Abstract and References. Applied Physics

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DEVELOPMENT OF A METHOD FOR PRODUCING EFFECTIVE CdS/CdTe/Cu/Au SOLAR ELEMENTS ON A FLEXIBLE SUBSTRATE DESIGNED FOR BACKUP SUPPLYING SYSTEMS PREVENTION OF EMERGENCY SITUATIONS (p. 6–11)

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The technology of forming film solar cells based on CdS / CdTe configuration of the “superstrate” type on a flexible substrate has been improved. To increase the efficiency of the developed solar cells on a flexible substrate, a chemical etching procedure in a nitrogen-phosphorus mixture was added to the traditional “chemical treatment”. The conducted studies of the output parameters of the developed device structures showed that the highest values are observed in the case of chemical etching, both before the “chloride treatment” and after it. In the course of the study, it was found that a mandatory procedure in the formation of effective device structures is chemical etching in a nitrogen-phosphorus mixture both before the “chloride treatment” and after it. Carrying out the described procedures made it possible to obtain solar cells on a flexible substrate with an efficiency of 13.1 %. The increase in the efficiency of solar cells with two-stage chemical etching can be explained by the formation of excess tellurium on the surface, which leads to a decrease in resistance and, therefore, to a more efficient penetration of chlorine during the subsequent chloride treatment. Analysis of the transverse cleavage of the investigated device structures demonstrates significant grain growth and surface smoothness of the base layer, which ensures good adhesion with back contact. A study of the degradation resistance of the developed device structures during operation has been carried out. It was found that the obtained solar cells based on CdTe on a flexible substrate have a high degradation resistance and after 10 bending cycles there is no decrease in the output parameters. Thus, it has been established that chemical etching in a nitrogen-phosphorus mixture is a mandatory procedure for the formation of efficient solar cells on a flexible substrate.

Keywords: film photocell, flexible substrate, micromodule, solar cell, cadmium telluride, current-voltage characteristic.

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DESIGN OF AN INFORMATION-MEASURING SYSTEM FOR MONITORING DEFORMATION AND DISPLACEMENT OF ROCK MASSIF LAYERS BASED ON FIBER-OPTIC SENSORS (p. 12–27)

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This paper reports a study into designing an information-measuring system that could be used in coal mines that are dangerous in terms of the explosion of coal dust and methane gas. The results of reviewing technical advancements in the field of fiber-optic system development are given. To solve the set task, prototypes of a fiber-optic sensor of a new type and a hardware-software complex were constructed. The research aims to improve the safety of workers at coal enterprises. The result of the theoretical research has established that additional losses related to a micro bending should be taken into consideration while analyzing the effect of photoelasticity. The fundamental difference between the idea reported here and existing analogs is the development of a hardware-software complex capable of working with a single-mode optical fiber of great length with a significant noise level. The data processing unit is equipped with a television matrix and can analyze changes in the pixels of a light spot. The proposed system is quasi-distributed; it controls individual points within a rock massif. The designed hardware-software system provides high noise immunity of measuring channels when the external temperature changes. The research results helped develop an information-measuring system for monitoring the deformation and displacement of rock massif layers based on fiber-optic sensors, capable of operating in an explosive environment. The system makes it possible to control several layers located in the roof of the workings, while the fiber-optic sensor may contain two or three sensitive elements that are connected to different channels. With a sharp fluctuation in pressure and an increase in the displacement parameter, the system triggers a warning signal about the danger.

Keywords: optical fiber, rock displacement, roofing, mining workings, fiber-optic sensors.
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INCREASING QUALITY OF THE WIRELESS MODULE FOR MONITORING AND SUPERVISION OF SOUND SERIES OF THE EXPANDED PURPOSE (p. 28–40)

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The sound series are considered as an addition to visual and thermal imaging information flows when using computerized monitoring systems (CS). A minimum complete structure of spaced microphones for collecting data on sound rows, which is suitable for calibrating, isolating and transmitting data on sound anomalies (SA), is proposed. Duplication of the data transmission channel by wire and Wi-Fi module for recording and determining the type and coordinates of the SA is provided.

An experimental receiving module has been assembled, which includes microphones, amplifiers and signals matching boards for digital and analog forms, an ARDUINO UNO WIFI REV2 controller with an integrated Wi-Fi module. It is presented that its addition with a personal computer and a smartphone with the Android operating system forms a CS for remote wireless control of the course of the experimental analysis of sound series. It has been confirmed experimentally that its structure is minimally complete. An algorithm was developed and a software package was written in C/C++ languages. It is shown that the number of microphones is selected from the conditions of the problem from 1 to 5, but their number is limited to five digital inputs of the ARDUINO UNO WIFI REV2 board. A wave representation of the law of temporal changes in intensity and the integral norm of the SA is applied. The possibilities of calibrating all data of sound series in analog and digital form are demonstrated. The article presents the suitability of testing the algorithms for determining the phases of echograms from time series data, containing SAs of different origins and recorded by three different microphones. The effect of connecting a Wi-Fi module on reducing the voltage drop by 0.5–1 V is shown. The necessity of an additional registration condition for all microphones is demonstrated. The software interfaces for the calibration of the receiving module and the operation of the mobile application have been developed.

Keywords: computerized system, modular structure, reception algorithm, software, system testing.

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A study of the functioning of reed switches under the influence of a magnetic field created by a current in a conductor in a transient mode with the presence of an aperiodic component has been carried out. A well-known method for determining current using reed switches was implemented. At the same time, it was determined that the originally formulated method did not give the required result within the limits of errors. This is most likely due to the peculiarities of the mechanism of movement of the reed switch contacts. Alternatively, the measurements were taken to take the return currents instead of the pick-up currents and the time between the return times. They are more stable. Simulation is performed, experimental determination of the value of surge current by measuring time is carried out. The main element of the created installation was the power transformer coil with low active and high inductive resistance. As part of the study, the reed switches were placed in a magnetic field with an aperiodic component, as in the transient mode. This study will show the applicability of reed switches for the construction of relay protection devices that will not need current transformers to obtain information about the primary current in the conductor. In the course of the research, it was found that the error in determining the magnitude of current was no more than 10%. Using microprocessors, it is possible to build relay protection devices with a speed of up to 20 ns. This result makes it possible to build new devices. Since in the well-known developments, it was only said about determining the magnitude of current in a steady state. When building relay protection devices on reed switches, without using current transformers, it will be possible to build backup protections that duplicate not only the devices themselves, but also the primary measuring transformers with other sensitive elements. This will improve the reliability of the power supply.

Keywords: relay protection, reed switch, microprocessor, surge current, time measurement, magnetic field, transient.

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This paper substantiates the pulse method for determining the time parameter for fire detectors with a thermoreisitive sensing element – the time constant. The method is based on using the Joule-Lenz effect, which manifests itself when an electric current pulse passes through the thermoreisitive sensing element of fire detectors. Thermal processes in such a sensing element are described by a mathematical model that belongs to the class of equations of mathematical physics. The solution to the differential equation of this class was derived using the Hankel integral transformation and is represented as a series relative to the Bessel functions. The resulting solution is used to construct a mathematical model of a thermoreisitive sensing element in the form of a transfer function, which takes the form of the transfer function of the inertial link. To trigger the thermoreisitive sensing element of fire detectors, a single pulse of electric current in the shape of a rectangular triangle is used. The integral Laplace transformation was applied to mathematically describe the response of a thermoreisitive sensing element to the thermal effect of such a test influence. To obtain information about the time parameter of fire detectors with a thermoreisitive sensing element, the ratio of its output signals is used, which are measured in the priori defined moments. A two-parametric expression was built to determine the time parameter of fire detectors; a verbal interpretation of the pulse method to determine it was provided. The implementation of this method ensures the invariance of the time parameter of fire detectors with a thermoreisitive sensing element relative to the amplitude of a single pulse of an electric current, as well as relative to the parameter that is included in its transfer coefficient.

**Keywords:** fire detector, thermoreisitive sensing element, Joule-Lenz effect, time parameter.

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The paper presents the results of testing and research of the characteristics of a controlled autonomous magnetoelectric synchronous generator with a magnetic shunt. Structurally, the studied generator is a modified asynchronous machine in which the rotor is made with permanent magnets and an additional system in the form of a magnetic shunt. By adjusting the winding current of the magnetic shunt, the output voltage of the generator is regulated. The following characteristics were investigated: the no-load characteristic during operation with permanent magnets and when the winding current of the magnetic shunt changes with forward and reverse polarity. Also, the external characteristic for active and active-inductive loads; the control characteristic when the load current changes at a constant generator voltage.

Analysis of the obtained characteristics makes it possible to determine the limits of regulation of the external characteristic, which is ±40% relative to the main magnetic flux. The obtained regulation depth allows maintaining the stability of the external characteristic for power factors not exceeding 0.9, which is the usual passport value for autonomous power plants based on synchronous generators. Comparison of the data of research conducted on the experimental setup shows sufficient convergence for engineering and practical tasks. The maximum quantitative difference is 0.3%, which suggests the adequacy of the previously developed mathematical model. The control characteristic, constructed experimentally at constant generator voltage, is the control law of the magnetic shunt winding for the studied generator.

The investigated version of a synchronous generator with a magnetic shunt should be used for autonomous power plants, renewable energy systems, and autonomous power supply systems.

Keywords: magnetic shunt, generator voltage regulation, magnetizing winding, magnetoelectric excitation, permanent magnets, experimental research.

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Розглянуто звукові ряди як доповнення візуальних та тепловізійних потоків інформації при застосуванні комп'ютеризованих систем. Підтверджено експериментально, що її структура є мінімально-повною. Розроблено навігаційний приймальний модуль, який входять мікрофони, підсилювачі та узгоджувачі цифрового і а날огового сигналу, контролер ARDUINO UNO WIFI REV2 з інтегрованим Wi-Fi модулем. Проведено дослідження розробленого апаратно-програмного комплексу для вирішення задачі контролю та здійснення вивчення звукових рядів.

Ключові слова: звукові ряди, інформаційно-вимірювальна система, контролер ARDUINO UNO WIFI REV2.
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МАГНІТНИМ ШУНТОМ ТА ЗБУДЖЕННЯ ВІД ПОСТІЙНИХ МАГНІТІВ

СПОВІЩУВАЧІ ІЗ ТЕРМОРЕЗИСТИВНИМ ЧУТЛИВИМ ЕЛЕМЕНТОМ (с. 41–48)

ЗАХИСТУ НА ГЕРКОНАХ І МІКРОПРОЦЕСОРАХ (c. 49–55)

СТАБІЛІЗАЦІЯ НАПРУГИ КЕРОВАНОГО АВТОНОМНОГО МАГНІТОЕЛЕКТРИЧНОГО ГЕНЕРАТОРА З МАГНІТНИМ ШУНТОМ ТА ЗБУДЖЕННЯМ ВІД ПОСТІЙНИХ МАГНІТІВ (c. 56–62)

†Анотацiї. Applied physics

алгоритм та написано комплект програмного забезпечення (ПЗ) на C/C++ мовах. Показано, що кількість мікрофонів обиратися із умов задачі від 1 до 5, але їх число обмежено п’ятьма цифровими входами плати ARDUINO UNO WIFI REV2.

Застосовано хвилявої метод настройку значення часового зміни інтенсивності та інтегральної норми ЗА. Показано, що величина магнітного індуктивного току обертання ракета магнітного шунта виконується регулювання вихідної напруги генератора. Досліджуються наступні характеристики:

в якій ротор виконано із постійними магнітами та додатковою системою у вигляді магнітного шунта. За допомогою регулювання синхронного генератора з магнітним шунтом відносно параметра, який входить до його коефіцієнта передачі.

Проведено дослідження функціонування герконів під впливом магнітного поля, створеного струмом в провіднику в перехідному режимі з наявністю аперіодичної складової. Був реалізований відомий спосіб визначення струму за допомогою герконів.

При цьому було визначено, що спочатку сформульований спосіб не дав необхідного результату в рамках похабок. Пов'язане це, звичайно за все, з особливостями механізму руху контактів геркона, які відрізняються в перехідному і розрідженому режимах. Дане дослідження дозволяє показати застосованість герконів для побудови пристроїв релейного захисту, які не потребуватимуть трансформаторів струму для отримання інформації про первинний струм в провіднику. В ході досліджень встановлено, що похибка визначення величини струму склала не більше 10 %. Із застосуванням мікропроцесорів можлива побудова пристроїв релейного захисту з швидкодією до 20 мсек.

Показано вплив підключення Wі-Fi модуля на зниження спаду напруги на 0,5–1 В. Підходи до реалізації ефективного методу для визначення величини ударного струму за допомогою мікрофона в трьох різних експериментальних умовах. Однак ефективність використання мікрофонів обмежена вимогами до ушкіднів. Основним ефектом є індуктивна зміна напруги, яка відбувається через відповідну кількість циклів.

Розроблено інтерфейси ПЗ калібрування приймального модулю і роботи мобільного додатку. Показано вплив моделювання закону часових змін інтенсивності та інтегральної норми ЗА. Продемонстровано можливість використання алгоритму для відображення випадків випробування мікрофонів.

Ключові слова: терморезистивний чутливий елемент, ефект Джоуля-Ленца, часовий параметр.
холостого ходу при роботі від постійних магнітів і при зміні струму обмотки магнітного шунта при прямій та зворотній полярності. Також, зовнішня характеристика для активного та активно-індуктивного навантаження; регулювальна характеристика при зміні струму навантаження за постійної напруги генератора.

Аналіз отриманих характеристик дає можливість визначити межі регулювання зовнішньої характеристики, яка становить ≈40 %, відносно основного магнітного потоку. Отримана глибина регулювання дозволяє підтримувати стабільність зовнішньої характеристики для коефіцієнтів потужності не більше 0,9, що є звичайною паспортною величиною для автономних енергетичних установок на основі синхронних генераторів. Норівняння даних досліджень, проведених на експериментальній установці, показує достатню, для інженерних і практичних завдань, збіжність. Максимальна кількісна відмінність становить 9,3 %, що дозволяє стверджувати про адекватність розробленої рішення математичної моделі. Регулювальна характеристика, побудована експериментальним шляхом при незмінній напрузі генератора, є законом управління обмоткою магнітного шунта для конкретно досліджуваного генератора.

Досліджений варіант виконання синхронного генератора з магнітним шунктом доцільно використовувати для автономних енерго- установок, систем відновлювальних джерел енергії та систем автономного енергопостачання.

Ключові слова: магнітний шунт, регулювання напруги генератора, підмагнічуюча обмотка, магнітоелектричне збудження, постійні магніти, експериментальне дослідження.