Optoelectronic Search Systems

Sergey V. SADKOV, Mikhail V. PONOMAREV, Alexey A. KOVALEV, Alexey V. KOVALEV, Association “SPEKTR-GROUP”, Moscow, Russia

Abstract. One of the hottest current tasks, in addition to provision of informational and personal security, is timely detection of remote hidden optical and optic-electronic surveillance systems (OESS). Between last ones sniper sights, video cameras of secret observation, night vision instruments, etc. can be mentioned. One of the most efficient methods of listed objects detection is the methods of laser location based on cat’s eye phenomena.
In the paper the basic schemes of developed instruments “Antiwatch-2”, “SPIN-2” designed for detections of various optic-electronic surveillance systems are presented as well as experimental results of research works and on-site tests. Discussed are the ways of this family instruments efficiency improvement.

Introduction

Currently a family of instruments able to detect optic-electronic surveillance systems (OESS) has been developed. The principle of operation of such systems and instruments is based on cat’s eye phenomena. This phenomenon occurs when OESS is illuminated by narrow band radiation beam. The phenomenon reveals itself in the following manner: regardless of the sensing radiation angle the reflected by OESS radiation propagates in the direction very close to the direction of incidence. The OESS itself acts as a light reflector. In the view field of receiving channel of the instrument the picked up reflection is presented as a white flare against the background. The flare (reflecting) feature of the OESS usually is analyzed upon its ability to reveal cat’s eye phenomenon that, in its turn, is determined by spatially-energetic, spectral, polarization parameters of the OESS and as an integral evaluation of this ability used is light-reflection parameter.
Like a source of sounding radiation for search of OESS, as a rule, used are laser sources that possess high monochromaticity and energy concentration. In the capacity of receiver use is made of charge-coupled device (CCD), intensity amplifier or hybrid matrix converter (HMC) in which intensity amplifier is joined with CCD matrix.

1. Principle of operation and some practical requirements

1.1. Detection of objects at long distances

When scanning or sounding the surface where suspected detection of hidden OESS the signal reflected from their optical-electronic components by order exceeds the signal from background. When the object, which search for, gets within the limits of illuminated by laser area (pattern) on the screen appears intensive glowing dot or spot of small diameter upon less bright background. The background usually presents images of some parts of building or other objects, the last ones can serve like tie in OESS coordinates. When the OESS leaves illuminated area (or when laser is switched off) intensive glowing dot disappears.

In fact operator compares two images of surveyed scenario – image in presence of laser illumination and image without such illumination – and by this simple operations detects “suspicious” flares appearing when illumination is present.
Long distances at which OESS detection should be provided define several requirements imposed on technical parameters of equipment of such type. For reliable detection of optical objects possessing cat’s eye feature at distances from 500 to 2000m the focal length of receiving lens should be at least 50mm (preferably 100mm) while laser power should be not less than 500mW. If to take into account the energy parameters the laser illumination divergence angle, as a rule, do not exceed 3 deg.
The laser can operate both in continuous or pulse mode. To eliminate the influence of background noise and improve the contrast ratio and hence to improve the detection reliability of the instruments it is required to have interference filter that strictly matches the laser working wave length.
In Fig. 1a presented is example of sniper sight of PO4x34 type detection at distance of 500m (laser illumination is on) by instrument “SPIN-2” developed in “Spectrum-RII”. In Fig. 1b presented is the image of the same scenario when laser is off.
The overview of this instrument is presented in Fig. 2. Its brief technical parameters are listed in Table 1.

a) laser is ON **b) laser is OFF**

Fig. 1. Detection of sniper sight of PO4x34 type (distance 500 m) with the help of «SPIN-2» instrument

Fig. 2. Overview of «SPIN-2» instrument

Table 1. Some technical parameters of "SPIN-2" instrument

Distance of searched object detection, m: • minimal (depend on the object type) • maximal	 5 1000
FOV of receiving channel, (HxV), deg	7 x 5
Laser pattern field, (HxV), deg	1 x 4
Power supply, battery, V DC	+7
Time of continuous operation, not less than, h	3
Operating temperatures range, ^{0}C	-10 … +40

In this instrument the laser beam pattern is vertical rectangular one with angle divergence of 1^0x3^0; this pattern covers only part of screen visible through viewfinders. The image of scanning laser pattern is presented in Fig. 3. In this case laser is operating in quasi-impulse mode. Vertical, rectangular pattern configuration makes space survey along horizontal line very convenient.

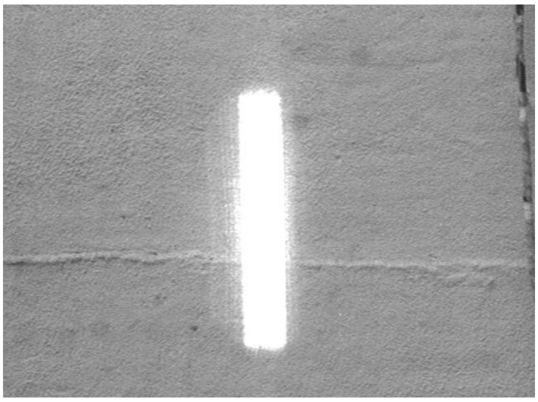


Fig. 3. Laser illumination pattern shape at distance 30m

It is necessary to mention that in general cases the probability of light reflecting optical objects detection strongly depends on on-site actual conditions, i.e. distance to the object, natural illumination, presence of background flashes and type of scenario background. Depending on these factors the maximal detection distance of the same objects can differ in several times.

The efficient method of detection distance increase implemented in instruments designed for OESS search, especially in severe climatic conditions, is based on special adjustment of receiving channel operating mode, i.e. use of gating option when some kind of time delay (determined by detection distance) is implemented. It means the receiving channel is switched on only in the moments when reflected from the OESS signal arrives.

But even this approach has two basic disadvantages. The first disadvantage is necessity to adjust the instrument to detection distance; and in this case the operator can see only limited part of surveyed area from the depth point of view. It means that operator has to perfume scanning not only along horizontal and vertical directions with set instrument parameters but along depth as well and the last one requires adjustment of parameters.

The second disadvantage is connected with operator's spatial disorientation when search for object is detected, this can be explained by the fact of "shallow" scanning of surveyed area, i.e. the tie in to the background is absent.

In the instrument presented in Fig. 2 these disadvantages were eliminated.

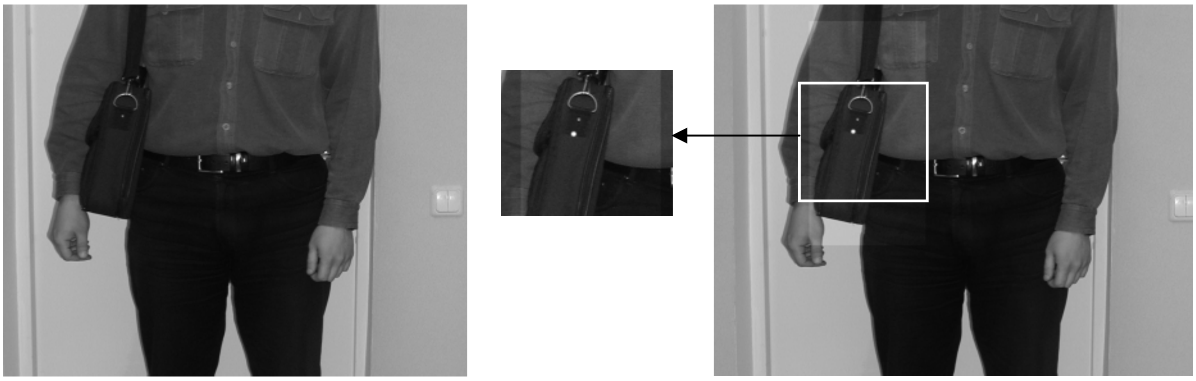
1.2. Detection of small-size objects at short distances

Detection of small size light reflecting objects (SLRO) impose a number of requirements on developed equipment, in particular, to detection distance. These type instruments are supposed to provide detection of small size optics at distances not less than 1m and not more than 10m. Small detection distance explains the necessity to develop instrument based on parallax-free optical scheme, i.e. combination of transmitting and receiving channels. `In instruments based on parallax schemes the minimal detection distance will be specified by distance (base) between receiving and transmitting channels as well as by field of views (FOVs) of above channels. It is clear that simultaneously with increase of FOVs the system resolution is deteriorating and the illumination power is increasing. In Fig. 4 presented is instrument “Antiswid-2” (Antiwatch-2) developed by “Spectrum-RII” in which mentioned disadvantages were eliminated due to implementation of parallax-free optical scheme. This instrument provides detection of SLRO at distances up to 15m. Specification is given in Table 2 while in Fig. 5 presented is example of detection of video camera with 1mm diameter “pinhole” type lens in standard conditions (normal room illumination); the camera is hidden in the bag. Fig. 5a & 5b demonstrate the difference of image and detection of hidden camera in presence of laser illumination.

Fig. 4. Overview of instrument “ANTIWATCH-2”

Table 2. Some technical parameters of “ANTIWATCH-2” instrument

Distance of searched object detection, m: • minimal • maximal	 1 15
FOV of receiving channel, (HxV), deg	8 x 6
Laser pattern field, (HxV), deg	2 x 5
Power supply, battery, V DC	+7
Time of continuous operation, not less than, h	5
Operating temperatures range, ^{0}C	-10 … +40



a) laser illumination is switched Off; b) Laser illumination is switched On.

Fig. 5. The sample of detection of video camera with lens of pinhole type.

Conclusions

Used technical solutions and improvements make it possible to develop instruments of new generation. These instruments help to solve tasks of public and economical safety in more easy and reliable manner.