INTELLIGENT CLUTTER REJECTION FOR VEHICULAR RADAR

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ABSTRACT: Externalities of road traffic include congestion, accidents, conception of scare space. One of the measures to control these externalities are by Intelligent Transportation System (ITS). Clutter is the major problem for outdoor Radar operations and there is no standard measure to reject it. Moving Target Indicator(MTI) is a proven technique which currently used in airborne Radar ,the advantage of the Doppler frequency in MTI is used in ITS and the desired results has achieved. In this paper, we focus on Spread Spectrum (SS) technology in the base-band section and MTI in the RF section of Radar operation are combined as a hybrid technique for clutter rejection.

Keywords: Clutter, MTI, Spread spectrum, Doppler, Intelligent Transportation System.

1. INTRODUCTION

Clutter is the major problem for outdoor Radar operations. Clutter refers to radio frequency (RF) echoes returned from targets which are uninteresting to the Radar operators. The nature of clutter varies with application and Radar parameters [1] because of many users and the over-crowding of the spectrum; electromagnetic interference is a common occurrence with current communication and electronic equipments. Hence, analysis performed to either avoid or eliminate such interference, which is termed as clutter. However, these analysis tend to be very difficult, costly, and time consuming. This work introduces a baseband signal processing approach that can simplify analysis of clutter problem that are encountered the solution for it. It also introduces MTI based clutter rejection method at the RF end for vehicular Radar operation. The Radar must detect target in a cooperative and electromagnetically compatible way. In order to illustrate this concept, we developed MTI and Spread spectrum system which involves exhibit clutter free Radar signal. SS signals are used widely in military and commercial communication systems due to their interference rejection capability and their lower probability of interception [2]

Usually, the clutter signal level is much higher than the receiver noise level. Thus, the Radar's ability to detect targets embedded in high clutter background depends on the Signal-to-Clutter Ratio (SCR) rather than the SNR. Since clutter returns are target-like echoes, the only way a Radar can distinguish target returns from clutter echoes is based on the target RCS σ_t, and the anticipated clutter RCS σ_c (via clutter map). Clutter RCS can be defined as the equivalent Radar cross section attributed to reflections from a clutter area(A_c)

The average clutter RCS is given by

$$\sigma_c = \sigma_0 Ac \qquad (1)$$

Where $\sigma_0(m2 / m2)$ is the clutter scattering coefficient, a dimensionless quantity that is often expressed in dB. Some Radar engineers' σ_0 express in terms of squared centimeters per square meter. In these cases, σ_0 is $40d$ higher than normal [3].

At present clutter rejection technique used are MTI and in this project we claim that technique of clutter rejection by Spread spectrum is efficient and introduce a new concept of hybrid approach based on theoretical study. The clutter is assumed to be a large number of independent scatterers that fill the cell containing the target uniformly. The clutter return from the volume is calculated as for the normal radar equation but the radar cross section is replaced by the product of the volume backscatter coefficient, η, and the clutter cell volume as derived above. The clutter return is then

$$C = \frac{P_t G_t A_r}{(4\pi)^2 R^4} \frac{\pi}{4} (R\theta)(R\phi)(cT/2)\eta_{\text{watts}} \qquad (2)$$

Where

- Pt = transmitter power (Watts)

- Gt = gain of the transmitting antenna

- Ar = effective aperture (area) of the receiving antenna

- R = distance from the radar to the target

- c = velocity of the light

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T is the time duration of the transmitted pulse then the pulse returning from a target is equivalent to a physical extent of *cT*, as is the return from any individual element of the clutter.

2. MTI FOR CLUTTER REJECTION

MTI is the existing system that is implemented for clutter rejection. MTI can detect moving targets from ground clutter, even in the bad weather by virtue of the Doppler Radar return of the moving targets. Radar can extract the Doppler frequency shift of the echo produced by a moving target by noting how much the frequency of the received signal differs from the frequency of the signal that was transmitted [4]. Clutter spectrum is concentrated around $f = 0$ and integer multiples of the RADAR PRF (Pulse Repetition Frequency) *fn*, and may exhibit a small amount of spreading as shown in Figure 1.
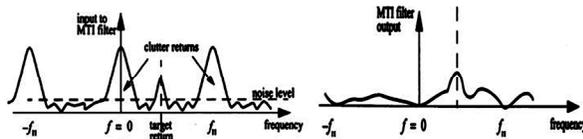

Figure 1: RADAR Return in Presence of Clutter and Target/ Figure 2: Output from an MTI Filter

MTI filter is periodic, with nulls at integer multiples of the PRF. Thus targets with Doppler frequencies equal to *n fn* are severely attenuated.

"Clutter Attenuation" (CA) and the MTI "Improvement Factor" are normally used to define the performance of MTI [5]. The MTI CA is defined as the ratio between the MTI filter input clutter power *Ci* to the output clutter power *Co*,

$$CA = Ci / Co \tag{3}$$

The MTI improvement factor is defined as the ratio of the signal to clutter (SCR) at the output to the SCR at the input,

$$I = (So/Co)/ (Si /Ci) = (So/si)\ CA \tag{4}$$

We have done MATLAB simulation of MTI by using delay line canceller for clutter mitigation and the results are shown in the Figure 5 and Figure 6.

3. SOFTWARE SIMULATION OF SPREAD SPECTRUM RADAR

Anti jamming features of SS technology can be utilized in RADAR operation for multipath rejection and the RADAR will become Pulse Compression RADAR with advantages like local suppression of interference due to coded Radar waveform and correlation of the received code. This model is capable enough to serve successful communication between Radar transmitter and receiver. The RF transmitter

used is an up-converter which uses a RF central frequency to convert the IF model to a complete RF model. RF transmitter is added where Radar is tunable for the full band of RF frequency from 300MHZ to 3000 MHz. RF Receiver is added which is also tunable for the entire band. Target is modeled where it is assumed that the incident vector of radio waves will be modified by the target in terms of amplitude, phase and frequency. User data generator generates the reference data which is to be spread by the spreading code. Spreading system consists of a spreading code generator which is multiplied with the incoming user data to generate the spreaded data which is passed to the RRC transmit filter. RRC (Root Raised Cosine) Transmit filter upsamples and filters the input signal using square root raised cosine FIR filter[6]. RF Transmitter section is up converting the incoming baseband signal to the particular RF frequency. Target is modeled where it is assumed that the incident vector of radio waves will be modified by the target in terms of amplitude, phase and frequency. There is a requirement of converting the RF band signal into the baseband signal which is achieved by a down converter mixer which is effective in simply removing the RF carrier thus making the signal suitable for baseband processing. This signal is further amplified using final stage amplifier.
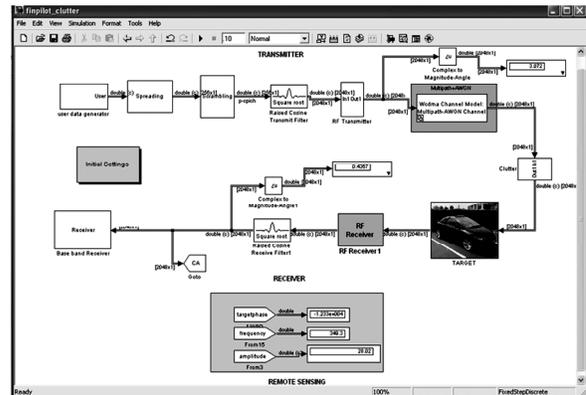

Figure 3: Simulation Model of Spread Spectrum RADAR

In SS Technique the frequency, amplitude and target phase that are transmitted from source to the receiver, from the receiver section the signals are calculated which matches the transmitted signal. Thus Clutter has been rejected by this SS Technique.

4. HYBRID TECHNIQUE [SPREAD SPECTRUM-MTI BASED]

The depicted block diagram consists of Transmitter baseband block, the SS baseband signal which is mixed with RF signal by RF Mixer. The signal is amplified and transmitted. The transmitted signal is received via Low-Noise Amplifier. In the Receiver, multiple filtering is made by MTI and SS. Then the signal is down converted with RF

mixer again. The down converted signal is made clutter free by signal processing block. With MTI, by MATLAB Simulation we have achieved 27db gain, which is the desired result in ITS.
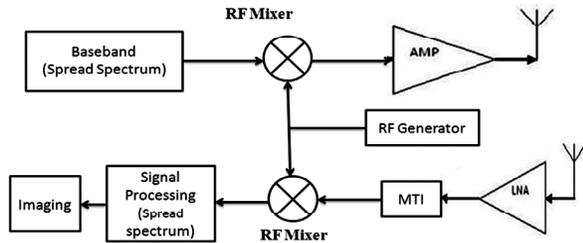

Figure 4: Block Diagram of Hybrid Technique in RADAR Operations

5. SIMULATION RESULTS

Here, we have done MATLAB simulation for MTI and we observed that the signal is quite below the accepted level. The system parameters for RADAR operation is given in Table 1.

Table 1
Outdoor RADAR System Parameters

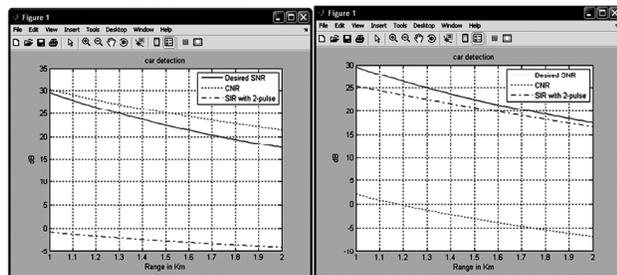| Notations	Value
Clutter backscatter coefficient	0
Clutter Attenuation	28
Antenna Gain	34.5dB
Side lobes	−20dB
Radar range	linspace(1,2,100)Km
Radar height	5m
Target height	20m
Peak power	0.1KW
Center Frequency	5.9GHz
Bandwidth	20.0e6Hz
Noise temperature	290Kelvins
Noise figure	6dB
Radar losses	8dB

Figure 5: Comparison Signal Figure 6: With MTI Clutter Without MTI   Rejection

From Figure 5 describes that required SIR, SNR is not achieved when the signals are processed without MTI. The parameters used are described in Table 1 for Figure 5. In order to overcome it, we include MTI technique Figure 6, in which the SIR levels almost achieves along with the desired SNR level, which is best when it comes to transportation system analysis for clutter rejection and the clutter attenuation parameter is used to achieve desired SIR.

In Figure 6 we have included Clutter backscatter coefficient as −15 dB, which rejects clutter in MTI in a successful rate. And using MTI we achieved 27dB gain at the received signal, which is a major achievement when implemented in ITS.

6. CONCLUSION

MTI, a form of pulse RADAR that uses the Doppler frequency shift to eliminate stationary clutter depending on the particular parameters of the signal waveform and that will be very much useful tool for dynamic RADAR measurement condition. MTI combined with SS technology is a valuable tool in outdoor RADAR operation. This combined system can be implemented in ITS, as Hybrid approach. This paper represent the need of Hybrid approach that is being analyzed to implement in ITS.

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