LFM-PC Radar Evaluation in Presence of Jamming using SystemVue

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LFM-PC Radar Evaluation in Presence of Jamming using SystemVue

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Abstract: Pulse Compression (PC) radars become; now a day; are the most commonly used in a lot of military applications. This is due to its capability to resolve the problem of designing long range radar with excellent range resolution. Also, it provides additional processing gain that enhances radar detection capability. Moreover, Pulse compression is considered as an electronic counter countermeasures (ECCM) capability. It provides the radar with a good immunity against different jamming techniques. There are a lot of types of PC waveforms. Linear Frequency Modulated (LFM) signals are the most tolerant to high Doppler shifts. This is why LFM-PC radars are widely utilized with high speed targets. However, the literature lacks a simulation model to evaluate the detection performance of LFM-PC radar in presence of different noise jamming techniques. This paper introduces a typical simulation model for LFM-PC search radar using SystemVue. The simulated model allows the studying of the PC radar performance with different jamming techniques. Also, the optimum jamming technique; from electronic warfare point of view; is explored.

Keywords: LFM-PC, Jamming, Simulation, SystemVue.

1. Introduction

Pulse compression radar is considered later in many on board radars such as AN/TPS-59 and AN/FPS-117 [1-2]. So, it has a great attention in an electronic warfare field. LFM-PC radar is a tenacious victim. It has a high ECCM due to its high processing gain. This gain is driven from the using of long pulses and wideband LFM modulation. The correlator receiver depends on the fact that the matched filter (MF) is the optimum receiver in presence of noise [3-4]. The MF is implemented in frequency domain so that a multiplication process is performed instead of the convolution process to decrease the complexity of the system [5].

In this paper, a typical simulation model for LFM-PC search radar is introduced using SystemVue. This model can be used as a standard model to evaluate a typical LFM-PC search radar detection performance under the effect of different noise jamming techniques. Namely they are Barrage, Spot, and Multispot. An efficient jamming technique is introduced.

The paper is organized as: this introduction is the first section of the paper. In the second section, the radar model simulation parameters are introduced. The third section introduces the performance of the LFM-PC Radar under the effect of different jamming techniques using SystemVue. The last section contains the conclusion.

2. Radar Model Simulation and Verification using SystemVue

Advanced radar systems are very complex, necessitating sophisticated signal processing algorithms. Effective algorithm creation requires both a platform for simulation and another platform for verification. Models for signal generation, transmission, antennas, T/R switching, clutter, noise, jamming, receiving, signal processing, and measurements are also needed to create advanced

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algorithms. Most simulation tools do not have enough models and the integration capability needed to design such complex algorithms. SystemVue provides an effective and efficient environment for algorithm creation. The SystemVue 2015.1 software; developed by Keysight; can be used for modeling different types of complex radar systems for creating realistic working radar scenarios. It contains the transmitter blocks, processing blocks, receiver blocks and environmental effect items. Its radar library saves development time and verification expense in research and development for complex radar system algorithm developers, architects, and system verifiers. The Environmental effect items include targets and radar cross section (RCS) different algorithm, intentional (jamming) and non- intentional interference, and the effect of various signal processing algorithms. The block diagram of the Radar Model is built on SystemVue Ver. 2015.1 as shown in 'figure1'.

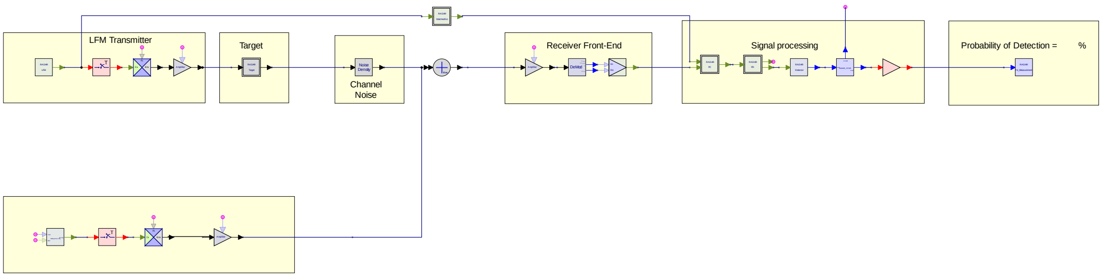

Figure 1 block diagram of the Radar and Jamming Models using SystemVue.

'Figure 2' shows the detailed block diagram for modeling the Radar and Jammer on SystemVue. The LFM-PC radar model block diagram is discussed in details as follows: The output signal from LFM-PC generator in the time domain and frequency domain is shown in 'figure 3'.This LFM signal is a complex signal has both Real; In-phase; component and Imaginary; Quadrature; component. The LFM-PC baseband generated signal is up converted with 9 GHz carrier frequency. The Simulation results for LFM-PC agree with theoretical results [6]. Secondly, set sample rate module as shown in 'figure 2(a)' is only responsible for ensuring that the sampling frequency which is set to 10 MHz from the predecessor is equal to the sampling frequency of the successor stage. The third module is complex to envelop converter. This block converts the input complex signal (Cx) to complex envelop (ENV) at the output. The carrier frequency is represented by Fc. It is set to 9 GHz. Finally, the amplifier is used to normalize the output power. 'Figure 2(b)' shows the target and noise models. The target model is used to simulate the target radar cross section, target speed and target distance. The target model in this system is acting as a virtual antenna which reflects radar transmitted signal back to radar receiver. The target sub network simulates the target model for radar system with RCS, transmission delay, transmission loss and Doppler shift. Five Swerling models are supported for target RCS fluctuation [7]. Swerling Case I is selected. The propagation effect is put into consideration. The Doppler shift is then added. Finally, transmission delay caused by target distance is added. Noise Density module, gives the radar model realistic environment condition. The effect of the noise is added to the transmitted signal to simulate the noise in the channel. This model is controlling the noise level comparing to signal. The noise power in the channel is varied according to the required. The noise power is constant over signal bandwidth.

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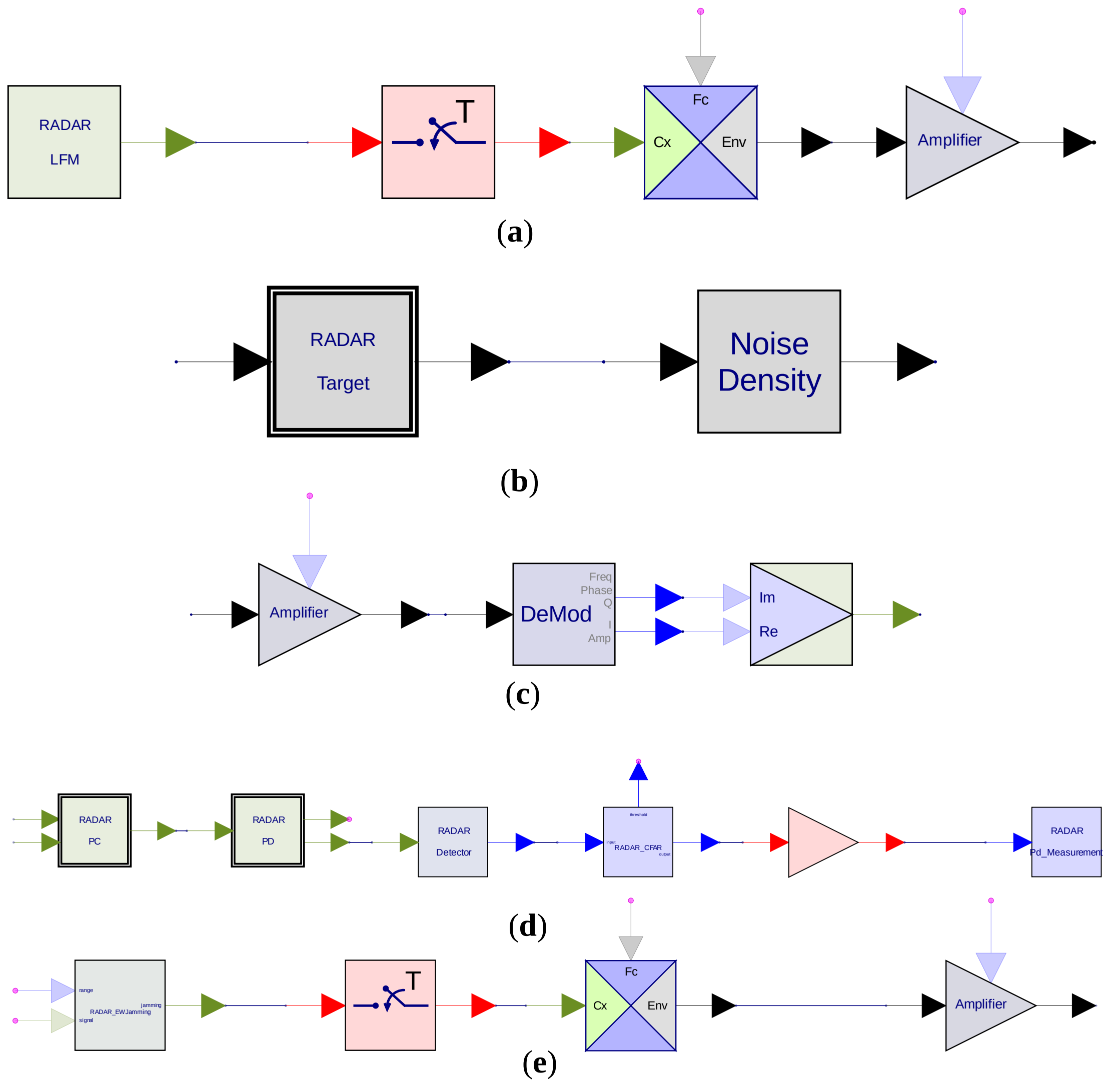
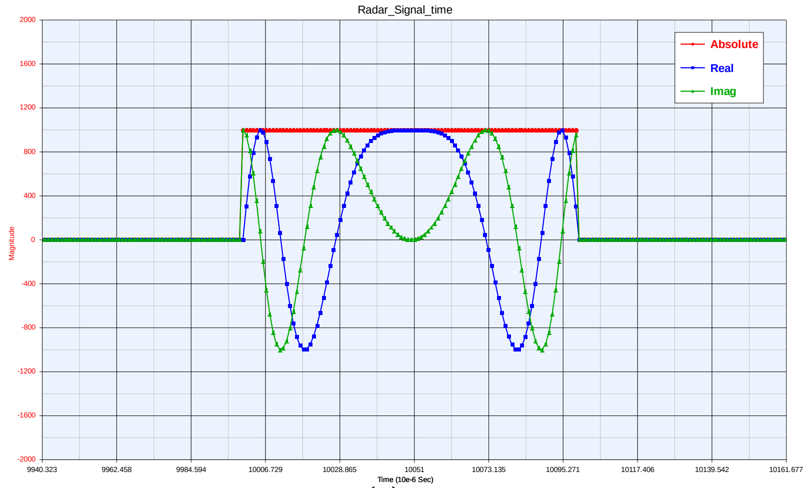
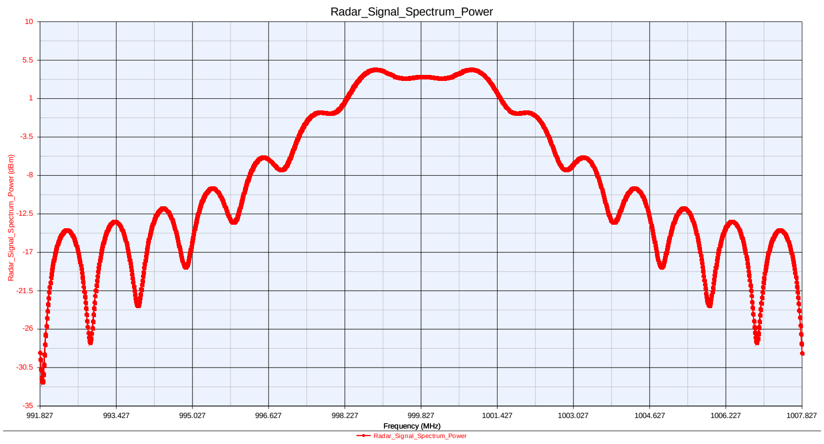


Figure 2 the detailed block diagram for modeling the Radar and Jammer using SystemVue. (a) LFM transmitter model, (b) Target and noise models, (c) Radar receiver model, (d) Radar signal processing model, and (e) Jammer model.

'Figure 2(c)' shows the radar receiver model. Demodulator module, acts as coherent demodulator that is used to perform amplitude, phase, frequency, or I/Q demodulation. Rec. To CX module changes the signal from real and imaginary form to complex form. Radar Pulse Compression Filter module is responsible for compressing the received pulse and hence increase the range resolution. 'Figure 2(d)' shows the PC filter is actually a matched filter follows by filter to reduce the LFM sidelobes level [8]. The reflected signal from the target enters the PC-filter from port SigIn and the reference signal in frequency domain is entered to the filter from RfIn port. Matched filter is considered as a linear process performing auto correlation between the received signal and the reference signal. The matched filter converts the signal from time domain to frequency domain using FFT model to perform multiplicative process instead of convolution process which is more complicated. After performing the multiplicative process with the reversed complex conjugate of reference signal the output is converted back to time domain using FFT model working in the inverse mode (IFFT). 'Figure 2(e)' shows the Jamming model. This model provides Cover Jamming with three different jamming techniques: barrage jamming, spot jamming, and multispot jamming.



(a)



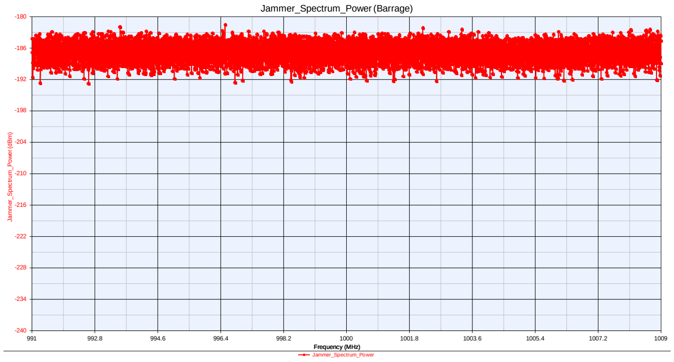
(b)

Figure 3 LFM-PC radar output in (a) time domain and (b) Frequency domain

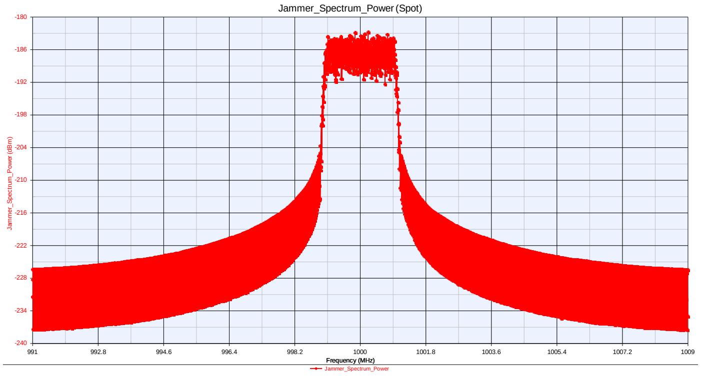
3. LFM-PC Radar Performance Simulation Under Jamming

The spectra of the three jamming techniques; Barrage, Spot, and Multispot is shown in Fig. 4. Barrage jamming is using a wide noise bandwidth; as shown in 'figure. 4(a)'; to compensate any uncertainty in the radar frequency but it comes at the expense of power. Spot jamming is simply narrowing the bandwidth of the noise jammer; as shown in 'figure. 4(b)' so that as much of jammer power as possible is in the radar receiver bandwidth. Multispot jamming generates band-limited noise in the several sub-bands of the radar bandwidth. It is possible to choose the number of noise sub-bands. As shown in 'figure 4(c)' the three sub-bands are used for generating the Multispot jamming.

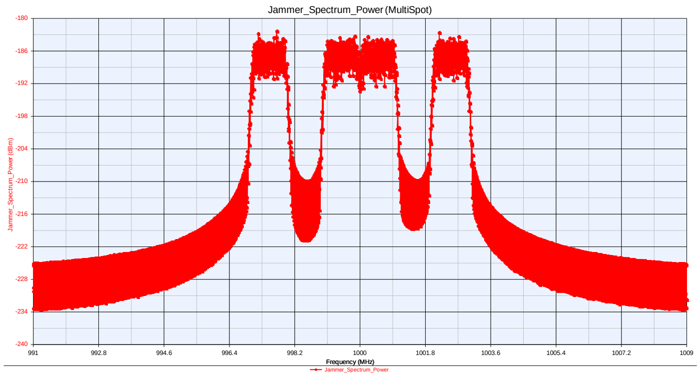
The performance of the simulated LFM-PC radar is shown in 'figure 5' under the effect of different jamming techniques at constant signal to noise ratio (SNR) = 30 dB. It is clear from the figure that both the Spot jamming and Multispot jamming techniques have the same effect on the radar performance which is better than Barrage jamming technique. 'Figure 6' shows the performance of LFM-PC Radar when increasing the SNR to 50 dB, as shown the Spot jamming more effective than the other two techniques.



(a)



(b)



(c)

Figure 4 The spectra of jamming techniques (a) Barrage jamming, (b) Spot jamming, (c) Multispot jamming

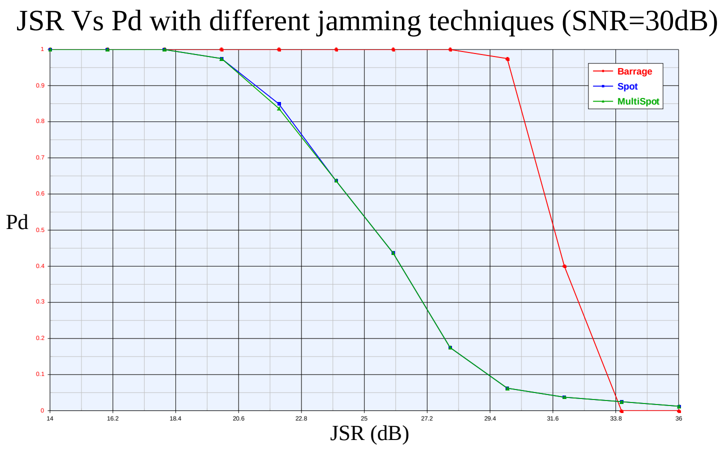


Figure 5 Performance of LFM-PC Radar under the effect of different jamming techniques SNR=30 dB

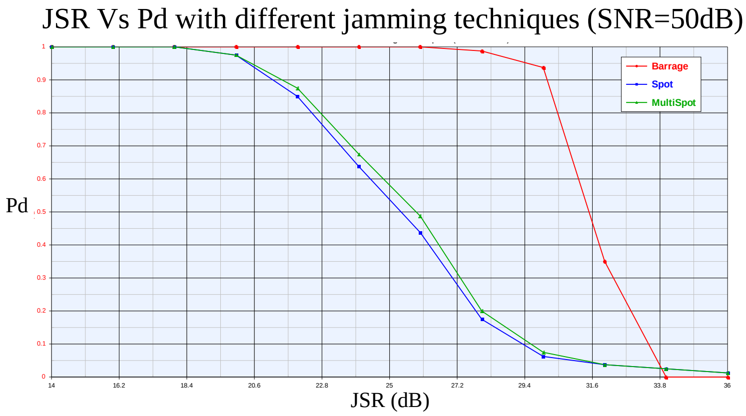


Figure 6 Performance of LFM-PC Radar under the effect of different jamming techniques

SNR=50 dB

4. Conclusion

In this paper, a simulation model for an LFM-PC radar is introduced and verified by SystemVue. The performance evaluation of the LFM-PC radar under jamming with different jamming techniques is introduced. The Spot and Multispot jamming techniques are more effective than Barrage jamming on the Radar performance. As SNR increased the Spot jamming is more effective than the other two techniques.

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