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Attenuation of Building used for HPM Testing

Variation with frequency, polarization, position, and window configuration

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***Abstract*— Before conducting a series of High Power Microwave (HPM) attack tests against electronic equipment placed inside a building, an estimate of the expected field levels at the test objects was desirable. For this purpose, basic attenuation tests were carried out using a handheld network analyzer over the frequency range 100 MHz to 7 GHz. Prior to the tests, a new window was mounted in the wall facing the road along the building in order to obtain a more realistic test configuration. Measurements were carried out before and after insertion of the window. In this paper, the measurement setup is described, and the main findings of the tests are reported. The measurements revealed a significant attenuation of the new, energy-saving window.**

Keywords-RF attack; attenuation; building materials; windows

I. INTRODUCTION

One of the objectives of the EU Consortium HIPOW (Protection of Critical Infrastructures Against High Power Microwave Threats) is to perform practical experimentation by irradiating test objects inside a building using high powered RF (Radio Frequency) sources outside. Prior to performing such tests, estimates of the electromagnetic field coupled into the building are desirable in order to plan the test conditions based on expected effects. The measurements reported here were carried out in August 2013 at a test site in Norway. An old building with concrete walls was used as a representative test environment. In the past, the windows in the wall facing the road were replaced by bricks, but before the HPM experiments a new window was inserted in one of the window positions.

II. MEASUREMENT PROCEDURES

A. Test Equipment

The basic test setup is seen in Fig. 1 and Fig. 2. An Agilent N9343C Handheld Spectrum Analyzer was used with a network analyzer capability up to 7 GHz. A variety of transmit and receive antennas were used to cover the frequency range from 100 MHz to 7 GHz. Measurements were made in two bands, 100 MHz to 1 GHz and 1 GHz to 7 GHz.

Figure 1. Test equipment outside.

Figure 2. Receiving antenna inside.

Figure 3. Window at 45 degrees.

Figure 4. Window at 90 degrees.

B. Calibration and Normalization

Calibration measurements were performed outside the building in order to establish a reference level corresponding to free-space propagation with compensation for cable losses etc. The distance between the antennas was a few meters, i.e., measurements were made in the near-field zone at the lower frequencies. However, due to the complexity and associated general uncertainty of this type of measurements, the results are considered representative for the purpose. Measurements were carried out for both horizontal and vertical polarization and with the antennas at different positions and heights.

III. SAMPLE RESULTS

Examples of obtained results are shown in Fig. 5 and Fig. 6, in which the relative amplitude with open and closed window is shown for the frequency ranges 0.1-1 GHz and 1-6 GHz, respectively. Obviously, the effect of an RF attack depends on the frequency of the source. Moreover, the attenuation depends on the configuration of inventory inside the building and the specific point of observation. In general, the characterization of electromagnetic fields inside buildings is complicated. The same applies to the interpretation of associated experimental data.

REFERENCES

[1] William C. Stone, "Electromagnetic Signal Attenuation in Construction Materials," NIST Construction Automation Program Report No. 3, Building and Fire Research Laboratory, National Institute of Standards and Technology, Maryland, October 1997.

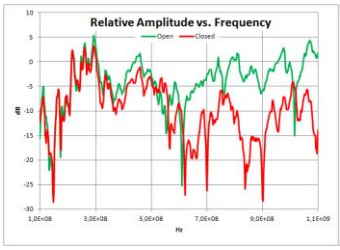

Figure 5. Lower frequencies.

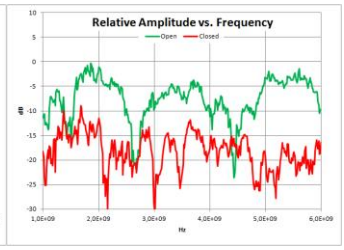

Figure 6. Higher frequencies.