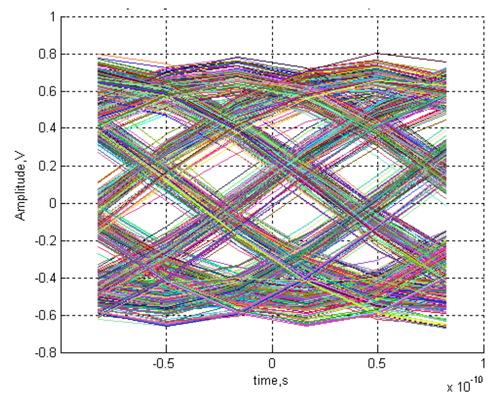

Figure 4a Eye diagram after receiver feed-forward equalization

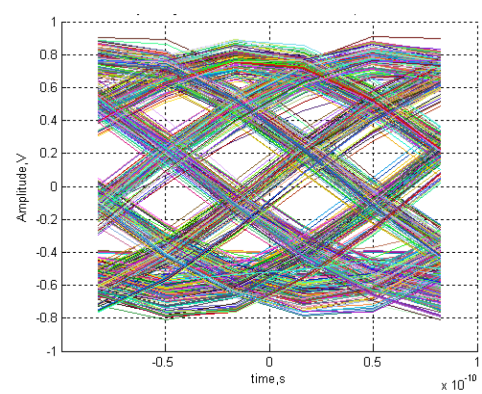

Figure 4b Eye diagram after DFE at the receiver