Case Note

DOI: https://doi.org/10.32353/khrife.1.2021.21
UDC 343.98

S. Rohalin,
Senior Researcher of the Laboratory of Forensic Engineering, Environmental Forensics, Military Forensics, Forensic Video and Audio Analysis at NSC "Hon. Prof. M. S. Bokarius FSI", Kharkiv, Ukraine,
ORCID: https://orcid.org/0000-0002-1934-8977, e-mail: rohalin@i.ua
I. Bohdaniuk,
PhD in Law, Senior Researcher, Head of the Laboratory of Forensic Engineering, Environmental Forensics, Military Forensics, Forensic Video and Audio Analysis at NSC "Hon. Prof. M. S. Bokarius FSI", Kharkiv, Ukraine,
ORCID: https://orcid.org/0000-0003-4782-9986,
e-mail: bogdanyuk.hniise@gmail.com
A. Lâsâi,
Head of the Forensic Engineering Expertise Laboratory of the National Center for Forensic Expertise of the Ministry of Justice of the Republic of Moldova, Chișinău, Republic of Moldova,
e-mail: lasai.anatol@gmail.com

Features of performing expert researches on electricity meters that have been exposed to radiofrequency electromagnetic radiation

The normative requirements for the stability of electricity meters to the influence of radiofrequency electromagnetic radiation on them were systematized. The mechanism of influence of radiofrequency electromagnetic radiation was outlined and the constructive elements of metering devices, sensitive to the action of such radiation, were determined. The division of constructive execution of electricity meters into groups according to the signs of protection against the specified influence is executed. Based on the division of the electricity meters into groups, the list of initial data required for such researches, was determined; recommendations for the researches of the effect of radiofrequency electromagnetic radiation on the studied meter are developed.

Keywords**:** *electricity meter, interference in the operation of the metering device, electromagnetic radiation, radiation frequency, electric field, electric field strength, level of electromagnetic radiation, Poynting vector, radiation power, electromagnetic field.*

Formulation of Research Problem. Researches on facts and circumstances of uncounted electricity consumption in the practice of conducting forensic electrical examinations is one of the most common. Currently, in forensic practice, there are certain developments in the implementation of electrical researches on electricity meters. The researches on the influence of electromagnetic radiation on the operation of electronic (static) watt hour meters are one of the areas of the electrical researches on electricity meters,

© S. Rohalin, I. Bohdaniuk, A. Lâsâi, 2021
The authors declares no conflict of interest of relavance to this topic.

but scientific and practical consideration of this area of forensic examinations does not meet modern needs. The research on operation of electronic electricity meters under the influence of external radiofrequency electromagnetic radiation with the determination of the researched radiation to random or artificially generated, i.e., a factor, formed intentionally for the purpose of unaccounted electricity consumption, is relevant.

Analysis of Essential Researches and Publications. Tasks, which are solved by forensic electrical examination of metering devices, which are to establish the facts of uncounted electricity consumption with violation by consumers of the Rules of the retail market of electricity [1] (hereinafter referred to as RRME), Code of commercial electricity accounting [2] (hereinafter referred to as CCEA) and requirements for the operation of meters established by the manufacturer. Researches in forensic examinations with establishment of violations of the RRME and the CCEA today are conducted in accordance with the provisions of the Methodology of research on means electricity accounting and schemes of their connection in order to solve diagnostic tasks [3]. This Methodology determines the general algorithm for researching the signs of interference in metering devices (the presence of mechanical and other damages to the device's body, protective elements, fishing line and sealing devices, revealing indicators, magnetic and electromagnetic effects, etc.) and provides instrumental confirmation, among other things, of impact technical feasibility on the researched metering device for the purpose of distortion of accounting with the use provided by the body or a person who initiated the research, of additional devices, apparatus, mechanisms (radiofrequency radiations, electromagnetic field sources, permanent magnetic field sources, etc.). General provisions of this Methodology make it impossible to specify the researches on circumstances of electromagnetic influence on the electricity meter, which complicates the determination of the existence of the influence of radiofrequency radiation on the electricity meter in the expert conclusion. Therefore, while forensic examination, the conclusion on the possibility of exposure to the radiofrequency electromagnetic radiation on the researched metering device is additionally based on other scientific and reference sources of information, where the electromagnetic compatibility of individual

[1] Правила роздрібного ринку електричної енергії : затв. постановою НКРЕКП від 14.03.2018 р. № 312 (as amended and supplemented). URL: https://zakon.rada.gov.ua/laws/show/v0312874-18 (date accessed: 21.01.2021).

[2] Кодекс комерційного обліку електричної енергії : затв. постановою НКРЕКП від 14.03.2018 р. № 311 (as amended and supplemented). URL: https://zakon.rada.gov.ua/laws/show/v0311874-18 (date accessed: 21.01.2021).

[3] Методика дослідження засобів обліку електричної енергії та схем їх підключення з метою вирішення діагностичних завдань ; укладачі: В. В. Сабадаш, В. О. Дмитрієв, Д. І. Фокін, О. М. Мєлєнцов, В. О. Рябухіна, Ю. О. Носатенко, В. І. Дубинка, В. В. Хоша, О. Б. Шмерего, О. С. Філіпчук, О. В. Лисенко. Харків, 2015. 20 с. URL: https://rmpse.minjust.gov.ua/page/1 (date accessed: 21.01.2021).

components, namely integrated micro schemes [1], as well as the issue of electromagnetic shielding [2] has engineering processing [3] taking into account the characteristic parameters of radiation sources that form the electromagnetic field of influence. These sources of scientific and technical information were given as an illustrative example among the available ones and are not limited to them.

The **Article Purpose.** Review of the structure of electronic (static) electricity meters and determination of their components that are vulnerable to electromagnetic radiation with power field characteristics exceeding the normative value. Review of the constructive operating of means of protection of individual vulnerable components, or metering devices in general from the impact of electromagnetic radiation with power field characteristics, exceeding the normative value. Determining the list of initial data, required for research on electricity meters that have been exposed to radio frequency of the electromagnetic radiation for the purpose of unaccounted electricity consumption. Development of recommendations for research of influence of radiofrequency electromagnetic radiation on the researched metering device and delineation of conditions, under which the conclusion on interference in operation of the metering device for the purpose of unaccounted consumption of electricity due to existence of influence of radiofrequency electromagnetic radiation on the researched metering device can have categorical character. Development of recommendations for solving diagnostic tasks to determine the probable source of radiofrequency radiation in cases where the source is not provided for instrumental researches in expert proceedings to study the interference in the operation of the metering device for unaccounted electricity consumption.

Main Content Presentation. ГОСТ 30206-94 [4], ГОСТ 30207-94 [5] provide for the use of electronic (static) watt-hour meters with different design of the counting mechanism, both electronic and electromechanical. Measurement of electricity consumption by electronic measuring devices requires the

[1] Ключник А. В., Пирогов Ю. А., Солодов А. В. Исследование стойкости интегральных микросхем в электромагнитных полях импульсного радиоизлучения. Радиотехника и электроника. 2011. Т. 56. № 3. Р. 370—374.

[2] Максимов М. В., Бобнев М. П., Кривицкий Б. Х. и др. Защита от радиопомех ; под ред. М. В. Максимова. Москва, 1976. 496 р.

[3] Князев А. Д., Кечиев Л. Н., Петров Б. В. Конструирование радиоэлектронной и электронной вычислительной аппаратуры с учетом электромагнитной совместимости. Москва, 1989. 224 р.

[4] ГОСТ 30206-94 Статические счетчики ватт-часов активной энергии переменного тока (классы точности 0,2 S и 0,5 S) (МЭК 687-92). [Чинний від 01.07.2001]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=55951 (date accessed: 21.01.2021).

[5] ГОСТ 30207-94 (МЭК 1036-90) Статические счетчики ватт-часов активной энергии переменного тока (классы точности 1 и 2). [Чинний від 01.07.2001] URL: http://online.budstandart.com/ua/catalog/doc-page.html?id_doc=56701 (date accessed: 21.01.2021).

conversion of an analog electrical signal, proportional to the amount of electricity consumption, into a digital signal. It is known from circuit design that: *"conversion of an analog signal into a digital form consists in measuring the instantaneous values of its amplitude at regular intervals and presenting the obtained values, called samples, in the form of a sequence of numbers. This procedure is called Analog-to-Digital conversion, and the device for its implementation is called analog-to-digital converter (ADC)"* [1]. This principle of measurement with the corresponding conversion of the measured electrical signal is implemented in all modern static (electronic) electricity meters. For example, we give the principle of operation of the electricity meter type NIC 2303L… E from its operating instructions: "*1.4.1 Measurement of active and reactive electricity is performed by analog-to-digital conversion of electrical signals from the primary converters of current and voltage to the input of the built-in analog-to-digital converter (ADC) of the microcontroller, which converts signals into digital code. The microcontroller calculates the RMS value of current, voltage, power, the current value of the power factor for each phase, as well as the value of active and reactive energy in total and for each tariff"* [2]. It is known that the effect of radiofrequency electromagnetic radiation on semiconductor devices and, above all, on integrated circuits (hereinafter referred to as *ICs*) leads to their inadequate operation in the electronic circuit. In the study of the resistance of ICs to electromagnetic radiation in the radio frequency range, in general, the following IC disturbances were distinguished that have been affected: "*Depending on the level of power absorbed by the elements of the SHF micro scheme, it is possible to distinguish such observed violations of the ICs performance that will determine its stability":*

- interference and reverse failures with the restoration of normal characteristics and parameters after the cessation of exposure to radio radiation;
- degradation changes in parameters and characteristics with a slow deterioration of the technical characteristics of the products during operation and the output of the operating parameters of the product outside the specified tolerances;
- rapid *catastrophic* failures with irreversible disability [3].

[1] Безвесільна О. М., Коротченко Н. П. Перетворювач аналогового сигналу у цифровий оптико-електронного акселерометра. *Вісник інженерної академії України.* 2013. № 3—4. P. 36—38.

[2] ААШХ.411152.012 НЕ Лічильники електричної енергії НІК 2303L…E. Настанова з експлуатації лічильники електричної енергії. Website підприємства-виробника ТОВ «Nik». URL: https://www.nik.net.ua/uploads/RE_2303LE.pdf (date accessed: 21.01.2021).

[3] Ключник А. В., Пирогов Ю. А., Солодов А. В. Методические аспекты исследования стойкости интегральных микросхем в электромагнитных полях импульсного радиоизлучения. *Журнал радиоэлектроники.* 2010. № 8. URL: http://jre.cplire.ru/jre/aug10/index.html (date accessed: 21.01.2021).

Forensic practice of research on metering devices (hereinafter referred to as MDs) that have been affected by radiofrequency electromagnetic radiation, faces the task of establishing the fact of unaccounted electricity consumption, in the case when improper operation of the ICs is a consequence of blocking the transmission characteristics of the ICs (microcontroller MDs) from exposure to electromagnetic radiation in the radiofrequency range, which did not lead to a degrading change or to a "catastrophic" failure in the operating of MDs, i.e. forensic researches usually investigate cases of MDS, when the cessation of radiation restores the proper operation of the microcontroller and the entire electronic circuit of the MDs. It should be noted that under the influence of radiofrequency radiation on measuring equipment, which includes ICs, the processes, occurring in semiconductor and dielectric film microstructures, are determined by the applied voltages and induced currents, the magnitude of which depends on the geometric dimensions of these microstructural elements and their orientation direction of the electromagnetic field, the so-called polarization factor and so-called antenna mechanism of influence. The external elements that ensure the operation of this ICs are also essential for determining the degree of influence on the operation of the entire circuit. That is, so to speak, "vulnerability" or the degree of impact on the MDs of a particular design using ICs together with the radio elements of the external circuit, which includes ICs, must be researched in each case due to uncertainty, which exists not only due to certain design (in particular, mounting), but also due to the uncertainty of the characteristics of the electromagnetic field of influence, formed by a particular source with parameters that determine its power, or the ability to create a field strength greater than the allowable (regulatory); due to the uncertainty of the direction of radiation, which is due to the radiation pattern of the antenna device; degree of polarization, etc. That is why, there are certain requirements for manufacturers of electricity meters, that should be implemented in a specific design to avoid the impact of external factors. The requirements for electromagnetic compatibility, defined for meters, assume the absence of exposure to electromagnetic interference among others, and from the radiofrequency radiation of the electromagnetic field. In particular, the industry standard СОУ-Н МПЕ 40 1 35 110-2005 [1] puts forward the following requirements: *Electronic meters must be resistant to radio interference from spark discharges up to 15 kV through the air gap created, for example, during the operation of electrical appliances. After their termination on the working counter:*

- meter registrations must not have additional changes greater than 0.1 kWh caused by this effect, and no more than the corresponding number of pulses should not be generated at the test output values;

[1] СОУ-Н МПЕ 40 1 35 110-2005 Додаткові вимоги до засобів обліку електроенергії, спрямовані на запобігання несанкціонованому втручанню в їх роботу. [Чинний від 12.09.2005]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=28386 (date accessed: 21.01.2021).

- *the meter must not be damaged, and the main error must remain within normalized values* [1].

The limit value of the electromagnetic field strength that varies in the radiofrequency range for a long time, according to the requirements of DSTU EN 50470-3:2010, according to which the manufacturer of the metering device must comply with electricity metering with a certain error (for the appropriate accuracy class) should not exceed 10 V / m [2]. It should be noted that the manufacturers of meters set their own indicators of adverse effects to electromagnetic fields in the radiofrequency range. Thus, for example, in the operating instructions of the meter NIK 2104… P2 in section 1.2.20 it is stated that: "*meters are not sensitive to high-frequency electromagnetic fields*" [3]. According to the definitions of DSTU 3254-95[4], high frequencies are radiofrequencies limited by the range from 3 to 30 MHz. That is, in the case under study, the favorable MDs should be regarded as affecting the accounting of electricity in the frequency range exceeding high frequencies from 3 to 30 MHz. It follows from the aforementioned that, taking into account the requirements of the manufacturer of the MDs under research to the favor of radiofrequency radiation, taking into account the forensic practice of research into interference in the work of MDs, the research of the MDs' favor to radiofrequency radiation should be performed in the following frequency ranges according to the definitions of ДСТУ 3254-95:

- very high frequencies (VHF) - radiofrequency 30-300 MHz;
- ultrahigh frequencies (UHF) - radiofrequency 300-3000 MHz;
- super-high frequencies (SHF) - 3-30 GHz radiofrequency.

It is known from forensic practice that interference in the operation of metering devices by generating radiofrequency radiation with a frequency corresponding to the range of SHF radiofrequencies is not common, and in the frequency range exceeding SHF radiation is not recorded at all for statistical processing of forensic examinations for this direction of research at Hon. Prof. M. S. Bokarius Kharkiv Research Institute of Forensic Examinations (currently, *National Scientific Center "Hon. Prof. M. S. Bokarius Forensic Science Institute"*). The generalization of the results of research on MDs electric power,

[1] СОУ-Н МПЕ 40 1 35 110-2005.

[2] ДСТУ EN 50470-3:2010 Засоби вимірювання електричної енергії змінного струму. Частина 3. Спеціальні вимоги. Лічильники активної енергії статичні (класів точності A, B і C) (EN 50470-3:2006, IDT). [Чинний від 01.07.2012]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=54740 (date accessed: 21.01.2021).

[3] ААШХ.411152.014 Лічильники електричної енергії NIK 2104…P2. Настанова з експлуатації. Website підприємства-виробника ТОВ «Nik». URL: https://www.nik.net.ua/files/all/2104-electronic/Operating-Instructions-2104-non-tariff-Ru.pdf (date accessed: 21.01.2021).

[4] ДСТУ 3254-95 Радиосвязь. Термины и определения. [Чинний від 01.07.1996]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=72635 (date accessed: 21.01.2021).

which were exposed to radiofrequency electromagnetic radiation (in a certain frequency range), allows to systematize the design of electricity meters and to divide into three groups by structure on the basis of protection against radiofrequency electromagnetic radiation.

The first group of susceptibility to radiofrequency radiation includes MDs that does not contain structural elements of protection of vulnerable components of MDs (ICs), sensitive to radiofrequency radiation in the VHF — UHF — SHF range. The first group of MDs is characterized by a high level of susceptibility to this radiofrequency radiation. The influence of this radiation on the reliable metering of electricity within the normatively established error determined by the manufacturer, extends to MDs with different structure of the counting mechanism — both electronic and electromechanical. Such MDs, for example, can include MDs of the trademark: *Energomera*, type CE6803V and CE 301 R33, or meter type: *Mercury 230 AR-03R*. MDs, which are referred to the first group, are the most vulnerable to the action of radiofrequency radiation in the VHF — UHF — SHF range. In the first group we can distinguish a separate subgroup of MDs, the structure of which has certain features, namely, consists of individual radio elements and is characterized by the absence of ICs, or which have a low level of ICs application, combining a significant number of radio elements. With such a structure, the researched MDs belonging to this subgroup of the first group have a slightly greater resistance to radiofrequency radiation in some parts of a certain range of radiation. Such MDs, for example, includes MDs type ST-EA05, which has a fairly large size, and in its structure used output, through-type installation of individual radio elements of general design in the holes on the PCB without the use of integrated assemblies, and the circuit application of ICs is insignificant.

The second group of susceptibility to radiofrequency radiation includes MDs in the design of which electromagnetic screens are used. According to the design, the software belonging to the second group differ in size and structure of the screens. There are designs of the researched MDs with a solid electromagnetic screen, made in the form of a straight prism, consisting of two parts and having a connector on one of the faces. Such MDs, for example, include MDs type ET 3A5E7KLRT enterprise-manufacturer CV PLC: *ELVIN*. MDs with partial electromagnetic shielding are also common. In such designs, prismatic screens are most often used, in which one face is missing. MDs with partial electromagnetic shielding also include MDs with a solid screen, which primarily protects the individual sensitive elements of the ICs. Such MDs, for example, include MDs type SL 7000 on the manufacturer: *Itron (Actaris) Ukraine*. MDs classified as the second group of susceptibility to radiofrequency radiation have a high resistance to radiofrequency radiation in the VHF — UHF — SHF range compared to the first group of this division.

The third group of susceptibility to radiofrequency radiation includes MDs, which design as an option (indicating the appropriate marking on the nameplate —

the MDs panel) provides for the existence of a built-in sensor of electromagnetic field. The built-in sensor of influence of an electromagnetic field is an integrated component, a constructive part of the device of the account of electric energy. That is, the equipment of the metering device with an additional structural device (namely the built-in sensor of the electromagnetic field) does not change the protection of the metering device from radiofrequency radiation in the VHF — UHF — SHF range, but detects the presence of radiation in the presence of exposure to certain characteristic parameters. Such MDs include, for example, MDs type NIK 2303L AP1 MS E enterprise-manufacturer CV *NIK*. The presence of the letter S in the MDs marking indicates the presence of a built-in electromagnetic field sensor. It should be noted that the MDs classified in the third group of susceptibility to radiofrequency radiation, the structure of protection does not differ from the first group, but (as noted above) MDs of the third group have an integrated device for detecting the existence of radiofrequency in VHF — UHF — SHF range, which distinguishes them by constructive structure and separates them from the first and second groups of this distribution. It is the third group of MDs that most satisfies the need of a forensic expert in the process of research in the actual establishment of the existence of a source of radiofrequency radiation of the electromagnetic field for the purpose of unaccounted consumption of electricity. "*When exposed to an electromagnetic field meter with a voltage of more than 10 V/m in the frequency range from 80 to 500 MHz for more than 3 seconds:*

- *the message "Error radio" appears on the display;*
- *a record of the influence of the electromagnetic field is formed in the event log of the meter"* [1].

As noted above, the existence of uncertainties in the research on the effect of radiofrequency electromagnetic radiation on the studied meter comes primarily from the structure of the MDs, provided for the research and the characteristics of the electromagnetic field, generated by a particular radiation source. In the presence of radiofrequency radiation of the electromagnetic field, these factors are a condition of improper operation of the electrical circuit of the researched MDs with violation of the relevant electricity meter, but because the achievement of electric potential in microstructures (films, layers) of ICs (in the presence of such uncertainties) is unknown by default, so the expert conclusion under these conditions can only be probable. This means that the study of the possibility of the source to the formation of radiofrequency radiation with a field strength of more than 10 V/m in the area of structural placement of the ICs of the researched MDs should be carried out taking into account the circumstances that determine the so-called material situation, namely: the place of installation of the researched MDs, the method of their installation (assembly) in the executive electrical circuit of electricity metering, as well as the presence (if provided) of radiofrequency radiation and data on other electromagnetic devices in the space

[1] ААШХ.411152.012 НЕ Лічильники електричної енергії НІК 2303L … . URL: https://www.nik.net.ua/uploads/RE_2303LE.pdf (date accessed: 21.01.2021).

close to the studied MDs, approximation distance, the existence of data on the passage of emergency modes in the electrical installation of the consumer, etc. Establishing in the research of these circumstances and providing for the study of the device that is the source of radiofrequency radiation of the electromagnetic field for the expert experiment in laboratory studies of objects allows the expert to reach a categorical conclusion about the impact of radiofrequency electromagnetic radiation on the corresponding account of the consumed electricity by the researched MDs. The study of these circumstances involves determining the level of radiofrequency radiation of the electromagnetic field at the place of installation of the researched MDs. Table 1 of ДСТУ IEC 61000-4-3:2007 [1] shows the test levels of radio frequency radiation of the electromagnetic field for general purpose devices (in particular, for electronic MDs, to which they belong) to test their immunity to radiofrequency electromagnetic fields of radiation. The following classes of electromagnetic environment correspond to the third level with a field strength of 10 V/m and more than 10 V/m:

class 2 — situation with an average level of electromagnetic radiation. Low-power transceivers (usually less than 1 W) are used, but there are restrictions on their use near equipment. This is a typical commercial environment;

class 3 — a situation with a high level of electromagnetic radiation. Portable transceivers (with a power of 2 W and more) are used quite close to the equipment, but not less than 1 m. These are powerful radio transmitters located close to the equipment, as well as close to high-frequency industrial, scientific and medical equipment. That is a typical industrial environment.

The first and second levels with field strengths of 1 and 3 V/m, respectively, belong to class 1 of the electromagnetic environment:

class 1 — an environment with a low level of electromagnetic radiation. Radiation levels are typical for radio and television stations located at a distance of more than 1 km, and in the presence of low-power transmitters/receivers.

It should be noted that the situation with a low level of electromagnetic radiation (class 1) is typical for household consumers of electricity and does not interfere with radiofrequency radiation with a field strength of more than 10 V/m, so does not affect the relevant electricity metering by the researched MDs. Detection of cases of blocking of MDs work by devices of radiofrequency radiation of an electromagnetic field at the household consumer of electric energy in the conditions of a situation with low level of radiation (class 1) taking into account regulatory requirements concerning the device of electric metering units radiofrequency range, should be qualified as a deliberate interference in the work of the researched MDs for the purpose of unaccounted consumption

[1] ДСТУ IEC 61000-4-3:2007 Електромагнітна сумісність. Частина 4-3. Методики випробування та вимірювання. Випробування на несприйнятливість до радіочастотних електромагнітних полів випромінення (IEC 61000-4-3:2006, IDT). [Чинний від 01.10.2007]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=52800 (date accessed: 21.01.2021).

of electricity by the household consumer. A forensic expert can reach such a conclusion only in case of exclusion of the facts of existence of emergency modes in the electrical installation of the household consumer, connected with the occurrence of the approximate arc discharge or lightning discharge, as well as according to the data, excluding welding works close to the researched MDs. That is, the existence of arc welding.

Cases of operation of the studied MDs in an environment with medium and high levels of electromagnetic radiation for commercial and industrial environments requires the establishment of the fact that the electricity consumer has certain commercial or technological equipment, so the forensic expert in the relevant request of expert proceedings should require such equipment. Failure to provide this device for laboratory or field researches gives grounds for a forensic expert to perform the following estimation of the distance from the researched MDs to the radiofrequency source for radiation power of 1 W and 2 W, which are decisive for class 2 and class 3 of electromagnetic radiation accordingly.

From the sources of scientific and technical information it is known that the power of electromagnetic radiation is defined as the flux of the electromagnetic energy density vector (Pointing vector) through an arbitrary surface S per unit of time, i.e.:

$$W = \int_S \vec{\Pi}\, dS, \qquad (1)$$ [1]

where $\vec{\Pi}$ — Pointing vector $\vec{\Pi} = [\vec{E}, \vec{H}]$ is the result of a vector product;

dS — is an element of an arbitrary surface *S*.

It is known that *E* and *H* — voltage of electric and magnetic fields in free space.

E and *H* are related by the following equation:

$$E = \rho_{св} H, \qquad (2)$$

where $\rho_{св}$ = *377* Ом — impedance of free space.

From this we have:

$$\Pi = 377\ H^2 \qquad (3)$$

or

$$\Pi = 2{,}65\ 10^{-3}\ E^2 \qquad (4)$$ [2]

For a surface of 1 m^2 with a minimum allowable value of electric field voltage of 10 V/m, when the effect of electromagnetic radiation in the researched MDs (for the case of the study of the meter type NIK 2303L AP1 MS E) take

[1] Никольский В. В., Никольская Т. И. Электродинамика и распространение радиоволн. Москва, 1989. Р. 52.

[2] Никольский Б. А. Бортовые радиоэлектронные системы : электрон. учеб. Самара, 2013. URL: https://repo.ssau.ru/bitstream/Uchebnye-posobiya/Bortovye-radioelektronnye-sistemy-Elektronnyi-resurs-elektron-ucheb-54583/1/Никольский%20Б.А.%20Бортовые.pdf С. 89 (date accessed: 21.01.2021).

place, the value of the electromagnetic energy flux density (Pointing vector module) is 0.265 W/m^2. The calculated value can be accepted for further study under the following assumptions:

- pointing vector intersects the surface of the meter (meter sensor) evenly and perpendicularly at any point on this surface, and the size of the sensor is equal to the size of the surface of the meter;
- further calculations are performed under the condition that the radiation is carried out when using a non-directional vibrator of a half-wave dipole antenna that emits electromagnetic waves evenly in all directions in free space.

Under the following assumptions, you can perform an estimation of the radiation power according to the formula:

$$P = 4 \cdot \pi \cdot R^2 \cdot \Pi, \quad (5)$$ [1]

where R — radius of the sphere (distance), m.

Taking into account the value of radiation power of 1 W and 2 W, previously determined for class 2 and class 3 of the electromagnetic radiation environment, it is possible to calculate the distance (radius of the radiation sphere) from the studied MDs to the radiofrequency source for two power values:

$$R_1 = \sqrt{\frac{\Pi}{4 \cdot \pi \cdot P}} = \sqrt{\frac{0.265}{4 \cdot \pi \cdot 1{,}0}} = 0{,}145 \text{ м} \quad (6)$$

$$R_2 = \sqrt{\frac{\Pi}{4 \cdot \pi \cdot P}} = \sqrt{\frac{0.265}{4 \cdot \pi \cdot 2{,}0}} = 0{,}103 \text{ м} \quad (7)$$

According to the results of the evaluation calculation, it is possible to make a generalization about the limit value of the approach distance in the space of the source of radiofrequency radiation of electromagnetic field with voltage over 10 V/m to the MDs, which in the studied case captures (due to the equipment of the MDs sensor of electromagnetic radiation in the studied example) the effect of electromagnetic radiation, which is able to block the accounting of electrical energy. The distance of the location of the blocking source of electromagnetic radiation to the MDs in the studied example is in the range of 100—150 mm. Comparison of the calculation result with the overall dimensions of typical electrical cabinets (input, distribution), which are installed separately, and typical electrical cells in the distribution devices, allows us to conclude that the distance, calculated in the study of the source of influence or its radiating (antenna) device to the studied MDs is relatively small and such that it is mostly within the electrical cabinet. Since the arrangement of electricity metering points is regulated by the Rules of Arrangement of Electrical Installations and

[1] Никольский Б. А. Op. cit.

the Code of Commercial Electricity Metering, it can be argued that the actual location (presence) within the electrical cabinet with calculation MDs or in close proximity to the source of radiofrequency radiation (or its antennas) with the given parameters of influence are executed by the consumer intentionally for the purpose of unaccounted consumption of electricity.

For cases of approximate but external (relative to the electrical cabinet with the studied MDs) location of the radiation source, to provide a categorical conclusion about the blocking of electricity metering is essential to study the method of installation of electricity metering unit. Establishing in the research the fact of grounding a solid metal electrical cabinet eliminates the possibility of blocking the accounting of electricity in the studied MDs due to the runoff of the electric field charge. However, the presence of such shielding of the studied MDs in the case of design of an electrical cabinet with an aperture and provided the use of a radiofrequency radiation device with a directional antenna (with a narrow pattern) is not effective, and blocking the electricity metering of the studied MDs groups of classification division, can occur.

It should be noted that in forensic practice (due to the coincidence of the frequency of radiation of mobile devices with the frequency range of influence of VHF — UHF — SHF on sensitive elements of MDs) the study of the possibility of mobile devices on electricity metering is common in formulations of expert task, and at the same time associated with certain difficulties in determining the power of electromagnetic radiation generated by the mobile communication terminal, because the value of the radiation power depends on the distance of the phone to the base station. Appendix E *Guidance for Product Level Committees for Test Level Selection* ДСТУ IEC 61000-4-3: 2007 states that *most GSM terminals on the market today belong to Class 4 (maximum ERP* [equivalent radiated power. — *Authors'note*.] *is 2 W*) [1]. From the general principles of cellular mobile architecture, it is known that the average power is 8 times less than the maximum for the GSM 900 standard and 16 times for the GSM 1800 standard and 5 times due to the sparse transmission intervals associated with frequency principle of channel separation (FDMA/TDMA) over time. That is, in practice (taking into account the distance to the base station) the radiation power is much lower and can be from 0.01 W to the maximum manufacturer's stated value of 2.0 W for 2nd generation systems (GSM) and 3rd and 4th systems generation (UMTS and LTE respectively) [2]. The data of Table E.1 of the reference Annex E ДСТУ IEC 61000-4-3:2007 show that the *safe* distance (distance of protection of the researched equipment) for the radiation power of 2.0 W is 5.5 and 1.8 m for the 1st and 2nd level of field strength, respectively (1 V/m and 3 V/m). For the 3rd level of field strength (10 V/m) the distance of protection is not set, because (as indicated in the notes to Table E.1)

[1] ДСТУ IEC 61000-4-3:2007 … . URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=52800 (date accessed: 21.01.2021).

[2] Лохвицкий М. С., Сорокин А. С., Шорин О. А. Мобильная связь: стандарты, структуры, алгоритмы, планирование. Москва, 2018. P. 214.

"*the consequences of failure are significant*". That is, taking into account the value of the maximum radiation power given in the reference data of Annex E ДСТУ IEC 61000-4-3:2007 (based on the provisions of ДСТУ IEC 61000-4-3:2007), we can conclude that there is an influence of radiofrequency radiation of the electromagnetic field, formed by the cellular mobile communication terminal, to general purpose electronic devices, however, it is practically impossible to qualify this influence as causing blocking of the account of consumed electricity by the studied meters for the following reasons:

- the value of the actual radiation power of the cellular mobile communication terminal is always much less than the value of the maximum effective radiated power due to the sparseness of the signal transmission intervals due to the frequency division multiplexing (FDMA/TDMA) principle;
- the value of the actual radiation power of the cellular mobile communication terminal is always much less than the value of the maximum effective radiated power due to the existence of cellular base stations with a guaranteed margin of coverage that does not meet the condition of maximum distance of base stations for operation in the area of the researched MDs;
- due to short-term exposure to radiation, which is associated with the alternate operation of communication channels, as well as the time limit set by the user of mobile services.

The aforementioned proves that the effect of electromagnetic radiation, generated by the mobile communication terminal, cannot be qualified as one that causes the blocking of electricity metering by the researched MDs.

Based on the results of the research, this article develops a list of initial data for forensic examinations to determine the existence of the influence of radio frequency electromagnetic radiation on the studied meter and the tasks of identifying radiofrequency devices as sources of influence. The amount of necessary initial data is divided and provided separately according to the stages of the research, which are recommended for use in forensic practice together with previous generalizations.

The list of initial data for forensic examinations on the effects of radiofrequency electromagnetic radiation on the studied MDs is recommended for use in forensic practice in the stages of the research

1. The forensic expert performs the establishment of the class of electromagnetic radiation on the basis of the following data:

1.1 establishment of an exhaustive list of devices that are sources of electromagnetic radiation that surround the studied MDs within the premises where it is installed for commercial metering of consumed electricity.

Clarification of the functional purpose of these devices (commercial, industrial, technological, scientific, which is associated with certain activities is set for consumers of electricity that are not household). Finding out the need to

place these devices (process equipment) in the room where the studied MDs is installed;

1.2 determining the value of the maximum power of each of the available devices that are sources of electromagnetic radiation;

1.3 setting the range of radiofrequency radiation for each of all available devices that are sources of electromagnetic radiation;

1.4 setting the mode of operation of each of all available devices that are sources of electromagnetic radiation: long-term, short-term, re-short-term, etc. Setting the radiation mode: continuous or discrete. For the last mode of operation, the duration of the radiation period is additionally set.

Note. The data according to sections 1.2, 1.3 and 1.4 are determined according to the passport data of devices that are sources of electromagnetic radiofrequency radiation, or on the basis of measurement protocols performed by employees of the National Commission for State Regulation of Communications and Informatization for control over Ukrainian radio-frequency resources, which must be provided at the request of a forensic expert.

2. Investigation of the circumstances of installation of the studied MDs.

2.1 installation with field inspection, or according to the data provided at the request of the forensic expert, determining the distance from each of all available devices that are sources of electromagnetic radiation, and from their antenna devices to the studied MD;

2.2 making a sketch of the spatial location of the studied MDs in relation to each of all available devices that are sources of electromagnetic radiation;

2.3 establishing all the facts of installation of the studied MDs in the electrical cabinet, the design of the electrical cabinet (solid or with a viewing window), the material of the electrical cabinet (polymer or metal), geometric dimensions of a cabinet, the existence of metal cabinet grounding, etc.;

2.4 establishment of a group of constructive execution of the researched MDs according to the division given above in this article.

3. Establishment of the existence facts of sources of radiofrequency radiation, which are not devices, but could exist (arise) under certain conditions in the studied period of time due to physical processes in the electrical installation, as well as due to actions of electricity consumers or outsiders and are not aimed at unaccounted for electricity consumption.

3.1 establishment of the facts of existence of the arc category which has arisen as a result of an emergency mode in a place of electric installation which is close to an arrangement of the studied MDs in a place of its installation at the consumer;

3.2 establishing the facts of the existence of a lightning discharge that occurred in the place of electrical installation, which is close to the location of the studied MDs in the place of its installation by the consumer;

3.3 establishment of the facts of performance of electric welding works in the place which is close to the location of the studied MDs in the place of its installation at the consumer.

Note. Establishing the existence of sources of radiofrequency radiation, which are not devices for use by electricity consumers or third parties, for the purpose of unaccounted consumption of electricity under SECTIONS 3.1, 3.2 and 3.3 is performed to obtain linear dimensions of distances from such sources to the studied MDs for comparison study of this distance with a standard distance of 100-150 mm (half the diameter of the test loop), for which the meters are tested according to the requirements of СОУ-Н МПЕ 40 1 35 110-2005 (loop diameter 200—300 mm).

4. Organization and implementation of the expert experiment to obtain data on the existence of the influence of radiofrequency radiation on the normal operation of the studied MDs. Research and obtaining data for this stage of the study is performed only in the case of providing the forensic expert with a remote device for laboratory research on the existence of such an effect.
5. Execution of the calculated part of the study is carried out by the forensic expert on the basis of initial data obtained from the previous stages of the study, and only if the source of radiofrequency radiation is uncertain or not provided for laboratory tests at the request of forensic proceedings to establish the existence of the influence of radiation on the studied MDs during the accounting of the consumed electricity.
6. Analysis of the data obtained as a result of the above stages of the study, using the recommendations of this article and on the basis of regulatory requirements for the investigated issues, the forensic expert provides an opinion on the expert task to determine the existence of radio frequency radiation on the studied MDs for the purpose of unaccounted electricity consumption, determination of the probable source of radio frequency radiation in case the radiation source is not provided for instrumental research or conclusion on the belonging of the studied radiation to accidental or artificially generated, i.e. such factor created intentionally for unaccounted electricity consumption.
7. Verification of a conclusion based on the results of the study is carried out by the forensic expert on the basis of data on electricity consumption from the event log of the studied MDs for calculation periods belonging to the studied period and in similar periods when electricity consumption is considered appropriate. Relevant data from the event log should be requested by the forensic expert in the request for additional materials.

Conclusions. The normative requirements established for the stability of electricity meters from the influence of radiofrequency electromagnetic radiation on them are systematized.

The mechanism of influence of radiofrequency electromagnetic radiation and constructive elements of metering devices, sensitive to the action of such radiation are determined. The division of types of constructive execution of electricity meters into groups on the basis of protection against the influence of radiofrequency electromagnetic radiation is performed.

Conditions are outlined under which the conclusion about interference in the operation of the metering device for the purpose of unaccounted electricity consumption may be categorical. Recommendations have been developed to determine the source of radiofrequency radiation as probable in cases where the source is not provided for instrumental research in expert proceedings to study the interference in the operation of the meter for the purpose of unaccounted electricity consumption.

Based on the results of the research, this article develops a list of initial data for forensic examinations to determine the existence of the influence of radiofrequency electromagnetic radiation on the studied meter and tasks of identification of radiofrequency devices as sources of influence. The amount of necessary initial data is divided and given separately by stages of research, which are recommended for use in the forensic practice.

References

AAShKh.411152.012 NE Lichylnyky elektrychnoi enerhii NIK 2303L … . URL: https://www.nik.net.ua/uploads/RE_2303LE.pdf (data zvernennia: 21.01.2021) [in Ukrainian].

AAShKh.411152.014 Lichylnyky elektrychnoi enerhii NIK 2104…P2. Nastanova z ekspluatatsii. Website pidpryiemstva-vyrobnyka TOV «Nik». URL: https://www.nik.net.ua/files/all/2104-electronic/Operating-Instructions-2104-non-tariff-Ru.pdf (data zvernennia: 21.01.2021) [in Ukrainian].

Bezvesilna, O. M., Korotchenko, N. P. (2013). Peretvoriuvach analohovoho syhnalu u tsyfrovyi optyko-elektronnoho akselerometra. *Visnyk inzhenernoi akademii Ukrainy.* № 3—4 [in Ukrainian].

DSTU 3254-95 Radiosviaz. Terminy i opredeleniia [Chinnii vid 01.07.1996]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=72635 (data zvernennia: 21.01.2021) [in Russian].

DSTU EN 50470-3:2010 Zasoby vymiriuvannia elektrychnoi enerhii zminnoho strumu. Chastyna 3. Spetsialni vymohy. Lichylnyky aktyvnoi enerhii statychni (klasiv tochnosti A, V i S) (EN 50470-3:2006, IDT). [Chynnyi vid 01.07.2012]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=54740 (data zvernennia: 21.01.2021) [in Ukrainian].

DSTU IES 61000-4-3:2007 Elektromahnitna sumisnist. Chastyna 4-3. Metodyky vyprobuvannia ta vymiriuvannia. Vyprobuvannia na nespryiniatlyvist do radiochastotnykh elektromahnitnykh poliv vyprominennia (IES 61000-4-3:2006, IDT). [Chynnyi vid 01.10.2007]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=52800 (data zvernennia: 21.01.2021) [in Ukrainian].

GOST 30206-94 Staticheskie schetchiki vatt-chasov aktivnoi ehnergii peremennogo toka (klassy tochnosti 0,2 S i 0,5 S) (MEHK 687-92) [Chinnii vid 01.07.2001]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=55951 (data zvernennia: 21.01.2021) [in Russian].

GOST 30207-94 (MEHK 1036-90) Staticheskie schetchiki vatt-chasov aktivnoi ehnergii peremennogo toka (klassy tochnosti 1 i 2) [Chinnii vid 01.07.2001] URL: http://online.budstandart.com/ua/catalog/doc-page.html?id_doc=56701 (data zvernennia: 21.01.2021) [in Russian].

Kliuchnik, A. V., Pirogov, IU. A., Solodov, A. V. (2011). Issledovanie stoikosti integralnykh mikroskhem v ehlektromagnitnykh poliakh impulsnogo radioizlucheniia. *Radiotekhnika i ehlektronika.* T. 56. № 3 [in Russian].

Kliuchnik, A. V., Pirogov, IU. A., Solodov, A. V. (2010). Metodicheskie aspekty issledovaniia stoikosti integralnykh mikroskhem v ehlektromagnitnykh poliakh impulsnogo radioizlucheniia. *Zhurnal radioehlektroniki.* № 8. URL: http://jre.cplire.ru/jre/aug10/index.html (data zvernennia: 21.01.2021) [in Russian].

Kniazev, A. D., Kechiev, L. N., Petrov, B. V. (1989). *Konstruirovanie radioehlektronnoi i ehlektronnoi vychislitelnoi apparatury s uchetom ehlektromagnitnoi sovmestimosti.* Moskva [in Russian].

Kodeks komertsiinoho obliku elektrychnoi enerhii : zatv. postanovoiu NKREKP vid 14.03.2018 r. № 311 (zi zmin. ta dopov.). URL: https://zakon.rada.gov.ua/laws/show/v0311874-18 (data zvernennia: 21.01.2021) [in Ukrainian].

Lokhvitskii, M. S., Sorokin, A. S., Shorin, O. A. (2018). *Mobilnaia sviaz: standarty, struktury, algoritmy, planirovanie.* Moskva [in Russian].

Maksimov, M. V., Bobnev, M. P., Krivitskii, B. X. i dr. (1976). *Zashchita ot radiopomekh* ; pod red. M. V. Maksimova. Moskva [in Russian].

Metodyka doslidzhennia zasobiv obliku elektrychnoi enerhii ta skhem yikh pidkliuchennia z metoiu vyrishennia diahnostychnykh zavdan ; ukladachi : V. V. Sabadash, V. O. Dmytriiev, D. I. Fokin, O. M. Mielientsov, V. O. Riabukhina, Yu. O. Nosatenko, V. I. Dubynka, V. V. Khosha, O. B. Shmereho, O. S. Filipchuk, O. V. Lysenko. Kharkiv, 2015. 20 s. URL: https://rmpse.minjust.gov.ua/page/1 (data zvernennia: 21.01.2021) [in Ukrainian].

Nikolskii B. A. *Bortovye radioehlektronnye sistemy* : ehlektron. ucheb. Samara, 2013. URL: https://repo.ssau.ru/bitstream/Uchebnye-posobiya/Bortovye-radioelektronnye-sistemy-Elektronnyi-resurs-elektron-ucheb-54583/1/Nikolskii%20B.A.%20Bortovye.pdf (data zvernennia: 21.01.2021) [in Russian].

Nikolskii, V. V., Nikolskaia, T. I. (1989). *Ehlektrodinamika i rasprostranenie radiovoln.* Moskva [in Russian].

Pravyla rozdribnoho rynku elektrychnoi enerhii : zatv. postanovoiu NKREKP vid 14.03.2018 r. № 312 (zi zmin. ta dopov.). URL: https://zakon.rada.gov.ua/laws/show/v0312874-18 (data zvernennia: 21.01.2021) [in Ukrainian].

SOU-N MPE 40 1 35 110-2005 Dodatkovi vymohy do zasobiv obliku elektroenerhii, spriamovani na zapobihannia nesanktsionovanomu vtruchanniu v yikh robotu [Chynnyi vid 12.09.2005]. URL: https://online.budstandart.com/ru/catalog/doc-page.html?id_doc=28386 (data zvernennia: 21.01.2021) [in Ukrainian].

С. В. Рогалін, І. В. Богданюк, А. А. Лисий

Особливості виконання експертних досліджень приладів обліку електричної енергії, які зазнали впливу радіочастотного електромагнітного випромінювання

Дослідження впливу електромагнітного випромінювання на роботу електронних приладів обліку електричної енергії — одне із затребуваних напрямів судової електротехнічної експертизи. Однак, науково-практичне опрацювання цього напряму судово-експертних досліджень не відповідає сучасним вимогам. Дослідження впливу електромагнітного випромінювання

радіочастотного діапазону на роботу електронних приладів обліку електричної енергії, а також ідентифікація такого випромінювання як випадкового або створеного штучно з метою безоблікового споживання електричної енергії, є актуальними.

Мета статті — систематизувати нормативні вимоги до стійкості роботи електронних приладів обліку електричної енергії в разі впливу на них електромагнітного випромінювання, виконати огляд конструктивної побудови електронних приладів обліку електричної енергії з визначенням вразливих компонентів, класифікувати конструктивні виконання приладів обліку за стійкістю до такого виду впливу, розробити перелік вихідних даних, необхідних для проведення досліджень приладів обліку електричної енергії, які зазнали впливу радіочастотного електромагнітного випромінювання з метою необлікованого споживання електричної енергії, а також розробити методичні рекомендації для проведення досліджень впливу радіочастотного електромагнітного випромінювання на прилад обліку в судово-експертному виробництві.

У статті систематизовано вимоги, передбачені нормативними документами до стійкості роботи приладів обліку електричної енергії в разі впливу на них радіочастотного електромагнітного випромінювання. Визначено механізм впливу радіочастотного електромагнітного випромінювання на прилади обліку електричної енергії та конструктивні елементи приладів обліку, чутливі до дії такого випромінювання. Оглянуто сучасні типові конструктивні виконання приладів обліку електричної енергії й виконано їх класифікаційний поділ на групи за ступенем захищеності в разі впливу на прилади обліку радіочастотного електромагнітного випромінювання.

Зазначено умови, за яких висновок про втручання в роботу приладу обліку з метою неврахованого споживання електричної енергії матиме категоричний характер. Розроблено рекомендації із визначення джерела радіочастотного випромінювання як імовірного, у разі коли джерело не надано для проведення інструментальних досліджень в експертних виробництвах із дослідження втручання в роботу приладу обліку.

Розроблено перелік необхідних вихідних даних для проведення судових експертиз з питань визначення існування впливу радіочастотного електромагнітного випромінювання на досліджуваний прилад обліку та завдань ідентифікації приладів радіочастотного випромінювання як джерел впливу. Розроблений перелік необхідних вихідних даних розподілено та представлено окремо за рекомендованими до застосування етапами виконання досліджень у судово-експертній практиці.

Ключові слова: *прилад обліку електричної енергії, втручання в роботу приладу обліку, електромагнітне випромінювання, частота випромінювання, електричне поле, напруженість електричного поля,*

рівень електромагнітного випромінювання, вектор Умова-Пойнтінга, потужність випромінювання, електромагнітне екранування.

С. В. Рогалин, И. В. Богданюк, А. А. Лысый

Особенности выполнения экспертных исследований приборов учёта электрической энергии, подвергшихся воздействию радиочастотного электромагнитного излучения

Исследование влияния электромагнитного излучения на работу электронных приборов учёта электрической энергии — одно из востребованных направлений судебной электротехнической экспертизы. Однако научно-практическая проработка этого направления судебно-экспертных исследований не соответствует современным требованиям. Исследование влияния электромагнитного излучения радиочастотного диапазона на работу электронных приборов учёта электрической энергии, а также идентификация такого излучения как случайного или созданного искусственно с целью безучётного потребления электрической энергии являются актуальными.

Цель статьи — систематизировать нормативные требования к устойчивости работы электронных приборов учёта электрической энергии при воздействии на них электромагнитного излучения, выполнить обзор конструктивного построения электронных приборов учёта электрической энергии с определением уязвимых компонентов, классифицировать конструктивные исполнения приборов учёта по устойчивости к такому виду воздействия, разработать перечень исходных данных, необходимых для проведения исследований приборов учёта электрической энергии, подвергшихся воздействию радиочастотного электромагнитного излучения с целью неучтённого потребления электрической энергии, а также разработать методические рекомендации для проведения исследований влияния радиочастотного электромагнитного излучения на прибор учёта в судебно-экспертном производстве.

В статье систематизированы требования, установленные нормативными документами к устойчивости работы приборов учёта электрической энергии при воздействии на них радиочастотного электромагнитного излучения. Определён механизм влияния радиочастотного электромагнитного излучения на приборы учёта электрической энергии и определены конструктивные элементы приборов учёта, чувствительные к воздействию такого излучения. Выполнены обзор современных типовых конструктивных исполнений приборов учёта электрической энергии и классификационное разделение этих конструктивных исполнений на группы по степени защищённости при воздействии на приборы учёта радиочастотного электромагнитного излучения.

Обозначены условия, при которых вывод о вмешательстве в работу прибора учёта с целью неучтённого потребления электрической энергии

может иметь категорический характер. Разработаны рекомендации по определению источника радиочастотного излучения как вероятного в случаях, когда источник не предоставлен для проведения инструментальных исследований в экспертных производствах по исследованию вмешательства в работу прибора учёта.

Разработан перечень необходимых исходных данных для проведения судебных экспертиз по вопросам определения существования воздействия радиочастотного электромагнитного излучения на исследуемый прибор учёта и задач идентификации приборов радиочастотного излучения как источников воздействия. Разработанный перечень необходимых исходных данных разделён и представлен отдельно по рекомендованным к применению этапам выполнения исследований в судебно-экспертной практике.

Ключевые слова: *прибор учёта электрической энергии, вмешательство в работу прибора учёта, электромагнитное излучение, частота излучения, электрическое поле, напряжение электрического поля, уровень электромагнитного излучения, вектор Умова-Пойнтинга, мощность излучения, электромагнитное экранирование.*

Submitted on 25.02.2021 / Revised 14.04.2021 / Approved 22.04.2021

Rohalin S., Bohdaniuk I., Lâsâi A. (2021). Features of performing expert researches of electricity meters that have been exposed to radiofrequency electromagnetic radiation. *Theory and Practice of Forensic Science and Criminalistics.* 23rd Issue, p. 270—289. DOI: 10.32353/khrife.1.2021.21.

Contributors
The authors contributed solely to the intellectual discussion underlying this paper, case-law exploration, writing and editing, and accept responsibility for the content and interpretation.