Identification of Interface in the Complex Systems Based on Radiated Emission of Mobile Computer

Rafal Przesmycki, Marian Wnuk, Pawel Skokowski, and Marek Bugaj
Faculty of Electronics, Military University of Technology
Gen. S. Kaliskiego 2 Str., Warsaw 00-908, Poland

Abstract— In the article structure of complex systems has been described and levels of radiated undesirable emissions deriving from contemporary IT equipment found on the European Union market have been defined and estimated. Moreover an analysis of radiated emission for particular equipment interfaces of a portable PC computer and results of identification of equipment interfaces for a portable device such as tablet characterized by increased radiated emission have been presented in the article.

1. INTRODUCTION

Generally, energy emitted by any source can depend on frequency (f), time (t) and direction (Φ). Its amount sent at the moment t towards Φ, with frequency f, falling to time unit, unitary solid angle and unitary frequency range (expressed in case of three-dimensional space in $[\mathrm{W} \cdot \mathrm{sr}^{-1} \cdot \mathrm{Hz}^{-1}]$), can be called source emissivity:

$$\varepsilon = f(\Phi, f, t). \tag{1}$$

Quantity ε can be found as operator describing conversion of energy released in source (which depends only on frequency and time) into space-time-frequency distribution of energy in medium surrounding source. If direction, frequency and time features of source are independent of each other, then its emissivity ε can be presented in the form of product of three functions representing separate characteristics describing frequency, direction and time selectivity of source [1, 2, 6].

2. COMPLEX SYSTEMS

Complex system is an internally compatible system. A set of electromagnetic signal sources and relations between them and their attributes can be called such a system. Relationship between sources are represented by their mutual interaction (internal interaction) and interaction towards surroundings (external interaction). An example of complex system is an IT device built from many electronic components with determined distinctive features. One of such features is spectrum of radiated emission being the mapping of emission of radiated disturbances. In case of complex system electronic devices cooperate with each other forming the whole system. So the example of complex system is central unit of PC computer or a portable device such as tablet which consists of many electronic components and equipment interfaces located in one casing forming the IT system as a whole [3–5].

3. THE LABORATORY STAND FOR MEASURING RADIATED EMISSION

Measurements of radiated disturbances emitted by IT devices have been conducted in accordance with the EN 55022 : 2011 standard. They consist in measurement of electromagnetic field intensity within the distance of 3 m from a device with the use of measurement antennas and measuring receiver within frequency range from 30 MHz to 6000 MHz. For automatic stimulation of operation of selected computer modules a program BurnInTest has been used. In the application BurnInTest we can select tests used for testing both software and hardware. Each test is assigned for testing various modules of computer system. Those tests can be conducted at the same time since each one has its own individual programs for testing particular components. There is also an opportunity to change load of specific interface into a particular cycle of processor clock through increase or decrease of the number of cycles for particular tests. On the tested portable computer ACER IconiaTab W700 it was necessary to install and activate the software BurnInTest, which allows to choose tests used during research.

Below in the next chapters selected settings and descriptions of tests used during testing the portable computer ACER IconiaTab W700 have been discussed and measurement results for such conducted tests have been presented [11–14].

4. TEST OF CPU AND RAM

This test allows to select a few subtests divided into two groups. The first one is 'Select Math Tests' and the second 'Select SIMD Math Tests'. In the first one there are two different tests: test on integers based on 32 bit table of random numbers from which numbers are processed with the use of mathematical operations. The second test is a test using floating-point numbers. Performed mathematical operations include: addition, subtraction, multiplication, division, addition and subtraction of floating-point numbers as well as multiplication and division of floating-point numbers. Each mathematical operation is performed twice and results are compared. If results obtained in two calculation differ, there is an error. For every test each mathematical operation lasts half second. This test allows to check RAM installed in a computer. It works in the way that standard is entered into RAM and next read out sequence numbers from RAM are verified. The formula changes automatically after transition of each cycle.

5. TEST OF GRAPHICS CARD

There is a possibility to choose one of a few available graphics tests: Local Video Memory Only: testing only local video memory. All Video Memory: testing total video memory, that is local video memory and other video memory such as RAM reserved for graphics. EMC Scrolling Characters: is used to test emissivity of monitors. Monitor and displayed image must be adjusted in such a way to maximize electromagnetic field at a monitor output (e.g., by selecting maximum brightness and white text against black background, letter H etc.). In each case, at first the test determines how much appropriate memory is free and then fills this memory with series of test formulas. Every test formula is entered into video memory and displayed in test window. After display data of test formula are read out again from video memory and verified.

6. TEST OF USB

This test allows to test USB ports. Two test versions are available in the test: USB1 (USB which 1. x transfer rate up to 12 Mb/s) and USB2 (USB 2.0 transfer rate 480 Mb/s). The number of operations in the performed test matches the number of bytes sent and received to and from interface load. Using versions USB1 or USB2 and the BurnInTest program it is possible to check: if USB port is turned ON, data which can be sent and are received by USB, USB error rates and transfer rate, if USB ports were correctly installed, USB cabling and a few USB ports simultaneously.

7. TEST HDD

This test contains series of operations which use a mass storage memory device (hard disk or other data carrier) connected to a computer. In the test we can connect to twenty drives which can be tested or checked at the same time. The drives can be connected via IDE, SATA, SCSI, USB, FireWire buses or any different method operated by the Windows system. User can select one of the following sequences or choose automatic switching between formulas. Available binary sequences in the test HDD are: cyclic data, data formula (0, 1, 2, ..., 255), random data contributing high or low level, binary data (10101010), binary data (01010101), binary data (00000000), binary data (11111111), pseudorandom binary data. During each test cycle a file is formed which is next verified on a tested HDD. The file size is equal to some percentage of disk capacity. All files are formed in main directory of selected disks. Default file size is 1.0% of disk size.

8. MEASUREMENT RESULTS

From among available tests the following ones have been selected: of processor, RAM, graphics card, USB and hard disks. During conducting emissivity tests three kinds of measurements have been made:

- all interfaces worked simultaneously,
- all interfaces were turned off. The computer worked with activated operation system in idle state. Thanks to that noise background for measuring environment was obtained,
- interfaces which at particular moment were tested have been turned on one by one: CPU and RAM, VGA, USB, Serial ATA IDE (HDD) [7–10].

In Figure 1 levels of electromagnetic field intensity have been presented in frequency function for noise background of measuring environment(blue colour) and portable computer with operation of all equipment interfaces (red colour). Presented in Figure 1 in blue colour noise background (computer operation without extorting movement on interfaces) is reference diagram to which other frequency spectra of portable PC computer working under load of particular interfaces are

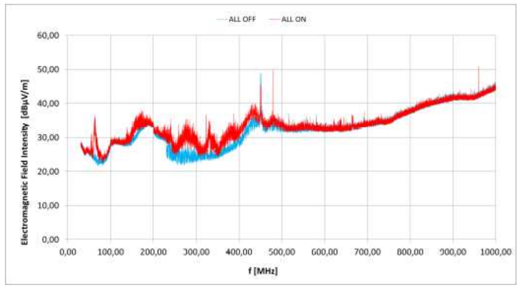

Figure 1: Levels of radiated emission of tablet with no load of equipment interfaces (blue colour) and with operation of all equipment interfaces (red colour).

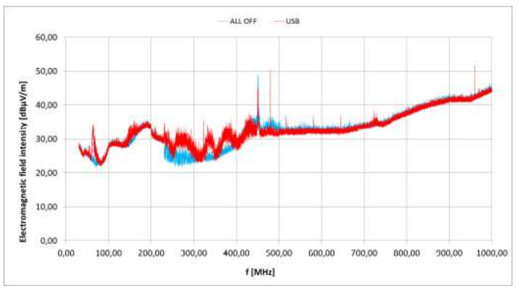

Figure 2: Levels of radiated emissions of tablet with no load of equipment interfaces (blue colour) and with operation of USB interface (red colour).

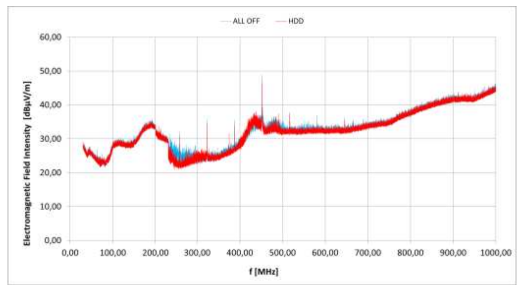

Figure 3: Levels of radiated emission of tablet with no load of equipment interfaces (blue colour) and with operation of HDD (red colour).

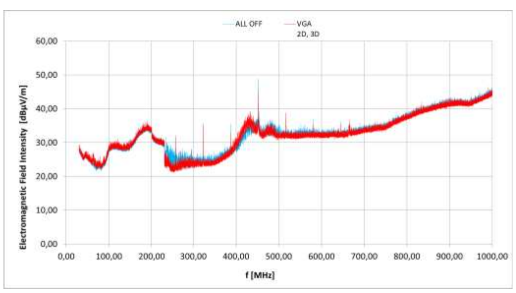

Figure 4: Levels of radiated emission of tablet with no load of equipment interfaces (blue colour) and with operation of VGA graphics (red colour).

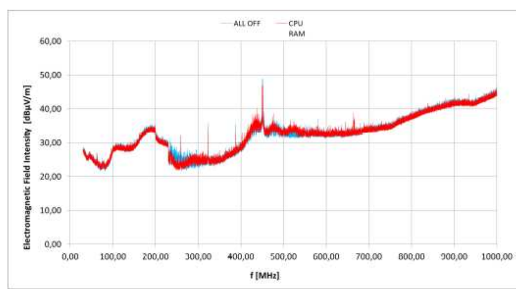

Figure 5: Levels of radiated emission of tablet with no load of equipment interfaces (blue colour) and with operation of CPU and RAM (red colour).

Table 1: Levels of EM field intensity from equipment interfaces situated in tablet ACER.

Device/kind of interface	f [MHz]	Emission level within the distance 3 m from tablet ACER IconiaTab W700 [dBμV/m]		Device/ kind of interface	f [MHz]	Emission level within the distance 3 m from tablet ACER IconiaTab W700 [dBμV/m]	
		With work of Interface	Without work of interface			With work of Interface	Without work of interface
USB	62–70	33,67	24,50	VGA	417–421	43,08	28,67
USB	140–160	33,18	28,79	USB	480,00	50,28	34,14
VGA	153,00	37,22	28,92	VGA	511–514	38,42	32,61
USB	260–290	31,05	24,30	CPU, RAM	663–666	36,89	33,04
VGA	288,00	41,98	34,55	HDD	680,00	46,91	40,02
HDD	374,00	31,56	28,01	VGA	820,00	46,71	38,84
VGA	382,00	43,46	35,10	USB	960,00	51,80	42,53

compared. In that way it will be possible to state if the emissivity increase occurred within a particular frequency range for tested interface. In Figures 2 to 5 measured values of the noise background level have been presented along with Values of electromagnetic field intensity radiated by tablet ACER IconiaTab W700 within the range from 30 MHz to 1000 MHz for various loads of the device. Load should be understood as activation of particular equipment interfaces of IT device.

On the basis of obtained measurement results one can state that there is a possibility to identify equipment interfaces of tablet which cause the increase of emissivity level. So, a distinctive feature of operation of specific interfaces is its work frequency and emissivity level allowing to identify a given equipment interface. The results of equipment interface identification have been collected in Table 1.

9. CONCLUSIONS

In the article levels of radiated undesirable emissions deriving from modern IT equipment present on the European Union market have been determined and estimated. Those emissions are by-products generated in unintentional way during realization of basic function of the device and therefore one should strive for as low their level as possible. Determined levels might be the basis at initial stages of designing electromagnetic safety of contemporary IT devices by striving for providing conformity with suitable norms effective in the European Union. Moreover due to identification of internal components of portable device causing increased emission there is a possibility of significant acceleration of the process of preparing the device for sale in case when its emissivity level is inconsistent with the norm. The collected within the study measurement results of radiated emission generated by particular components of the above mentioned devices have allowed to build data base which could be used for identification of components characterized by too high level of radiated emission.

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