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Immunity of Web Camera against Electrostatic Discharge

Stanislav Kovář[1], Jan Valouch[1], Hana Urbančoková[1] and Milan Adámek[1]
[1]Faculty of Applied Informatics, Tomas Bata University in Zlín
Nad Stráněmi 4511, 760 05 Zlín, Czech Republic.

Abstract
Currently, electrostatic discharge constitutes one of the major problems of in designing of electrical and electronic devices which must be solved by the manufacturers. Electrostatic discharge exploits the weaknesses of the devices especially circuits and components. Identification, analysis, and assessment of vulnerabilities are an essential aspect to meet electromagnetic compatibility for electronic and electrical products. According to these requirements of the standard, all device must be constructed to resist the adverse effects which could affect the correct operation of the device. The purpose of this paper is to determine the effect of electrostatic discharge on modern web camera representing the camera systems.

Keywords: Electrostatic discharge, equipment under test, electrostatic discharge test system

Introduction
The electrostatic discharge has become a major issue of many electronic and electric components because this physical phenomenon usually arises unexpectedly and a broad range of components are very sensitive to its effects. Electrostatic discharge is defined as a brief and abrupt electrical current that emerges between the two objects with different electrical potential. If one of the objects contains too many electrons at any available point, and the other implies very few electrons, a high voltage creates between these points. To achieve shift into places with low electron density, they use conductive pathways. However, conductive pathways for traveling are not always possible to ensure, and the electrons must find an alternate path for moving, usually through the non-conducting environment (air, vacuum, glass). Electrostatic discharge is a problem especially for the design of integrated circuits with the high indoor resistance, which can be destroyed by a slight discharge. There is often latent damage that may not be immediately identified and that may appear over time.
Electrostatic discharge is primarily associated with integrated circuits that become more sensitive to external influences after the extension of the miniaturization of components. Attention must be paid to these problems by manufacturers of electronic and electrical devices because the products marketed must be in compliance with current requirements of European or national standards. Standard EN 50130-4 ed. 2 [2] belonging to the group of standards relating to electromagnetic compatibility deals with this issue in the Czech Republic.
Currently, only several research papers are dedicated to the resistance of the cameras against electrostatic discharges. Hence, the idea was born to create a publication that provides information about the status of the cameras in the field of ESD. The main purpose of the experiment reported here was to determine the negative effects of discharges on the activities of the cameras.

Equipment under Test
Testing of electrostatic discharge was performed on the web camera because it was possible to watch the changes of image. The web camera is device serving for image capture and subsequent transmission in the computer, laptop or another device with similar function for further processing. In other words, the light transmitted through the lens falls on the electronic chip (CMOS, CCD) to convert into an electrical signal, which is digitized by an A/D converter and sent to the microprocessor.
The web cameras are a cheaper alternative to classical IP or analog cameras; nevertheless, their structure is similar and it is the reason why was chosen the webcam. The webcam is called Genius FaceCam 2020 and disposes of CMOS sensor. The camera communicates with the personal computer (PC) via Universal Serial Bus (USB).

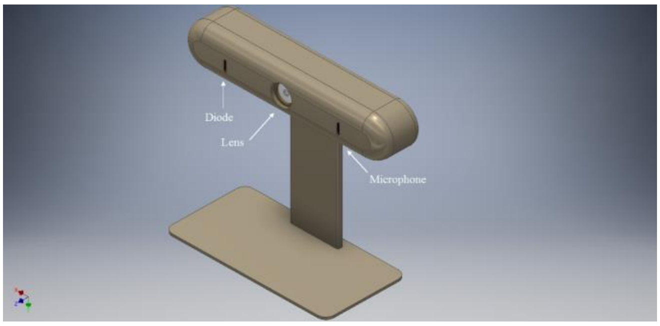

Figure 1: 3D Model of Web Camera

Measuring Equipment
The testing of the EUT was performed by the special electrostatic discharge simulator which is called ONYX. Selected device works with an electrostatic voltage up to a maximum 16kV and uses standard discharge network 150pF/330Ohm. The product allows to set the discharge repetition in the range of 0.1 to 20Hz. The simulator is equipped with two interchangeable spikes for air discharge and contact discharge which differ in shape discharge electrode. This measuring technique is located in the laboratories of electromagnetic compatibility at the Tomas Bata University in Zlin.

Process of Measurement

The web camera has repeatedly been subjected to tests of resistance to electrostatic discharges. Measuring technique allowed to use a maximum voltage of 16kVA; however, such voltage would have destructive effects for the camera and had to be selected lower voltage. Despite this information, the set voltage exceeds the requirements of the standards for detection of real working limits. The process of measurement can be summarized in several steps:

1) Preparing the workplace

The first step implies the selection and preparation of measuring techniques to execute the test of ESD. Electrostatic discharge simulator was chosen to perform this test.

2) Configuration of EUT

To obtain relevant results during the testing process, the EUT must be configured accordingly for a specific task. The detailed view on the disposition of the EUT is shown in
Figure 2.

3) Change of testing places

The position of the electrostatic discharge simulator should be varying in order to search for weaknesses of devices, which could be a potential input of electrostatic voltage. This process must be repeated until all vulnerabilities are not found.

4) Evaluation of results

The last step includes processing and evaluation of the obtained data.

Disposition of EUT

As can be seen in
Figure 2, the EUT was organized in such wiring in order to monitor the changes caused by ESD. For this reason, the test device was connected to a notebook that could ever take an image of the scene. Both devices were located on an insulated surface to avoid distortion of the results. According to the requirement of standard, ESD simulator was with grounded. All devices were powered by the battery, therefore, no separating filters were necessary to use on the laptop.

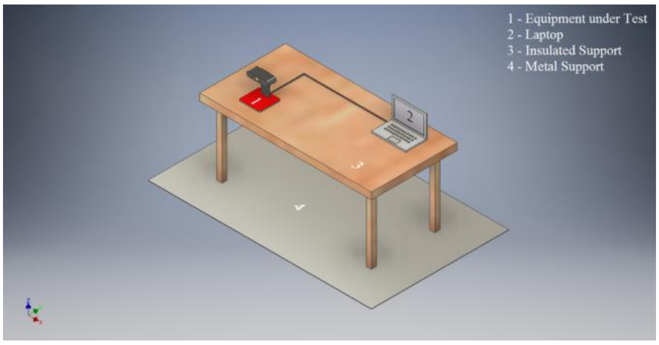

Figure 2: Disposition of EUT

Results

This chapter is devoted to the results of testing. The measurement process was performed in accordance with the standard 55024; however, for research purposes, the recommended value was increased to detect the influence of the ESD. Investigation of device revealed potential vulnerabilities of the web camera, which were subsequently put to the test using the ESD simulator. Vulnerabilities are meant especially diode, microphone, lens and vents in the rear of the camera revealing the part of integrated circuits. To achieve the relevance of the results, the experiment was realized by a series of tests for each voltage level. The measurement results were recorded in a table with respect to the type of test.

Table 1: Results of Contact Discharge Methods

Level	**Test voltage**	**Comment**
1	2	No change in image of camera
2	4	No change in image of camera
3	6	No change in image of camera
4	8	Disconnection of camera
5	10	Disconnection of camera or slight image disturbance
6	12	Disconnection of camera or image disturbance

Table 2: Results of Air Discharge Methods

Level	**Test voltage**	**Comment**
1	2	No change in image of camera
2	4	No change in image of camera
3	8	No change in image of camera or occasional disconnection of camera
4	15	Disconnection of camera or image disturbance

Although the ESD simulator allows to set the voltage up to 16kV, there was no point to test device against such a high value because there was a danger of destruction.
Figure 3 shows the changes in the image, which occurred after an increase of static voltage to 12kV.

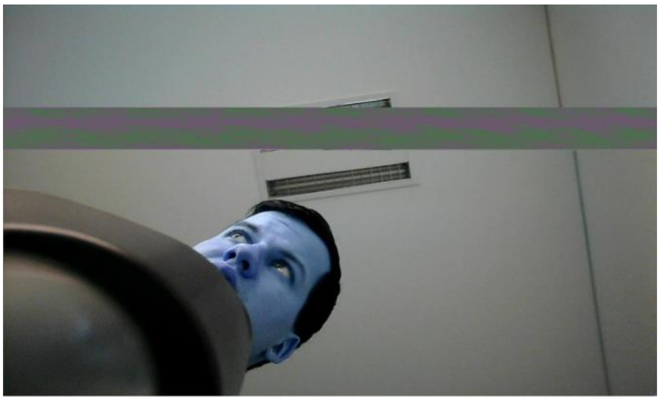

Figure 3: Consequence of electrostatic discharge

As can be seen in Fig. 3, the higher level of electrostatic discharge leads to the quality deterioration of the camera image. Damage to the image is presented by the violet-gray stripe in the upper third of the image; however, the size and positions of the strip need not always be the same. This change is influenced by the input of electrostatic discharge in the electronic or electrical device.

Conclusion

The purpose of this paper was to expand the existing knowledge of CCTV systems in terms of their immunity and to acquire a comprehensive picture of the current state. The importance of this publication lies in the uniqueness of issue because there are not many research studies that would cover the topic. Web cameras represent a cheaper alternative of classic security cameras, nevertheless, they were an ideal choice for experimental testing. The selected camera was exposed to electrostatic discharges of different voltage levels during testing and the changes of camera function were recorded. As expected, the camera meets the requirements specified in the standard 55024; despite of the recommendation it was also exposed to a higher voltage to get an idea of the discharge effects exceeding the recommended limits. The overall results indicate that the camera is more sensitive to contact ESD than air ESD. Despite the results, it is necessary to take into account the fact that the components of web camera might not have as high quality as those used in security cameras. The purpose of this paper was to expand the existing knowledge of CCTV systems in terms of their immunity and acquired a comprehensive picture of the current state.

Acknowledgments

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