Use Of Signals of Telecommunication Systems in Passive Radar Systems

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Abstract – The article discusses the features of the use of modern telecommunications systems signals in passive radar systems.

Key words – telecommunication system, passive radar system, power budget, radar cross section, range resolution, attenuation of radio waves.

I. Introduction

The planet surface is surrounded by a variety of radio signals used for various purposes: television, radio, cellular communications, microwave links and the others. Transmission of listed signals is performed over wireless communication channels. Signals from known sources may be utilized in passive radar systems.

For use the purpose of utilizing in passive radar systems, the signals listed and it's sources must have the following characteristics:

- signals must be known,
- signals must have a bandwidth above 1MHz,
- sources of radio signals should have the antennas with the wide directional pattern,
- Power at the exit of the transferring antenna output power has to be rather high in order that signals reflected from the target could be identifiedto identify the target reflected signals,
- coordinates of the radio source location must be known,

Digital television signals and signals of cellular systems have the characteristics listed above.

II. Parameters of researched signals

Let us consider the signals of the modern 4^{th} generation communication systems, such as: WiMax, LTE and also DVB-T2 standard signals of a digital television.

For passive radar system, the following signals can be used: WiMAX synchronization signals, LTE and DVB T2. These signals are known and have good correlation properties. Main parameters of these signals are given in Table 1.

TABLE 1

PARAMETERS OF SIGNALS

	3GPP LTE [1]	WiMAX [2]	DVB – T2[3]
Carrier frequency (varies by country)	2.5 GHz	2.4 GHz	174–834 MHz
Bandwidth	1.4 MHz	1.75–28 MHz	8 MHz
Power	20 W	20 W	50 W
Symbol duration	71 µs	72 µs–1,14 ms	0,1–3,5 ms
The maximum frame duration	5 ms	20 ms	8–250 ms

III. Power budget for passive radar system

Let us calculate the range of the passive radar system where emitter source is the same as receiver.

System range in free space is given by [4]:

$$R_0 = \sqrt[4]{\frac{2 \cdot P_T \cdot \tau \cdot N \cdot G_T \cdot G_R \cdot \sigma \cdot \lambda^2}{(4\pi)^3 \cdot q_{\min}^2 \cdot k_n \cdot T_0 \cdot k \cdot L}} \qquad (1)$$

Where:

P_T – power of transmitted signal, G_T – transmitting antenna gain, σ – radar cross sections, G_R – receiving antenna gain of passive radar, λ – wavelength, $q_{\min}$ – detection parameter, τ – pulse duration, T_0 – is the reference temperature (290 degrees absolute temperature), $k_ш$ – effective noise index of the receiver, k – Boltzmann constant, L – loss on transmitter and receiver.

Detection parameter $q_{\min}$ often is defined graphically, proceeding from probability of the correct detection D and a false alarm of F [4].

Range of the system also limits the attenuation of radio waves in the atmosphere, caused by absorption and dispersion of radio waves by hydrometeors (a rain, snow, a fog, a hail), and also absorption of radio waves by molecules of the gases making air. Bassed source [5], at researched frequencies the attenuation coefficient is about 0.01 dB / km, it has not essential influence on range effect of the passive radar-tracking system.

In addition to listed, one of the main factors affecting the range of the system is the target radar cross section (RCS). Average values of typical RCS purposes are given [5].

The parameters, are used for calculating the range of the system are shown in Table. 3

TABLE 3

SYSTEM PARAMETRS

	WiMax	LTE	DVB T2
Power of transmitted signal	15 watt	15 watt	50 watt
Transmitting antenna gain	15 dB	15 dB	15 dB
Radar cross sections	0.8–40 m^2	0.8–40 m^2	0.8–40 m^2
Carrier frequency	2.4 GHz	2.5 GHz	834 MHz
Receiving antenna gain	15 dB	15 dB	15 dB
Detection parameter $q_{\min\ TM}$	10	10	10
Effective bandwidth of receiver	28 MHz	1.4 MHz	8 MHz
Pulse duration	1.14 mc	71 µs	3.5 ms
Effective noise index of the receiver	2dB	2dB	2 dB
Loss on transmitter and reciever;	5 dB	5 dB	5 dB

Using Equation 1, the passive radar system range for target RCS from 1 to 40 square meters is calculated.

The system range to target RCS relation is shown in Fig. 1.

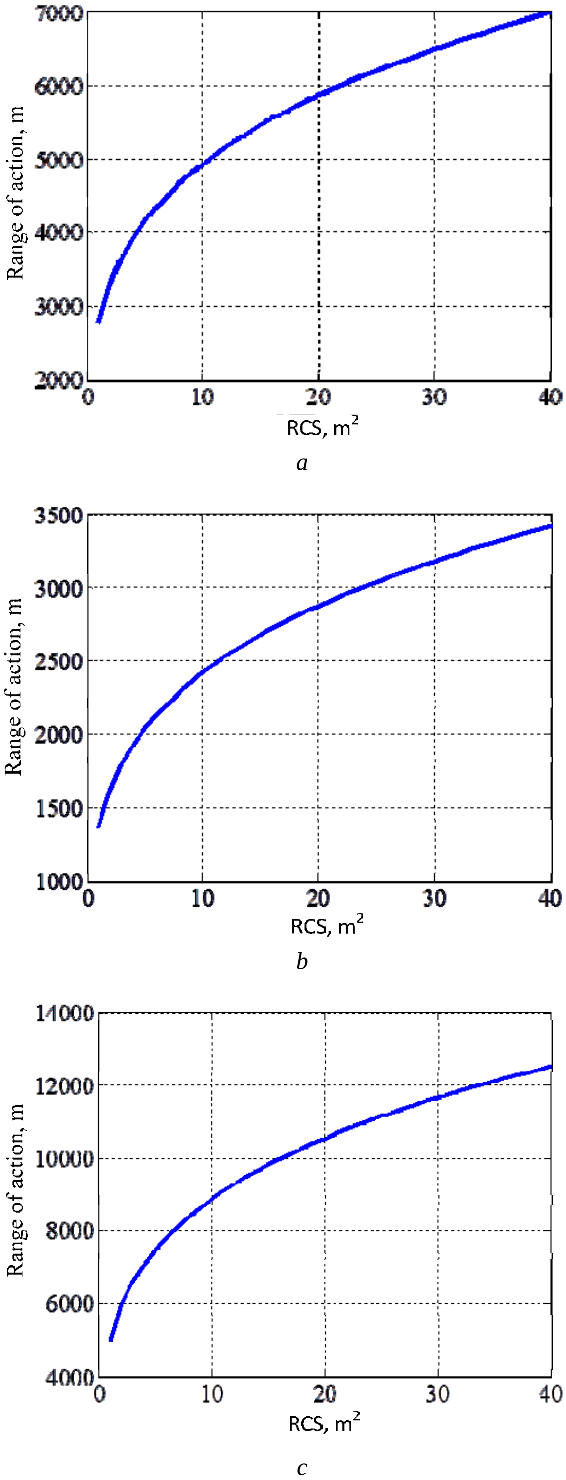

Fig. 1. The system range to target RCS relation, when working on a signal of a) WiMAX, b) LTE, c) DVB T2

One important feature of the system is range resolution. Range resolution - the minimum distance between the objects for which the range to each of them separately can be measured [8]. Range resolution depends on the signal bandwidth.

$$\Delta R = \frac{c \cdot \Delta\tau}{2} = \frac{c}{2 \cdot \Delta f},$$

Where: ΔR – range resolution; c – light speed; $\Delta\tau$ – time resolution; Δf – signal bandwidth.

Results of calculation resolution and range of the system are shown in Table. 4.

TABLE 4

THE RESULTS OF CALCULATION OF THE RESOLUTION AND RANGE OF THE SYSTEM

	WiMax	LTE	DVB T2
Signal bandwidth	1.4 MHz	28МГц	8 МГц
range resolution	107.14 m	5.3 m	18.7 m
Range of the system (Target RCS 40 м^2)	6000 m	7200 m	19000 m
The signal repeats with a frequency	200 Hz	50 Hz	4 - 125 Hz

Conclusion

The article discusses the features of utilizing the telecommunication signals in passive radar systems. DVB T2 standard signal with its long duration, and DVB T2 transmitter with its high output power (maximum among the all telecommunication systems), provides the maximum range of passive radar system, but cannot provide the best range resolution which is 18m. WiMAX signals have maximum bandwidth of the compared systems and provide the best range resolution to 5.3m. Range of passive radar system which uses LTE and WiMAX signals are almost the same, it is limited by a base station output power and the signal duration. Using LTE signals significantly limits the range resolution, as the band of LTE synchronization signal is 1.4 MHz.

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