The Proposal of New MMA Algorithm

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Abstract - In this paper, new Multi-Modulus blind Equalizer Algorithms for QAM signal set is propsed and analyzed and its performance is evaluated. The MMA algorithm combines the benifits of RCA and CMA. A new Dual-mode blind Algorithms for QAM signal set is derived. The concept of this algorithms is based on the Dual-Mode algorithm and the MMA algorithm.

In order to analyze and evaluate the performance of new MMA algorithms, computer simulation are performed for the nonsquare QAM signal constellations. Form the simulation results, we can verify that new MMA algorithms converges very fast comparing to conventional MMA algorithm.

I. INTRODUCTION

Blind Equalizers of self-recovering equalizers have recently received a great deal of attention. Several papers have appeared in the paper [1][2][3][4].

The major advantage of MMA, however, is that it is much more flexible than both RCA and CMA, and can easily be adapted to systems using nonsquare and very dense signal constellations , for which RCA and CMA are not very effective.

In this paper, RCA and CMA, MMA is discussed first and then new MMA is analyzed. To evaluate the performance of new MMA, some experimental lab results are presented under the multi-path fading channel environment.

The main idea of this method is that the transitions between the two modes are automatically done by evaluating an error function determined by the radius defined as [5] of the equalizer output. If the equalizer output has a relatively large error level, the equalizer considers itself far from optimum and thus adapts the MMA to adjust its tap weights. However, if the error level of the equalizer output comes within a predetermined range, the equalizer considers itself close to optimum and thus updates its tap weights. Even though the Dual-Mode algorithm [6] switches in two modes, this algorithm's problem still remains.

II. Description of RCA, CMA, and MMA

Fig. 1 shows Phase splitting Equalizer's structure. It consists of a parallel arrangement of two adaptive digital filters, which take their inputs directly from the A/D at the sampling rate are implemented as finite impulse response(FIR) filters.

All the blind equalization algorithms used in practice minimize a cost function, which depends on the equalizer and some statistics of the symbols. The LMS, RCA,CMA, and MMA cost functions for the equalizer structure shown in Fig. 2 are given by the following expressions:

$$CF_{LMS} = E[\,|Y_n - \hat{A}_n|^2]$$

$$\hat{h}_n = \hat{a}_n + j\,\hat{b}_n \tag{1}$$

$$CF_{RCA} = E[\,|y_n - R(sgn\, y_n + j\ sgn\ \tilde{y}_n)|^2]$$

$$R = \frac{E[a_n^2]}{E[|a_n|]} \tag{2}$$

$$CF_{CMA} = E[\,(|Y_n|^L - R^L)^2]$$

$$R = \frac{E[|A_n|^{2L}]}{E[|A_n|^L]} \tag{3}$$

$$CF_{MMA} = E[\,(y_n{}^L - R^L)^2 + (\tilde{y}_n{}^L - R^L)^2]$$

$$R = \frac{E[|a_n|^{2L}]}{E[|a_n|^L]} \tag{4}$$

where E[ ] means expectation and L is an integer. The LMS and RCA cost function in (1) and [2] use second order statistics of the equalizer's output samples. For most application it is preferable to use L=2,.

The tap updating algorithms for MMA algorithms as follows[5].

$$\boldsymbol{c}_{n+1} = c_n - \alpha(y_n^2 - R^2)y_n \boldsymbol{r}_n \tag{5}$$

$$d_{n+1} = d_n - \alpha(y_n^2 - R^2)\widetilde{y_n} r_n \quad (6)$$

$$R^2 = \frac{(12m^2-7)}{5} \quad (7)$$

where we have assumed $L=2$ in Eq. (4). The expression in (7) for the modulus R can be used for square constellations which use symbols a_n and b_n with values $\pm1, \pm3, \pm5, \cdots, \pm(2m-1)$.

MMA is much less prone to create diagonal solutions than RCA and, unlike CMA, it does not generate rotated signal constellations. In addition, it has much more flexibility to accommodate nonsquare and very dense signal constellations. Figure 3 shows the moduli used by MMA for a 32-point signal constellation, The dotted line are used for the in-phase dimension, the solid lines for the quadrature dimension.

This figures applies to the quadrature dimension for 32QAM and shows that the tap updating algorithm for the imaginary coefficients. d_n uses R_1 if $|y_n|<k$ and $|y_n|>k$. For the 32-point constellation we have $R_1=4.49$, $R_2=2.86$, and $k=4$.

With MMA we can take advantage of this knowledge and used two different moduli along each dimension. There is no straightforward way of doing the same with RCA and CMA.

Another generalization of MMA is for very dense constellations having 256 or more points. In this case more than two piecewise linear contours can be used for each dimension. This topic will be referenced in more detail in future publications.

III. Description of Dual-Mode MMA

Fig. 1 shows Phase splitting Equalizer's structure. It consists of a parallel arrangement of two adaptive digital filters, which take their inputs directly from the A/D at the sampling rate are implemented as finite impulse response(FIR) filters.

The tap updating algorithms for MMA algorithms as follows[5].

$$c_{n+1} = c_n - \alpha(y_n^2 - R^2) y_n r_n \quad (8)$$

$$d_{n+1} = d_n - \alpha(y_n^2 - R^2)\widetilde{y_n} r_n \quad (9)$$

$$R^2 = \frac{(12m^2-7)}{5} \quad (10)$$

The expression in (10) for the modulus R can be used for square constellations which use symbols a_n and b_n with values $\pm1, \pm3, \pm5, \cdots, \pm(2m-1)$.

DMMMA(Dual Mode Multi Modulus Algorithm) which is proposed in this paper can be expressed as

$$\begin{aligned} c_{n+1} &= c_n - \alpha(y_n^2 - R_K^2) y_n r_n \\ d_{n+1} &= d_n - \alpha(y_n^2 - R_K^2)\widetilde{y_n} r_n \\ y_n &\in D_k, \quad k=1,2,3,\cdots \end{aligned} \quad (11)$$

$$\begin{aligned} c_{n+1} &= c_n - \alpha(y_n^2 - R^2) y_n r_n \\ d_{n+1} &= d_n - \alpha(y_n^2 - R^2)\widetilde{y_n} r_n \\ y_n &\notin \bigcup D_k, \quad k=1,2,3,\cdots \end{aligned} \quad (12)$$

$$R^2 = \frac{(12m^2-7)}{5} \quad (13)$$

where, α denotes the step size, $\bigcup D_k$ denotes the union of the regions D_k, $k=1,2,3,\cdots$ D_k contains the QAM signal points which possess a common amplitude R_k

IV. Simulation Result

We present the simulation results for the MMA and Dual_mode MMA algorithms. A rectangular 32-QAM random symbol signal Equalizers are usually realized in the form of a transversal filter with variable tap gains and tap spacing equal to the symbol spacing T. A 223-tap equalizer is assumed with an initial tap weight setting of (1.0,0.0) for the center tap and (0.0,0.0) for all other taps. For pulse shaping, raised-cosine filter with roll-off factor of 0.5 is used. Signal to Noise Ratio(SNR) is set to 100dB. The adaptation step size α for the algorithm was chosen so as to minimize convergence time with a reasonable residual error. In the simulation, α is used, 2.5×10^{-7} and for MMA and Multi-Mode MMA.

In order to compare the performance of the different algorithms, we compute the ensemble pseudo MSE denoted, MSE(n) defined follows,

$$MSE(n) = \frac{1}{m}\sum_{k=1}^{m}(z_{n(k)} - \hat{a}_n(k))^2 \qquad (14)$$

where m is the number of iteration symbol, In simulation, m is used 1000.

A multi-path channel can be represented as a TDL (Tapped Delayed Line) with time-varying coefficients and T fixed tap spacings. The output signal can be written

$$y(t) = \sum_n \alpha_n(t) \cdot S(t - \tau_n(t)) \qquad (15)$$

S(t) is the bandpass input signal, $\alpha_n(t)$ is the attenuation factor for the signal received on the n-th path, and $\tau_n(t)$ is the corresponding propagation delay. If we express S(t) as

$$S(t) = Re\ \{\tilde{S}(t) \cdot e^{j2\pi f_c t}\} \qquad (16)$$

where, $\tilde{S}(t)$ is complex envelope then we can express the channel output as

$$y(t) = Re\ [(\sum_n \alpha_n(t) \cdot e^{-j2\pi f_c t} \cdot \tilde{S}(t - \tau_n(t))) \cdot e^{j2\pi f_c t}] \qquad (17)$$

and it is clear that the complex envelope of the output is

$$\begin{aligned}\tilde{y}(t) &= \sum_n \alpha_n(t) \cdot e^{-j2\pi f_c \tau_n(t)} \cdot \tilde{S}(t - \tau_n(t)) \\ &= \sum_n \alpha_n(t) \cdot e^{-j2\varphi_n} \cdot \tilde{S}(t - \tau_n(t))\end{aligned} \qquad (18)$$

where $\tilde{\alpha}_n(t)$ is the complex envelope of $\alpha_n(t)$, $\tau_n(t)$ is the complex envelope of $\tau_n(t)$, and φ_n is the variation in phase. In the simulation. the number of multi-path components excluding the main path is 3. In simulation program, sampling frequency is set to 172.16Mhz. The characteristics of Multi -path channels shown in Table 1, which is the Multi-path characteristic used in [8].

Fig. 3 shows the MSE curves for the MMA and Dual-Mode MMA blind equalization algorithms. From the simulation result shown in Fig. 3, we can confirm that the convergency characteristic of Dual Mode MMA is better than that of MMA.

Table 1. The characteristics of Multi-path channel

Delay	Attenation Factor	Phase
-1.153 μs	0.1	-24.7 °
2.203 μs	0.3	151.2 °
5.046 μs	0.2	-63.8 °

V. Conclusion

In this paper, we have analyzed a Dual-Mode MMA blind algorithms for QAM modulation scheme and evaluated its performance. From the simulation results, we can verify that Dual-Mode MMA algorithms converge very well. In this paper , multi-path fading channel is modeled and used. Dual-mode MMA algorithms shows almost same convergency characteristics comparing to conventional MMA blind algorithms.

Therefore, these algorithms is expected to operate well in practical blind equalizer. From the result of the analysis of MMA, it should be performed to study about the method of increasing the convergency rate of MMA.

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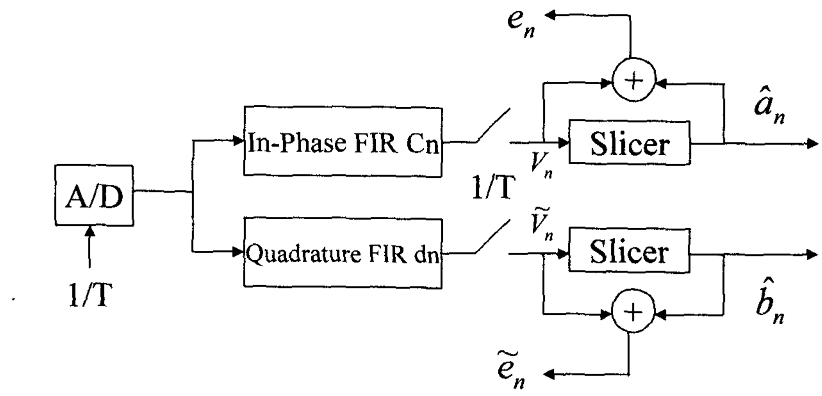

Figure 1. A Structure of a phase spliting equalizer

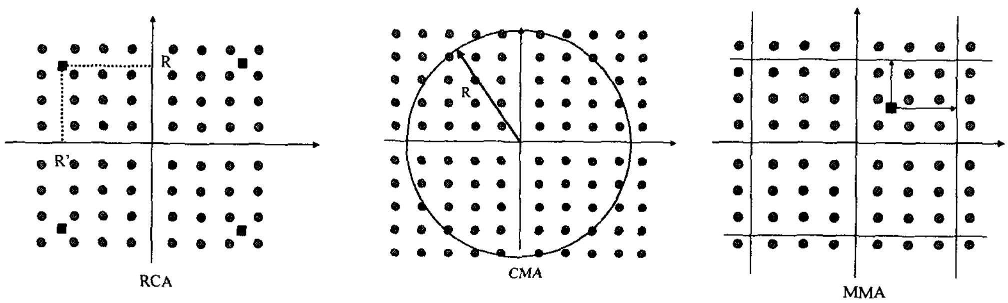

Figure 2. Conceptual Diagram of RCA,CMA, AND MMA

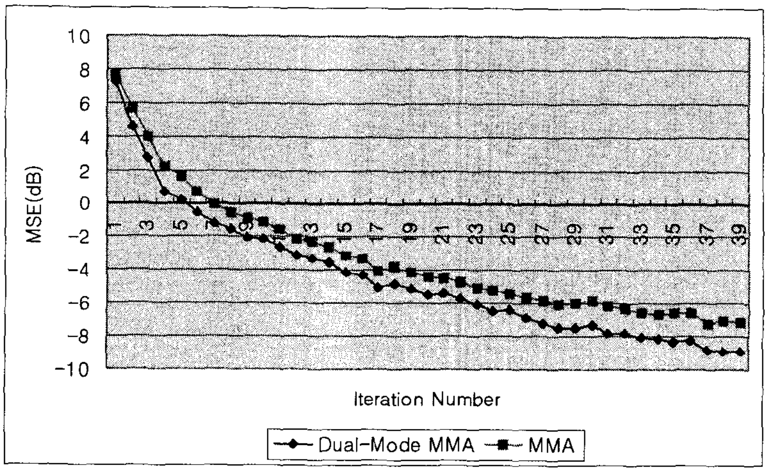

Figure 3. MSE Charcteristic