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PROTECTIVE ENCODING OF INFORMATION CARRIERS. (Protective encoding of information carriers, including optical discs and digital external information carriers)

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Abstract

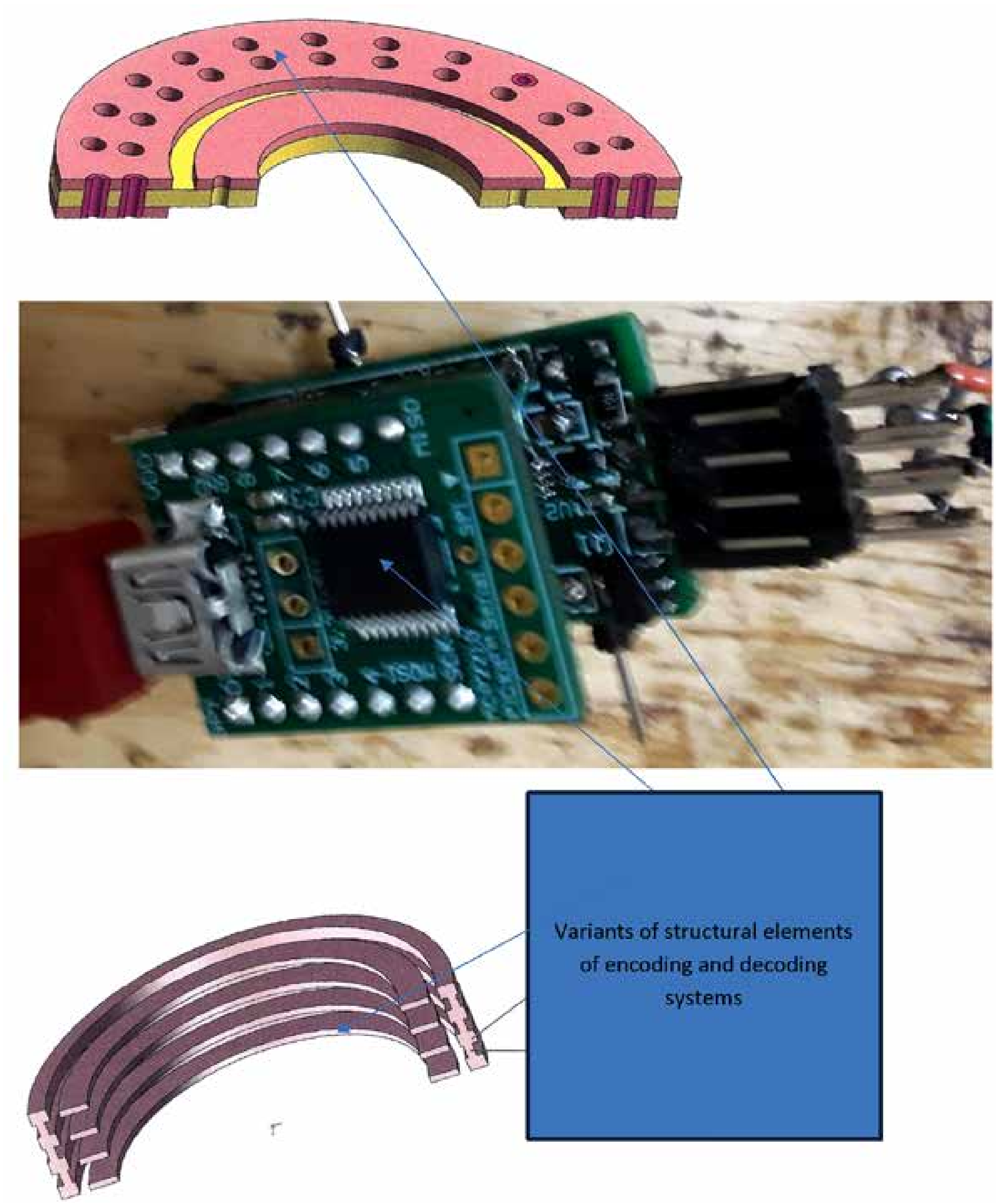
The article examines a technology for the protective encoding of information carriers based on the application of a coding coating and the subsequent identification of its parameters through resonance measurement methods. The proposed technical solutions are intended for the protection of optical discs and digital external information carriers, including single-layer and multi-layer optical storage systems. Special attention is given to the principles of encoding and decoding using electromagnetic resonance spectroscopy and impedance analysis, enabling non-contact identification and verification of coding elements with high sensitivity and accuracy.

The article describes the technological features of the system, including the possibility of selective three-dimensional encoding of multilayer optical discs, real-time monitoring of information carriers within corporate security infrastructures, and the creation of mobile or stationary sensor-based analytical devices. The advantages of the proposed technology over existing protection systems are considered, including flexible coding configurations, full production-line quality control, independence from optical drive systems, compatibility with different recording formats, and the possibility of integrating the technology into complex information security systems.

Additional attention is devoted to the practical application of the technology in corporate, industrial, scientific, medical, and military environments, as well as to issues of confidentiality and protection of sensitive information. The article also outlines the physical principles underlying the resonance method and impedance spectroscopy used for the identification and analysis of coding parameters in protected information carriers.

Keywords: *Encoding; Decoding; Protective encoding; Optical disc; Digital external information carriers; Film inspection; Identification of control parameters; Single-layer optical disc; Multi-layer optical disc; Electromagnetic resonance spectroscopy; Additional features and application possibilities; Additional devices and systems*

Figure 1.



Introduction: General information

All projects of this group of technical solutions are based on a single method of encoding and subsequent identification of the recording of the encoding element.

The essence of the principle consists in applying a coding coating or its technological equivalent onto the protected object and subsequently measuring the thickness of this coating, which determines the coincidence or non-coincidence of the measurement results with the code.

If the obtained result coincides with the established one, positive identification of the encoding element occurs; in the case of non-coincidence, negative identification occurs along with the stopping or blocking of the operating cycle of the equipment or the information consumer, for example, a computer.

Additional technological features.

Technologically, the issues related to the application of special coatings have been resolved, and this technology has been repeatedly tested in similar tasks associated with the control of film thickness on solar battery panels and in traditional semiconductor manufacturing.

Figure 2. *Electronic encoding module in the form of a microassembly*

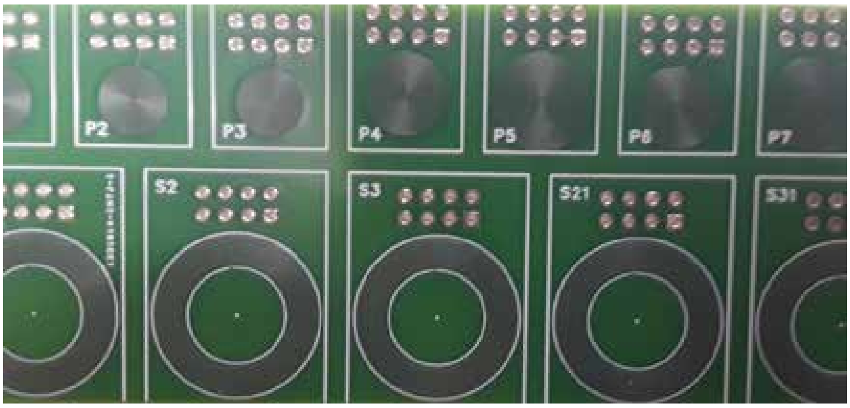
Scale factor of the encoding and decoding system

Additional features and possibilities for the application of the technology in relation to the new conditions that have emerged in the market of information carriers and storage devices during the last year.

In connection with the emergence of new recording and reading formats on optical information carriers using blue lasers, and in connection with the beginning of the production of multilayer optical discs based on the same technology, the proposed principles and technical solutions for protective encoding have acquired even greater significance, since the amount of recorded information on each disc is increasing and the absence of protection leads to ever greater losses of secret or confidential data.

In addition to the information already provided, it is necessary to indicate the possibilities for encoding each layer in multilayer discs, in which each level of the recording layers is encoded, which constitutes a significant improvement of the optical information carrier formatting system in three-dimensional form and serves as a means of ensuring (for especially important and secret information) local selective encoding of information within a single disc.

Figure 3. *Flat coils of encoding and decoding systems*



Organization of corporate protection systems

The proposed technology, when organizing a system for protecting information flows within a single corporation, provides protection at several system levels, including real-time monitoring of the condition and location of each disc available within the corporation.

When using the proposed encoding methods for protecting information on mobile external information carriers, it is assumed that the same advantages will be obtained as when applying them to optical information carriers and storage devices.

Changes in the structure and boundaries of use of the product created as a result of the project implementation

Thus, on the basis of similar solutions, it is possible to create at least two projects with a large number of applications in each: a technology project for encoding optical information storage devices in the form of discs, including a corresponding analytical-sensory device, which in turn may have numerous applications in various fields and industries; and a project for encoding and protecting information on mobile external information carriers, including a corresponding mobile or stationary sensory measuring-analytical-comparative device, also having numerous applications and design models.

Additional devices and systems that can be created on the basis of the same fundamental technological solutions

At the request of the project customer, the projects may include a section concerning additional devices by means of which the entire corporate system for the security and protection of information flows is formed within a single corporation or group of corporations or (according to Russian specifics, state corporations), as well as separate research institutions, academic institutes, and large healthcare institutions.

As a special product, an information protection system may be created not only in the field of storage but also in the operational field, during the transmission of commands and signals in the conditions of army units and formations and in the conditions of the Navy.

Under modern conditions, when information is concentrated in relatively very small sizes and volumes of storage devices, possible damage from unauthorized or criminal access to these arrays of information may be prevented or localized through the creation of a special infrastructure of the specified protection systems, which may be standardized within the specificity of a given ministry, main administration, or structural corporate associations and enterprises of a lower organizational level.

Information confidentiality

In more detail (in volumes exceeding the scope of this presentation and the illustrative materials attached to it), all necessary information may be provided upon the documentary and legal formulation of the intentions of a potential customer or partner, after the signing of confidentiality agreements with them (in a mutually agreed and acceptable legal form for both parties).

For a more complete understanding of the existing physical principles underlying the execution of encoding and decoding operations of optical discs, a magneto-resonance method has been applied, a brief description of which is provided below.

Brief description of the resonance method:

The method provides for the creation of an alternating electromagnetic field in the space in which the investigated sample is located. This field acts as an intermediary between the resonant circuit and the tested sample. On the one hand, the resonant circuit is the emitter (radiator) of this field, and on the other hand, it is the acceptor (sensitive element) of those changes in the electromagnetic field introduced by the tested sample.

Even in the absence of the tested sample, the alternating electromagnetic field created by the solenoid is the sum of two electromagnetic fields that change in antiphase relative to each other. One field is generated by the change in the magnetic induction of the solenoid and results in a vortex electric field (Maxwell-Faraday equation).

The other is generated by the change in the electric field created by the potential difference between the extreme turns of the solenoid most distant from each other (if the sample is placed inside the solenoid) or by the potential difference between the turn closest to the surface of the measured sample and the sample itself (if the sample is located opposite the end face of the solenoid), and results in a vortex magnetic field (Ampère's circuital law with Maxwell's correction).

Under the influence of the external alternating electromagnetic field, depending on the nature of the tested sample, such electrical phenomena as linear and vortex conduction currents, linear and vortex displacement currents, as well as linear and vortex ionic currents (ordered movement of ions) may be induced in the sample.

In accordance with the principle of field superposition, these electrical phenomena introduce distortions into the external alternating electromagnetic field. These distortions are perceived by the solenoid of the resonance sensor. The resonant circuit, which includes this solenoid, changes its behavior analogously to the way it would if additional elements such as a capacitor, inductance, and resistor were added to it. The combination of additional capacitive, inductive, and active resistance represents an additional impedance introduced into the system by the tested sample, and this attribute is measured by the resonance sensor.

Changes in the parameters of the resonant circuit are reflected in changes in its amplitude-frequency characteristic, namely, the resonant frequency and amplitude of the circuit change. By studying these changes, it is possible to judge the impedance of the investigated sample.

Principle of processing data obtained from resonance sensors

The resonance sensor makes it possible to determine the value of the total impedance of the investigated sample at the operating frequency of this sensor (see "Brief description of the resonance method"). By itself, this value is of little informational significance. However, everything changes fundamentally if a set of sensors with different operating frequencies is available.

In this case, it becomes possible to use a unique natural phenomenon observed in all types of substances: inorganic, organic, and biological. This phenomenon consists in the fact that a substance changes its specific impedance depending on the frequency of the electric field acting upon it, and this change depends on the composition of the investigated substance.

This phenomenon is studied and actively used by the rapidly developing scientific field known as Impedance Spectroscopy.

Impedance spectroscopy – A method for investigating various objects based on the measurement and analysis of the dependence of impedance on the frequency of alternating current. Different objects and processes are characterized by different dependences of active and reactive impedance on frequency, which makes it possible to solve the inverse problem – obtaining information about these objects and processes through the analysis of the frequency characteristics of their response to alternating current.

The fact that the change in impedance with a change in frequency depends on the composition of the substance makes it possible to identify the influence of each component on the total impedance of the substance at various frequencies. After determining the weighting coefficients of the influence of the corresponding components on the total impedance of the substance at each of the operating frequencies of the resonance sensors, it is possible, on the basis of the sensor readings and by solving a system of linear equations, to obtain information about the concentration of the investigated components.

The accuracy of this method is greatly influenced by the correct selection of the operating frequencies of the sensors. By scanning over a wide frequency range, it is necessary to determine the frequency regions most characteristic for each component, that is, the frequencies at which the component gives the greatest response.

Traditional impedance spectroscopy in its studies uses a source of alternating voltage that acts on the investigated sample by contact, while an electric current arises in the circuit, the magnitude and phase shift of which depend on the impedance of the sample.

The results are usually displayed in the form of Lissajous figures or Nyquist diagrams. In such studies, it is difficult to achieve high sensitivity and measurement accuracy.

The proposed methodology, in which impedance measurement is performed using resonant circuits, possesses significantly higher sensitivity and accuracy; moreover, it is non-contact.

There are certain technical difficulties in creating an oscillatory circuit with a resonance frequency tunable over a wide range, therefore traditional impedance spectroscopy will have to be used to search for the frequencies "characteristic" of the components.

After the characteristic frequencies are found and resonance sensors for these frequencies are created, the component monitoring system developed on the basis of these sensors will possess exceptional sensitivity and accuracy.

Interference immunity

Such "mechanical" parameters as VISCOSITY, DENSITY, TRANSPARENCY, PRESSURE (if the medium is incompressible) should not have any influence on the measured electrical parameters of the substance. FLOW VELOCITY IN THE PIPELINE and TURBULENCE – these phenomena are too slow to influence the "megahertz" impedance measurement processes. HARDNESS is a chemical indicator completely determined by the components contained in the substance. Temperature, as a rule, influences the value of impedance, but temperature measurement and its consideration during impedance measurement do not represent a complex technical task.

Advantages of the Proposed Technology Addressing the Essence of the Problems Identified in the Market of Optical Information Carrier Systems:

1. There are multiple variants of coding coating thicknesses, which make it possible to have numerous variants of the protection code, unlike existing technologies that have only one code variant;
2. During the coating application process, a control technology fully identical to the decoding technology is used, which makes it possible to completely control the quality of encoding during disc manufacturing without removing the disc from the conveyor, unlike existing technologies in which the disc must be removed from the conveyor and installed into a testing device for inspection; thus, control is selective in existing technologies, whereas in the proposed technology it is 100% control, which excludes the release of defective discs that in existing technologies are detected only during operation;
3. The proposed technology provides the possibility of encoding all categories and types of discs regardless of recording and reading format, unlike existing technologies in which encoding depends on the recording and reading format of the disc;
4. In the proposed technology, the coding coating may serve as the basis for a personal secret code or cipher, which is absent in existing technologies;
5. In the proposed technology, the decoding and identification sensor is mobile and may have several delivery variants, including an autonomous variant not connected to the disc drive, whereas in existing technologies the decoding system is installed only in disc drives; thus, the presence and correctness of encoding can be controlled only during installation of the disc into the drive, while in the proposed technology the code can be controlled and identified outside the disc drive, for example in stores or at the entrances of enterprises and institutions, which is especially important for ensuring a complete information confidentiality regime;
6. In the proposed technology, decoding excludes any dependence on the optical systems of the disc drive, but the decoding results may alter the operation of the optical systems, for example the servo drive for orientation and focus position control of the reading or writing laser, unlike existing technologies in which the decoding process completely depends on the optical elements of the disc drive, which complicates its design and sharply reduces reliability;
7. The proposed technology has several hierarchies of the fundamental operating scheme, possesses a flexible algorithm, and can be integrated into any security system of optical memory, including hybrid information carriers that, in addition to the optical component, also contain carriers built on other basic principles; existing technologies do not possess such flexibility;

8. The proposed technology makes it possible to use the disc code as an access password for entry into professional information arrays of the Internet, which existing technologies do not provide.

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