

Studies on Phased-Array Radar Jamming and Simulation System

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Keywords: Phased Array radar, Jamming, Simulation

Abstract. Analyzing the current developing status and actual problems of radar system simulation, based on continuous system simulation, combining signal simulation and function simulation, considering current development of simulation technique and the request of air battle to EW, the simulation system of phased array radar based on MATLAB/SIMULINK is presented and designed, which conquered the contradiction between simulation precision and real-time characteristic. And the key techniques of composition, modeling and exploitation of modules are studied in-depth. The simulation system is checked and tested by illustration of one jamming to phased array radar system in the end. Simulation is carried out whose result verifies the efficiency. The successful exploitation of the system will supply the analyses evaluation of the whole simulation system efficiency with platform and basis, which has instructive sense for the tactical use and simulation of phased array radar.

Introduction

The current simulation research on phased array radar system mainly adopts signal simulation or function simulation. The function simulation models on part function or part work parameter of reconnaissance receiver and jammer based on radar equation and jam equation, which neither can construct “system-system” simulation system, nor reach the precision, fidelity and real-time characteristic of signal simulation. Conquered above contradiction, signal simulation still has complex configuration and great compute, which weaken its engineer application. Moreover, with the development of Phased Array radar, its design, investigation, modeling and simulation are challenged. Thus, constructing phased array radar simulation with high precision, real-time characteristic and easy to engineer application is the urgent demand of EW simulation, and make great sense to the conduct of technical specification, module investigation, efficiency evaluation and tactical use, this paper is brought forward for that.

System Modeling and Simulation

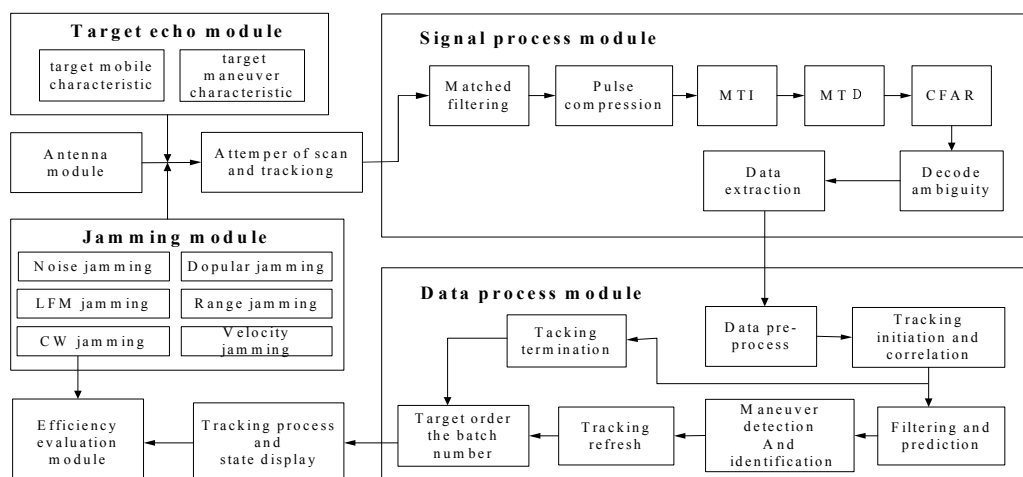


Fig.1. System constitution and simulation flow

The basic constitution of phased array radar includes: phased array antenna, transmitter, receiver, signal processor, data processor and master computer. In system simulation, the phased array radar can be plotted to six key modules: antenna module, target echo module, jamming signal module, signal process module, data process module and efficiency evaluation efficiency. Besides, it also has battle state compiling module, which finish battle state setting, compiling and other assistant work. In system simulation, the signal process module adopts signal simulation and others adopt function simulation. The constitution and simulation flow are as Fig.1.

A. Modeling and Simulation of Signal Process Module

The signal process module finish the following work: detect targets and suppress clutter, noise, radio jamming and man-made jamming etc, output video signal, estimate weather target is detected through detection threshold, and transmit target characteristic such as range, azimuth, pitch angel, radial velocity, etc to data logger to finish correlation process. Figure2 show the structure and flow of signal process module.

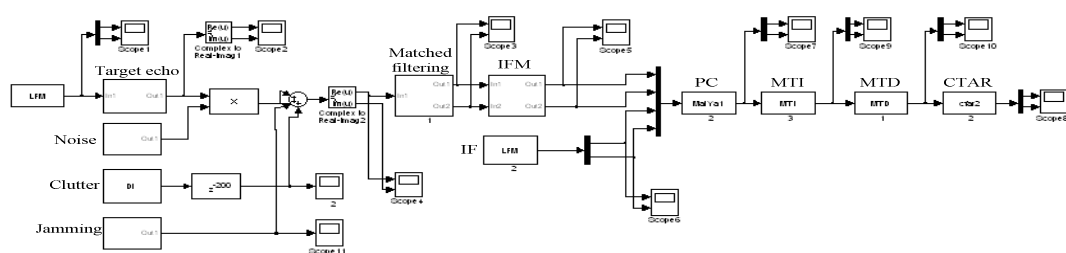


Fig.2. Structure and flow of signal process module

B. Modeling and Simulation of Data Process Module

The data process module finish the following work: capture target locus, motion parameters and then correlation, track, filter, smooth, prediction, etc, introduce random noise when suppressing gauge, track targets locate and relational motion parameters accurately, finish maneuver detection and mobile identification, predict target coming locate, and form immobile target trace. Figure 3 show the structure and flow of data process module.

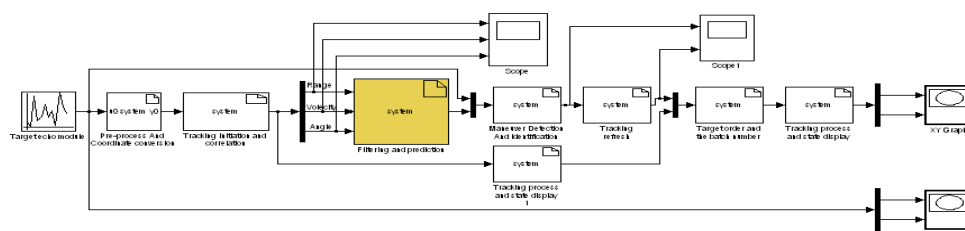


Fig.3 Structure and flow of data process module

C. Modeling and Simulation of Other Modules

Antenna Module: Set modeling and simulation of phased array antenna-directivity. **Target echo Module:** Set target echo according to transmitter signal parameters, target number, target mobile characteristic, target maneuver characteristic, etc.

Jamming Signal Module: Transmit radio jamming signal, includes blanket jamming and deception jamming. The blanket jamming includes noise jamming, LFM jamming, CW jamming, narrow band Dopular jamming, etc. The deception jamming includes distance, azimuth, pitch angel and velocity deception jamming.

Efficiency Evaluation Module: Under jamming, record and display, each node outputs of signal process module and data process module, make efficiency evaluation to tactical jamming with quantitative and qualitative analysis.

Noise And Clutter Module: Produce noise signal for target echo, receiver noise and other modules, produce ground clutter, weather clutter and sea clutter, to offer one more realistic simulation environment.

Battle State Compile Module: Set phased array work mode like scan or track, set jamming method and parameters each simulation test adopt.

Sysrem Test and Sumulation Outputs Analysis

Part simulation parameter settings are as follows:

Transmitted power: 20kW;

Antenna gain: 32dB;

Horizontal polarization ;

Transmitting loss: 2dB;

Receiving loss: 3dB;

Bandwidth of transmitted LFM signal: 10MHz;

Pulse duration: 8us;

Intermediate frequency: 5MHz;

Sampling frequency: 2MHz;

Transmitted signal: LFM with one PRF;

Jamming power: 40kW;

Jamming antenna gain: 6dB;

Beam width: 20° ;

Jamming width: 5MHz;

Jamming transmitted loss: 3dB.

Tactical jamming settings includes: range deception jamming, velocity deception jamming and range/velocity common jamming. In simulation, adopting range/velocity common jamming, add target maneuver characteristic cooperated with it to test maneuver detect capability of module. The anti-jamming methods settings includes quadrature demodulation, pulse compression, MTI, MTD, CFAR detect module. The simulation can start when each module parameters are inputted, then present several key outputs waveform with analysis.

By the simulation outputs, Fig.4 show the echo after PC and MTD, we can see that signal-to-clutter-ratio is improved more. Fig.5 show the echo after PC and MTD with noise FM jamming, we can see that signal-to-clutter-ratio is reduced.

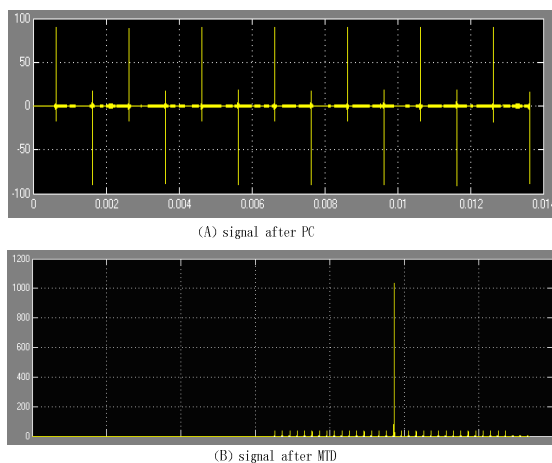


Fig.4 Signal output without jamming

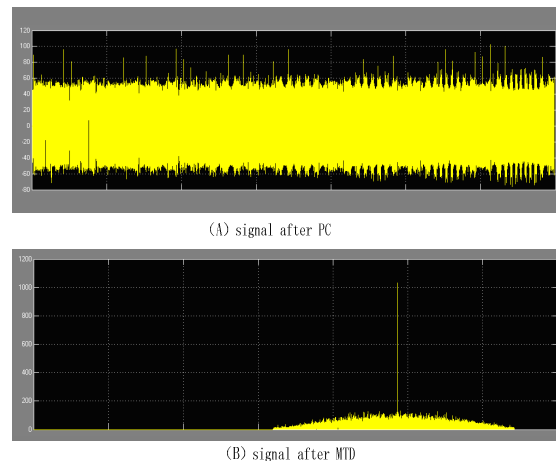


Fig.5 Signal output with noise FM jamming

Set the jamming signal to multi-false targets jamming, figure.6 the signal output after CFAR. The outputs show that there are several false targets in each detection period, and the false targets can move in velovity/range gate by regular speed.

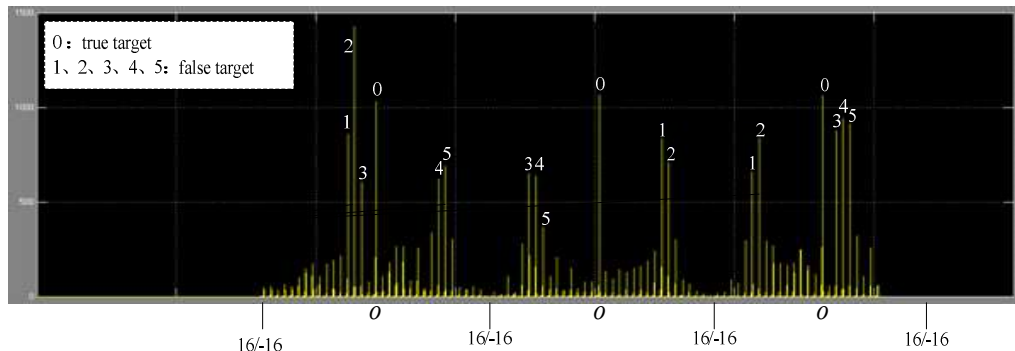


Fig.6 Signal output with multi-false targets

The simulation indicates that this system can reflect each detail through simulation process factually, which make engineers easy to realize the function of each module, and the simulation output inosculate with its academic analysis, its reliability is higher, kinds of jamming/anti-jamming battle notions can be achieved through adjusting radar jamming/anti-jamming parameters repeatedly.

Summary

This paper researched the composition of phased array, analysed its digital modules structure and simulation flow. According to its operation mode and process technique, adopting simulation method combining signal simulation and function simulation, the contradiction between simulation precision and real-time characteristic is conquered. Adopting evaluation inosculating quantitative and qualitative analysis, which improved the reliability of evaluation results. The perfect of modes is also dynamic process making simulation system approach to actual radar system, the models this paper found are contracted, which finish part function simulation of phased array merely. As for the improvement of system models and condition fidelity, they still demand research in depth.

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10.4028/www.scientific.net/AMM.385-386

Studies on Phased-Array Radar Jamming and Simulation System

10.4028/www.scientific.net/AMM.385-386.1476

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