COMPUTATIONAL PROBLEMS OF ELECTRICAL ENGINEERING

Vol. 2, No. 2, 2012

TESTING ELECTROMAGNETIC FIELD METERS

Eugeniusz Grudzinski[1], Vitaliy Nichoga[2], Ivan Prudyus[2], Hubert Trzaska[1]

[1]Technical University of Wroclaw, Poland, [2]Lviv Polytechnic National University, Ukraine

E-mail: nich@org.lviv.net

Abstract: In this paper selected solutions of testing electromagnetic fields (EMF) meters used for the purposes of labour safety and environment protection are presented.

Keywords: exposure systems, the accuracy, uncertainty, embedded power supply.

1. Introduction

Measuring electromagnetic fields (EMF) for the purposes of labour safety and environment protection is usually performed outside of laboratories, in poor industrial of climatic conditions. Thus, a basic requirement of Polish Accreditation Center, which certificates the laboratories allowed to perform these measurements, is to have a possibility to check a EMF meter during the measurements. There are two reasons for setting up the requirement:

- a meter (probe) is likely to be damaged due to overloading during measurements, transportation down the local roads or off-road terrain and unfavourable meteorological conditions, etc.
- the results obtained are likely to be misleading due to the relatively low EMF levels near high power sources (for instance at transmitting centers) and comparatively high levels near low power sources (e.g., near to portable communication equipment).

The authors' experience would suggest one reason more: very often the measurements are performed by people without a basic knowledge in electromagnetics. In many labour safety and environment protection inspectorates the electromagnetics is "a bay product" for their employees generally specialized in radiology or even in chemistry. A possibility of checking a meter *in situ*, that is while measurements are being done, can prevent the staff of the inspectorates (notably, testers) against doubts or mistakes.

Moreover, laboratory tests have shown that EMF meters available on the market are useless in the case of measurements in complex electromagnetic environment. Doubts being raised, a tester may be helpless as well.

The first reason for surveying an EMF is usually a necessity to state if its levels do not exceed those limited by appropriate protection standards. On the ground of the measurement results various legal decisions may be proposed; for instance: the reduction of working time, extra payments or necessary medical examinations, the reduction of radiated power, the rearrangement of radiating system, etc. The latter requires maximal measurement accuracy and reliability. Rather imprecise EMF measurements do not go with the legal decisions, which require regular, periodic testing with verified meters and by the authorized labs. But in comparative measurements the accuracy equivalent to EMF standards is not necessary.

In the paper the selected solutions of testing the EMF meters have been presented that were designed with the authors' participation [1–3, 6].

2. The oldest solutions

Poland was one of the first countries where legal measures were taken in order to protect population against unwanted exposure to EMF. As a result first series of selective E- and H-field meters were designed at the Technical University of Wroclaw. The meters were designated mainly for radio and TV transmitting centers Wideband E-, H- and S-field MEH-type meters of the second generation were widespread throughout the country and abroad. At the beginning the meters were equipped with sinusoidal probes in the form of a flat loop for H-field measurements and a dipole for E and S measurements. The theory of the measurements of nearby electromagnetic fields was developed in cooperation with the National Bureau of Standards, Boulder, CO, the USA (presently National Institute of Standards and Technology, NIST) [4]. For *in situ* meter testing a tester USMEH was designed. The block diagram of this device is shown in Fig.1.

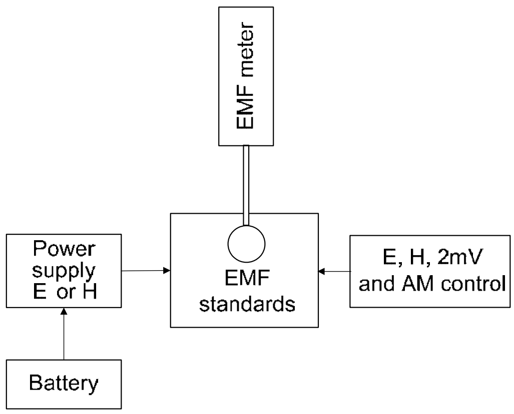

Fig. 1. Block diagram of the USMEH-type tester.

The tester included a LC generator, working at frequency 1 or 10 MHz, buffer and amplifier loaded with a capacitor and a coil. Because of using wideband probes testing the frequency stability was here of secondary importance; however, it was higher than 1 %. The construction of this tester included a pocket in the back-side of the tester for a testing loop. For E-field probes there were a connector in the top-side of the tester, as shown in Fig. 2. The figure shows an E-field probe during the test and an H-field probe in the front of the set. An analog indicator allowed regulating field levels about 10 V/m and 1 A/m. Additionally, it was possible to check the sensitivity of indicating part of the meter to DC (2 mV) and to test a loop (AM mode).

Fig. 2. MEH-type meter tested usingthe USMEH-type tester.

3. More advanced designs

The rapid increase of society attention to labour safety and environment protection as well as the developement of protection standards have caused the necessity of modernizing MEH-type meters and to the appearance of the wide range of meters, manufactured by world-known firms like Narda [5], on the market. The modernization included, among others, widening frequency ranges and using spherical probes. No However, neither of manufacturers offers any auxiliary devices for testing EMF meters *in situ*. It has lead to a necessity of developing more universal testers that would allow testing different types of meters at different frequencies. For this purpose several kinds of testers have been designed. A block diagram of one of them, intended for testing MEH-type meters, is shown in Fig. 3. It is equipped with three generators working at low, medium and high frequencies (LF, MF and HF). Their inputs are connected to the system of coils and electrodes around the probe of any type. As opposed to the USMEH-type testers, in the above mentioned one the output amplitude of signals exciting the electrodes cannot be regulated. The former, with its possibilities and accuracy, could be applied as a secondary standard. The later generates fields with amplitudes stable enough and should be primarily calibrated by any other meter and a probe. This calibration is performed by reading out the data from the meter while its probe is staying in the compartment of the tester directly after the calibration of the meter at the certified laboratory. During any testing operation, the data should be identical to confirm the correct work of the device tested. It is evident that the universality of the tester was achieved at the expense of its accuracy; however, this fact does not influence its workability, since the uncertainty of the procedure in the first approximation is acceptable. Only the repeatability of the indications of the tested meter in any conditions is important here.

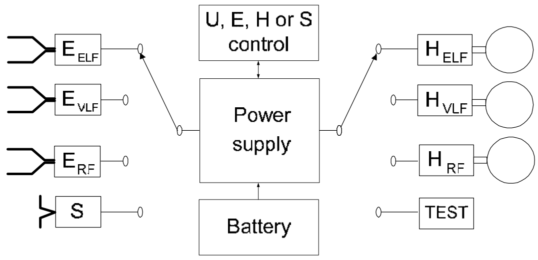

Fig. 3. Block diagram of a UTEST-3 type tester.

A MEH type meter testing in UTEST-3 tester is shown in Fig. 4.

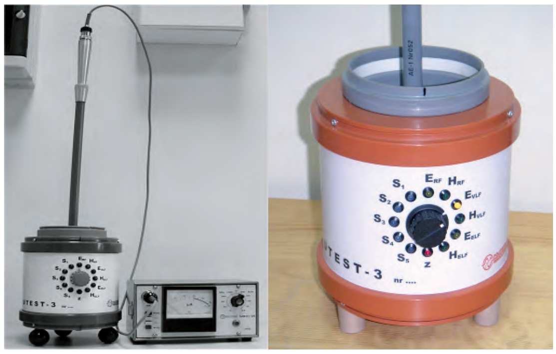

Fig. 4. MEH-type meter tested in UTEST-3 type tester.

The concept, similar to one shown in Fig.3, was applied in the other tester construction. The example of a more universal device is shown in Fig. 5, where a PMM meter is tested using tester UTEST-5.

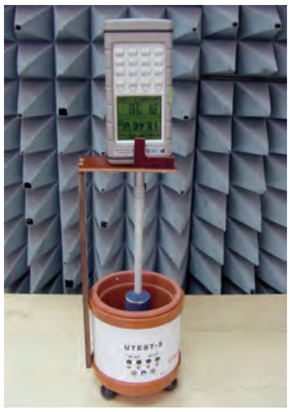

Fig. 5. PMM-type EMF meter during the test in UTEST-5.

4. Pulsed EMF generation

As a rule, EMF meters are calibrated and recalibrated using standard fields excited by the sources of stable oscillations. The calibration, in some sense, is universal one and the meters are used then for measuring the EMFs with alternating amplitudes. The accuracy of the measurement, with a meter calibrated in such a way, is correct while fields of constant amplitude are measured. The measurements of the fields of time-varying amplitudes lead to errors exceeding one order of magnitude. Such alternations, apart from propagation reasons, take place, for instance, as a result of amplitude modulation in telecommunications or variations of electric parameters with temperature in heated objects. The worst situation appears in unstable fields, for instance, near radar stations. There, in a point of observation, EMF with the pulse modulated carrier is generated in the form of pulse packets. The shape and duration of the packets is a function of the radar antenna diagram and of its rotation velocity. In order to improve the accuracy of the field measurements a new method of calibration was proposed. A special design of a tester construction for unstable measurement purposes has been developed and a block diagram of such a device is shown in Fig. 6.

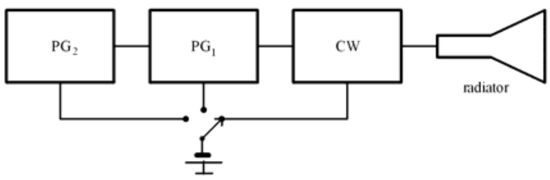

Fig. 6. Block diagram of a tester for the meter of a non-stationary EMF.

The device includes three generators: the HF generator (CW) based on a Gunn-diode which is directly connected to an antenna (typical devices are available for different frequency ranges); a pulse generator (PG_1) which carries out the continuous pulse modulation similar to that of a source being a subject of measurements; and a pulse generator (PG_2) which generates rectangular pulses simulating the emission of the radar antenna in the point of observation.

The tester is able to work using:

1. CW carrier wave, while the power supply is connected to the carrier wave generator;

2. the pulse modulated carrier wave, while the power supply unit is connected to the pulse generator PG_1;

3. pulse packets, while the pulse generator PG_2 is powered.

The concept in item 2 is identical with those used in radar transmitters, where a carrier wave generator is excited by a pulse generator. The case presented in item 3 is exactly the same; however, here pulses from generator PG_2 excite generator PG_1, and its output voltage excites the carrier wave generator.

An example of testing is shown in Fig. 7. A tested probe (meter) is placed at a distance from a typical set of Gunn-diode generator and a horn antenna. In order to make testing possible in different frequency ranges different sets “generator-antenna” are used. Any of them can be connected to the same source of excitation, containing power supply and two pulse generators. The procedure here is similar to previous: if the amplitude of the generated field is stable enough in time (since frequency stability is not important as tested meters are wideband ones) and tested probe (meter) is placed always at the same distance, the indications of the meter are similar, and this would confirm the correct work of the meter.

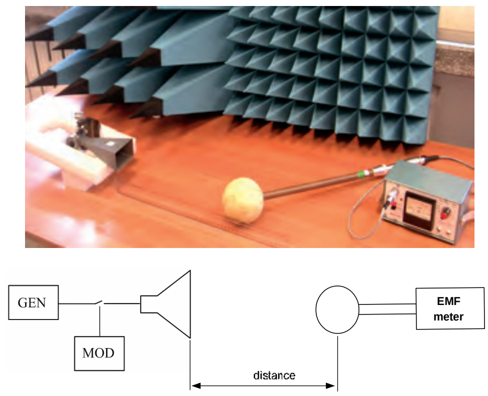

Fig. 7. Testing in non-stationary conditions.

5. Summary

EMF surveying is usually performed in complex EM environment, in different meteorological conditions, in harsh industrial conditions at factories or transmitting centers, etc. These conditions may affect a measuring team and measuring equipment used by the team. Apart of obligatory periodic calibrations, any device, exploited in these conditions, may be damaged; thus, a possibility of checking it during the measurements is of primary importance. Presented constructions of meter testers are intended mainly for labour safety or environment protection inspections, which usually perform the measurements outside a laboratory. This equipment may also be useful in any laboratory involved in bioelectromagnetics, or even in electromagnetic compatibility, where EMF meters are applied. In the latter cases checking a meter may confirm the correctness of an emitting system and emitting conditions can be determined and estimated.

References

1. E. Grudziński, W. Nichoga, V. Antonyuk, I. Prudyus, Monitoring of Electromagnetic Sources in Diagnostic of Environmental Risks // Przegląd elektrotechniczny. – Vol. 85, № 11. – 2009. – P.105–110.

2. E Grudziński, V. Nichoga, I. Prudyus, Antennas in Metrology of Electromagnetic Fields near Radiation Sources // In Proc. 8th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Services (TELSIKS’2007). – Niš, Serbia. – Vol. 2. –2007. – P.407-413.

3. E. Grudziński, I. Prudyus, T. Dąbrowski, W. Niczoga, Loop Aerial and Dipole Antennas in Metrology of Electromagnetic Fields // Biuletyn Wojskowej Akademii Technicznej. – Warsaw, Poland: WAT. – Vol. LVI, Special edition № 2. – 2007. – P. 179-186. (Polish)

4. E. Grudziński, Calibration of Measuring Equipment used for the Control of Electromagnetic Fields in the Workplace and Environment // Medycyna Pracy. – Lodz, Poland. – № 57(2). – 2006. – P. 171-185. (Polish)

5. http://www.narda-sts.de

6. E. Grudzinski, H. Trzaska, EMF Standards and Exposure Systems. – USA: Noble Publ. – 2013.

ТЕСТУВАННЯ ВИМІРЮВАЧІВ ЕЛЕКТРОМАГНІТНОГО ПОЛЯ

Еугеніуш Грудзіньскі, Віталій Нічога,
Іван Прудиус, Губерт Тжаска

У цій статті представлено деякі питання, пов'язані з тестуванням вимірювачів електромагнітного поля (ЕМП), які використовуються в галузях охорони праці та захисту навколишнього середовища.

Eugeniusz Grudziński – D.Sc., Professor, born in 1948. He is the manager of the Accredited Laboratory of Electromagnetic Field Standards and Metrology of the Institute of Telecommunication, Teleinformatics and Acoustics of the Wroclaw Technical University. Poland.

He is the author of more than 160 publications dealing with generation and metrology of electromagnetic fields with frequencies up to 50 GHz.

Vitaliy Nichoga – Ph.D., D.Sc., Professor, born in 1938, holds a post of the Professor at the Department of Radio Electronic Devices and Systems of the Institute of Telecommunications, Radio electronics and Electronic Technique of Lviv Polytechnic National University, Ukraine; the author and co-author of more than 330 scientific works.

Ivan Prudyus – Ph.D., D.Sc., Professor, born in 1942. The director of the Institute of Telecommunications, Radio electronics and Electronic Technique of Lviv Polytechnic National University, Ukraine; the author and coauthor of more than 170 scientific works.

Hubert Trzaska, D.Sc, Professor, born in 1939. He holds a post of the Professor of the Wroclaw Technical University and the manager of the Electromagnetic Environment Protection Department at the Institute of Telecommunication, Teleinfor-matics and Acoustics.

He is the author of more than 300 publications dealing with electromagnetic field metrology.