# Improving The Steady State Error And Convergence Based On Variable Step Size Constand Modulus Blind Equalization Algorithm

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**Abstract**
In this paper presents improving the steady state error and convergence based on variable step size modulation (VSS-CMA) blind equalization algorithm. In the past, constant-modulus algorithm (CMA) has low convergence rate and high error rate. In CMA has less step size can decrease the convergence rate, but at the same time it decrease the steady-state error. This paper propose a new variable step size constant-modulus algorithm (new VSS-CMA) with an adjustable step size that greatly increases the convergence rate for noise colorings with large eigenvalue spreads. A new VSS-CMA is simpler in computational requirements, faster convergence and lower steady state error and compare to conventional CMA, and VSS-CMA. The experimental results shows that the proposed VSS-CMA algorithm has considerably better performance than the conventional CMA and VSS-CMA.

***Index term:***
*Cross correlation, VSS-CMA, blind equalization, adaptive blind training.*

## I. INTRODUCTION

The convergence speed for the CMA is much slower than that of adaptive algorithms using a training sequence, e.g., the LMS algorithm, since it depends on higher order moments of signals, which are implicitly hidden in the cost function of the CMA.

Liyi and co-workers [1] proposed an alternative scheme that considers a nonlinear function of instantaneous error for adjusting the step-size parameter. Shahzad and co-workers [2] use two adaptive equalizers that work in parallel to increase the speed of convergence while reducing the trade off between the convergence speed and steady state error. Zhao and co-workers [3] derive a new VSS constant modulus blind equalization algorithm, which uses the cross-correlation coefficient estimation between the input signal and the error signal to control the step-size of CMA. However, the above algorithms are based on an assumption that the input is statistically independent. In the case of correlated signal, especially highly correlated signal, these VSS algorithms converge slowly. Additionally, most of these approaches involve significant increases in complexity or computational cost.

On the other hand various kind of successful studies have concentrated on adjusting the step-size of the CMA algorithm obtaining a better convergence and error performance using analytical or fuzzy logic based approaches [3]-[6]. As far as authors' knowledge all these systems were considering an analytic approach to the step size adjustment by doing either considering error variations or obtaining a possible trajectory for the training. However, instead of using an analytic approach, this work, inspired by [2] and [7], aims to design a training trajectory for the simple CMA algorithm employing cross correlation between channel output and error signal which provides a simple and more deterministic control on the training trajectory. Thus, with the help of proposed technique the performance of the conventional CMA algorithm has become comparable to other blind adaptive VSS-CMA training algorithms and non-blind conventional LMS training algorithm. Simulation results have shown that the proposed VSS-CMA algorithm performs better than the conventional CMA and Zhao's VSS-CMA [2] blind training algorithms, and the conventional LMS non-blind training algorithm found in the literature.

In this paper is organized as follows. Conventional CMA in section II. VSS-CMA in section III. PROPOSED CMA in section IV. EXTEND CMA in section V. The simulation results are presented in Section VI. Concluding remarks are made in Section VII.

## II. CONSTANT MODULUS ALGORITHM

The CMA, proposed by Godard[7], is the most popular technique for blind equalization. It is easy to implement by circuit design. Consider the base-band model of a digital communication channel characterized by finite impulse response (FIR) filter and additive white Gaussian noise. The received signal of equalizer is given in (1). In order to remove effect of channel distortion, we use the equalizer to eliminate this effect.

The weight is updated by the equation.

$$W(n+1)=W(n)+\mu e(n)U(n)$$

where $\mu$ is the fixed step-size parameter(n) is the input vector, and the range between 0 to 1

where

$$e(n)=Y(n)(R2-|Y(n)|)$$

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Y(n) is the array output after the nth iteration.
The drawback of CMA algorithm is slow convergence and steady-state error at fixed step size. A larger step size can speed up the convergence rate, but at the same time it increases the steady-state error. A smaller step size can decrease the steady-state error, but the convergence rate will be poor. n order to solve this problem, many variable step size CMA has been proposed in section III.

## III. VARIABLE STEP SIZE CMA (VSS-CMA)-I

The greatest advantage of the VSS-CMA algorithm is the fact that it requires far less computational complexity as for the other blind algorithms. The complexity incurred by the proposed technique does not prevent its application's. Inter symbol interference is one of the greatest impediments of high data rate digital communication systems. In order to overcome the effects of the impairment, several channel estimation and equalization methods have been developed in the last few decades. One of the best ways to cancel the effects is to use an equalizer filter which eliminates the ISI while combining the multi path energy. In practice, Linear Transversal Equalizers (LTE) and Decision Feedback Equalizers (DFE) are the most common structures used. But, in suppressing the ISI, the LTE inevitably enhances the channel noise. This basic limitation of a LTE's ability to cope with severe ISI has motivated a considerable amount of research into suboptimal nonlinear equalizers with low computational complexity such as the DFE.
The received signal of a wideband channel v(k) , is given by

$$v(k) = \sum_{i=0}^{L-1} h(i)x(k-i) + \eta(k)$$

where, x(k) is the transmit data sequence, h(i) is the ith tap coefficients of the tapped-delay-line filter model of a channel, L is the tap number of the channel, η(k) is the additive white Gaussian noise (AWGN) component and k is the time index.
The transmit data sequence x(k) is given by

$$\hat{x}(k) = \sum_{i=0}^{N} w(i)v(k-i)$$

The error function to verify CMA criterion is

$$e(k)=x(k)(\Delta 2-|x(k)|2)$$

The weight is updated by the equation.

$$W(i+1)=W(i)+\mu e(k)v(k-i)$$

## IV. VSS-CMA –II

Liyi's algorithm [9] utilizes a nonlinear function of remainder error to control the step size. The remaining errors should be properly transformed, and then control the step size, that is

$$\mu(k)=\beta[1-e(-\alpha|e(k)|]$$

Where
β is the proportionality factor
α is the control parameter. It should be positive value. in this paper The step size factor α was equal to 0.63 and the positive control parameter β is equal to 0.75.

## V. PROPOSED VSS-CMA

In this algorithm, improving convergence speed and less steady state error. This algorithm does not require the transmit signal. Moreover, the proposed VSS method provides both noise and ISI immunity since the channel output signal includes both ISI and noise information. The step size parameter is calculated as in given by

$$\mu(n)=b\times[|e(n)/a2|\times\exp((-e(n)2)/(2a2))]$$

where, α is the step size factor, to guarantee convergence the value of α must make the maximum of μ. The total computational complexity of the CMA algorithm is 8N+6 multiplications and 8N additions at each iteration. The Proposed VSS-CMA has two performance criteria were used to assess the convergence rate of blind equalizers in simulation studies. The first criterion was a decision-based estimated mean square error (MSE) metric at each adaptation sample based on a block of NMSE symbol-spaced data samples. NMSE was equal to 200 for all simulated blind equalizer in this study.

$$MSE = \frac{1}{N_{MSE}} \sum_{k=1}^{N_{MSE}} \left| Q(\hat{x}_k) - \hat{x}_k \right|^2$$

where Q(xk) denotes the quantized equalizer output defined by

$$Q(\hat{x}_k) = \arg\min_{x_k} \left| \hat{x}_k - x_k \right|^2 .$$

The algorithm of proposed VSS-CMA as shown below
Initialization the parameters are a,b ,M and SNR
Noise=whitegausan noise
Isi=[0.28,1,0.28];
n=sign(rand(1,signal_length)
y =conv(isi,n)+noise;
μ(n)=b×[|e(n)/a2|×exp((-e(n)2)/(2a2)]
for n=1:signal_length-M+1;
y1=y(n+M-1:-1:n-M-1);
d1 =wk*y1';

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e(n) = y(n-2)-d1;
wk=wk+mu*e(n)*(y1-1);
e(n)= (abs(e(n)^2));
end
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## VI. EXPERIMENTAL RESULTS

The simulation studies have composed of two stages. In the first stage studies are performed using the simulated communication channel. In the second stage studies are implemented employing the experimental real communication channel. Bit error rate (BER) performances are obtained at the output of error correcting decoder for both the simulated communication channel and the experimental real communication channel. In this section, simulation results are compare different CMA algorithm. The proposed vss-cma method is compared with Zhao's VSS-CMA [5] and fixed step size conventional CMA for blind equalization. The simulation studies are performed via 1000 Monte Carlo type iterations using the QPSK modulation. In this paper, a three taps channel profile with average coefficient amplitudes given by (0.407, 0.815, 0.407), which is defined by Proakis and corresponds to an RMS delay spread of approximately 42 ns, is used

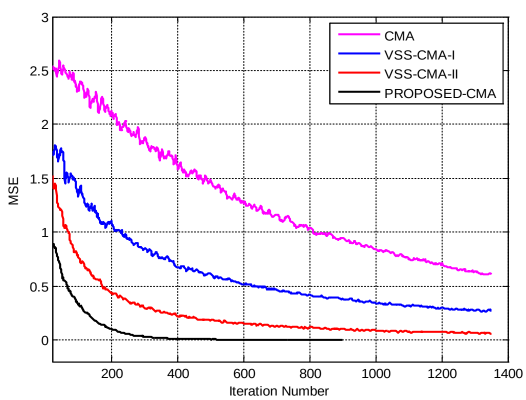


Fig.1. Comparison of the MSE convergence performances of the blind adaptive channel equalizers for a stationary environment.

Figure 1 shows that proposed VSS-CMA algorithm has faster convergence speed and lower MSE floor than the conventional CMA. However, the proposed technique outperforms the performance of all blind equalization algorithms and converges to the lowest steady state MSE floor.

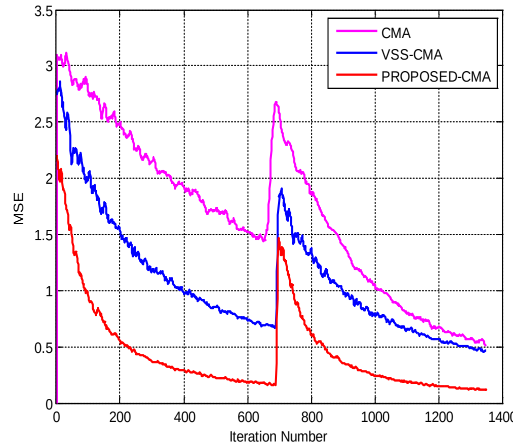


Fig.2. Comparison of the MSE convergence performances of the blind adaptive channel equalizers for a non-stationary environment.

Figure 2 shows that proposed VSS-CMA algorithm has faster convergence and tracking speed than the conventional CMA in both regions. However, the proposed technique outperforms the performance of the two blind equalization algorithms and converges to the lowest steady state MSE floor in both regions.

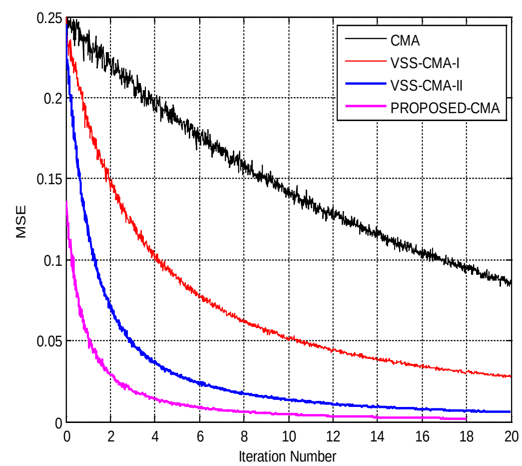


Fig. 3. Comparison of the BER performances of the blind adaptive channel equalizers.

The BER performance of the proposed VSS-CMA algorithm outperforms the performance of the two blind equalizers, the conventional CMA and the VSS-CMA . The proposed method improves the performance of the conventional CMA algorithm significantly. The controlled training by the proposed technique has become faster, very accurate and more stable.

## VII. CONCLUSION

In this paper, proposed VSS-CMA has slow convergence and minimizes the error state. The performance of proposed VSS-CMA method is less complexity. Thus, the simple CMA has become with a high performance blind adaptive channel equalizer technique. The results of this study show that the proposed VSS-CMA is suitable for high speed blind trainings and offers a very low complexity alternative for high performance applications.

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