Measurement of Electromagnetic Interference of Electronic Devices

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Abstract — **Measuring levels of electromagnetic interference, which are emitted by electronic devices, must be carried out in specialized laboratories that are equipped with an anechoic or semi-anechoic chamber. Electromagnetic interference of electronic devices is measured in these chambers at a distance of several meters; therefore, this interference is included in the far-field of electronic devices. Another possibility of measuring of electromagnetic interference is the measurement in a Gigahertz Transversal Electromagnetic (GTEM) cell. Unlike the chambers, the GTEM cells measure electromagnetic interference in the near-field of devices. Since the chambers are often fully booked, manufacturers of electronic devices can not test products in every phase of their development. The measurement of electromagnetic interference of electronic devices in the GTEM cell might be a possible alternative measure for manufacturers.**

Keywords- Electromagnetic compatibility; Electromagnetic interference; Intrusion and hold-up alarm systems; Electronic device; Level of interference signals.

I. INTRODUCTION

Nowadays, the level of electromagnetic interference (EMI), which is normally found in our surroundings, can be a serious problem for the operation of electronic devices. The level of EMI is sometimes so high that it can cause malfunction or damage, and even the destruction of electronic devices. Because every electronic equipment, system or device is not only a receiver of electromagnetic interference, but it is also the source of interference, the problem with EMI is growing [1].

We face the question of problems of electromagnetic interference from the very development of electronic devices. One of the aims of the manufacturers is to bring to the market a product, which has a high resistance to electromagnetic interference. Also, this product should not produce electromagnetic radiation that could disrupt the functionality of other electronic equipment in its surroundings during its current operations. For this reason, manufacturers must test their products in laboratories of electromagnetic compatibility (EMC) [2] [3].

Specialized generators that can produce various types of electromagnetic interference are used for most of the tests for electromagnetic susceptibility of electronic devices. These generators are quite expensive but their cost is negligible in contrast to the construction of the anechoic or semi-anechoic chamber. For example, the Haefely AXOS5 Compact Immunity Tester costs € 19,000 and constructing and equipping the semi-anechoic chamber may require the investment of € 450,000 and more. Therefore, some manufacturers have invested money in the purchase of such generators and they carry out themselves the most basic tests of electromagnetic susceptibility of devices at the time of development. Subsequently, when the finished product is tested in an accredited EMC laboratory, the manufacturer can be sure that the product meets the criteria in international technical standards for electromagnetic susceptibility for selected types of electromagnetic interference. For manufacturers, the problem is testing of electromagnetic radiation of their products when they want to find out the level of electromagnetic interference emitted by a new product during its development. The anechoic or semi-anechoic chambers are used for this type of tests in the EMC laboratories, however, these chambers are often fully occupied due to their small number and the repeated tests for testing of electromagnetic interference of device is expensive for manufacturers.

All electrical and electronic devices must be designed in accordance with the standards for EMC. In the field of electromagnetic interference, the components of intrusion and hold-up alarm systems (I&HAS) are tested in accordance with the international standard CSN EN 55022 ed.3. This technical standard determines uniform requirements for the high-frequency interference level of the information technology equipment, defines limits on the levels of the EMI and the methods of measurement [4] [5].

The aim of this paper is to publish the measured levels of electromagnetic interference radiated by the basic set of intrusion and hold-up alarm system in the semi-anechoic chamber and GTEM cell. The basic difference in the measured levels of EMI is based on the type of the measured electromagnetic interference. Electromagnetic interference, which is located in the far-field of an electronic device, is recorded in the semi-anechoic chamber while the interference in a near-field is recorded in the GTEM cell. In a further research, these data will be used for analysis, which answers the question whether the GTEM cell can be an adequate substitute for a semi-anechoic chamber for the measurements of EMI of electronic devices.

In Section II, the (semi)anechoic chamber is described and Section III focuses on the basic characteristics of the GTEM cell. In Section IV, we describe the set of I&HAS on which the level of electromagnetic interference was

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measured in the semi-anechoic chamber and the GTEM cell; in addition, this section discussed the measuring instruments used. In Section V, the results of the measurements are shown.

II. (SEMI) ANECHOIC CHAMBER

An ideal space for testing and measuring of EMC parameters of electronic equipment is an absorption chamber. This chamber is electromagnetically impermeable (electromagnetic shielding) through the outer structure of a well-conductive metal material. In our case, the semi-anechoic chamber was built from the panels that were of galvanized sheet steel with a thickness of 2.0 mm.

The interior of the chamber is covered with an electromagnetically absorbent material which significantly reduces the internal reflections in a broad frequency. This absorbent material can be made of a ferrite or a carbon with a styrofoam. The absorption chamber exists in two versions both as the anechoic chamber or semi-anechoic chamber.

The anechoic chamber has covered with an absorbent material, not only interior walls and ceiling but also the entire floor. As such, the anechoic chamber simulates unlimited open area. In practice, we often encounter a semi-anechoic chamber (shown in Figure 1), which has covered with an absorbent material only the ceiling and walls and simulates the open area with reflections from the ground plane.

The absorbent material can be placed on the floor in the semi-anechoic chamber if it is required under the technical standards or requirements of the manufacturer of the equipment under test (EUT).

Figure 1. Semi-anechoic chamber

The absorbent material converts the energy of the incident wave into heat using the magnetic or dielectric losses. Due to the price, dielectric materials are preferred, such as the different toughened foam materials of polystyrene, polypropylene or polyurethane that contain electro-conductive or graphite fillers. Most frequently, these materials have the shape of a pyramid or cone, but we can also encounter the absorber surface area. The main disadvantage is that a quality anechoic chamber is technologically and financially very demanding [5] [6] [7].

III. GTEM CELL

The GTEM cell (shown in Figure 2) is a specially constructed shielded space which allows the measurement of EMC parameters of small electronic devices. The GTEM cell enclosure is made of conductive material and has the shape of a pyramid. The rear internal space is covered with the absorbent material, the side walls are left bare to act as a waveguide. The antenna or field probe is placed in front of the cell and the EUT is placed in the space between the absorber and the antenna or field probe (transducer) [8].

Figure 2. GTEM cell

The GTEM cells can be of different sizes depending on the septum height from 0.25 m to 2.0 m. The GTEM cell is considerably smaller and its price is much lower in contrast to the anechoic or semi-anechoic chamber [9].

IV. SET OF I&HAS AND MEASURING INSTRUMENTS

This basic set of intrusion and hold-up alarm system belongs to the product lines of Oasis and includes the following components:

- Control panel JA 82-K
- Accumulator 12V, 2.4Ah
- Mains power module
- Keypad JA-81E
- Passive infrared detector JS-20
- Siren SA-913TM

The control panel was powered from the mains supply 240V/50Hz and the control panel with accumulator and mains power module were closed in the plastic box. The electromagnetic radiation of this set was tested in the semi-anechoic chamber and GTEM cell in the EMC laboratory at the Tomas Bata University in Zlin in the Czech Republic.

The used semi-anechoic chamber was from the manufacturer Frankonia and was equipped with a BiLog antenna CBL 6112, which is the broadband biologarithmic-periodic antenna which operates with a range from 30 MHz to 2 GHz. The polarization of this antenna can be varied (horizontal or vertical polarization) and the height of the antenna is adjustable from 0.8 m to 4.0 m above the ground plane.

The BiLog antenna was connected to the EMI test receiver ESU8 with a range of 20 Hz to 8 GHz by using the switching and control units OSP130 and OSP150. The whole

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set was controlled by a computer with EMC Software EMC32 for simplifying control of the antenna, the setting of limits and higher quality display of measured data.

The used GTEM cell 250 from the manufacturer Frankonia had a maximum septum height of 250 mm and was suitable for the measurement of electromagnetic radiation of small electronic devices. The measuring probe EFS-10 was located inside the cell and it was connected to the test receiver ESPI (Rohde & Schwarz), which had an operating frequency from 9 kHz to 7 GHz.

V. THE RESULTS OF SELECTED MEASUREMENTS

The equipment under test was the basic set of I&HAS. We measured the levels of electromagnetic interference of this set in the semi-anechoic chamber and GTEM cell. The set of I&HAS was measured in the mode where the whole set was in the ON state (state of guarding) or when the alarm was induced.

The selected measurements from the semi-anechoic chamber and GTEM cell are shown in Figures 3, 4, 5 and 6. In the figures, the x-axis shows the frequency from 30 MHz to 1 GHz and the y-axis shows the measured level of electromagnetic interference. The levels of electromagnetic interference are stated in the specific unit dBμV/m. The red line, which is in the figures from the semi-anechoic chamber, shows the maximum level of electromagnetic interference, which the EUT can generate at the respective frequencies. This maximum level is defined by the standard CSN EN 55022 ed. 3. If the measured interference of the EUT exceeds this red line, it means that the device generates the interference which endangers functionality of electronic devices in its surrounding area and this EUT can not have the Certificate of the EMC tests.

Two coloured lines are shown in the figures from the semi-anechoic chamber. This is because each measurement was carried out in both polarities of the antenna. The antenna height was 250 cm above the ground plane. From our previous series of measurements, we determined that this was the ideal antenna height for the measurement of this EUT. The highest levels of electromagnetic interference emitted by the EUT were recorded at this height.

Figure 3 shows the electromagnetic interference generated by the EUT in the ON state. This EMI was recorded in both polarities of the receiving antenna. As apparent from the figure, the biggest differences in the levels of the electromagnetic interference of the EUT, when the polarity of the antenna was changed, have been recorded in the frequency range from 40 MHz to 80 MHz and then from 120 MHz to 220 MHz.

Figure 4 shows the set of intrusion and hold-up alarm system in the state of alarm. We also carried out two measurements for both polarities of the receiving antenna. With the antenna in the horizontal position (green line), a clearly recorded electromagnetic interference generated by the siren can be observed, which announced the alarm by the sound signal in the frequency range from 180 MHz to 280 MHz.

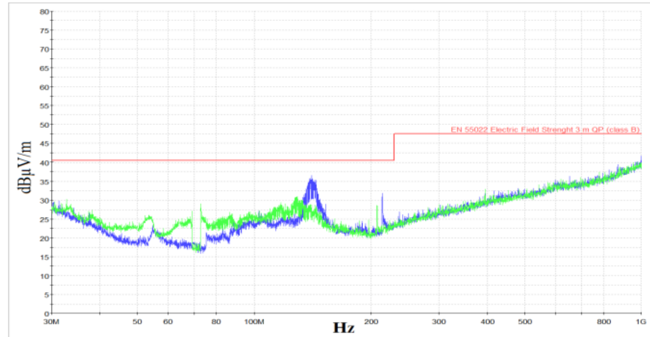

Figure 3. Semi-anechoic chamber - the EMI of the EUT in the ON state – the antenna in the horizontal (blue line) and vertical (green line) polarization

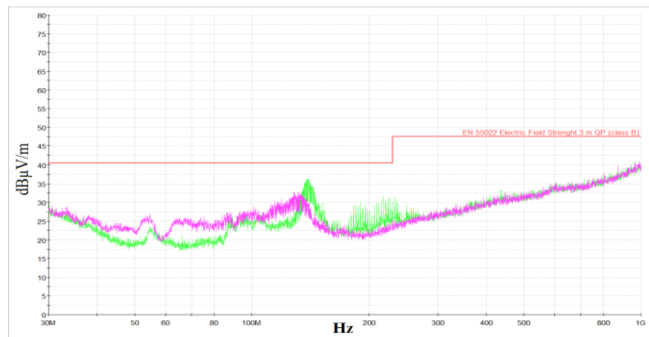

Figure 4. Semi-anechoic chamber - the EMI of the EUT in the state of alarm – the antenna in the horizontal (green line) and vertical (violet line) polarization

In the GTEM cell, we carried out same measurements as in the semi-anechoic chamber. In Figure 5 and Figure 6, the limit of 40 dBμV/m has been highlighted in red for better orientation and comparability of measurement data. The x-axis shows the frequency from 30 MHz to 1 GHz and the y-axis shows the measured level of electromagnetic interference in the unit dBμV/m.

Figure 5 shows the set of I&HAS in the ON state. As in the semi-anechoic chamber, the significant electromagnetic interference of EUT has been measured in the GTEM cell in the frequency range from 100 MHz to 200 MHz.

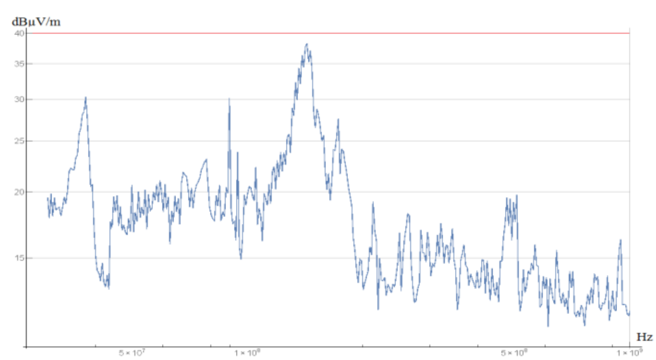

Figure 5. GTEM cell - the EMI of the EUT in the ON state

The difference between the measured data can be observed especially in the frequency range from 30 MHz to 50 MHz and from 200 MHz to 1GHz. These differences can be attributed to the fact that a certain low electromagnetic interference stably occurs in the semi-anechoic chamber and it overlapped interference which was emitted by the EUT. It is also necessary to take into consideration that electromagnetic interference measured in the near-field should have a higher level than electromagnetic interference measured in the far-field of the EUT.

Figure 6 shows set of I&HAS in the state of alarm.

Figure 6. GTEM cell - the EMI of the EUT in the state of alarm

The level of interference of the EUT in a state of alarm recorded in the GTEM cell at a frequency of 150 MHz exceeded the limit of 40 dBμV/m, which is determined by the standard CSN EN 55022 ed. 3. Due to the fact that interference in the near-field is higher than in the far-field and this limit is proposed for measurements in the far field, this result was to be expected.

VI. CONCLUSION AND FUTURE RESEARCH

The measured levels of electromagnetic interference radiated by the set of components of intrusion and hold-up alarm system in the ON state or state of alarm indicate that the measurements from the semi-anechoic chamber and GTEM cell are partially similar. The similarity in measured levels EMI of far-field and near-field the EUT indicates that there is the possibility of using GTEM cells as an adequate substitute for a semi-anechoic chamber in design time of electronic devices and it could be of great significance for manufacturers of these devices.

In all cases, electromagnetic interference of the EUT reached the highest level at a frequency of approximately 150 MHz. However, since the GTEM cell records electromagnetic interference in the near-field of the device and semi-anechoic chamber records the interference in the far-field of the device, the levels of EMI in the GTEM cell are noticeably higher. When the EUT was in the ON state, the level of EMI is closer to the border of 40 dBμV/m in the GTEM cell than in the semi-anechoic chamber. In the case of measurements when the set of I&HAS was in the state of alarm, the border of 40 dBμV/m was even exceeded in GTEM cell. However, exceeding of this limit was not very pronounced.

In future research, we will examine and analyze the measured data and we will carry out other measurements on other types of electronic devices. If it is established that the measured levels of EMI in the GTEM cell are stably higher than in the semi-anechoic chamber, the GTEM cell can be an adequate substitute for a semi-anechoic chamber intended to the pre-certification measurements of EMI of small electronic devices, however, with the necessary modifications of the maximum level of electromagnetic interference which is defined in the standard CSN EN 55022 ed. 3.

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