Monitoring of the tests EMS information technology equipment using the CCTV system

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***Abstract*—** The tests of electromagnetic susceptibility equipment on the emitted high-frequency the electromagnetic field is carried out in laboratory conditions due to the high intensity field generated in shielded chambers. During the testing of equipment in anechoic/semianechoic chambers the operator is located outside the chamber. Therefore, it is necessary shielded spaces equip a camera system that ensures monitoring of the state of the equipment. This article aims to analyze the requirements for measurement and testing of information technology equipment. Information technology equipment and their sub-components are electronic equipment, ie. the products which are potential sources of electromagnetic interference and also their correct operation threatened interfering emission of electromagnetic environment on site. The assessment of product conformity includes measuring and testing parameters of electromagnetic compatibility. The main outcome the article is the proposal of the camera system, which provides technical support for the implementation of EMC tests for the information technology equipment.

***Keywords*—** Electromagnetic susceptibility, electromagnetic interference, information technology, equipment under test, electromagnetic compatibility, security camera system, shielding.

I. Introduction

Information Technology Equipment (ITE) represent in accordance with the wording technical standard EN 55022 ed.3 (CSN, 2011), any device whose primary function is input, storage, display, retrieval, transmission, processing, switching, or control data and telecommunication messages. Such the device can be equipped with one or more terminal ports typically operated for information transfer. ITE devices are powered with an input voltage, which is not exceeding 600 V. In practice, we include between these devices for example personal computers, laptops, printers, switches, modems, routers, IP phones, VoIP gateways, IP set top boxes, etc.

Construction the equipment of Information technique include (such as electrical / electronic equipment) between products, which could increasingly threaten the health or safety of persons, property or the environment (specified products). Based on this fact, such products may be marketed only if they comply with the technical requirements that are specified in government regulations, issued for each group of specified products.

The basic legislative framework in the field of technical requirements for products is Act No. 22/1997 Coll. on technical requirements for products. On the various components of information technology equipment are assigned the following government regulations issued to implement the act on technical requirements for products:

- Czech Republic. Government Decree No. 616/2006 Coll. on technical requirements for products in terms of electromagnetic compatibility, (2004/108/EC);
- Czech Republic. Government Decree No. 17/2003 Coll., technical requirements for low voltage electrical equipment, (2006/95/EC);
- Czech Republic. Government Decree No. 426/2000 Coll., technical requirements for radio equipment and telecommunications terminal equipment, (1999/5/EC).

Above mentioned the government regulation is based and process requirements of the relevant documents of the European Community, issued in the form of Directive of European parliament and of the Council (see the designation in parentheses after the name of government decree).

In terms of the requirements for EMC for information technology equipment is a basic national legal document Government Decree No. 616/2006 Coll. on technical requirements for products in terms of electromagnetic compatibility. Czech Republic adopted by issue GR No. 616/2006 Coll. into its national legislation system the Directive of the European Parliament and Council Directive 2004/108/EC on the approximation of the laws of Member States relating to electromagnetic compatibility.

Government Decree No. 616/2006 Coll. determines:

- basic technical requirements for products,
- conformity assessment procedure of devices,
- the conditions for authorization of legal entities.

Technical requirements for products are generally determined with respect to the basic principles of electromagnetic compatibility:

- equipment must be designed and constructed so that:
  - EMI - the electromagnetic interference which device is causing generated does not exceed the level above which radio, telecommunications

equipment or other equipment cannot operate as intended;
- EMS - equipment has a level of immunity to the electromagnetic interference at the installation site allows operate without unacceptable degradation of its intended use.

Other requirements of the EMC regulate the area of fixed installations, when the installation must be carried out using the correct technical practices and respecting the parameters of the individual components.

Product conformity, as a necessary process for its placing on the market can provide the manufacturer himself or the approved body (legal person who has been to Member State of the European Union notified to the European Community and all Member States of the European Union as a person authorized by the Member State of the European Union on the activities in conformity assessment of products with the technical requirements). Documents of the conformity assessment include:

a) ES declaration of conformity,
b) technical documentation.

The technical documentation must contain:

- a full description of the device,
- demonstration of compliance with harmonized standards,
- if the manufacturer has not applied harmonized standards, or has applied them only in part, so the technical documentation must contain a description and explanation of the steps taken to meet the basic requirements, including a description of the electromagnetic compatibility assessment (calculations, tests ...),
- statement the notified body (if the manufacturer taken this conformity assessment procedure).

Demonstrate that the individual components of information technology equipments or complete systems meet the requirements for electromagnetic compatibility in accordance with the wording of the Government Regulation No. 616/2006 Coll. requires practical perform me-asurement of electromagnetic radiation and testing of electromagnetic immunity of the pro-duct. Such measurements and testing, including the release of the test report, are realizable by accredited bodies, in this case EMC testing laboratories that have the appropriate technical equipment and professional staff. Currently (October 2014), the following entities are autho-rized for activities in conformity assessment of products in terms of their electromagnetic compatibility in the Czech Republic (these are also within the EU Notified Bodies):

- AO 201 - Electrotechnical Testing Institute, s.p.,
- AO 202 - Engineering Test Institute,
- AO 211 - TÜV SÜD Czech s. r. o.,
- AO 224 - Institute for Testing and Certification, Inc.
- AO 266 - Military Technical Institute, state enterprise.

Product of information technology equipment must comply with terms of electromagnetic compatibility requirements of the following technical standards:

- EN 55022 ed. 3 Information technology equipment-Radio disturbance characteristics - Limits and methods of measurement,
- EN 55024 ed. 2 Information technology equipment - Immunity characteristics - Limits and methods of measurement.

Within the measurement of electromagnetic emissions for information technology equipment are carried out the tests:

- measurement of radiated interference,
- measurement disturbance (noise voltage at the line terminals, unbalanced interference on telecommunication ports).

Testing electromagnetic immunity of information technology equipment mainly includes the following types of tests:

- electrostatic discharge,
- radiated electromagnetic field,
- disturbance indicated by high-frequency fields,
- fast transients,
- slow surge,
- dips and short interruptions of mains supply.

ITE products are further tested by measuring the emissions of harmonic currents and verification of an installation for distribution system of low voltage.

Measurement and testing is performed according to the standards of standardized methodologies in testing laboratories. Measurement of radiated disturbances is performed in anechoic / semi anechoic chambers, respectively. at the test site in open space OATS-Open Area Test Site. Testing electromagnetic immunity in the test radiated high-frequency electromagnetic field would be due to the high intensity of the generated field is also carried out in shielded chambers. In the case of large systems or equipment, the measurements are carried out on site. (Valouch, 2012).

In the case of measuring and testing equipment in anechoic/semi anechoic chambers is an operator located outside the chamber and he doesn't have an ability to monitor the status of the equipment under test. Therefore, it is necessary to equip these spaces by shielded camera system, which ensures the monitoring of the state of the equipment under test with respect to:

- the risk of damage to the equipment under test while turntable is moving,
- monitoring changes in operating conditions of the test equipment when exposed to artificially generated interfering signals,
- risk of malfunction or damage to the equipment under test by the effect of artificially generated interfering signals.

The following part of the paper describes a proposal for implementation of CCTV in a semi anechoic chamber.

II. Electromagnetic Shielding

Shielding is an important part of how electromagnetic interference, as well electromagnetic susceptibility. Because the correct shielding of devices can increase its electromagnetic immunity, but also reduce the emission level, which sends to the environment. Shielded may be the entire device or only its important parts. Electromagnetic shielding is used in the design of the device. However, it is appropriate the device design with regard of all EMC requirements from the beginning and not rely on only shielding all of interfering signals, because interference also be caused by functional (useful) signals.

An important parameter through which we can express the influence of electromagnetic shielding is **shading coefficient** $\boldsymbol{K_S}$ (1). This coefficient is the ratio of the electric field intensity E_t at a certain point which is shielded, the field intensity E_i at the same point, but without shielding partition. The same coefficient applies also to the magnetic field H_t, respectively H_i.

$$K_s = \frac{E_t}{E_i} \qquad resp. \qquad K_s = \frac{H_t}{H_i} \tag{1}$$

We can meet with the **shielding effectiveness SE** (2) very often. It expresses the attenuation or shielding effectiveness and it is expressed in logarithmic rate. The abbreviation SE is of the English name Shielding Effectiveness.

$$SE = 20.\log\frac{1}{|K_S|} = 20.\log\left|\frac{E_i}{E_t}\right| \qquad [dB] \tag{2}$$

The worst case for shielding is, when the interfering signal perpendicularly incident on the shielding surface because shielding has the weakest effect. When the interfering signal incident at different angles its size, which passes through the shielding bulkhead, is always smaller than in the case when signal perpendicularly incident on the shielding surface.

The formula for the calculation of shielding effectiveness SE (3) can be expressed as the following equation, which better expresses the physical processes of the shielding effect.

$$SE[dB] = R[dB] + A[dB] + M[dB] \tag{3}$$

wherein:

R is the reflection loss, which arises when waves incident on the shield wall. This shielding wall should be of a good conductor, so that the impedance of air (surrounding area) was much greater than the impedance shielding bulkheads. The reflection loss is not dependent on the thickness of the bulkhead, but its conductivity.

A is the absorption loss, which arises as a result of the heat loss when the electromagnetic interference passes through the shielding wall. During this process is some of the energy absorbed by the shield.

M is the loss due to the multiple reflections and arises at the interface between the shielding bulkhead and surrounding environment. Effect multiply reflected waves may affect the resulting loss bulkheads. Therefore, it is important that the thickness of the shielding bulkhead was too small, then would occur of the reflections and a reduction shielding effectiveness. However, if the thickness of bulkhead will be much greater than the depth of formation of the multiple reflections is possible their affect on the overall shield be neglected. On the Fig. 1 we can see the effects of the multiple reflections on the shading bulkhead.

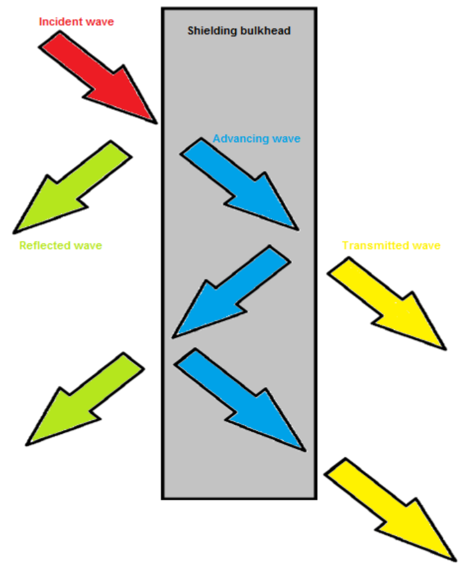

Fig. 1 Multiple reflections at the input and output shielding bulkhead [5]

The absorption loss and reflection loss are the most important parameters for the calculation of the overall shielding effectiveness. The reflection loss is higher at low frequencies and the absorption loss is is higher at high frequencies. Therefore, in the design of the shielding we must take into account the expected environment in which the device will be. The loss due to the multiple reflections can reduce the overall shielding effectiveness at low frequencies, because the depth of formation of the multiple reflections at low frequencies can be quite a bit greater than the thickness of shielding bulkhead. The depth of formation of the multiple reflections ceases to have effect on the overall shielding effectiveness with increasing frequency. Shielding bulkhead must not be too thin. In Table. 1 is an example of shielding effectiveness with very thin copper coating.

Table 1 Example of shielding effectiveness very thin copper coating [5]

Thickness of shielding	0,1 µm		1,25 µm		2,2 µm		22 µm	
Frequency [MHz]	1	1000	1	1000	1	1000	1	1000
Reflection loss **R** [dB]	109	79	109	79	109	79	109	79
Absorption loss **A** [dB]	0,014	0,44	0,16	5,2	0,29	9,2	2,9	92
Multiple reflections **M** [dB]	-47	-17	-26	-0,6	-21	-0,6	-3,5	0
Shielding Effectiveness **SE** [dB]	62	62	83	84	88	90	108	171

A. The shielding effectiveness in the near zone sources of waves

Above mentioned situation has been described for sources of interference, which is located in the so-called "distant zone ". However, if we have the source in the so-called "near zone" is very important, whether it is a nearby electric field or nearby magnetic field. The near zone this is, when the distance the source wave from the shielding plate r is much smaller than the wavelength λ.

For electrical sources in the near zone apply that their losses due to reflections are much greater than for the field in the distant zone and these losses increasing in reducing the distance between the source and the shielding plate. By contrast, the reflection losses for magnetic sources are much smaller in the near zone than in the distant zone. These losses are even more decrease in reducing the frequency and reducing the distance between the source and shielding. Additionally, absorption losses are small at low frequencies, therefore, we try to increase them by using a thick shielding bulkhead of high magnetic material.

B. The influence of holes and leaks in the shielding effectiveness SE the shield cover

To achieve the required shielding effectiveness of shielding cover is necessary to take into account the functionality and the technical needs of the entire equipment such as the power supply, data cables, ventilation or access to the control equipment, etc. These functions cannot be ensured without disruption of the integrity and homogeneity of shielding surface and existence of these disruption and leaks reduce the overall shielding effectiveness. We distinguish three types of such leaks:

- *The holes slits and other open shielding surfaces:* doors, windows, slits and leaks between shielding surfaces;
- *Poorly conductive the shield parts:* poorly conductively connected different parts of the shield or the presence of glass surfaces when necessary the visual supervision and control of device;
- *External the supply cables and the connection cables:* connected cables, through which they can be received interfering signals into the shield cover (eg. power supply, data or signal lines).

In the production of shielding cover for achievement of good electromagnetic shielding must be respect certain design principles. Their summary is as follows:

- We must maintain the adequate overlap of two shielding plates in their connecting, so as avoid a slits during so called connection "butt welding" (connection without overlap);
- Big holes should be equipped with a conductive material or waveguide vias;
- In the cover not to do no slits;
- Opening holes sealed with conductive elastomer or spring contact strips;
- The outer shield of the cable to connect with the cover and not to lead him into the inner space;

Input filter placed directly on the shield cover.

III. Materials and Methods

The camera system will be operating in an environment with strong electromagnetic field, so the selection of high-quality IP camera is very important. It must also be equipped with night vision, because inside the anechoic chamber are a poor lighting conditions during the measurements. I focused on the selection of PTZ dome cameras with the possibility of recording and zoom for better orientation in space. Operator must watch the test equipment for its proper functioning (eg, flashing indicator light) and therefore must have a high resolution camera, FullHD at best. Data output from anechoic chamber is implemented via an optical cable through the penetration panel; therefore camera should have the output directly to the optical cable. In this a case, media converter which implementing a conversion to fiber optic cable, would was unnecessary. The optical cable also has far better properties to the area with strong electromagnetic interference than metallic cable. Unfortunately, the cameras with such output are highly specialized and their prices are around CZK 150,000 and up. That's why I chose a cheaper alternative for my design of camera system. The quality camera with metallic data output and transfer to the optical cable by media converter. Other requirements for IP camera are quite common and during the selection isn´t a problem with them.

The camera which is chosen for design the camera system is Merit Lilin, IPS5184S. This camera meets the above requirements and its image is shown in Figure 2.

Fig. 2 IP camera IPS5184S

IV. Results - Solution Design

A. Solution Design of Shielding Box

As soon as you want to put the camera into a shielded anechoic chamber, you must reduce the level of emission of electromagnetic signals to a minimum; thereby decrease their effects on the ongoing measurement. At the same time, the camera must maintain its functionality, even in extremely unfriendly electromagnetic environment. For these purposes, is suggested a shielding box made of stainless steel with a wall-thickness of 1 mm. There is also a hole which is located at the front of the box for the camera lens. The camera will be mounted into the box by a bolt.

All leaks or openings are affecting the overall effectiveness of the shielding box, and therefore is requires careful welding of the edges, the large hole on the front side is overlaps by using a conductive material and the space between the cover and the box is sealed. The cost of producing a shielding box represents approximately 1,800 CZK.

In order the hole for the camera lens, there arise are two conflicting requirements. Firstly, the hole must be electromagnetically shielded as much as possible, while maintaining correct transparency sufficient for the camera. This objective is achieved by using the technology similar to that used in a microwave oven, which employs using a conductive metal foil with holes much smaller than the wavelength of the test signals is. Anechoic chambers are usually designed to test the frequency range approximately from 26 MHz to 18 GHz which roughly corresponds to wavelengths from 11.5 m to 1.66 cm. The metal foil is attached to the shield box by means of a rectangular stainless steel strip of the same thickness as the box walls have. The second option is a strip of foil attached by a screw connection.
Electromagnetic sealing the opening between the box and the cover is provided by metal contact strips supplied by Laid Technologies, a company specializing in the production of elements for electromagnetic shielding (fig. 3).

Fig. 3 Sample of strips from all-purpose series, type 97-538

Model of shielding box is shown in Figure 4, cabling for IP camera leads at the bottom of the shielding box through a hole.

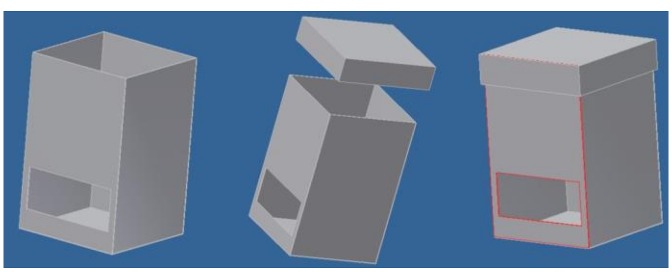

Fig. 4 Sample of modeled shielding box with a lid

B. *Solution Design of Rack*

Shielding anechoic chamber is completely covered from the inside by absorbent material and a larger portion of the chamber is covered by absorption pyramids. Therefore is inadmissible to interfere in any way to the integrity of the walls. This would mean automatic loss guarantee from the manufacturer. IP camera can´t be attached in the ceiling or elsewhere in the room just for that reason and must be placed in the room with its own rack. The rack in terms of electromagnetic compatibility and construction of anechoic chamber is designed from polypropylene, which is one of the most common plastics; the sample is shown in Fig 5.

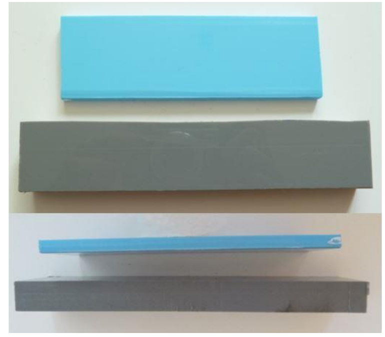

Fig. 5 Sample of rack´s material

The cost of production of the rack is 1650 CZK. Layer thickness is 6 mm (Fig. 5 - blue pattern), the size of the base is 400 mm, and thickness of base is 15 mm (Fig. 5 - brown pattern) due to the stability of the entire rack. Depending on the strength of the entire structure can change the size of the base. The shielding box will be inserted from the top, so also the rack will be provided with a lid. It is important so that both openings for the lens were the same height. This is ensured by two rails inside the rack. The shielding box is placed on them and their height is calculated so that the two holes coincide. Model of rack is shown in Figure 6. The far left of the picture is rack without lid. Second from left is a view from the bottom and you can notice a hole in the pedestal. The hole is required for cabling or also if anything fell into a rack that is an easy way to simply pulled out. Third from the left is the rack with the lid on top and far right is a detail of upper part with the lid. One of the rails for the shielding box is seen through the opening for the lens.

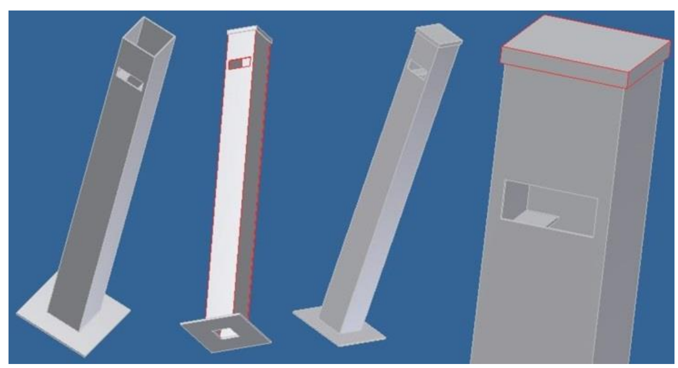

Fig. 6 Rack modeled from multiple perspectives

Rack height is determined by the requirement to camera view. The camera will control a measured device in the anechoic chamber, which may be smaller and lie on the table at a certain height. The camera must have a good view of the device at all times. Therefore the camera should be placed in minimum height of 170 cm. How can put together the entire assembly of the shielding box and the rack is shown in Figure 7.

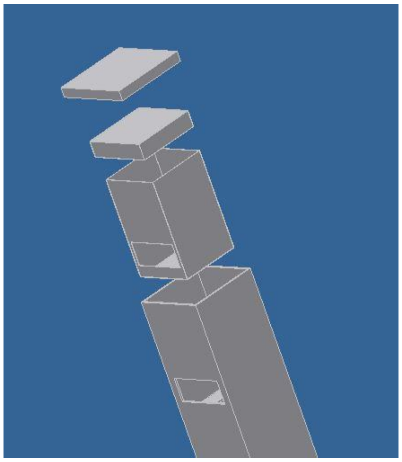

Fig. 7 Modelled rack with folding shielding box for camera

C. Proposed location

Location of rack with IP camera must always be chosen so as to have as little impact on the results in an anechoic chamber. The rack shouldn't stand in the direction of the antenna radiation, or even between the antenna and test equipment. In this case, would occur to undesired reflection of electromagnetic waves, before they hit into the absorbent material of the pyramids and lose much of its energy. Therefore, the expected best place for the rack is in a corner behind an antenna, as illustratively shown in Figure 8.

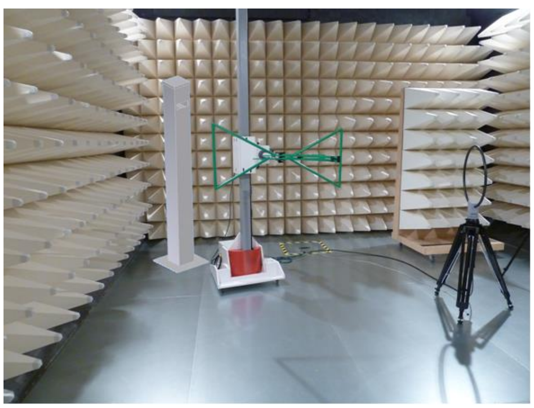

Fig. 8 The proposed location of the rack

D. Camera power

The camera needs a 24V AC for its operation. Part of the cameras is a power adapter with power cord. However, I would recommend replacing a cable for a shielded one, which then leads across the floor to the bottom of the rack and through it directly into the camera.

E. Data connections to IP camera

Optical fiber as the data cable is preferable due to its electromagnetic compatibility during a data transmission. So, the ongoing measurement does not represent an additional source of interference and is highly resistant to external electromagnetic activity. The transfer from a metallic cable to an optical cable can be used for example, media converter AT-MC102XL (fig. 9). It is a media converter from ethernet network cable UTP to 2x optical fibers MM (multimode). Max. length of fiber is 2000m. Wavelength is 1310nm. Metallic connector is RJ45. Optical connectors are 2x SC. The power adapter is included. The dimensions are 95 mm x 105 mm x 25 mm (length x width x height). Supply voltage is 12V DC. So, together with power cable for the camera also leads a cable for power supply media converter and I would recommend replacing the cable for the shielded cable. The price of this media converter is CZK 2,064.

Fig. 9 Media converter AT-MC102XL

The best location for media converter is in the rack and due to its small size is not excluded the possibility that lay directly at the bottom of the shielding box. But then is necessary to calculate the dimensions of media converter during the design of the box.

V. Conclusion

Table 2 shows the approximate pricing of the proposed camera system. The final price is 47 191 CZK including VAT. The most expensive item is the purchase of high-quality IP camera, which would meet the requirements for placement in anechoic chamber. The result price is without cabling.

Table 2 Price list of the proposed camera system

	Product	Price including VAT
1	IP camera, Merit Lilin, type IPS5184	41 772 CZK
2	Production of shielding cover	1 755 CZK
3	Production of the rack	1 650 CZK
4	Media converter AT-MC102XL	2 064 CZK
	Total price:	47 191CZK

The shielding box main task is protection IP cameras from destruction due to strong electromagnetic fields. The measurements taken with an older IP camera MIP-6430-2 showed high levels of electromagnetic radiation in the frequency range from 30 MHz to 2 GHz (Fig. 10). The IP camera is comply with the standard EN 55022 (emission information technology equipment), but at some frequencies has very high amounts of radiation and that is an important finding. This measurement shows that results of next measurements of electrical equipment will be significantly affected by the location of old IP camera into the anechoic chamber without the shielding box.

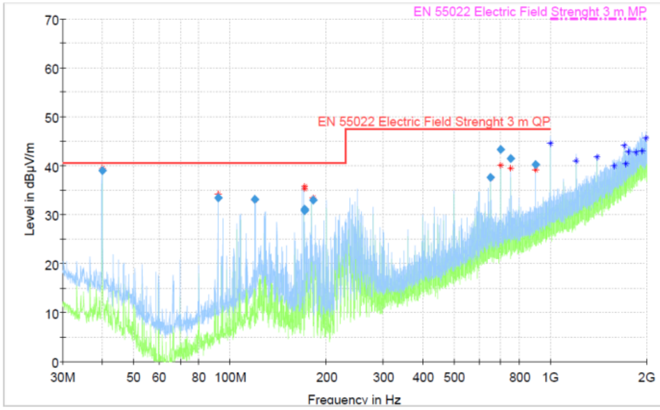

Fig. 10 The measurement result in the test range

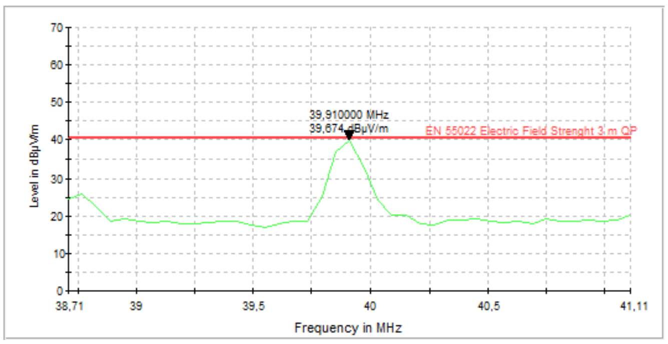

Fig. 11 Detail of the peak on 39.91 MHz

But the recommended camera Merit Lilin (type IPS5184S) is far more modern and more suitable for industrial environments than the old tested camera. So this measurement will end probably much better with the recommended camera.

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