The Configuration of Alarm Systems during the Measurement of Electromagnetic Interference

The Analysis of the Requirements of Legislation and Technical Standards

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***Abstract*–Alarm systems shall meet the requirements of electromagnetic compatibility. This is one of the basic prerequisites for their successful application, and thus, the quality of security of buildings. The article analyzes the configuration requirements of security alarm systems during a measurement of radiated electromagnetic interference. Requirements for configuration and operation are not uniform. Inconsistent and unclear requirements of technical standards may result in the differences in measurement results.**

Keywords-electromagnetic compatibility; alarm systems configuration; equipment under test; alarm security systems.

I. INTRODUCTION

Requirements for electromagnetic compatibility of products (in the European Union) are regulated by relevant documents, which are issued as directives of the European Parliament and the Council of the European Union. Currently, *Directive 2014/30/EC on the harmonization of the laws of the Member States relating to electromagnetic compatibility* regulates the electromagnetic compatibility (EMC) requirements of products.

Verification of compliance with the electromagnetic interference (EMI) requirements is realized in the form of standardized tests - measuring the levels of electromagnetic emissions. Components of alarm systems (control panel, detectors, keypad, power supply, access module, communicator, etc.) as electronic or electrical equipment are products which are the source and receiver of electromagnetic interference too [1].

The intention of EMI standards is to establish requirements for methods of measurement, to fix limits of disturbance, to describe general measurement conditions, recording and interpretation of measurement results, etc. Requirements for measurement conditions include in particular configuration, arrangement, installation and operation of the Equipment Under Test (EUT). Requirements for configuration and operation are not uniform. This may result in differences in measurement results.

A. Basic definitions

EUT-representative equipment or functionally interactive group of equipments (system) which includes one or more host unit(s) and is used for evaluation purposes.

Configuration - mode of operation and other operational conditions of the EUT.

Arrangement - physical layout of the EUT that includes connected peripherals/ associated equipment within the test area [2][3].

An analysis of requirements that are applicable to the configuration of intrusion and hold-up alarm system (IHAS) when measuring the radiated electromagnetic disturbances is presented in Section 2. Section 3 presents a comparison of requirements for EUT configuration.

II. CONFIGURATION REQUIREMENTS FOR EQUIPMENT UNDER TEST

Configuration of the EUT within the verification of EMC parameters represents the determination of the manner of its operation and the determination of next operating conditions. EUT configuration requirements are set forth in the relevant legislation, but especially in the technical standards EMC (basic, generic and product) for different types of tests.

A. EU Legislation – Directive 2014/30/EU

The currently valid EMC Directive 2014/30/EU on the harmonization of the laws of the Member States relating to electromagnetic compatibility sets out in particular the following configuration requirements for EUT:

- The electromagnetic compatibility assessment shall take into account all normal intended operating conditions,
- The equipment shall meet the essential requirements in the configurations foreseeable by the manufacturer as representative of normal use in the intended applications,
- During the test it is sufficient to perform an assessment on the basis of the configuration most likely to cause maximum disturbance [2].

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1) Historical EU requirements according to Directive 2004/108/EC

The directive, which applied from 2005 to 2016, includes almost the same configurations requirements as a currently valid Directive 2014/30/EU. In 2007, the manual was published Guide for the EMC Directive 2004/108/EC. Guide explains and clarifies some of the most important aspects related to application of the directive (including EUT configuration requirements).

The basic requirement is an assessment on the basis of the configuration most likely to cause maximum disturbances. This method is often referred to as the "worst case" scenario [4].

Previous Directive 1989/336/ EEC (valid 1992-2007) not describe issues of the configuration of the EUT within the parameters of EMC verification. EMC Directive 76/889/ EEC was valid during the period 1976-1992. This directive has set out the following configuration requirements:

- apparatus is to be operated under normal operating conditions as indicated in the manufacturer's instructions,
- for individual types of products directive sets out a standardized load.

B. National legislation - Govermment Decree No. 616/2006 Coll. on technical requirements for products in terms of electromagnetic compatibility

The electromagnetic compatibility assessment shall take into account all normal intended operating conditions. EMC test shall confirm whether the EUT meets the essential requirements in all the possible configurations identified by the manufacturer as representative of its intended use.

C. Basic standard EN 55016-2-3

The standard EN 55016-2-3 ed. 3 (Specification for radio disturbance and immunity measuring apparatus and methods, Part 2-3: Methods of measurement of disturbances and immunity- Radiated disturbance measurements) represents the basic standard for the implementation of the radiated disturbance measurement (regardless of the type of EUT). This standard sets out particular, the following EUT configuration requirements:

- the testing of equipment shall satisfy the following conditions:

a) EUT is configured for use of typical manner,

b) EUT is configured is a manner that will maximize disturbance,

- During measurement, the configuration of EUT shall be adjusted so that the above two conditions, the conditions a) being satisfied first and followed by conditions b),
- Interface cables shall be connected to each interface port on the EUT,
- The normal load conditions shall be as defined in the product specification,
- EUT should be tested in different modes of operation [7].

D. Generic standard EN 61000-6-3

Standard EN 61000-6-3 ed. 2 (Emission standard for residential, commercial and light-industrial environments) specifies requirements for products and systems operating in residential or industrial environments. This standard in particular sets out the following EUT configuration requirements:

- EUT operation mode must be selected in relation to the highest expected emissions,
- All types of input/output ports shall be tested,
- In the case where the EUT may be part of another system, it must be tested in a minimum configuration of auxiliary equipments necessary for the operation of its inputs,
- EUT configuration shall be varied in order to find the maximum emissions (within the typical applications and installation) [8].

1) Historical configuration requirements according to EN 50081-1

In the past, previous technical standard EN 50081-1 (valid from 1994 to 2004) has set the following requirements, for example:

- If the EUT has a large number of terminals, it is necessary to select their sufficient number so as to simulate actual operating conditions,
- The operating mode of EUT corresponds to the normal use [9].

The configuration requirements of EUT are described very briefly.

E. Product family EMC standard EN 55022

European standard EN 55022 ed. 3 Information technology equipment- Radio disturbance characteristics - Limits and methods of measurement sets out limits and procedures for the measurement of the levels of spurious signals generated by the Information Technology Equipment (ITE). These requirements are also applied to components of alarm systems. The measurement conditions include, in particular:

- The EUT shall be configured, installed, arranged and operated in a manner consistent with typical applications,
- The operational conditions of the EUT shall be determined by the producer according to the typical use of the EUT with respect to the excepted highest level of emission,
- Interface cables, load and devices shall be connected to at least one of each type of port of the EUT,
- Multifunction equipment shall be tested with each function operated in isolation,
- A system that consist a number of separate units shall be configured to form a minimum representative configuration [3].

Where there are multiple interface ports of the same type, additional cables, loads or devices may have to be added to the EUT depending upon the result of preliminary tests (the actual number of additional cables may be limited to the condition where the addition of another cable does not

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significantly affect the emission level, i.e. varies less than 2 dB, provided that EUT remains compliant).

Figure 1 shows an example of pre-compliance measurement of electromagnetic emission of the alarm system component (relay module). The differences in measured values are due to differences in the number of connected electrical load.

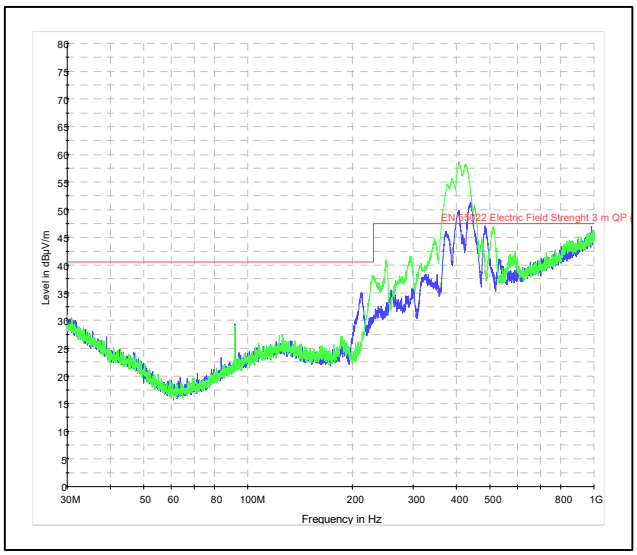

Figure 1. The results of measurements of electromagnetic radiation

Blue values indicate EMI of relay module with electrical load 20 W, green value - electrical load 50 W.

F. *Military standards*

Military standard MIL STD 461 establishes requirements for the control of the electromagnetic compatibility of electronic, electrical, and electromechanical equipments and subsystems designed or procured for use by activities and agencies of the Department of Defense (DoD) [10]. In the Czech Republic, these requirements are implemented in a defense standard COS 599902. Standard sets out the following configuration requirements of the EUT:

- During emission measurements, the EUT shall be placed in an operating mode which produces maximum emissions.
- For EUT with several available modes, a sufficient number of modes shall be tested for emissions such that all circuitry is evaluated,
- All electrical input and output interfaces shall be terminated with either the actual equipment from the platform installation or loads which simulate the electrical properties (impedance, grounding, balance, etc.) present in the actual installation,
- When variable electrical loading is present in the actual installation, testing shall be performed under expected worst case conditions [5].

A prerequisite for maximum emission levels are the conditions under which the EUT draws the highest primary supply current. The result is the highest activity of interface circuits and generating the maximum current consumed for the digital signals internal time base.

III. COMPARISON OF REQUIREMENTS FOR CONFIGURATION EQUIPMENT UNDER TEST

Legal and technical regulations set out many operational variants (EUT configurations).

Table I. presents application possibilities of EUT configuration during EMC measurements. Configuration options correspond and can be met in accordance with the standard technical thinking. Test engineer configures EUT in cooperation with the manufacturer. For normal products (e.g., personal computer) is not a problem to determine the representative configuration (PC, monitor, keyboard, mouse, loud-speakers, etc.), but opinions may differ on the configuration of specific products (e.g., IHAS). The notion "normal operating conditions" may be understood differently for IHAS (status arm, disarm status, alarm status, fault status, service mode). From a technical perspective, variants of configuration that are set by regulations can be regarded as comparable, so as synonyms. Variants can be divided into several groups:

a) **typical application** (foreseeable configurations, usual usage, common operating conditions, normal operating conditions, standardized load, normal installation practice, normal composition of system, typical installation, typical mode, typical load condition, configuration according to manufacturer, active mode),

b) **worst operating conditions** (worst case, expected worst case conditions, experimental configuration changes, maximum current consumption of EUT, expected highest emission levels),

c) **actual usage** (simulation of the actual operating conditions, operating mode according to the acquisitions requirements),

d) **minimum configurations** (minimum representative configurations, configuration with one of each type module, at least one cable for each type of interface, gradual addition of cables and modules

e) **maximum configuration** (all representative configurations, operation using test programs, test for each function operated in isolation, all possible configurations according to producer, cables connected to each port of the EUT),

f) **standby mode**

We distinguish typical and actual use. Actual use may not always be typical, e.g., in a situation where the user uses only additional functions of the product (e.g., IHAS may be utilized to control a large number of non-alarm applications and alarm functions will be utilized at a minimum). We distinguish the concepts of maximum configuration and "worst case". EMI of EUT at maximum configuration may not always be the highest [6].

This classification does not solve the problem of practical measurement EMI in terms of configuration settings EUT. There still remain a few other different configurations.

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TABLE I. THE EUT CONFIGURATION VARIANTS

Legislation and EMC technical standards / Variant of Configuration of equipment under test	Directive 2014/30/EU	Directive 2004/108/ES	Directive 76/889/EHS	GD No. 616 / 2006 Coll.	EN 55016-3-2	EN 61000-6-3	EN 50081-1	EN 55022 ed. 3	MIL STD 461F	AECTP-500
Typical application						x		x		
Foreseeable configurations	x	x								
Usual usage					x					
Common operating conditions				x						
Normal operating conditions			x							
Standardized load			x							
Normal installation practice								x		
Normal composition of system								x		
Typical installation								x		
Typical mode								x		
Typical load condition								x		
Configuration according to manufacturer	x	x		x	x			x		
Active mode										x
Worst case		x								
Expected worst case conditions									x	x
Experimental configuration changes					x		x			
Maximum current consumption of EUT									x	x
Expected highest emission levels	x	x			x	x	x	x	x	x
Actual usage					x					
Simulation of the actual operating conditions						x	x			
Operating mode according to the acquisitions requirements									x	x
Minimum representative configurations						x	x	x		
Configuration with one of each type module								x		
At least one cable for each type of interface								x		
Gradual addition of cables and modules								x		
All representative configurations	x	x								
Operation using test programs								x		
Test for each function operated in isolation								x		
All possible configurations according to producer				x						
Cables connected to each port of the EUT					x				x	x
Standby Mode										x

During a test, a manufacturer or a testing engineer does not always know exactly:

- The environment where the product (EU) is used,
- The real production version of the EUT (risk of additional production adjustments and changes),
- The real configuration in practice,
- The real types of connected peripherals,
- The distance between the EUT and peripherals,
- The range of EUT integration with other devices or systems,
- The typical operating mode in practical application,
- The installation technology, etc.

A Testing engineer searches the maximum levels of EMI (usually by changing the orientation of the EUT, changing adjustable operating modes, height and polarization of measurement antennas). Actual installation and operating conditions of EUT can be different in a practical application.

IV. DISCUSSION OF RESULTS

The most common laws and standards set the following configurations:

- The typical applications (33% of total recommendations),
- The worst operating conditions (29%),
- The maximum configuration (16%),
- The actual usage (10%),
- The minimum representative configurations (10%).

Most often, technical standards specify configuration according to typical applications or configuration with the expected highest emission levels. However, often also they recommend other operating modes and configurations (maximum configuration, minimum configuration, actual usage, etc.). Requirements vary widely. This situation is not ideal within the the measurement of electromagnetic radiation disturbances. It would be appropriate that the EUT configuration requirements were precisely defined for individual EMC tests. The opposite situation may result in the divergent interpretation of the provision of technical standards.

V. CONCLUSION AND FUTURE WORK

The article analyzes the configuration requirements of security alarm system during a measurement of radiated electromagnetic interference. Legal and technical regulations set out the many operational variants of EUT configuration. Requirements for configuration and operation are not uniform. This may result in differences in measurement results. Most often, the technical standards recommended configuration according typical applications or configuration with the expected highest emission levels. However, often also they recommend other operating modes and configurations (maximum configuration, minimum configuration, actual usage, etc.). These terms can be interpreted differently. Requirements analysis forms the initial part of the research, which will continue by thorough experimental measurement and evaluation of electromagnetic radiation of the security alarm systems, including an optimization proposal of configuration requirements. A thorough comparison between the proposed requirements and related standards will be done. This is

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essential for determining the exact requirements for changes in standards. Currently, a separate technical standard for EMI measuring of alarm systems is missing.

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