SPOTLIGHT LASER RASTER HIGHLIGHTING OBJECTS OBSERVATION

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Spotlight raster laser illumination based in block of elastic material size 100x100 mm, which contains 10 semiconductor lasers IR radiation in tubular containers. To control the geometrical dimensions of the elastic block compression mechanism used by the back of the unit that lets you manage divergent fan light beams lasers and edit raster horizontally.

Keywords: *invisible scanning, backlight observed objects, sound governance raster.*

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SUPPRESSION OF SATELLITE NAVIGATION SYSTEM OF LAND-MOBILE ROBOTOTECHNICAL SYSTEMS (COMPLEXES)

An efficient approach of counteraction to the use of land-mobile robototechnical systems (complexes) of the enemy on the battlefield through the suppression of the satellite radio-navigation system is proposed.

Keywords: *mobile robot and satellite radio navigation, GPS, GLONASS, GALILEO*

Statement of the problem

The nature of armed combat in wars and armed conflicts of the early 21st century determines appearance and development of fundamental changes in the basic regulations of military strategy and operational art , including:

- increased rate of deployment and conducting combat operations;
- the war is complemented with qualitatively new component which is the information component;
- put forward are the forms and methods of combat operations, involving the coordinated use of disintegrated troops and equipments;
- continuous influence on the enemy that requires accurate coordination of efforts in time and space

This requires full cooperation in gaining information it means the compulsory formation of the so-called «unified information space» of the battlefield, which «adequately reflects on an electronic map the operational and tactical situation on the battlefield in real time mode and which is identical in the control bodies of all hierarchical levels of control system» [3].

Different types of intelligence (radar, electronic, thermal imaging, visual, etc.) and navigation are the basis of formation of the «unified information space».

Automatic collection of information on location of friendly and enemy ground forces as well as displaying it on electronic maps is realized through the combination of two basic information systems: the GIS and the navigation systems, the content of which includes the shipping information for effective movement of ground moving objects in a unified grid and time space.

This is to determine that in the present situation the military experts from major world countries view navigational information as one of the main types of troop's combat support.

Analysis of recent achievements and publications

The problem of establishing of effective means of counteraction the use of land-mobile robototechnical systems (complexes) on the battle field is new and is carefully studied.

Statement of the task

The aim of the article is to investigate ways to counter the use of land-mobile robototechnical systems (complexes) on the tactical battlefield level is to pay due attention to the problem of preventing interference in navigating signals in the development of national land-mobile robototechnical systems (complexes).

Research core materials

The development of production of radio-electronic devices led to appearance and development of radio navigation systems first ground based, and then the satellite based ones. Satellite radio navigation systems can perform a number of different tasks with high accuracy and reliability.

These systems employ space beacons – navigation satellites. Navigation radio signals have ephemeris information containing parameters of movement of navigation satellites.

5-6 navigation low elevation orbital satellites in circular orbits about 1000 km above the Earth were included in the orbital grouping of the first generation satellite radio navigation systems represented by the «Transit» (USA) and the CICADAS (USSR) systems, developed and put into operation in the 60s of last century. They had some significant drawbacks stating that they:

- couldn't figure out the height of the ground objects;
- provided low accuracy of the planned coordinates (about 100 m errors) through improper accounting of own movement of ground objects;
- had too long intervals between observations.

The need for high-precision navigation for the Army, NAVY and the Air Force led to the creation of the medium orbital systems of satellite navigation: NAVSTAR GPS in the U.S. and Russian GLONASS and GALILEO in the EU in the 80-90s of the last century.

Satellite navigation systems of the second generation were created to provide troops and military equipment with grid and time information about the location and movement of troops. The advantages of using satellite navigation devices were so impressive that the U.S. GPS equipment was modified for civil needs, cancelling the selective access which was about 10 times worsening the location accuracy standard [1].

However, widespread use of satellite navigation in the military field, with experience of modern military conflicts during peacekeeping operations in Yugoslavia, Iraq and Afghanistan, revealed a number of shortcomings.

Jamming the satellite navigation signals [2] was used quite effectively to counter means of aiming of cruise missiles and aircraft, which led to self-destruction of cruise missiles during the flight, as well as nonstandard flights of the same missiles at unauthorized trajectories. The reason for this was the use of phase-modulated signals considered the most protected from interference in the satellite navigation systems. However, it appeared that in order to drown out the satellite navigation signals, it was sufficient to emit modulated sinusoidal electromagnetic waves, while the transmitter power could be only a few watts [3].

Today a number of leading countries have actively developed the satellite navigation signal jammers which a serious threat to the navigation systems of the Armed Forces. These concerns will become even stronger with the start of the widespread use of so-called intelligent transportation systems, including land-mobile robototechnical systems (complexes) to be necessarily equipped with locating means. These systems determine and report their own position (location) in order to create joint virtual environment image.

However, as a result of the active application of the satellite navigation signal jammers on the battlefield destroyed are not only navigation systems of such vehicles, but of other closely located objects such as: binding, guidance, and personal navigation systems, as part of the so-called "future soldier's kit", as well.

For example, a set of hi-tech outfit individual infantryman FELIN – is an abbreviation of Fantassin a Equipement et Liaisons Integres, which translated from French means "Infantryman's integrated equipment and communications means", which necessarily includes the GPS signal receiver with the ability of connecting a wide set of digital terrain maps.

In turn, the combat and support ground robotic systems (complexes) , which are currently undergoing the process of standardization, are primarily intelligent transport systems that determine and report their own location, resulting in creating a virtual picture of the real world based on their own geographical location.

This principle lies beneath a lot of automatic or automated movement control systems.

The GATE (Galileo Test Range) laboratory of the Bundeswehr University has conducted tests where actual conditions of use of GPS signal suppression [4] were simulated. Measurements were made using the experimental software receiver, which allowed analyzing the impact of noise using spectrum analyzer.

Most of the jammers emit modulated linear frequency (MLF) pulses in the frequency range from 9.4 to 44.5 MHz and are classified as focusing interference, effectively destroying the signals received by the navigation signal receivers.

Creation of (MLF) pulse is performed by the pulse oscillator, which is controlled by voltage with the input voltage of saw-tooth function. This is a sinusoidal function with a change in frequency over time, which can be described as:

$$x(t) = a(t) \cdot \sin\left(2\pi \int f(t)dt\right).$$

For the unidirectional linear MLF -signal the instantaneous frequency varies linearly with time:

$$f(t) = f_0 + kt,$$

where f_0 is the initial frequency;

k is the MLF degree .

The $a(t)$ amplitude is constant; the corresponding time domain for the sinusoidal unidirectional linear MLF signal is given as:

$$x(t) = a(t) \cdot \sin\left[2\pi\left(f_0 + \frac{k}{2}t\right)t\right].$$

All jammers are linear with a positive one- or two-directional sweep. The negative rake is so large that it cannot be neglected.

To obtain information about the synchronization of signals the analysis in the time domain by using a software-controlled radio bound was made.

Further processing was carried out using the MATLAB software package. Change in frequency upon time for the three types of jammers is shown in Figures 1, 2, 3, respectively.

If we compare the diagrams, we can see how the complexity of jammers is increasing. The type 1 jammer uses a standard saw-tooth voltage oscillator with an upward sloping line for incoming oscillator pulse.

Type 2 jammer uses two saw-tooth voltage oscillators with decreasing angle; sweep time is increased four times. Type 3 jammer has totally four oscillators.

Various obstacle static and dynamic tests that have shown the active influence of GPS signal jammers on satellite navigation system in real conditions were conducted in the GATE laboratory. The ratio of the noise relative density at the input indicated a weakened reception. As you move the receivers towards the jammers the adopted noise power increases with the distance according to the losses in free space.

These GATE laboratory data are consistent with the theoretical, provided that the input stage is not saturated, that is not being used to the maximum. If the input analog-to-digital converter is used for maximum value, it causes severe signal degradation which exceeds the degradation resulting from the increased power of noise before the signal lock. The degradation of performance of the GPS system causes an error in locating the position.

Measurements show that the existing jammers of GPS signals can actively influence the land-mobile robototechnical systems (complexes) at a considerable distance from the source of noise, and the location corresponding robotized product becomes completely impossible.

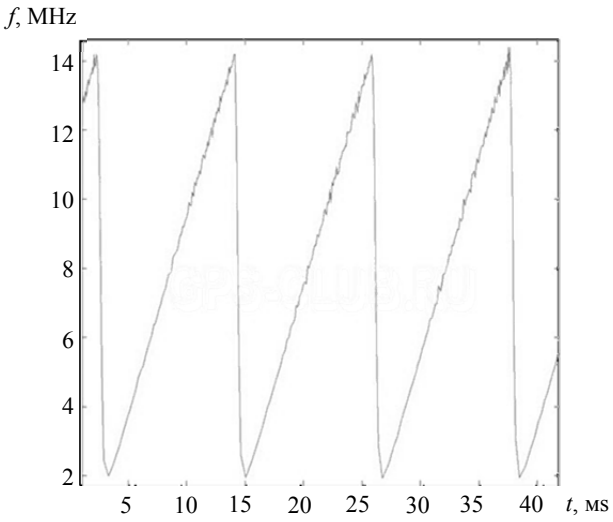

Fig. 1 - Frequency resource of type 1jammer

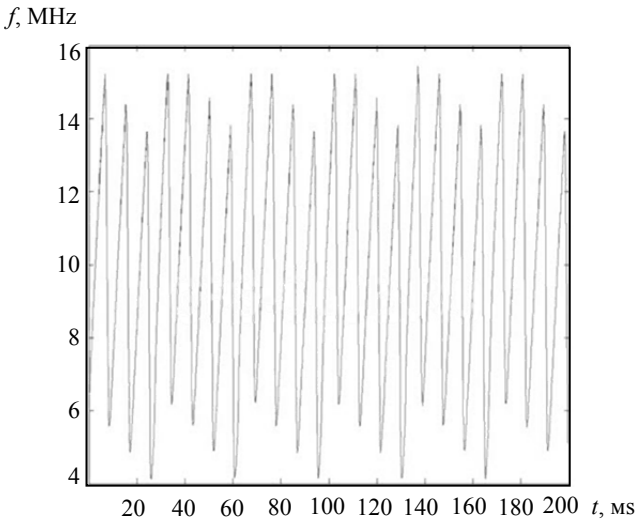

Fig. 2 - Frequency resource of type 2 jammer

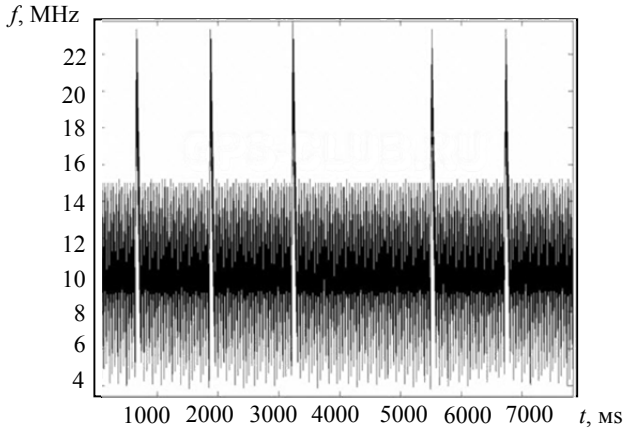

Fig. 3 - Frequency resource of type 3 jammer

Damaging the subsystem of navigation and topographic binding of mobile robots is a starting point to create significant barriers to the subsystems of movement and adaptive (intellectual) control, whereupon determining the current coordinates for the adequate representation of the environment and combat situation on the topographic background as well as laying and controlling the trajectory and timetable of the planned or desired route gets impossible.

Conclusions

Military experts point out that up to the year of 2025 the ground combat robot will be capable of fighting together with a human fighter, and often in his stead, to carry out a large number of tasks on the battlefield. [5] In

this case, the required level of «intelligence» of the moving robot, especially movement control system is determined by the degree of uncertainty of the environment, i.e. the degree of autonomy of land-mobile robototechnical system (complex) on the battlefield, which corresponds to the list of actions that may be performed without direct involvement of the human operator depends on the reliable navigation information.

Thus, jamming of the satellite navigation is an effective means of countering the use of land-mobile robototechnical systems (complexes) of the enemy on the battlefield.

Prospects for the further research

The analysis of the conditions of use of satellite navigation system by the land-mobile robototechnical systems (complexes) at the tactical level indicates that now there is a real opportunity to create an effective counteraction to their use by the enemy on the battlefield.

In addition, preventing interference in navigating signals should be the subject of a thorough research during the development of the national land-mobile robototechnical systems (complexes), moreover, creation a fully autonomous ground robotized combat means without that is meaningless.

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ПРИДУШЕННЯ СИСТЕМ СУПУТНИКОВОЇ РАДІОНАВІГАЦІЇ НАЗЕМНИХ РОБОТОТЕХНІЧНИХ СИСТЕМ (КОМПЛЕКСІВ)

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Запропоновано ефективний підхід щодо протидії застосуванню наземних робототехнічних систем (комплексів) противника на полі бою шляхом придушення систем супутникової радіонавігації.

Ключові слова: *мобільний робот, супутникова радіонавігація, GPS, ГЛОНАСС, GALILEO.*

ПОДАВЛЕНИЕ СИСТЕМ СПУТНИКОВОЙ РАДИОНАВИГАЦИИ НАЗЕМНЫХ РОБОТОТЕХНИЧЕСКИХ СИСТЕМ (КОМПЛЕКСОВ)

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Рассмотрен эффективный способ противодействия применению наземных робототехнических систем (комплексов) противника на поле боя путем подавления систем спутниковой радионавигации.

Ключевые слова: *мобильный робот, спутниковая радионавигация, GPS, ГЛОНАСС, GALILE.*