VIRTUAL MODEL OF A SURVEILLANCE RADAR

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The aim of this paper is to present the created algorithm for movable target detection by a surveillance radar. This algorithm was created in the Matlab software, as this is a very convenient tool for such purposes. As will be presented in the paper, the final algorithm was capable of detection of all the artificial targets, with identification of their distance, angular position and speed of their movement.
K e y w o r d s: surveillance radar, target detection, Matlab

1 INTRODUCTION

The radiolocation became during its development one of the key industries of radio-electronics. The radar implements the principle of radiolocation in practice and is successfully and effectively used in areas such as management of transport, air safety, cosmos research, meteorology and so on. Like any other technology, the radar is constantly being refined, miniaturized and its energy requirements are reduced. Radiolocation is the area of radio-electronics that deals with obtaining the information about objects through processing the emitted or reflected electromagnetic waves from these objects. Similar physical effects, as in the case of radiolocation, are successfully used in satellite navigation. Many todays experts devote their time to radar modelling for the purpose of gaining even better characteristics of the device. Probably the best solution to do this task in these days is the computer software called Matlab. Its toolbox "Phased Array System Toolbox" implements necessary algorithms for the design, simulation and analysis of systems, signal processing of phased antennas.

2 MODELING THE SURVEILLANCE RADAR

The created program model in Matlab simulates operation of a surveillance radar, which sweeps the predefined area periodically. A phased antenna of 900 elements is used, each with very small power handling. Antenna is unmovable; the main radiation lobe is steered electronically. After the reception of the pulses, the target detection takes place, with detectable parameters estimated distance and azimuth of every target. After that, the target speed is calculated based on the Doppler effect. The designed radar has its parameters as listed in Table1.

Table 1. Parameters of the surveillance radar

Parameter	**Value**
Detection probability P_D	0,9
False alarm probability P_{FA}	10^{-7}
Reach distance	5000 m
Effective reflective area	10 m^2
Number of integration pulses	10
Centre frequency of the radar	10 GHz
Wavelength	0,03 m
Sampling frequency	5,9958 MHz
Pulse repetition frequency	29,9792 kHz

The designed phased array antenna consists of 900 elements arranged in 30x30 blocks. Its resulting radiation pattern is displayed in Figure 1.

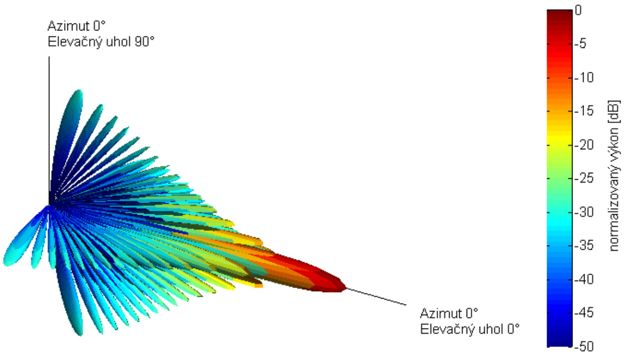

Figure 1. Radiation pattern of the radar antenna

One of the most critical parameters in radars is the peak power of the radar. It depends on many parameters, including maximum reach distance, desired S/N ratio at the receiver part and how wide the transmitting signal is. Concerning the desired S/N ratio, it is determined by operational characteristics between the detection probability and the false alarm probability. It is possible to get better SNR by integrating more pulses than the considered 10 pulses. On the other hand, the targets are movable and the background environment is also not totally static, therefore it is desirable to have finite and as small number of integration pulses.

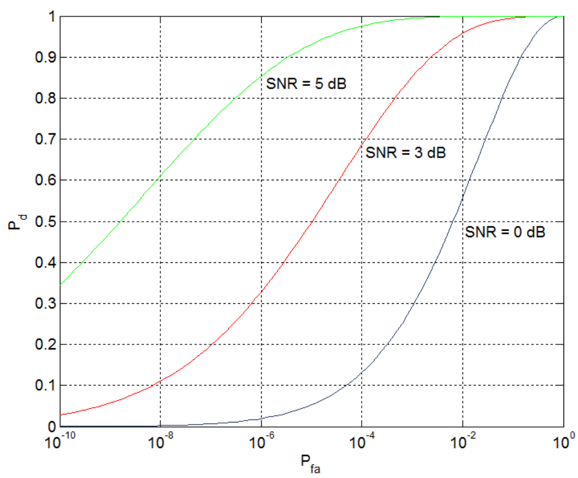

Figure 2. Characteristics of the receiver after implementation of the pulse integration technique

We can get the required value of SNR by the Albersheim's formula, which gives us the value of SNR = 4.9904dB. For the peak power calculation we also need to know the transmitter gain, which is 20dB. The individual peak power is small due to the many antenna elements used and equals to $6.4524 * 10^{-5}$ W.

The next step included designing the search area to be swept. We decided to go with values of azimuth from -60° to +60°, total 120° angular area. The radar ray is swept only in horizontal cut, so the targets can be detected only in small azimuth angle near 0°. To get the required number of scans, we have to know the width of the ray. The antenna array gives, for -3dB, the width equal to 6.7703°. To get better output, the final scan step was set to be 6°. The resulting scan period then equals to 0.0067s. After the integration across the whole area, we should get a map of possible target location. Therefore we created few artificial targets to test the created algorithm. The parameters of those targets are mentioned in Table 2.

Table 2. Input parameters of the artificial targets

	Distance [m]			**Speed [m/s]**			**EOP [m²]**
Target	X	Y	Z	X	Y	Z	
T1	1500	-1500	20	0	-180	0	10
T2	3232	1700	0	0	0	0	10
T3	4200	300	0	55	205	0	10
T4	2000	2000	0	-135	-120	0	10
T5	3700	-1700	0	140	135	0	10
T6	1200	-200	0	-15	185	0	10

Processing the data by the algorithm created the radar's target map. We had to specify correct detection threshold to be able to read any meaningful data from the created target map. The main parameter taken into account when deciding the threshold is the white Gaussian noise. The resulting data after the threshold filtering is displayed in Figure 4.

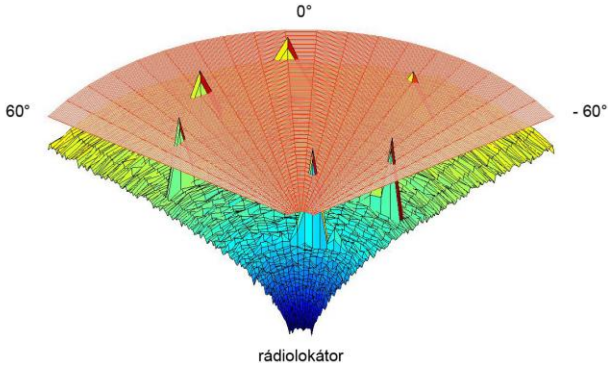

Figure 4. Detected targets

The obtained data of the targets by the created program algorithm are in Table 3.

Table 3. Parameters of the detected targets

Target	**Distance [m]**	**Azimuth [°]**	**Radial speed [m/s]**	**Air speed [m/s]**
T1	2850	45	180.80	180.62
T2	3675	27	0	0
T3	4225	3	-70.22	212.25
T4	1225	-9	45.64	185.61
T5	4075	-27	-71.97	194.49
T6	2125	-45	-128.14	180

5 CONCLUSION

The article presented the designed algorithm for surveillance radar capable of target detection. The designed model can serve as a foundation for further improvement of the model, which would bring the design closer to the real, constructed radars. The presented algorithm showed its promise by its capability not only to detect steady targets, but also movable targets and is able to evaluate their motion speed. The main limitations of presented algorithm are the inability to scan for targets in wide elevation angles and non-integrated anti-noise protection. This gives the foundation for future work.

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