Comparison of Beam forming algorithms for better Convergence

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***Abstract* - This paper focuses on comparison of a new technique FOUR WAY LMS with Variable step size Normalised least mean square (VSSNLMS) and Normalised least mean square(NLMS) with respect to mean square error for various cases by varying the number of interference users and number of antenna elements. VSSNLMS focuses on varying the step size to avoid a trade-off issue between convergence rate and steady-state Mean Square Error (MSE). Better convergence can be achieved by four way lms algorithm. We here focus on comparison of VSSNLMS (previous approach), NLMS and LMS with FOUR WAY LMS and prove it provides better convergence.**

***Index Terms* - Radiation pattern, convergence, Mean square error**

I. INTRODUCTION

Smart antenna is used to reduce interference. It evaluates signal conditions continuously of each signal that is transmitted or received .In the earlier antenna radiation was directed based on frequency or time. Therefore spectrum was not utilized efficiently because as the number of users increases the quality of service decreases. Hence in this work a solution to use the same amount of spectrum and provide service to large amount of mobile users is deduced. This is done by separating the users with respect to direction[7] . Currently, the use of smart antennas in mobile communication to increase the capacity of communication channels has reignited research and development in this very exciting field. One such innovation is Smart Antenna (SA) and the type of multiple accesses it works on is Space Division Multiple Access (SDMA)[5].
Mean Square error(MSE) is a parameter which is important in beam forming algorithms which depicts the rate of convergence. It is calculated by measuring the average of squares of errors

II. BACKGROUND AND MOTIVATION

To increase the system capacity the driving force behind the use of adaptive Smart antenna signal processing, Transceiver design, array design etc[3]. An adaptive antenna array or a smart antenna is also named as 'software antenna' because it can form a desired antenna pattern and adaptively control it, if an appropriate set of antenna weights is provided and updated in software. The radiation pattern can be adjusted to place nulls in the paths of interferers as shown in figure 1.

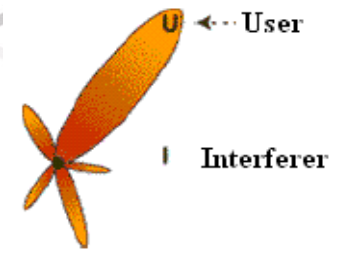

Fig.1 Designing the beam in the required direction and simultaneously nullifying interference.

As the number of mobile users are increasing day by day it is necessary to serve such a huge market of mobile users with high QOS even though the spectrum is limited[2]. This works on Smart Antenna which ensures high capacity providing with the same Quality of Service(QOS).

III. ADAPTIVE BEAMFORMING ALGORITHMS

A . *Normalised least mean square(NLMS)*

It is one of the beam forming technique [6] using a fixed step size. The functionality of Normalized Least Mean Square (NLMS) adaptive algorithm is presented in Fig below Where $x(k)$ is the input signal, whereas $y(k)$ is the output signal obtained that is subtracted from the desired signal $d(k)$ to calculate the error signal $e(k)$. $x(k)$ and $e(k)$ are both combined in the NLMS algorithm which are used to controls the adaptive beamformer behaviour to reduce the mean square error (MSE).

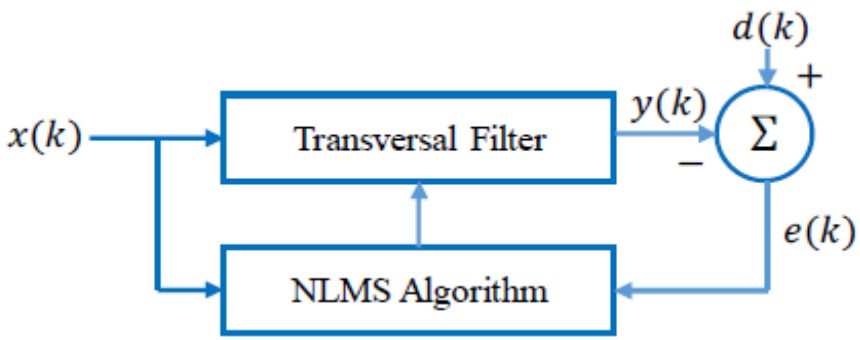

Fig.2 NLMS Algorithm

The weight for the NLMS algorithm is given by

$$w(n+1) = w(n) + \frac{\mu e(n) x(n)}{\sigma + \|x(n)\|^2} \quad (1)$$

$\mu = step\ size$

$e(n) = error\ signal$

$x(n) = recieved\ signal$

$\sigma = sigma$

$w(n) = weight$

The step size is given by

$$\mu = \frac{2}{3tr(R_{xx})} \quad (2)$$

Where R_{xx} is the auto correlation matrix.

IV. Variable step size Normalised least mean square (VSSNLMS)

[1]It is one of the beamforming techniques where the step size is varied instead of using a fixed step size.Usage of variable step size improves the convergence rate and avoids a trade off issue[1].The variable step size is given by

$$\mu(n) = \{((\frac{6}{N})^2 (k - (\frac{N}{6}))^2) + 0.001 \quad 1 \le k \le \frac{N}{6}$$

$$0.0001 \qquad \frac{N}{6} \le k \le N \quad (3)$$

$N = number of\ iterations$

Using the Variable step size the array weights are calculated as

$$w(n+1) = w(n) + \frac{\mu(n) e(n) x(n)}{\sigma + \|x(n)\|^2} \quad (4)$$

e(n) is the error signal obtained by s(n)-y(n)

x(n) is the received signal, w(k+1) is the the updated array weight and w(k) is the previous array weight .

V. FOUR WAY LMS(Novel LMS)

LMS algorithm [3] has low computation complexity hence its convergence rate is slow. In this section, a novel implementation scheme for LMS algorithm is simulated to form a modified LMS algorithm. The scheme is similar to the structure of FOUR WAY LMS decoder, which consists of one feedback module called as convergence-speediness module, two LMS algorithm modules, and one speediness module which connects two LMS algorithm modules. Meanwhile, two LMS algorithm modules can be implemented parallel, as well as the speediness module and converge-speediness module.

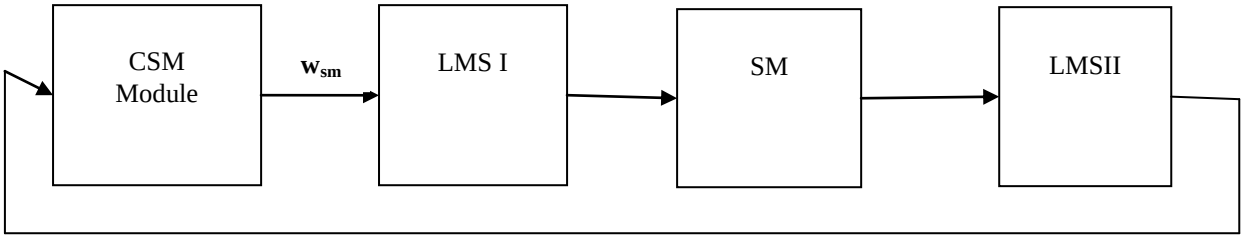

Fig.3 FOUR WAY LMS

The convergence speedy module uses equation (5) in order to calculate the array weights

$$w_{csm}(n+1) = w_{csm}(n) + ([I - 2\mu_{csm} R_x]^{-1}[v_k - 2\mu P_k]) \quad (5)$$

$w_{csm}(n+1)$ are theLx1 updated array weights , I is LxL identity matrix, μ is the step size as in (4), R_x is the LxL autocorrelation matrix of induced signal x(n) , v_k are Lx1 array weights obtained from LMSII module initially this value is zero and P_k is the cross-correlation .

$$\mu_{csm} = \frac{1}{3tr(R_x)} \quad (6)$$

The speedy module uses equation (7) in order to calculate the array weights

$$w_{sm} = \psi(\psi(w_k)) - \frac{power\{\psi(\psi(w_k)) - \psi(w_k)\}}{\psi(\psi(w_k)) - 2\psi(w_k) + w_k} \quad (7)$$

and $\psi(w_k) = M_K w_K + N_K$ (8)

Where $M_K = I - 2\mu R_K$ and $N_K = 2\mu P_k$ Where R_K is correlation matrix and P_k is cross correlation matrix

VI. SIMULATION RESULTS

Comparison of FOUR WAY LMS, VSSNLMS and NLMS for Mean square error for different cases .

Less Antenna Elements and Single Jammer

Number of Antenna Elements = 8, Jammer Direction = 10

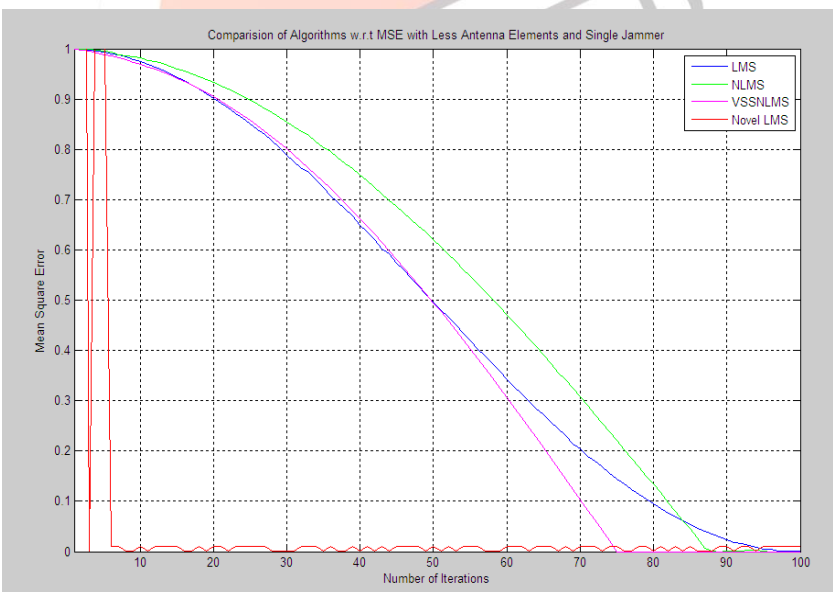

Fig 3: Comparison for Less Antenna Single Jammer

In the figure it can be observed for 8 antenna elements with a single jammer four way LMS provides faster convergence

More Antenna Elements and Single Jammer

Number of Antenna Elements = 100, Jammer Direction = 10

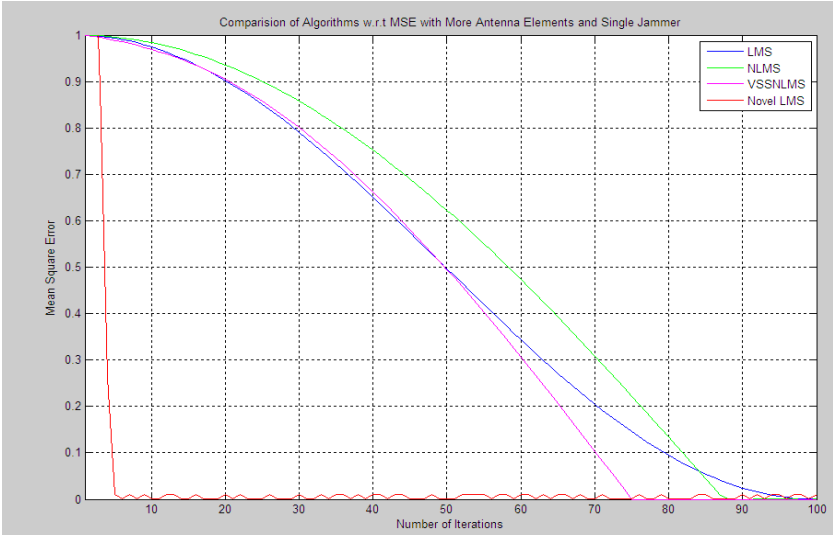

Fig 4: Comparison for More Antenna Single Jammer

In the figure it can be observed for 100 antenna elements and one Jammer also FOUR WAY LMS provides the best output

Less Antenna Elements and Multiple Jammers

Number of Antenna Elements = 8, Jammer Direction = [10 20]

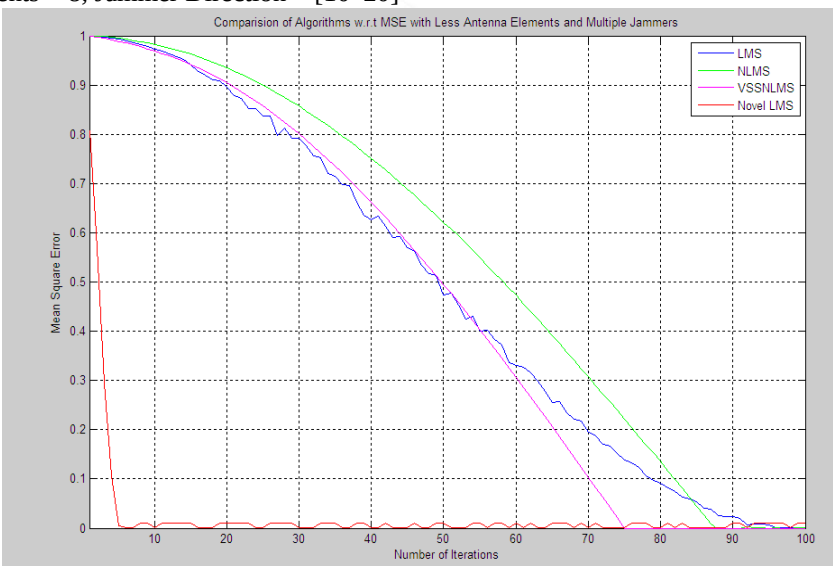

Fig 5: Comparison for Less Antenna Elements & Multiple Jammers

In the figure it can be observed for 8 antenna elements with a two jammers, four way LMS provides faster convergence

More Antenna Elements and Multiple Jammers

Number of Antenna Elements = 100, Jammer Direction = [10 20]

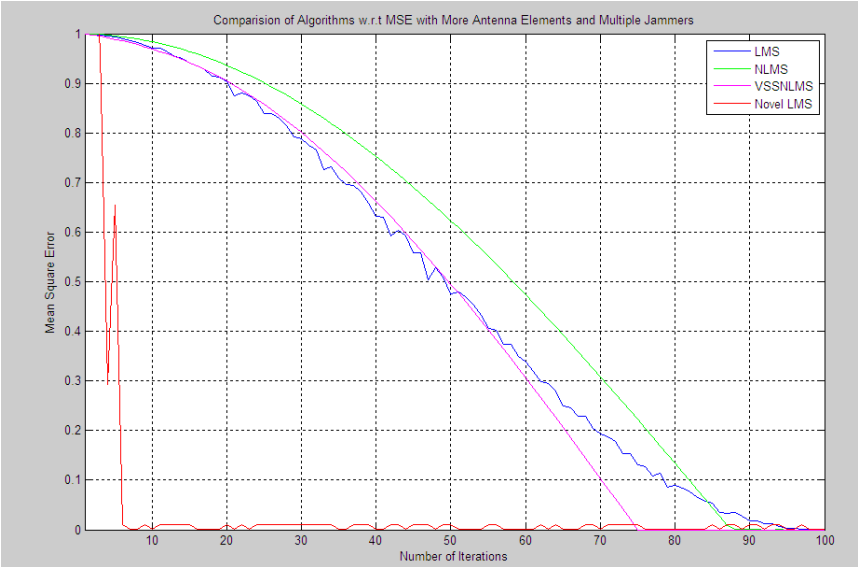

Fig 6: Comparison for More Antenna Elements & Multiple Jammers

In the figure it can be observed for 100 antenna elements and one Jammer also FOUR WAY LMS provides the best output..
The input parameters considered are number of antenna elements N=8 (for less) and 100 (for more). Inter element spacing d=0.5.. The graph is plotted for 100 iterations, accordingly the convergence response is shown.Simulation is done using MATLAB software**.**

VII. ACKNOWLEDGMENT

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VIII. BIBLIOGRAPHY

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IX. CONCLUSION

The paper presented and analysed the use of a new FOUR WAY LMS in the design of adaptive beamforming smart antenna system for interference suppression. The used FOUR WAY LMS algorithm enhances the performance of the smart antenna by reducing the mean square error(MSE) which results in faster convergence rate when compared to VSSNLMS and NLMS.In general the processing time of FOUR WAY LMS is less compared to VSSNLMS and NLMS even when the number of antenna elements are more.

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