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MEASUREMENT AND ANALYSIS OF STATIC AND ELECTROMAGNETIC FIELDS OF VERY LOW FREQUENCY

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ABSTRACT

The sources and characteristics of static and electromagnetic fields of very low frequency (VLF) are presented at the beginning . Different sources of VLF fields are found in environment, houses and the workplace. Measurement and analysis of static and electromagnetic fields of very low frequency is the main topic of the paper. Some devices for measuring static and electromagnetic fields of very low frequencies are represented.

Key words: *Electromagnetic Radiation, Sources of static and VLF, Measurment of static and VLF.*

INTRODUCTION

Static electric and magnetic fields arise from both natural and man-made sources, whereas electric and magnetic fields in the VLF range (3–3000 Hz) are mostly associated with man-made sources. These are numerous and include electric power systems, electric and electronic appliances and industrial devices. Environmental levels of ELF fields are very low. Exposure levels for the general population are typically 5–50 V/m for electric fields and 0.01–0.2μT for magnetic fields.

Considerably higher exposure occurs for shorter durations and in some occupational settings. It should be noted that the earth’s magnetic field (25–65μT, from equator to poles) is a static field to which everyone is exposed. Measurements of electric and magnetic fields are used to characterize sources and levels of exposure to humans. The capabilities of instruments to measure such fields have advanced in recent years, particularly for magnetic fields. In addition to simple, easy-to-use hand-held survey instruments, there are now portable personal exposure meters capable of recording and describing the statistical, threshold, frequency and waveform characteristics of magnetic field exposure. The limiting factor in exposure assessment is not instrumentation but the lack of a consensus as to what exposure characteristics should be measured that are biologically relevant. Computational methods are available to calculate fields and their parameters for instrument calibration, laboratory exposure systems and certain categories of indoor and outdoor sources.

SOURCES UNIDIRECTIONAL AND VLF ELECTRIC AND MAGNETIC FIELDS

Electric fields caused by direct current (DC) are known as static fields, because they do not change over time. Their frequency is equal to zero and the wavelength of the atom. In this case, the circuit transmits all the energy and does not radiate at all. Therefore, we have only field. Since the field is static, there is no excitation of surrounding molecules and there is no heating. The electromagnetic field produced by direct current can cause a burning sensation when standing close to the source or high voltage source straightened hair[1]. The Earth produces an electromagnetic field, which is almost static. This field makes the Earth with its magnetism, Solar activity and atmospheric discharges in the form of electrical and lightning storm. Earth's static electric field depends on the conditions in the atmosphere. During the calm and clear weather conditions, the field has a strength of about 150-300 V / m, but during an electrical storm may reach a value over 10.000V/m.

Intensity of the magnetic field ranges from 30µT to 70 µT depending on latitude and composition of the Earth's crust (magnetically conductive ore or local mountains). The volume density of the Earth's magnetic field at latitude of 50° is 58 µT, and on the equator (0 ° latitude) is 31 µT. The average volume density of Earth's magnetic field is 45 µT(K. Dervić, S. Janković, Ž. Despotović, V. Šinik, V. Kerleta**,)**.

It is interesting to note that human movements within the Earth's magnetic field caused by induced electric field inside its body. For example, a quick run around 8 m / s creates an internal electric field of 400 µV / m. Such strength of the electric field can induce a low frequency magnetic field magnetic flux density of 20µT(K. Dervić, S. Janković, Ž. Despotović, V. Šinik, V. Kerleta**,)**.

Time-varying electromagnetic fields generated by time varying AC (Alternating Current) electricity during transmission, distribution and use of electricity. The main sources of time varying electric fields in the work area are electric cables. The strength of these fields is in the range from 1 to 100 V/m. Flow of electrical current through a conductor produces a magnetic field. These fields always form a closed loop around the conductor which caused them. As the basic unit of magnetic flux density Tesla [T] is very large, it is the practice of using smaller units: microtesla [µT] and nanotesla [nT]. Under normal conditions in the workplace time-varying magnetic fields caused by electric grid ranging from 10 nT to 1 mT.

Frequency of a VLF field depends on the field sources. Although the dominant frequency of 50 Hz and 60, people are generally exposed to a mixture of frequencies, some of which may be much larger. For example, the frequency of certain parts of electronic equipment or TV monitor can go up to 120 kHz.

Electric power system

Electrical energy produced in power plants is distributed to consumer areas via high voltage power lines from 35 kV to 400 kV. The voltage is reduced by transformers to 400/230 V for local distribution. The general population is exposed to magnetic fields at the network frequency, 50 Hz in as, via three individual sources: high voltage transmission power lines, the local system for the distribution and low voltage electricity at home and at work, and electrical household appliances. The first two sources create basic, so-called background magnetic radiation, known as the magnetic flux density of the environment.

Overhead power lines

Transmission and distribution lines can be called by one name **-** power lines. Overhead power lines are the less expensive way to transfer electricity. Usually consist of parallel conductors, which carry most of the energy with very few losses or small radiated energy. Field between the conductors is intense, but it is usually closed between them. The strength of the magnetic field line is determined by the rate of electricity, the proximity of the transmission line, the transmission line height above ground, distance between phases, column geometry and distance from other lines.

Highest levels of electric and magnetic field lines are located in the area where the conductors are closest to the earth, and it is midway between the two pillars. Because of the ambient temperature, the height of the lowest conductor was flying lower and higher in the winter, because the levels of the fields in the area flying higher and lower in winter.

All over the world there are vast energy network. That means that almost complete human populations exposed to various fields of power system components. The only difference is in the degree of exposure that varies in the day, days in the week, the season, and depending on the ambient temperature. Most fields are usually located beneath high voltage transmission lines, however, the field strength depends on the strength of the current.

Transformer stations

Transformer stations are one of the most important parts of the energy system, which is used to change the voltage level, and perform other functions in the transfer of control and flow of electrical energy. There are several ways to build substations in order to achieve a reliable electricity system. In essence, they are complex equipment such as circuit breakers, high voltage switches, grounding, transformers intended course with the changing voltage control. Since the substations are often located near schools and homes, must be considered as sources close to the electric and magnetic fields.

Transformers are sources of strong magnetic fields because their principle of operation is based on a time-varying magnetic fields. The problem of the magnetic field near cells is more complex, since the current entering or leaving the station, in the general case are not symmetric. Field produced by equipment weaks with distance and do not spread outside the physical boundaries stations. However, the magnetic field near the station is stronger than in other parts.

Transformer as standalone devices found in rural areas (Column transformers), and in urban areas, mostly inside residential buildings. Transformers in buildings adversely affect the people in the apartments above them. These transformers, create an extremely strong electric and magnetic fields. Unfortunately, to enable lower expenses of their installation, they are frequently installed in the buildings. That is not in line with technical recommendation which allowed that kind of installation in exceptional cases, only. This radiation is stronger than transmission radiation.

Electrical installations

Average value of the magnetic fields in homes which are away from power lines and transformer stations is small. The mean value of the magnetic fields in the houses in major cities is around 0.1 μT. Values in the smaller towns and villages are of half of noted value. In cities, about 10% of homes have at least one room where a field value exceeds 0.2 μT. If a house is near power lines and substations strength magnetic fields are even greater. It was found that 0.5% of houses have values of magnetic fields in excess of 0.2 μT. For commercial buildings, transformers and distribution boxes are placed in separate rooms in the buildings. Field values in areas around such premises or buildings have a value from 1 μT to 10 mT.

Vehicles on electric power

Electric trams and trains are also sources of static and VLF fields. For traction they somewhere use direct current somewhere alternating current. Near the coaches floor the static magnetic fields can reach 0.2 mT, and time-varying magnetic fields can reach several hundred μT. At the headquarters of passengers, electric fields can reach up to 300 V / m and magnetic field reaches values of a few tens μT.

Values are highly dependent on the level of design and location of electrical equipment and machinery within the train composition. Traction motors and equipment are often placed under the floors in the coach. They create a ver intense fields in the area of the floor below which they are located. Passengers were further exposed to magnetic fields from sources that are close to the tracks

INSTRUMENTS FOR THE MEASUREMENT OF STATIC FIELDS

In Figure 1 is shown an instrument ETM-1.Due to its specific characteristics (frequency range O Hz), only used to measure electrostatic magnetic fields.

Directional characteristic . . . . isotropic, three dimensional
Meas. range . . . . automatic ranging, three ranges
Temperature range. . . . . 0 to +40 ^{0} C
Sensor type . . . . magnetic field(H)
Frequency range . . . . static; 0 Hz
Specified measuring range . . . . 19.99, 199.9 and 1999 mT
Accuracy. . . . . +2% of measured value
Drift . . . .+0.05%/ëC starting at +25 ^{0} C
Ambient field for device with battery 0.1T
Ambient field for device
without battery (a.c. line power) 1.5T
Dimensions in mm
Weight . . . . 250 g

Figure 1. The meter of static magnetic field and its features

Applications

The probe is designed for use in measuring constant magnetic fields, as occur with medical equipment (magnetic resonance imaging, MRI), metal production and railway systems.

Features

The ETM-1 extends the EFA-1 to EFA-3 family of low-frequency field analyzers to cover measurement of constant fields. The device has automatic ranging, or one of three ranges can be selected manually (19.99 mT, 199.9 mTand 1999 mT). Results have units of mT in the 31/2 digit LC display. All three axes can be evaluated, or just one of the three (x, y, z). The probe is connected via a 1.5 m shielded cable to the test instrument. The small size of the probe (dimensions: 126126100 mm) enables measurements in tight places.

Calibration

The device is factory-calibrated. Recalibration is recommended every two years. Calibration data are traceable to national/international standards. The specified confirmation interval is only a recommendation. Users can choose a confirmation interval to suit their needs, based on the type of application and ambient conditions.

Rugged design

The rugged mechanical and electrical design of the device destines it for field use. The ETM-1 runs for about 15 hours on a standard 9 V lithium battery. The ETM-1 can also be powered from an a.c. line unit (included).

Functional principle

The probe uses three separate sensors. Hall probes are used as sensor elements for the magnetic field. The three channels are realized separately and evaluated in the mainframe. This assures display of the RMS value across a wide measuring range. Usage of these detector elements guarantees excellent overload protection, making it practically impossible to destroy the sensors through everyday usage. For remote control, the ETM-1 has an RS232 interface. The device can be remotely controlled via the supplied cable and the serial interface of a PC. This allows users to control the device from a remote site while it measures very powerful fields.

INSTRUMENTS FOR THE MEASUREMENT OF VLF

Magnetic fields are present in production areas, public places and the everyday environment. Measurements are often made in these areas to ensure that people are not exposed to fields that could cause injuries. Global efforts to provide effective protection have resulted in a range of national and international guidelines and standards in recent years, which specify reference limit values for field strengths for various frequency ranges and signal shapes. In practice, simple equipment must be used to determine the fields that occur and to check that the limit values are not exceeded. The ELT-400 is a completely new type of tester for workplace and public area exposure to magnetic radiation. It was developed specially for the above areas, for use by health and safety representatives in industry, insurers, and service providers.

Production areas The ELT-400 is particularly suitable for applications involving production plant, including welding, smelting and heating, as well as most magnetic stirring equipment. It can handle special requirements such as the pulsed signals or phase control encountered in resistance welding without problems. **Everyday environment** Magnetic fields occur everywhere in the everyday environment, being produced by everything from power supply plant through to medical equipment. For example, the electromagnetic and magneto-acoustic security systems used in department stores also operate within the frequency range of the ELT-400.

EMC test laboratory The ELT-400 is ideal for investigating the magnetic fields produced by household equipment or other electrical devices. The reference test method described in the latest product standards such as EN 50366 and prEN 50392 is implemented precisely in this instrument. **Instrument description** The ELT-400 is extremely easy to operate using just 6 buttons and can be used practically anywhere. **Exposure STD mode** Exposure STD mode is suitable for particularly simple and reliable measurements on all signal shapes (single or multiple frequency fields, pulsed fields). The level of the magnetic field is displayed directly as a percentage of the reference limit value, regardless of the signal shape and frequency. The evaluation schemes specified by the relevant safety standards are implemented in the instrument. The numerical result therefore clearly expresses the actual situation and indicates the available safety margin. **Field strength mode** The ELT-400 has a flat frequency response over a very wide frequency range. Detectors for RMS and peak value measurements can be used for broadband measurements. The results of field strength measurements are displayed in µT or mT. **Active probe** The ELT-400 can be connected to an oscilloscope or FFT analyzer for more in-depth analysis. The signal voltages from all three field probes (isotropic coil configuration) are output with proper phase. The amplified voltage can be input directly to the oscilloscope or FFT analyzer.

EMR-20C and EMR-21C, E-Field Measurement Systems

The EMR-20C and –21C are complete systems that consist of a meter and probe, along with a charging system for the NiCad batteries. The EMR-20C and EMR-21C are supplied with a cali- brated Type 8 probe that provides coverage for many industrial systems operating at 915 and 2450 MHz, as well as measuring extremely low field levels. Users appreciate the wide measurement range and extreme ruggedness of this multipurpose survey system. The EMR-20C and -21C have even been designed to withstand drops from two meters directly on the sensor head! Operation of this series of survey systems could not be any easier. All you need to do is connect the probe and turn on the meter. The system automatically detects the probe and auto-zero’s the system – even while immersed in an RF field environment. Electric field readings are displayed in units of V/m, W/m2 and mW/cm2 , with over 62 dB of measurement range, without touching a button! Both the EMR-20C and -21C feature a bi-directional fiber-optic link. With the optional software and cables, real-time readings can be displayed on a personal computer.

Figure 2. The meter of the magnetic field ELT-400 and E-electric field measurement systems EMR-20C, EMR-21C

MEASUREMENT OF STATIC ELEKTROMAGNETSKILI FIELDS (O Hz)

This type of measurement is particularly suitable for later distribution planning in areas (places to sleep and stay longer) in order to avoid long exposure to elevated values of static electromagnetic radiation. The measurements were carried out at a height of 1 m above the floor with isotropic probe, which accounts resultant measured components of static electromagnetic fields and is not sensitive to the position of the hand. Values were read after 10 sec. of stabilization and each node. After the measurements, and electronic processing of measurement results obtained are the results for the entire apartment. In order to gain better insight and analysis of the measured values of the static electromagnetic fields and Figure 3 shows the 3D look at the measured results.

In areas that are facing rgema street, measured been slightly increased radiation density of the static magnetic field with respect and natural magnetism of the country (the magnetic flux density of the earth's natural magnetism varies from 0.4 to 0.85 mT).

The assumption that the cause of communal infrastructure, and natural water flows along the street. At two places is also registered slight increased emissions due to influence of the speaker.

Although the radiation is within acceptable limits, the observed higher intensities of radiation in the bedrooms and living rooms along the north wall.

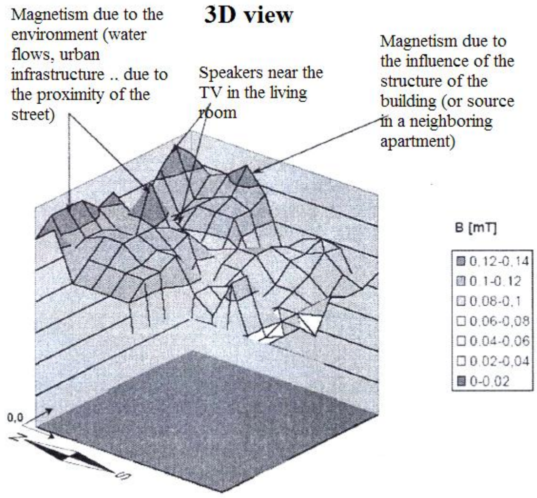

Figure 3. An example of the results and analysis of measurements of static EM fields

MEASUREMENT OF LOW-FREQUENCY ELECTROMAGNETIC FIELDS

Since the spectral analysis showed radiation power grid as the most dominant component of low frequency spectrum measured density the magnetic flux in the room. The electrical field strength was not measured in this way because of the possible distortions due to the proximity of the field of furniture and walls.

After the measurements in all the rooms and the electronic processing of the measurement results, the obtained results for the entire apartment. In order to gain better insight and analysis of the measured values of the electromagnetic fields of low frequencies in Figure 4 shows the 3D view of the measured results. The room measured maximum magnetic flux density is relatively low to moderately high intensity. Jumps occur and 4 places: the TV, the computer, the area with the kitchen cabinets and a source of radiation in the bathroom wall.

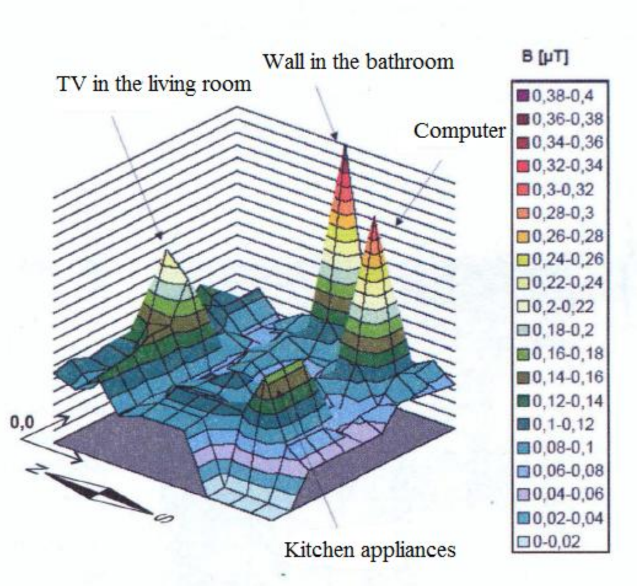

Figure 4. Example analysis of low frequency electromagnetic fields in the flat

CONCLUSION

Following the results of the analysis of exposure to electromagnetic radiation apartment in Figures 3 and 4, we can see that it recorded a slight increase in the static magnetism in the northern areas, it is in the living room and bedroom, near the road, and also in one of the eastern wall of the bedroom. As the cause of the said radiation usually impact the Earth's natural magnetism, natural waterways, the geological structure of the soil, municipal infrastructure, etc. .., you can see that the position of the apartment on the 3rd floor contributed to the reduced intensity of radiation electromagnetic static fields.

The measured radiation have a not greater impact on the body of people who reside in the specified area. Although the radiation is far below the allowed limit values, however, the intensity in some areas twice the size of Earth's natural magnetism. For some people, there was an increased sensitivity, the greater the difference in relation to the natural magnetism may, after long-term exposure (these are the years), due to the accumulating effect, lead to sleep disturbances, minor fluctuations in the cardiovascular system and the like.

As the most radiation may accumulate during sleep (average of 7 hours per day in the same place), the recommendation is to set protective coverings on the bed frame.

Also, as one might expect increased low-frequency radiation and electrical fields magnetskili near electrical devices fed voltage grid (50 Hz and 220 V), so close to the TV and the computer may notice more radiation on average distance of half to one meter. Although the aforementioned radiation of low intensity and within the permitted limit values, to avoid prolonged stay in their vicinity.

As tenants do not stay a long time in the bathroom there mentioned radiation and will have no adverse effect. However, it should be borne in mind that the radiation of low frequency and stronger intensity, due to its characteristics, it has significant negative effects on the human body (among other things, it is assumed that promotes the creation of cancerous cells).

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