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VEHICULAR SAFETY IN HOSTILE ENVIRONMENT FOR INTELLIGENT TRANSPORT SYSTEM

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ABSTRACT

An approach to predict real-time & Matlab Simulation Technique for realisation of speed, classification, ranging of different moving and static target in hostile environment using MIMO Radar.LMS & NLMS Algorithms, TCF are used for unwanted noise & clutter elimination technique using Matlab Programming. In this context authors are try to make an automated system that adjust target's dynamic characteristics on the fly to better match its changing environment of the entire radar channel and profile. A new test method of sufficient flexibility is developed to describe most pulse Doppler radar search systems which can be used to predict the classification of the target. The object of this section is to predict the detection capability of a pulse Doppler radar where the Doppler filter bandwidth is much wider than the bandwidth of each spectral line in the received signal.

Keywords:- *TCF(Time correlation Function), SISO(Single Input Single Output), LMS, NLMS MIMO(Multiple Input Multiple Output)*

1. INTRODUCTION

With the tremendous growth of FPGA,VLSI,SDR,vehicles are now commercially available with multiple collision avoidance radars with Short range (SRR) and Long range (LRR).Pulse-Doppler Radars [1] typically process bursts of pulses to provide range and Doppler information of the environment. Range information is provided by range-gating of the pulse returns whilst Doppler information is provided by coherent integration of samples from the same range gate from different pulses. To evaluate and warrant the adequate performance of a Doppler radar system, it is important to know the noise and clutter level in the RF signal of radar transmitter. For the inter-vehicle communications, the unused millimeter wave frequencies are much expected by the reasons of the effective practical use of frequencies at high-speed and for a large volume of communications. The range equation of the radar gives the maximum range at which a multi target may be detected with probability. So far the probability of detection calculations based on non fluctuating target was first analyzed by Marcum & Swerling extended Marcum's work to four distinct cases known as Swerling I, Swerling II, Swerling III, Swerling IV. The constant RCS case analyzed by Marcum is widely known as Swerling 0 or equivently Swerling V. The target fluctuation lowers the probability of detection or equivently reduces the SNR. It includes the radar cross section (RCS) of the different target which is nothing but a measure of the proportion of the incident energy scattered back to the radar. Radar cross-section of complex target like vehicles, trees, human beings, buildings are rather

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complicated. compressed pulsed radar mounted on a car or ship or aircraft and it is in motion ,the detection of a moving target in different range in presence of clutter and noise becomes more difficult than when it is stationary, clutter make difficult to detect the desired tergets.The clutter include the reflection from land ,sea,rain,birds,insects,and chaff ,but reflection due to storm clouds are wanted by the radar observer to investigate the rainfall rate over a large area. This information is sent to another car, aircraft and ships to help the transportation & navigation. MIMO based cognitive Doppler radar that can measure experimentally velocity, RCS and ranging of different moving object in hostile environment. Unwanted Clutter and noise can be eliminated by proper adaptive filters and match filter that iteratively alter their parameters in order to minimize the difference between a desired target and clutter and noise. Using various algorithms of adaptive filtering, match filtering technique target‘s dynamic characteristics can be predict .Multi channel clutter ,noise rejection is a key problems for several decades for the Technologist and radar Engineers. Recently digital radar and wireless communication systems plays a major role for more efficient transportation environment. This dissertation focuses on three major R& D efforts towards the development of high data, secure broadband communication system, development of digital radar system and their system integration for ITS and other applications. These models may be used to simulate radar clutter for the purpose of analyzing radar performance under a wide range of environmental conditions. In conjunction with simulation of the receive chain of a radar the performances of various receiver designs can be objectively compared. Pulsed radars use a train of modulated pulsed waveforms. Pulse Repetition Frequency (PRF) can be classified as low PRF and high PRF radars where the low PRF radars are primarily used for ranging purposes and high PRF radars mainly measure target velocity. pulsed radars can measure both target range and radial velocity by utilizing different modulation schemes. But in dynamic condition when the environment changes non linearly the conventional radar system performance degraded. The existence of clutter in open range radar system deteriorates the RCS estimation of the targets. For that reason, radars should incorporate efficient clutter reduction techniques [2]. In order to enhance the radar system performance in terms of clutter, multipath rejection, noise rejection, target detection and high quality imaging etc, some sort of adaptive, cognitive approach needed. This model allows the target to be steady or to scintillate slowly with a Rayleigh amplitude distribution where the target cross section remains constant during the time on target but may vary randomly from scan to scan. Inspired by the success of MIMO systems in communications [2-4], several publications have advocated the concept of MIMO radar [5][6] from the system implementation point of view [7], as well as for processing techniques for target detection and parameter estimation[8].Target parameters of interest in radar systems include target strength, location, range and size Doppler characteristics. Efforts are also put to extend the above Pulse Doppler radar towards MIMO radar. MIMO radar [5][9]-[12] systems employ multiple antennas to transmit multiple waveforms and engage in joint processing of the received echoes from the multiple moving target. Like MIMO communications, MIMO radar offers a new paradigm for signal processing research. Elements of MIMO radar transmit independent waveforms result in an omnidirectional beam pattern or create diverse beam patterns by controlling correlations among transmitted waveforms. MIMO radar may be configured with its antennas co-located or widely distributed over an area and able to provide independent diversity paths. MIMO radar possesses significant potentials for fading mitigation, resolution enhancement, interference and jamming suppression. Fully exploiting these potentials can result in significant improvement in target detection, parameter estimation, target tracking and recognition performance.

2. SYSTEM BLOCK DIAGRAM

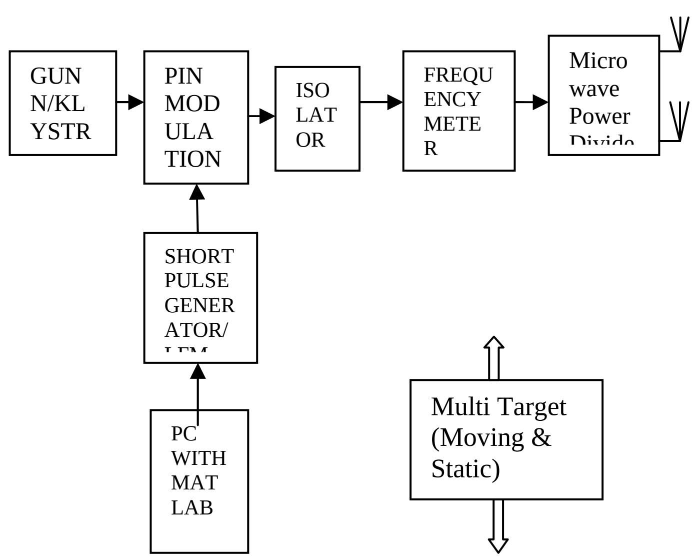

Fig.1:Block diagram of MIMO Transmitter.

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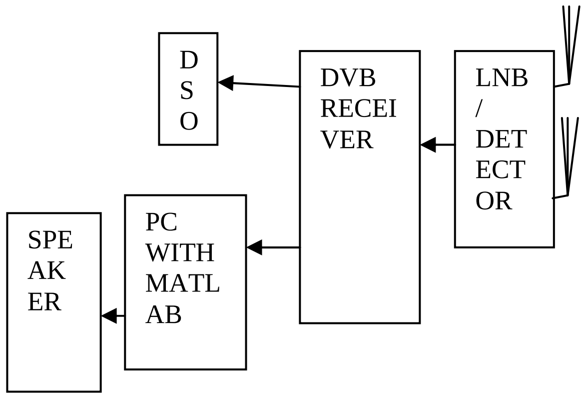

Fig-2: Block Diagram Of Mimo Receiver.

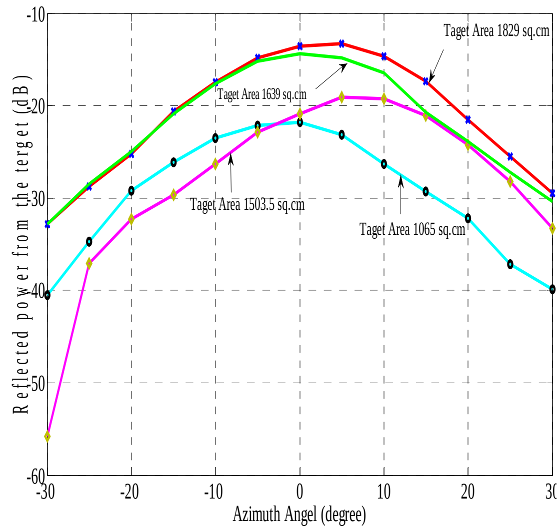

Fig.3. Variation of Azimuth angle with reflected power from target using SISO system

3. DESCRIPTION OF TRANSMITTER AND RECEIVER:

A short uncompressed pulse width of 10 microseconds is generated through MATLAB of version 2009b simulation technique. This uncompressed pulse is connected through line out port of the portable laptop to PIN modulator of the RF transmitter. It is then up converted to (9.4-10.4) GHz(X-Band) modulated by X band carrier signal which is from Gunn oscillator supplied with 10-Volt DC voltage. Two horn antennas are connected at the transmitter side using same type of source. Generated modulated waveform propagate to the noisy environment channel and incident on different multiple targets reflect back towards the radar receiver, the reflected echo with noise & clutter being intercepted by the RF system. The signal is received through two horn antenna which better than single antenna. This signal is fed to the DVB of the DTH received signal and fitted with laptop or DSO for interfacing to analyze the reflected signal. At the receiver end MATLAB simulation is being processed through different algorithms, or passed through different matched filter we are able to predict the nature, type, velocity, ranging all the information can predicted in laboratory scale. A schematic of the radar system is shown in

4. EXPERIMENTAL DATA ANALYSIS

After rigorous experimentation on the following system model, the data are analyzed to bring forth strong conclusions. Pulse Doppler radars typically process bursts of pulses to provide range and Doppler information of the environment. The authors have used aluminum sheets of different area as a target (vehicle), small table fans (for moving vehicle) for implementing hardware reconfigurable pulse radar system which operates in the X-band frequency range. The authors have designed a suitable look-up table comparing different target's reflected power versus different target area (RCS) which has been plotted at different azimuthal angle for both stationary and moving targets. Vehicle classification can be easily done from the values obtained in the table. The experiment has been successfully implemented using various antenna configurations. In this measurement procedure the distance of transmitter target and receiver target is set at 53.5 cm and 77.5 cm for SISO system which is shown as Table-1and Fig.3. The distance between transmitter and receiver can be enhanced up to 100 meters to detect the target using LNB of the satellite whose input frequency range is 10.70-12.75GHz,and local oscillator range 9.75-10.6 GHz and tolerable noise label is 0.5dB

4. DETERMINATION OF TARGET USING MATLAB CODE

To predict the dynamic & Static Characteristics of Moving & static object author have taken LFM signal of short pulse width (10^{-6} sec.) 50 MHz Radar

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Band Width for very long & short distance communication shown in Fig.4-Fig 5 .From reflected compressed echo signal multi target can be identified and ranging with proper RCS values. The net energy concentration of the incident radiation from the targets will be towards their focus as they are parabolic in nature. Accordingly the measured received beam patterns are tabulated in the TABLE-1 for SISO Radar .A calibration curve is shown in Fig.7 which results in a straight line curve will be very much useful in quantifying the target classification and also used in finding RCS of any unknown targets.

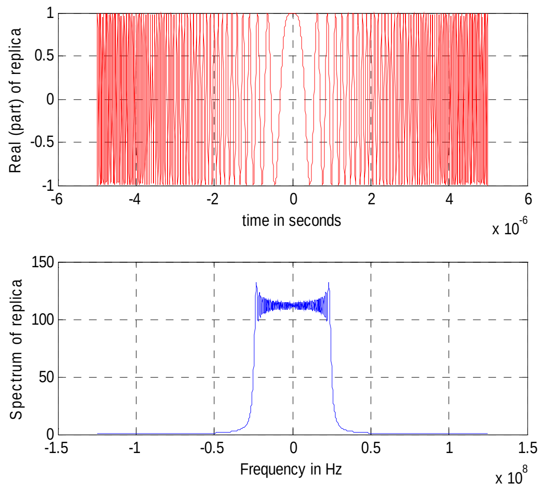

Fig:4

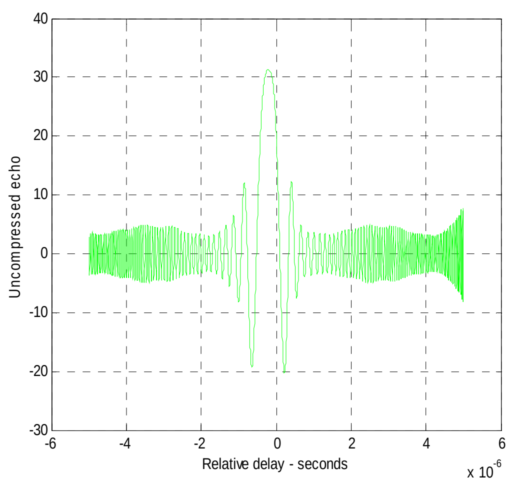

Fig:5

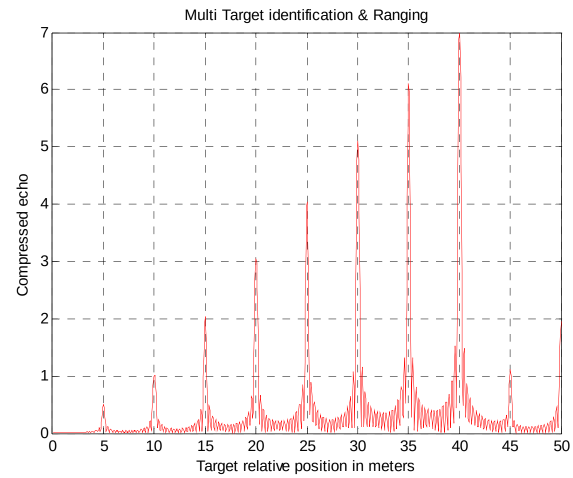

Fig:6

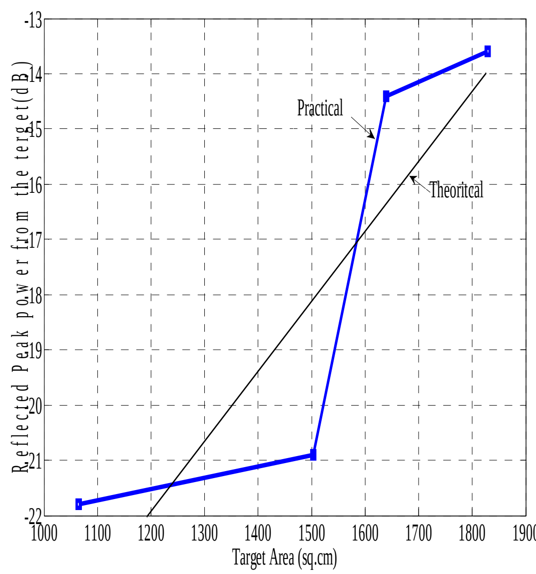

Fig:7 Determination of unknown Target using SISO based pulse Doppler radar

After achieving success in the field of SISO based pulse radar, the author has delved into the MIMO radar in various aspects of radar operation such as medium to high range of detection probability, exploiting RCS diversity, handling slow moving targets by exploiting Doppler estimates from Multiple directions and supporting high resolution target localization in presence of noisy environment and unwanted open field clutter also. The observations for different antenna configuration such as SISO, SIMO, MIMO and SISO Pulsed Rader using LNB of DTH, are shown in Table- 1-2 and their implemented result is shown in Fig.8-Fig.9

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Table-1 SIMO Radar

Doppler	Practical R.P.M using digital Tachometer	Theoretical R.P.M using Doppler frequency	(Practical R.P.M-Theoretical R.P.M)= Error
47.5	657	526.3	130.7
66.25	694	734.05	-40.05
86.25	880	955.65	-75.65
96.25	1031	1066.45	-35.45
112	1282	1240.96	41.04
130	1486	1440	46
150	1722	1662	60
170	1992	1883.6	108.4
187.5	2120	2077.5	42.5
192.5	2200	2132.9	67.1
210	2320	2326.8	-6.8
212	2358	2348.96	9.04
231	2412	2559.48	-147.48
230	2457	2548.4	-91.4
231.3	2520	2562.804	-42.804
230	2560	2548.4	11.6

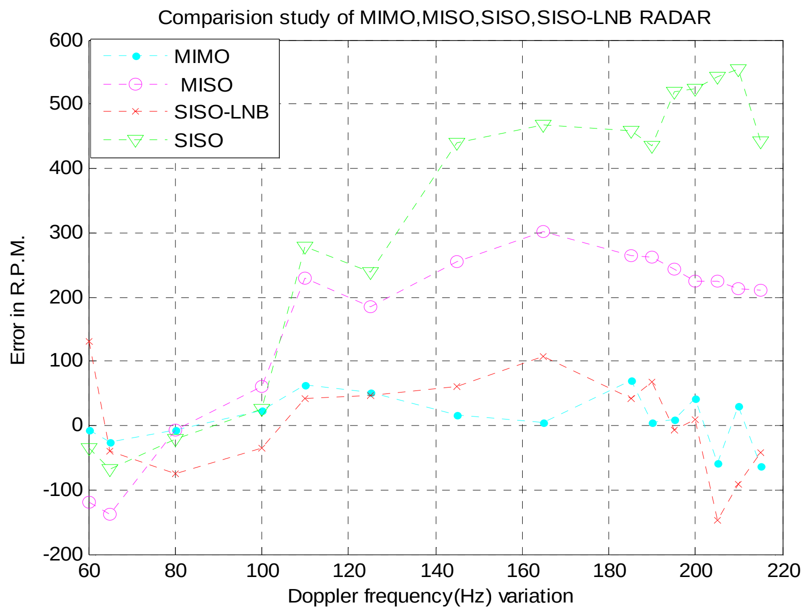

Fig. 8 . Comparison Study Of Radar Performance

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Table-2 MIMO RADAR

Doppler Freq.	Practical R.P.M using digital tachometer	Theoretical R.P.M using Doppler frequency	(Practical R.P.M-Theoretical R.P.M)=Error
60	657	664.8	-7.8
65	694	720.2	-26.2
80	880	886.4	-6.4
100	1031	1008	23
110	1282	1218.8	63.2
125	1486	1435	51
145	1722	1706.6	15.4
165	1992	1988.2	3.8
185	2120	2049.8	70.2
190	2200	2195.2	4.8
195	2320	2310.6	9.4
200	2358	2316	42
205	2412	2471.4	-59.4
210	2357	2326.8	30.2
215	2320	2382.2	-62.2

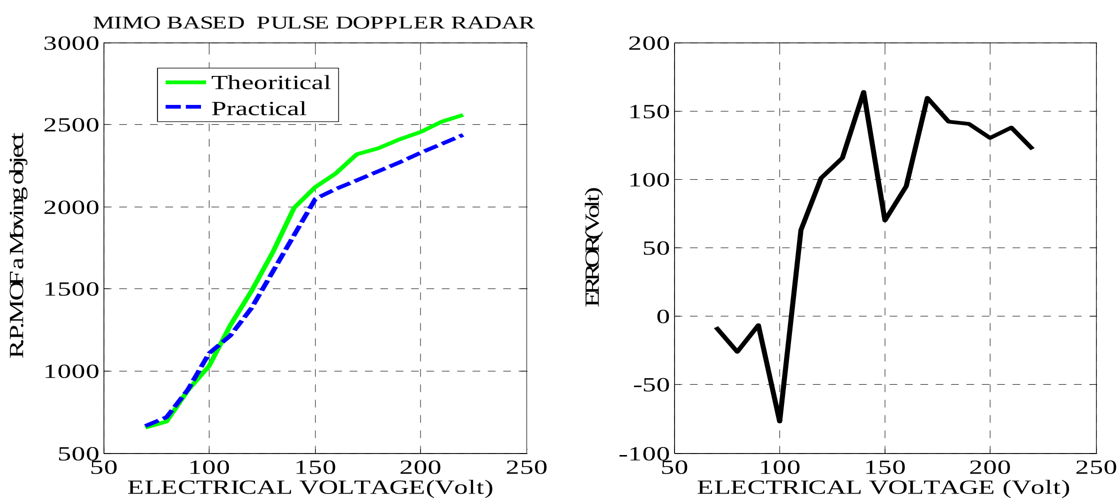

Fig.-9

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5. CLUTTER REJECTION TECHNIQUE & RANGE RESOLUTION

i)Measurement of range and range resolution

In the Laboratory, instead of vehicles, standard metal surfaces like two Flat Plates of dimension (0.68m x 0.91m) and (1m x 1m) are placed in front of the radar to measure the range between the two. The range and range resolution are tested and is shown in Fig.10.

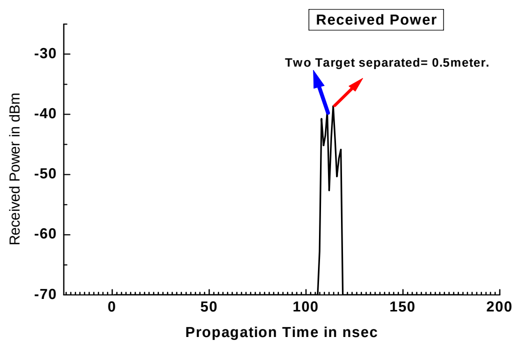

Fig.-10

ii) Clutter Rejection Through Time Correlation Function

If we observe the following plot, it is clearly visible that around the Target Zone, the unwanted peaks are vanished. This implicates that the Ground clutters are rejected significantly over the Target Zone.

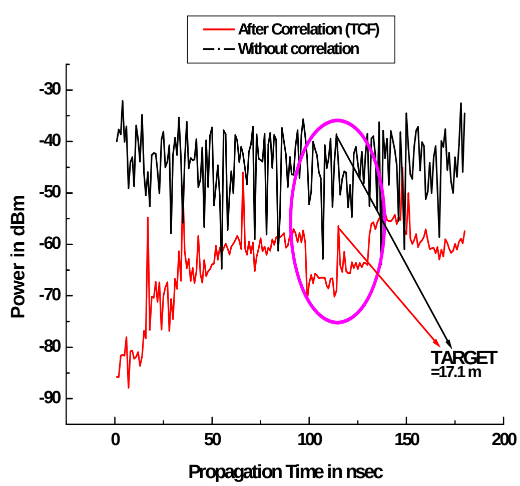

Fig.-11

6. NOISE ELIMINATION TECHNIQUE:

To maintain desired SNR for this radar system author have applied LMS & NLMS algorithms to get proper noise free reflected signal from various moving or static target .The main reason for the LMS algorithms popularity in adaptive filtering is its computational simplicity & easier to implement than all other algorithms. But for LMS algorithm all the filter coefficients must be updated for every sample value taken in. This is mainly due to the fact that the algorithm lies in time domain, leaving the algorithm at an obvious disadvantage when an impulse response is very long .Another point is that computational power required becomes too high for efficient use; as a result frequency domain adaptive filtering holds the key to the solution of the very long impulse response . Fig9(a) refers to comparison of the actual and estimated weights and Fig9(b) shows actual and estimated signal and corresponding error signal taking 16000 random noise samples for iteration using LMS Algorithm. Reflected noisy signal from target fed to the line in port to PC with MATLB-2009 & signal is processed through LMS & NLMS algorithms to gate noise free signal. Similarly varying filter coefficients and system order and reflected echo delay author have studied same parameters for NLMS Algorithms . NLMS algorithm shows for greater stability with unknown signals as the step size parameter is chosen based on the current input values. This combined with good convergence speed and relative computational simplicity make the NLMS algorithm ideal for the real time adaptive noise cancellation system. lastly Fig11 shows the reflected signal noise can be totally eliminated gradually at the end of iteration of 16000 numbers of random samples.

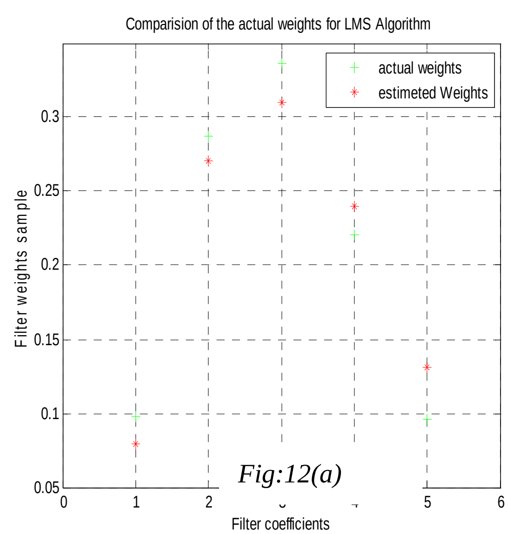

Fig:12(a)

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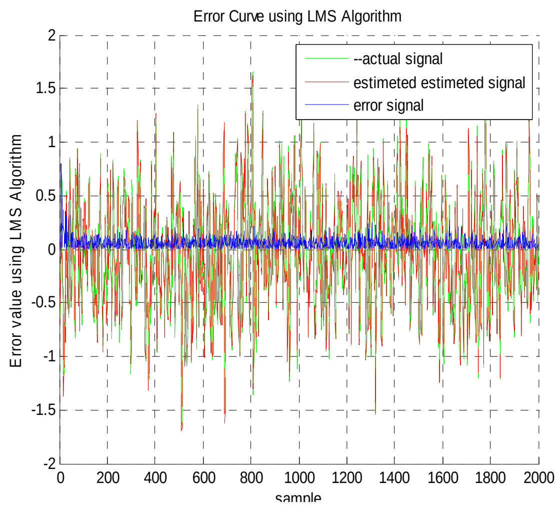

Fig:12.(b)

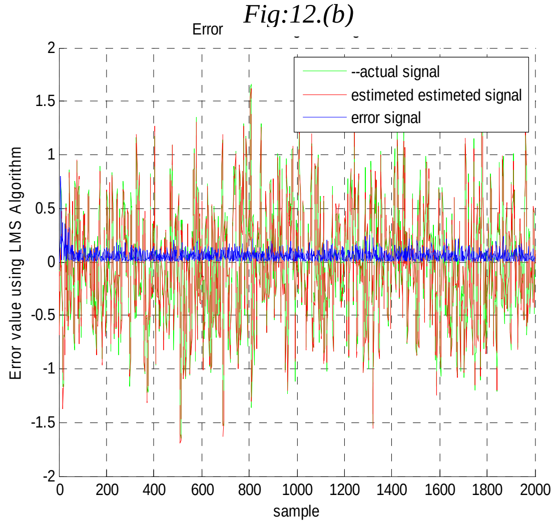

Fig:13(a)

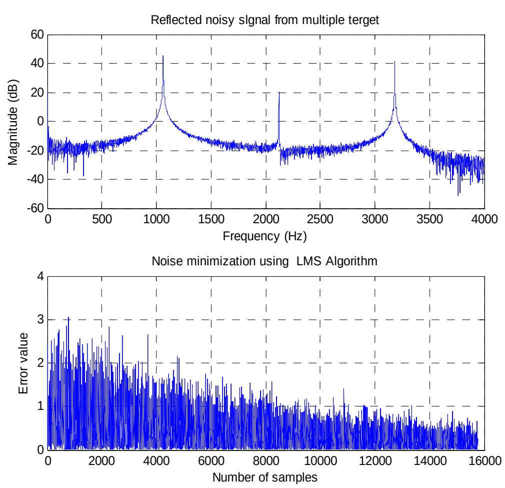

Fig:14

7. CONCLUSION

It is therefore found that the vehicles, whether stationary or moving can be classified even in presence of noisy environment & unwanted open field clutter. Among all the antenna configurations, MIMO is found to be superior because of its interference and jamming suppression property, its ability to enhance resolution, high detection probability and applicable for steady and moving targets by exploiting Doppler estimates from multiple directions.

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