Semiconductor Physics, Quantum Electronics & Optoelectronics, 2022. V. 25, No 2. P. 219-226.

Intelligent electronic-optical sensor for information-measurement system of detection and identification of ground and aerodynamic objects

Ya.I. Lepikh, V.I. Santoniy, L.M. Budiyanskaya, V.I. Yanko, A.P. Balaban

Interdepartmental Scientific and Educational Physicotechnical Center
of the Ministry of Education and Science and the National Academy of Sciences of Ukraine
at the Odesa I.I. Mechnikov University; e-mail: ndl_lepikh@onu.edu.ua

Abstract. This work describes an original intelligent electronic-optical (laser) sensor (EOS) operating in the infrared range for systems that detect ground and aerodynamic objects and send control commands to the executive devices of portable information-measurement systems using specified algorithms. EOS proposed here differs from the known analogues by its ability of early detection and recognition of high-speed special machinery objects and small-sized unmanned aircrafts. EOS generates and sends probing optical pulses in the direction of a monitored high-speed object, processes the reflected location signal and retrieves the object coordinates and motion parameters. The classification features of the object are determined from the parameters of optical location signal used for object identification with the account the specific nature of optical location information systems.

Keywords: electronic-optical sensor, optical location signal, algorithm, information-measurement system.

https://doi.org/10.15407/spqeo25.02.219
PACS 42.79.Pw, 42.79.Qx

Manuscript received 22.10.22; revised version received 03.06.22; accepted for publication 22.06.22;

1. Introduction

Modern level of the complexity of tasks solved with the help of information systems constantly increases. The main trend in the development of modern optical location systems is to improve the accuracy of the detection of objects moving under the conditions of artificial and natural external optical jamming and measurement of their motion parameters by creating high-precision intelligent adaptive electronic-optical (laser) sensors (EOS) [1–5]. Because of the complex operation conditions of monitored objects, such as fast change of parameters in time, the increase of EOS operation speed, sensitivity and stability under the influence of external jamming to avoid false positives has become necessary. The main challenge in creating EOS is to determine the classification features for object recognition in the reflected signal [4, 5]. Infrared laser EOS is the main element of a portable high-precision information-measurement system for the detection and identification of ground and aerodynamic objects. EOS emits a probing laser beam in the direction of monitored object as well as detects and analyzes the reflected signal to obtain the information about the object. EOS operation is based on the developed algorithm for adaptation to noises and jamming and recognition methods, which use plausibility criteria and artificial intelligence. Using optical location methods, EOS detects, identifies the object and measures its parameters under the conditions of high-speed motion and presence of destabilizing factors.

2. Block diagram of EOS and schematic diagram of measurement channel

The main element of the detection information system is laser EOS, which measures the motion parameters and the relative geometric dimensions of monitored objects [6–8]. The EOS measurement channel is based on the analysis of the phase relations of irradiation signal and the photo of response. The structural scheme of developed EOS is shown in Fig. 1.

3. Algorithm of EOS operation according to the structural scheme

The signal from the master oscillator (ZG) *1* amplified by the power amplifier *2* modulates the current of the laser emitter (LV) *3*. The intensity-modulated laser radiation is directed by lenses onto the reflecting surface *4* of monitored object. The part of the radiation reflected from the surface of the object is intercepted by the receiving lenses and focused on the photodetector plane (FP) *5*.

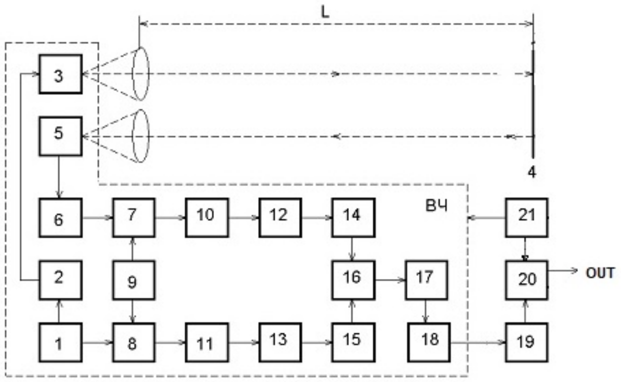


Fig. 1. EOD block diagram. *1* – main generator (ZG), *2* – laser power amplifier, *3* – laser emitter (LV), *4* – reflecting surface, *5* – photodetector (FP), *6* – resonant amplifier, *7*, *8* – mixers, *9* – local oscillator, *10*, *11* – broadband amplifiers, *12*, *13* – band filters, *14*, *15* – amplifier-limiters, *16* – phase detector, *17* – low-frequency filter (LPF), *18* – repeater, *19* – analog-to-digital converter (ADC), *20* – microcontroller (MK), *21* – power supply unit, *L* is the distance to the surface of monitored object.

The electrical signal received from AF is amplified by the resonant amplifier *6* synchronized with the ZG first harmonic. The ZG reference signal and the measurement signal passing through the delay line of the open optical channel are multiplied with the local oscillator signal by the mixers *7* and *8* and their amplitudes are amplified by the broadband amplifiers *10* and *11*. The differential low-frequency signals of the intermediary frequency of reference and measurement channels are extracted by the band filters *12* and *13* and are fed to the phase detector *16* through the amplifier-limiters *14* and *15*. The output signal from the detector *16* is fed to the input of the filter *17*. The repeater *18* matches the output resistance of the low frequency filter (LPF) and the load. The measured signal is digitized by the analog-to-digital converter (ADC) *19* and enters the input of the microcontroller *20*, where it is processed according to the internal algorithm. The measuring part and the microcontroller are supplied by the autonomous power supply unit *21*. The schematic diagram of EOD measurement channel presented in Fig. 2 is developed for performing real tests and elaboration of operation modes and interaction of analog part with the calculation unit.

The scheme includes the following functional units. Optical signal emitter unit consists of the generator of measurement signal made of the elements DD1.1…DD1.4, modulator T1 and emitter S1. The frequency of measurement signal is stabilized by the quartz resonator Q1 (10.7 MHz) and precisely tuned by the capacitor C1. The dynamic current range through the emitter is set by the resistors R16 and R17. The resistor R16 sets the maximum value of the operation current of the emitter. The total value of R16 and R17 determines the minimum value of the operation current of the emitter. The AF unit is made up by the photodiode S2 and the resonant amplifier based on a low-noise field-effect transistor T2. The generation unit of measurement and reference signals consists of the local oscillator made of the elements DD2.1…DD2.4 and two frequency converters A3 and A4 (m/s SA612A). The frequency of the local oscillator is stabilized by the quartz resonator Q2 and the capacitor C5. The value of this frequency is set by 1000 Hz lower as compared to that of the generator of measurement signal. A low-frequency filter is represented by the elements R36, R37, C34 and C35. Amplifier-limiters units are made of the elements A6...A8. A digital multiplier of measurement and reference signals is implemented using the elements DD3 and DD4. The repeater of analog signal is based on the operational amplifier A10. The circuit also includes DC voltage stabilizers realized on the chips A1, A2, A5, A9, A11 and A12, which provide individual power supplies to the above described units.

4. Algorithm of the operation of the schematic diagram of EOS measurement channel

The measured signal with a frequency of 10.7 MHz is fed from the output of the element DD1.4 of the generator of measurement signal to the “gate” of the transistor T1. The latter modulates the current through the emitter S1. The modulated optical signal from LV is directed by the optical system towards an object, the distance to which is measured. The signal reflected from the object surface is fed to AF S2 through the receiving system and modulates the current in its circuit. The AF load in the input circuit of the L2C8 resonant amplifier is set to a frequency of 10.7 MHz. The signal with amplified amplitude is fed from the output circuit of the amplifier L4C18 through a transformer connection to the input of a frequency converter assembled on the chip A4. The second input of the converter (pin 1) receives a signal from the local oscillator. The generation frequency of the latter is less than the frequency of the master generator of measurement signal by 1000 Hz. The low-frequency component of the converted measured signal, separated from the RF components by the filters C19 and C21, is fed to the input of the amplifier-limiter made of the elements A6 and A8.

The measurement low-frequency signal is fed from the output of the amplifier-limiter to the input of a digital multiplier made of the elements DD3 and DD4. Its second input receives a reference low-frequency signal obtained similarly to the measurement one by multiplying the signals of the master measurement generator and local oscillator. Signal multiplication is carried out using the chip A3. The low-frequency component of the signal is further extracted by the filter C24 and C26 and amplified by the element A7. The reference and measurement signals of equal frequencies of 1000 Hz multiplied by the digital multiplier are shifted in phase relative to each other resulted from the time delay of measurement signal due to passing double distance to the object. These signals are fed to the RF filter R36, R37, C34 and C35. A constant voltage is formed at the output of the RF filter.

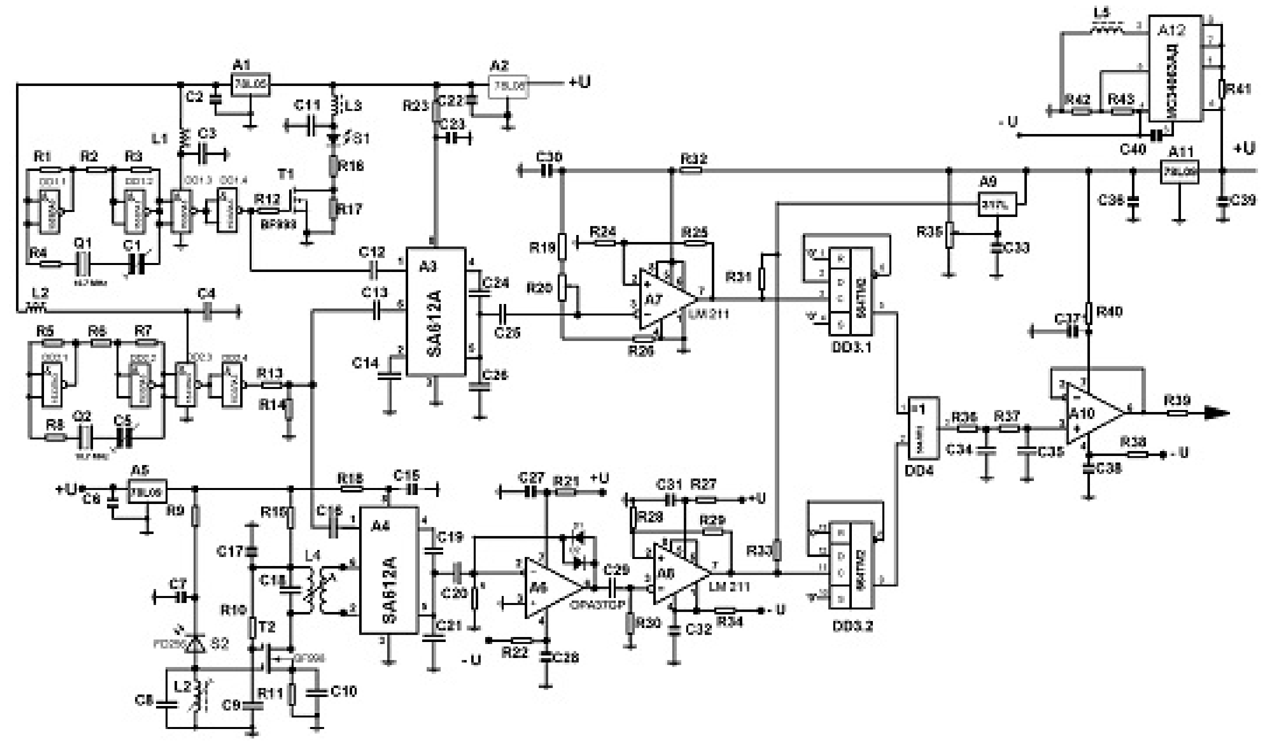


Fig. 2. Schematic diagram of the EOD measurement channel.

The amplitude of this voltage is directly proportional to the phase difference between the reference and measurement signals and varies linearly. The obtained DC voltage is fed to the microcontroller through the analog repeater A10, where the motion parameters and the relative geometric dimensions of monitored objects are calculated.

In order to obtain high stability of measurement parameters over time, mutual influences of the EOS functional units were estimated. It should be noticed that operation of EOS is based on the proximate location principle and its design encounters classical problems for this class of devices, namely:

– the ratio of the values of signals in the emitting and receiving parts is 150 dB;

– the complexity of the time separation of emitted and received signals due to the short travel time of measurement signal;

– arrangement of emitting and receiving parts in the same construction.

The greatest issue is the electrical crosstalk from the emitter on the electrical input of the low-noise amplifier of optical signal. The amplitude of this crosstalk is comparable to the signal received from the photodetector. This changes the phase of signal at the output of the electronic path, but the sensitivity limited by noise is not a critical parameter. The level of received optical signals under all operation conditions is above the noise threshold of the input amplifying element. Therefore, noise does not limit the integral sensitivity of EOS. This is achieved by using modern element base in the input circuits.

Industrial jamming cannot as well significantly reduce EOS sensitivity at long measured distances due to the narrow band of the input amplifier as well as the absence of structural elements acting as receiving antennas of jamming at the operation frequency of the gauge (8 MHz). Therefore, the required EOS sensitivity is achieved by multi-level shielding of the structural elements of the transmitting and receiving units as well as by rigorous electromagnetic decoupling of electrical power supply circuits and control signals.

5. Phase sensitivity and parasitic couplings of EOS design elements

It is known that parasitic couplings can be the combinations of three coupling types, namely: transformer (inductive), capacitive and electromagnetic. Due to the smaller size of EOS structural elements as compared to the wavelength of measurement signal (by about two orders of magnitude), the electromagnetic coupling may be excluded.

We determined shielding coefficients according to the classical methods of calculating the parameters of parasitic couplings in electronic circuits [6]. The optimal layouts of units, electromagnetic screens and circuits for decoupling power supply and control signals were designed by computer modeling.

The assembly diagram of the EOS measurement channel is shown in Fig. 3.

To reduce capacitive couplings, the functional units of EOS were placed in separate compartments.

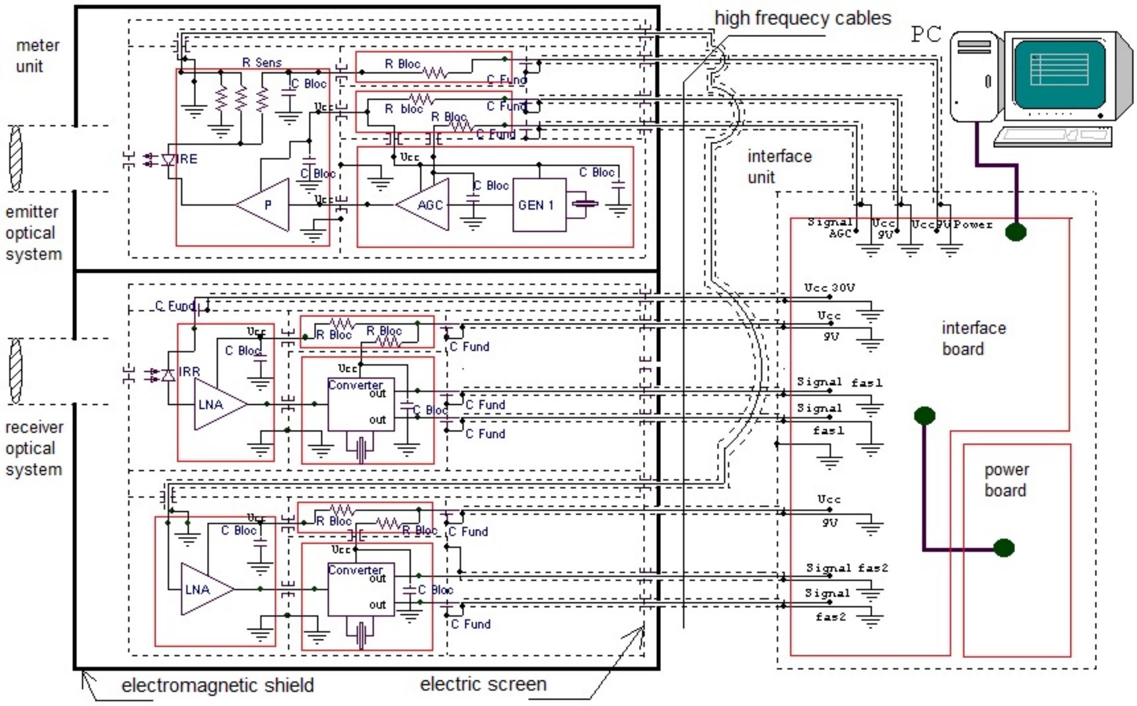


Fig. 3. Wiring diagram of the measurement channel of intelligent EOS.

SMD technology and a permalloy plate screen separating the structural elements of the emitter and receiver were used to reduce the transformer connection of conductors with high-frequency (RF) currents of the emitter unit and the input circuit of the low-noise optical signal amplifier.

During the production of an EOS sample, the conductors supplying power and transmitting control signals to individual compartments of the structure were filtered and decoupled. A shielded cable was used to apply bias voltage to the receiving photodiode. Radio elements were assembled on double-sided printed circuit boards. The opposite board surfaces were used as an electric screen. Parasitic capacitances between the elements and the screen did not impair the electromagnetic compatibility.

The connections between the EOS units are shown in the wiring diagram (Fig. 3). Two structural units may be separated, which are used for measuring the distance, namely:

– measurement unit; and

– interface unit, which supplies power to the system and provides links between the units.

The measurement unit consists of two optical systems and, accordingly, two signal processing nodes – the receiving and transmitting ones [7]. These nodes located in the same housing are separated into two compartments with high mutual shielding. The receiving node has a cellular design. Individual cells contain functional modules assembled on the miniature printed circuit boards by SMD technology. The elements in the compartments and individual cells are electrically connected by conductors in Teflon insulation, which pass through the 0.5 mm holes. The power to the cell of the input low-noise transistor is supplied by a shielded cable. The measurement and interface units are connected by a bundle of three shielded cables. The interface unit is assembled on a printed board by SMD technology and placed in a shielded case.

The developed computer software executes the algorithm of EOS operation. Laboratory tests of OED in static and dynamic regimes were carried out based on the developed software structure that implements the main EOS functions, measurement algorithm and calculation of target parameters. Experimental studies enabled to identify key causes of the reduction of EOS phase sensitivity and develop technical solutions to decrease their negative impact on the accuracy and reliability of measurements. Technical calculations and computer modeling of the electromagnetic compatibility of nodes and structural units were performed. The optimal designs of transmitting and receiving nodes were developed and a functional model of EOS was created.

A method of the research of destabilizing external factors is developed to identify optical signals under nonstationary jamming conditions. Main patterns are established and corresponding physical and mathematical models are developed. Physical and computer methods with mathematical support are used. A software structure for processing rapidly changing information in the remote space control by the methods of structural and object-oriented programming is created. It implements four functions, tentatively called “Instrument”, “Calibration”, “Experiment” and “Processing” [8].

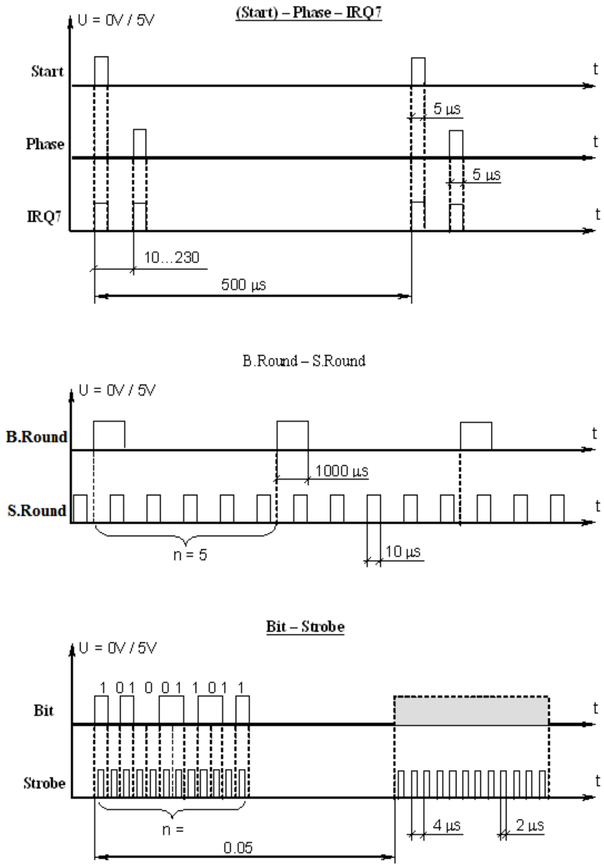


Fig. 4. Time diagrams of input and output signals.

Receiving EOS measurement signal from outside and its processing are considered for the "Device" function as an example. The signal diagram (Start) – Phase – IRQ7 is shown in Fig. 4. The EOS electronic circuit generates a signal (Start) every 500 µs.

The measured distance is indicated by the interval between the leading edges of the signals (Start) and Phase. A duration of 10 µs corresponds to the minimum distance. Based on the measurement algorithm, the duration of the signal Phase must be greater than 250 µs. The software analyzes the presence of signal asynchronously and periodically at intervals of about 2 µs. The nominal duration of the signals (Start) and Phase is set to 5 µs. The IRQ7 signal is the sum of the signals (Start) and Phase.

The minimum time interval between the leading edges of the signals (Start) and Phase corresponding to the minimum measured distance is about 10 µs, and the maximum time interval is about 230 µs [9]. The software must measure this interval with the maximum possible accuracy. For this purpose, the interval is filled with counting pulses at the frequency of the microprocessor generator.

The B.Round signal (tracking signal change) is analyzed once every 500 µs not to omit positive difference. Its duration is set to 1000 µs (the diagram of B.Round-S.Round signals is shown in Fig. 5).

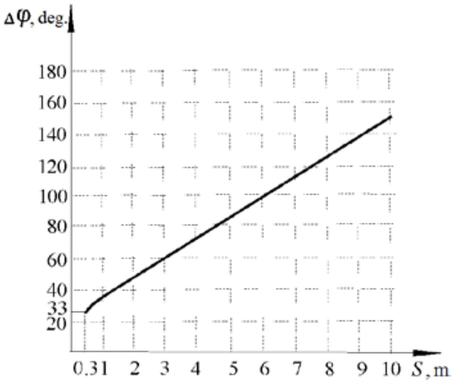


Fig. 5. Calibration characteristics of EOS.

EOS distance characteristics were measured at different values of parameters characterizing the experimental conditions, namely: the level of the illumination of the object surface, and the temperature and reflection coefficient from the object surface.

The measurements were performed according to the following repeated algorithm. The minimum value of the distance of 10 cm was first set on the set-up. After this, the step of the measurements of distance characteristic Δl was defined.

1. The conditions of experiment are set (measured).
2. The value of basic information signal (phase shift) is measured N times (the process is automatic).
3. The expected values m_1 and the variances δ for a given distance are calculated and fixed. The value of N (number of measurements) is a constant parameter during the entire process of the measurements of distance characteristic.
4. The value of distance greater than the previous one by Δl is set on the set-up.
5. If the distance range is not covered the algorithm goes to the step 3.
6. If the distance range is covered the measurement algorithm of distance characteristic ends.

Based on the obtained characteristics, the optimum EOS design was proposed, the technical characteristics of which are presented in Table.

Table. Technical characteristics of EOS.

Factor	Characteristics
Source of optical radiation	GaAs laser diode
Type of modulation	Amplitude
Modulation frequency (basic)	7.5 MHz
Photodetector	Si *p-i-n* photodiode
Measured distances: S_{min} S_{max}	0.3 m 10.0 m
Relative accuracy of measurements	±1.0%
Maximum speed to achieve this accuracy	100 m/s
Single-run measurement time	0.15 ms

The most informative are the distance characteristics measured under different experimental conditions, *i.e.* the dependence of the main information signal (as a four-digit number with fixed point, equal to the phase shift between the measurement and reference signals) on the distance to the object. The accuracy of numerical value is determined by the EOS hardware. The distance was determined in EOS using an experimentally measured calibration characteristic $\Delta\varphi = f(S)$ (Fig. 5), which is the dependence of output information signal $\Delta\varphi$ (phase shift) on the controlled input distance S.

The measurement algorithm of $\Delta\varphi$ includes measurements of not only the absolute value of time interval t corresponding to the phase mixing, but also the duration of measurement period T. The entire measurement period includes both positive and negative change of sinusoidal singnal level in the EOS electronic circuit. At this, the distance is indicated not by the absolute value of t, but by the ratio of this value to the duration of measurement period T. This enables to increase the allowable instability of the frequency of quartz generators to the level of 10^{-9} that excludes their additional thermal stabilization.

Analysis of calibration characteristic showed that deviations from linearity to smaller values appear near the boundaries of measured distance range. Measurement accuracy or variance deteriorates in the nonlinearity ranges of 0.3 to 0.5 m and above 4.5 m and does not exceed 1%. These nonlinear ranges of the calibration characteristic are caused by both external conditions (variable reflection coefficient of the object surface), and internal crosstalks from the emitting unit. The dispersion value at large and very small distances was reduced by increasing the power of location optical signal and improving the shielding of the power amplifier in the emitting unit.

Hence, experimental laboratory studies of the results of the measurements of the metrological characteristics of EOS in static and dynamic tests using a developed software, containing both visual control and numerical evaluation of measurement accuracy, demonstrate high reliability of the computer analysis of EOS. The measurement error is shown not to exceed the normalized level of 1%. The information flow in the created EOS reaches 1.6 Mb/s that relates the latter to high-complexity-class devices.

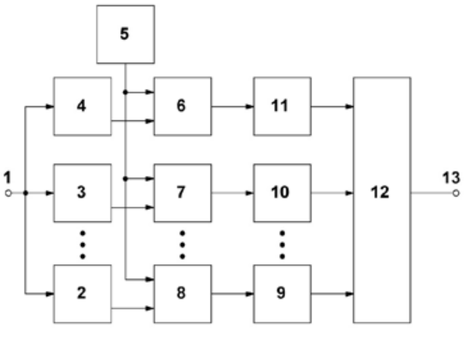


Fig. 6. Block diagram of the object classifier. *1* – measurement data; *2*, *3*, *4* – objects; *5* – signature library; *6*, *7*, *8* – design angle; *9*, *10*, *11* – adder; *12* – choice of the highest value; *13* – decision.

EOS with a higher level of detection and identification is developed based on the information about the characteristics of natural and artificial objects. Each object is characterized by a number of features, the most essential of which are height, length, area, and the terrain roughness coefficient. These classification features make the basis of the object classifier, which increases the detection probability. The algorithm for processing incoming information with higher level of target identification, which uses plausibility criteria, consists of 8 stages:

1 – selection of detection zone (surface), where the object is located;

2 – calculation of reference height between EOS and the reflecting surface;

3 – construction of obstacle profile;

4 – determination of the minimum and maximum current height of flat intersections characterizing the object;

5 – measurement of object width;

6 – adaptation of height jump recorded at the fourth stage;

7 – check for the presence of straight lines on the object surface;

8 – calculation of object length.

For classification of objects based on the distinction of geometric specific features (signatures), optoelectronic measurements of the geometric parameters of an object with sequential processing in N parallel channels is used. The data from the libraries are represented by a single vector in the feature space. The position of this vector uniquely depends on the shape and size of object. The object is classified by determining the minimum degree of similarity between the measured and library data [10]. The block diagram of the object classifier is shown in Fig. 6.

The measure of proximity is the plausibility function, which is a function of probability density. For each measurement, the classifier calculates and selects an object that corresponds to the maximum value of plausibility function. Such approach allows the synthesis of classification algorithm, since the input data are processed without adjusting and fitting unknown parameters with the adaptation of decision rule to object motion.

6. Conclusions

The approach used in this work to create intelligent EOS provides complex processing of optical location signals to obtain reliable information related to early detection and identification of high-speed objects.

Use of laser IR emitter and development of corresponding algorithm enabled to create an intelligent adaptive EOS for information and measurement system, which detects and automatically identifies optical location objects, taking into account external conditions and destabilizing factors as well as nonstationary operation conditions.

EOS adapts its parameters to external conditions, corrects errors, sincronizes the sensitivity and dynamic range of measurement path and signal source as well as provides a 100% protection against false positives.

The intellectual electron-optical sensor has no analogues by the set of mentioned characteristics.

Acknowledgments

The authors are grateful to the administration of the M.K. Yangel Design Bureau “Pivdenne” for financial support and valuable expert advices during discussing the work results.

References

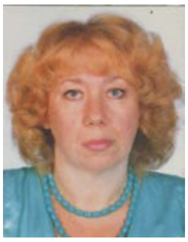
1. Akyildiz I.F., Su W., Sankarasubramaniam Y., and Cayirci E. Wireless sensor networks: a survey. *Computer Networks*. 2002. **73**, No. 4. P. 393–422. https://doi.org/10.1016/S1389-1286(01)00302-4.
2. Arora A., Ramnath R., Ertin E. *et al*. ExScal: elements of an extreme scale wireless sensor network. In: *11th IEEE Int. Conf. on Embedded and Real-Time Computing Systems and Applications* (*RTCSA’05*), Hong Kong, China, August 2005. P. 102–108. https://doi.org/10.1109/RTCSA.2005.3.
3. Vorontsov M. Overview of long-range (149 km) laser beam propagation and atmospheric sensing experiments. Imaging and Applied Optics 2019. *OSA Technical Digest* (Optical Society of America. 2019). JW2A.36.
4. Guthery C.E., Hart M. Theory and design of a hybrid wave-front sensor for adaptive optics. Imaging and Applied Optics 2019. *OSA Technical Digest* (Optical Society of America. 2019). PTu3 C.4.
5. Donval A., Fisher T., Blecher G., Oron M. Dynamic sunlight filter (DSF) – a passive way to increase the dynamic range in visible and SWIR cameras. *SPIE Proc*. 2010. **7660**. P. 766024 (8 p.). https://doi.org/10.1117/12.852495.
6. Levis P., Madden S., Polastre J., Szewczyk R. TinyOS: An operating system for sensor networks. In: *Ambient Intelligence*, W. Weber, J.M. Rabaey, E. Aarts (Eds.). New York, NY, Springer-Verlag, 2005. P. 115–148. https://doi.org/10.1007/3-540-27139-2_7.
7. Ivanchenko I.A., Lepikh Ya.I., and Budiyanskaya L.M. Application of optics-geometrical method in short-range optical radar. *Radioelectron. Commun. Systems*. 2012. **55**, No. 2. P. 82–88. https://doi.org/10.3103/S0735272712020045.
8. Lepikh Ya.I., Ivanchenko I.A., Budiyanskaya L.M., Santoniy V.I. Ways of intellectualization of an optoelectronic sensor. *Sensor Electronics and Microsystem Technologies*. 2014. **11**, No. 2. P. 61–64. https://doi.org/10.18524/1815-7459.
9. Lepikh Ya.I., Santoniy V.I., Yanko V.V. *et al.* Direct phase method of measuring small distances by an optical-electronic sensor at dynamic conditions. *Sensor Electronics and Microsystem Technologies*. 2015. **12**, No 4. P. 37–43. https://doi.org/10.18524/1815-7459.
10. Yanko V.V. PSpice-modeling of optoelectronic locators. *Technology and design in electronic equipment* (*Tekhnologiya i konstruirovaniye v elektronnoy apparature*). 2006. No 4. P. 14–17. http://dspace.nbuv.gov.ua/handle/123456789/52963.

Authors and CV

Lepikh Yaroslav Illich, Professor, Director of the Interdepartmental Scientific and Educational Physico-technical Center of the Ministry of Education and Science and the National Academy of Sciences of Ukraine at the Odesa I.I. Mechnikov National University. Research interests is physics and technology of semiconductors, acousto- and optoelectronics, nanoelectronics, sensors. Author of more than 500 scientific articles, more than 50 patents, 5 monographs, 7 scientific manuals. E-mail: ndl_lepikh@onu.edu.ua; https://orcid.org/0000-0001-6769-835X

Yanko Volodymyr Vasyliovych, Researcher at the Odesa I.I. Mechnikov National University. Research topics are development and creation of opto-electronic information and measurement systems, methods and principles of their physical and computer modeling, as well as design and development of simulation equipment. Author of more than 60 publications, 10 patents, 1 monograph. E-mail: yankovova@gmail.com; https://orcid.org/0000-0002-4711-4211.

Santoniy Volodymyr Ivanovych, Senior researcher at the Odesa I.I. Mechnikov National University. Research topics are development and creation of opto-electronic information and measurement systems, methods and principles of their physical modeling, as well as design and development of simulation equipment. Specialist in microelectronics. Author of more than 150 publications, 12 patents, 1 monograph. E-mail: vsantoniy@ukr.net; https://orcid.org/0000-0002-8605-7803



Budiyanskaya Lyudmyla Mykolaivna, Senior researcher at the Odesa I.I. Mechnikov National University. Research topics are development and creation of opto-electronic information and measurement systems, methods and principles of their physical modeling. Author of more than 70 publications, 5 patents, 1 monograph. E-mail: dirsony@ukr.net; https://orcid.org/0000-0003-0481-5576.

Balaban Andrii Petrovich, Senior researcher at the Odesa I.I. Mechnikov National University, PhD in Physics and Mathematics. Research interests are physics and technology of semiconductors, acousto- and optoelectronics, nanoelectronics, sensors. Author of more than 80 publications.
E-mail: semst-journal@onu.edu.ua;
https://orcid.org/0000-0002-6372-479X

Authors' contributions

Lepikh Ya.I.: conceptualization, methodology, writing – review & editing.
Santoniy V.I.: conceptualization, methodology, resources, writing – original draft, writing – review & editing.
Budiyanskaya L.M.: validation, investigation, writing – original draft.
Yanko V.I.: conceptualization, methodology, software, formal analysis, visualization.
Balaban A.P.: validation, investigation, resources, data curation

Інтелектуалізований електронно-оптичний датчик для інформаційно-вимірювальної системи виявлення та розпізнавання наземних та аеродинамічних об'єктів

Я.І. Лепіх, В.І. Сантоній, Л.М. Будіянська, В.І. Янко, А.П. Балабан

Анотація. Описано створений інтелектуалізований електронно-оптичний (лазерний) датчик (ЕОД) інфрачервоного діапазону для системи, що виявляє наземні та аеродинамічні об'єкти та відповідно заданим алгоритмам видає керуючу команду на виконавчий пристрій портативної інформаційно-вимірювальної системи. ЕОД відрізняється від відомих можливістю раннього виявлення та розпізнавання швидкісних об'єктів спеціальної техніки та малорозмірних безпілотних літальних апаратів. ЕОД формує і посилає зондуючі оптичні імпульси у напрямку досліджуваного швидкісного об'єкта, обробляє відбитий локаційний сигнал та визначає координати і параметри руху об'єкта виявлення. Розроблений ЕОД здійснює визначення класифікаційних ознак за параметрами оптичного локаційного сигналу, за якими проводиться розпізнавання об'єкта, з урахуванням специфіки інформаційних систем оптичної локації.

Ключові слова: електронно-оптичний датчик, оптичний локаційний сигнал, алгоритм, інформаційно-вимірювальна система.