International Journal of Information Technology and Knowledge Management
July-December 2010, Volume 2, No. 2, pp. 379-382

IMPLEMENTATION OF MTI BASED PULSE COMPRESSION RADAR SYSTEM USING DSRC COMMUNICATION CHANNEL

D. Kandar, S.N. Sur, D. Bhaskar, A. Guchhait, R.Bera & C. K. Sarkar[1]

Spread Spectrum (SS) technology in the base-band section and moving-target indicator (MTI) in the RF section of RADAR operation can be used simultaneously for clutter rejection in open field. Dedicated Short Range Communication (DSRC) have one 5 MHz reserve channel with 70 MHz other channels for different purpose. So, SS RADAR can be implemented on reserved DSRC channel for Intelligent Transportation System (ITS) application. So these two methods have their advantages can be merged in DSRC channel and combined system will be very useful tool for open field RADAR measurement as well as short range communication.

Keywords: MTI, ITS, SS, DSRC.

1. Introduction

Vehicle and highway automation is believed to reduce the risk of accidents, improve safety, increase capacity, reduce fuel consumption and enhance overall comfort and performance for drivers. ITS efforts to add information and communications technology and should be carefully designed to fulfill the goals of it both for safety and non-safety applications. ITS has been the umbrella under which significant efforts have been conducted in research, development, testing, deployment and integration of advanced technologies to improve the measures of effectiveness of national highway network. It vary in technologies applied, from basic management systems such as car navigation; traffic signal control systems; container management systems; variable message signs; automatic number plate recognition or speed cameras to monitoring applications and to more advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems; weather information; bridge deicing systems etc.

Major technologies involved in ITS are communication and remote sensing. RADAR technology has been investigated for use on automobiles since the 1970s and has been employed for various functions on automobiles since the early 1980s [1,2]. From our past experience of RADAR measurement, narrow band operation of Network Analyzer (bandwidth 10 KHz) restricts the image resolution. Again clutter effect outside the Quiet zone of the closed chamber is severe which results in some clutter energy distribution over the quite zone of the chamber. In imaging RADAR instrumentation system in the open field, same ground clutter, multipath often introduce the probability of error to the return signal from the vehicular target forcing the deterministic signal to become probabilistic and often leads to wrong decision strategy. So, the proper modeling is necessary both for vehicular target as well as ground clutter/ multipath and also the proper signal processing tools for the remedial measures and accurate estimation of targets. Additionally, the interference and man made noise are severe. So, a need arises to design and develop a suitable modern radar technology which will address all above problems [3].

Sikkim Manipal Institute of Technology, Sikkim Manipal University, Majitar, Sikkim-737136, India.

[1]Department of Electronics and Telecommunication Engineering, Jadavpur University, Kolkata 700032, India.

kdebdatta@rediffmail.com

The Spread Spectrum, OFDM (Orthogonal Frequency Division Multiplexing), MIMO (multiple-input multiple-output) are the recent technological evolutions in radio technology which has the potential to dramatically improve the performance of communication as well as RADAR systems [4, 5]. The SS technology is well established in wireless mobile communication system for its antijamming and security features [6-13] and was initially developed for military and intelligence requirements [14]. Antijamming features of SS technology can be utilized in RADAR operation for multipath rejection [15] and the RADAR will become Pulse Compression RADAR [16,17] with advantages like local suppression of interference due to coded radar waveform and correlation of the received code.

2. Ground Clutter Model

RADAR's capability to detect targets in a high clutter background depends on the Signal-to-Clutter Ratio (SCR) instead of Signal-to-Noise Ratio (SNR). Normally, clutter signal level is much higher than the receiver noise level as because of clutter echoes are random and have thermal noise-like characteristics. Grazing angle (Ψ_g), surface roughness, and the RADAR wavelengths mainly affect the amount of clutter in the RADAR operation. RADAR can distinguish target returns from clutter echoes are based on the target RCS s_t, and the anticipated clutter RCS sc (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 is given by

$$\sigma c = \sigma^0 A_c$$

Where σ^0 (m^2/m^2) is the clutter scattering coefficient, expressed in dB.

The clutter area A_c and SCR are defined as

$$A_c \approx R\theta_{3dB} \frac{c\tau}{2} \sec \Psi_g$$

$$SCR = \frac{2\sigma_t \cos \Psi_g}{\sigma^0 \theta_{3dB} R c\tau}$$

Clutter-to-Noise(CNR) is defined as

$$CNR = \frac{P_t G^2 \lambda^2 \sigma_c}{(4\pi)^3 R^4 K T_0 BFL}$$

Pt is the peak transmitted power, G is the antenna gain, λ is the wavelength, K is Boltzman.s constant, T_0 is the effective noise temperature, B is the radar operating bandwidth, F is the receiver noise figure and L is the total radar losses.

For Gaussian clutter, the clutter and noise can be combined and RADAR measurement can be derived from the Signal-to-clutter + Noise ratio is given by

$$SIR = \frac{1}{\left(\frac{1}{SNR} + \frac{1}{SCR}\right)}$$

We have done matlab simulation considering clutter and the simulation result is shown in the Fig. 1(P). The simulation parameters are written below.

Transmitted power (pt) = 1 Kwatt.

Antenna azimuth and elevation 3dB bandwidth are 11 and 12 degree respectively

Noise Figure = 1.6 dB

Environmental Loss = 10 dB

Bandwidth = 5 MHz.

sigmmat = 0 dBsm.

sigmma0 = –30 dBsm.

Antenna Sidelobe Level = –30 dBsm.

Antenna and Target Height = 10 m.

Operating frequency = 3 GHz.

The desired SNR is shown in the top of the graph (Fig. 1) which is quite high, but whenever, we are considering the clutter, the SCR is well below the SNR level. So we have to concentrate to clutter rejection.

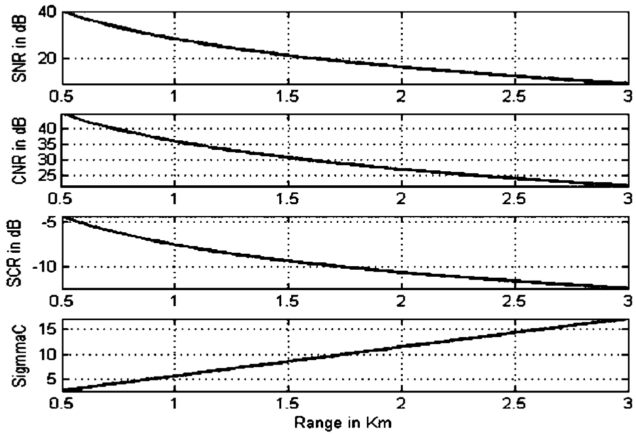

Fig. 1: Variation of SCR, SNR, CNR with Distance (KM)

3. MOVING TARGET INDICATOR (MTI) FOR CLUTTER MITIGATION

The moving-target indicator (MTI) can detect moving targets from ground clutter, even in the bad weather by virtue of the Doppler RADAR return of the moving targets [18,19]. 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.

Clutter spectrum is concentrated around f = 0 and integer multiples of the RADAR PRF (Pulse Repetition Frequency) fr, and may exhibit a small amount of spreading as shown in Fig2.

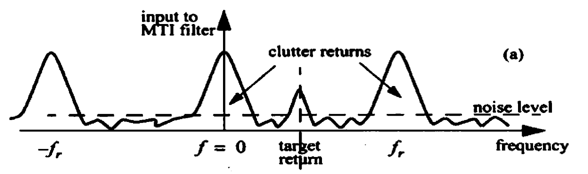

Fig. 2: RADAR Return In Presence of Clutter and Target

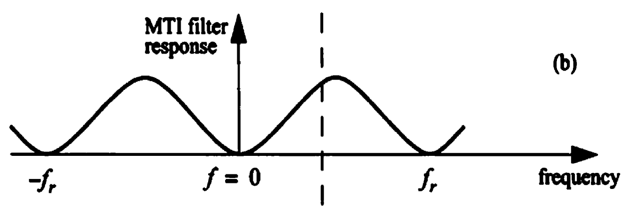

Fig. 3: MTI Filter Frequency Response

In order to effectively suppress clutter returns multiples of the PRF, Fig 3 shows a typical sketch of an MTI filter response, while Fig 4 shows its output when the PSD shown in Fig 2 is the input. MTI filters can be implemented using delay line cancellers. The frequency response of this class of MTI filter is periodic, with nulls at integer multiples of the PRF. Thus targets with Doppler frequencies equal to n fr are severely attenuated.

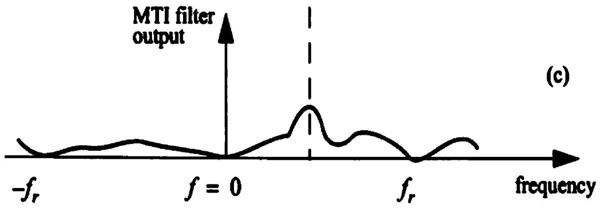

Fig. 4: Output from an MTI Filter

A single delay line cancellers or "two-pulse cancellers" can be implemented as shown in Fig. 5.

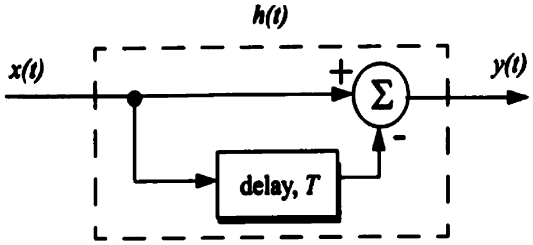

Fig. 5: Block Diagram of Single Delay Line Cancellers

Double delay line cancellers or "three – pulse cancellers" are shown in Fig. 6.

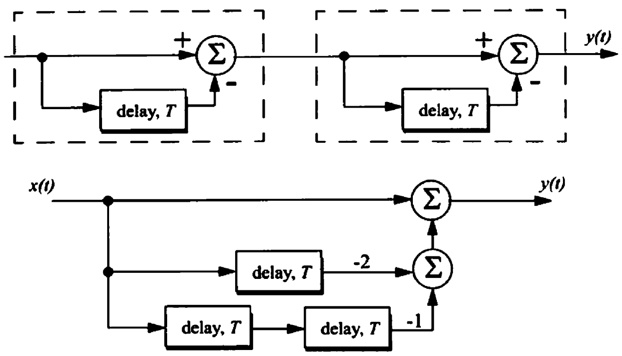

Fig. 6: Block Diagram for Double Delay Line Canceller

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

$$CA = Ci/Co$$

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

$$I = (So/Co)/ (Si /Ci) = (So/si) CA$$

We have done matlab simulation of MTI by using delay line canceller for clutter mitigation and the results are shown inthe Fig. 7. In the previous graph (Fig 1) SIR level was well below the desired SNR level. But here the SIR levels achieve the desired SNR level.

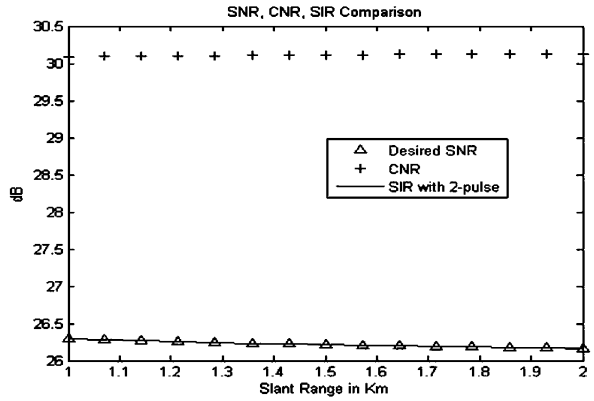

Fig. 7: Variation of SIR, SNR, CNR with Distance (km) Considering MTI

4. MTI BASED RADAR COMBINED WITH DSRC

ITS, as a broad range of wireless and wire-line communications-based information, control and electronics technologies. Short-range communications can be accomplished using IEEE 802.11 protocols, specifically WAVE or the DSRC standard being promoted by the Intelligent Transportation Society of America and the United States Department of Transportation. DSRC, sub-set of the RFID-technology offers communication between the vehicle and roadside equipment. This technology for ITS applications is working in the 5.9 GHz band (U.S.) or 5.8 GHz band (Japan, Europe). Frequency allocation for DSRC channels are shown in Table 1.

Now same DSRC channel can be utilized for RADAR operation. The 5.9 GHz DSRC spectrum is composed of six service channels and one control channel 10 MHz each as shown in Fig. 8. The first (remaining) channel of DSRC (having 5 MHz bandwidth) is reserved. This reserved channel (5.850 – 5.855 GHz) can be used for remote sensing using MTI based Digital Radar.

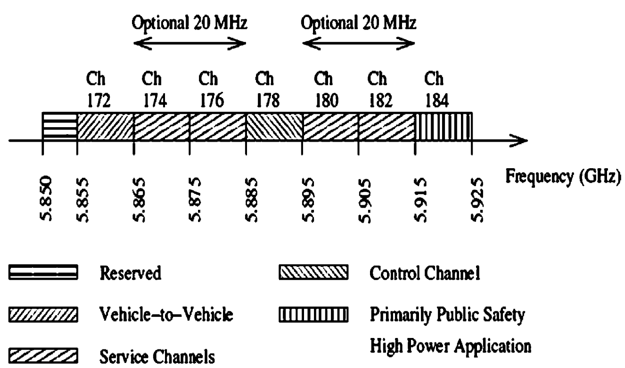

Fig. 8: DSRC Channel Scheme Assigned in the United States

5. 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 out door RADAR operation. This combined system can be implemented in ITS. 5 MHz DSRC channel can be utilized for short range communication as well as RADAR operation having advantages of clutter rejection capabilities. The software simulation model of combined system is ready in our lab. Hardware implementation is limited by our Lab infrastructure. However, sacrificing or limiting some parameters of the Simulation model can be implemented using Software Defined Radio (SDR).

REFERENCES

[1] E. F. Belohoubek, "Radar Control for Automotive Collision Mitigation and Headway Spacing," IEEE Trans. Veh. Technol., 31, Pp. 89–99, May 1982.

[2] E. Brus, "Vehicular Radar: The Ultimate Aid for Defensive Driving?," Microwaves & RF, Pp. 53–58, Sept. 1987.

[3] D. Kandar, R. Bera, "Development of a Imaging Radar Instrumentation System Using DS-UWB Wireless Technology", Published in the Proceedings of XXVIIIth General Assembly of International Union of Radio Science (URSI) Held During 23-29th October, 2005 at New Delhi.

[4] G.J.Foschini, "Layered Space-time Architecture for Wireless Communication in a Fading Environment when using Multi-element Antennas" Bell Laboratories Technical Journal, 1, No.2, Pp-41-59, 1996.

[5] P.W.Wolniansky, G.J.Foschini, G.D.Golden, and R.A.Valenzuela, "V-BLAST: an Architecture for Realizing very High Data Rates Over the Rich-scattering Wireless Channel," Proc. of ISSSE, pp. 295-300, Pisa, Italy, Sep.-Oct. 1998.

[6] Special Issue on Spread-spectrum Communication, IEEE Trans. Commun., COM-30, May 1982.

[7] Simon, M.K., et al., "Spread-Spectrum Communications," 1, 2, 3, Comp. Sci., 1985.

[8] Scholrz, R.A., "Spread-Spectrum Concept," IEEE Trans. Commun., COM-25, August 1977.

[9] Torrieri, D.J., Principles of Secure Communication Systems, Norwood, MA: Artech House, 1992.

[10] Cooper, G. R., and C.D. McGillem, Modern Communication and Spread-Spectrum, New York; McGraw-Hill, 1986.

[11] Glisic, S.G., and P.A. Leppanen (eds.), Code Division Multiple Access Communications, Norwell, MA: Kluwer Academic Publishers, 1995.

[12] Viterbi, A. J., CDMA Principles of Spread-Spectrum Communications, MA: Addison-Wesley, 1995.

[13] Dixon, R.C., Spread-Spectrum Systems, New York: John Wiley & Sons, 1984.

[14] L. Hanzo, L-L Yong, E-L Kuan, K. Yen: "Single and Multi-Carrier DS-CDMA Multy-User Detection, Space-Time Spreading Synchronisation and Standards", John Wiley & Sons, 1st edition, 2003.

[15] N. B. Sinha, D. Kandar, and R. Bera, "Measurement of Target Parameters Using the DSSS Radar", Published in Progress In Electromagnetics Research M, 1, 185-195, 2008.

[16] Knott EF, "Radar Cross Section", Second Edition, Scitech Publishing, Raleigh, NC, 2004.

[17] M. I. Skolnik, "Introduction to RADAR Systems", TATA McGraw-Hill Publication, 2007.

[18] Richard J. Dunn, III Price T. Bingham Charles A. "Bert" Fowler, "Ground Moving TargetIndicator Radar Ground Moving Target Indicator Radar and the Transformation of U.S. Warfighting", Northrop Grumman Corporation, February 2004.

[19] Christopher Repesh , "Broadband FIR Moving-Target Indicator Radar Filters for Low-PRF Applications", VMEbus Systems, April, 2002.