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Electromagnetic compatibility of selected elements of building automation

***Abstract**. The article presents the results of electromagnetic compatibility tests of selected building automation devices. Elements of bus and wireless systems were tested. Electromagnetic compatibility measurements were carried out in accordance with EN 55014. Tests were performed for radiated disturbance emissions from equipment in the GTEM 1000 chamber in the frequency range from 30 kHz to 1 GHz and conducted disturbances in the frequency range from 150 kHz to 30 MHz.*

***Streszczenie.** W artykule przedstawiono wyniki badań kompatybilności elektromagnetycznej wybranych urządzeń automatyki budynkowej. Przetestowano elementy systemów magistralowych i bezprzewodowych. Pomiary kompatybilności elektromagnetycznej zostały wykonane zgodnie z normą EN 55014. Badania przeprowadzono dla emisji zaburzeń promieniowanych przez urządzenia w komorze GTEM 1000 w zakresie częstotliwości od 30 kHz do 1 GHz i zaburzeń przewodzonych w zakresie częstotliwości od 150 kHz do 30 MHz. (**Kompatybilność elektromagnetyczna wybranych elementów automatyki budynkowej**).*

Keywords: building automation, electromagnetic compatibility, measurement of emissions.
Słowa kluczowe: automatyka budynkowa, kompatybilność elektromagnetyczna, pomiary emisji.

Introduction

Building automation refers to the individual subsystems of a building that are electrically controlled. The individual subsystems are linked together to form a single system. The aim is to manage the building efficiently and increase its comfort. The level of advancement of building automation is determined by one of six classes, with class 5 indicating the ability to fully manage the building [1]. Every building currently being designed is more or less automated. Through automation, it is possible to ensure the energy efficiency of the building and to provide an appropriate microclimate for the people in it. The extent to which a building is to be automated must be decided at the design stage so that the individual installations can be planned accordingly [2].

There are many types of installations on the market for the automation of building management. These installations can be divided according to various criteria. The first criterion is the openness of the system. Here we divide systems into open systems, i.e. those in which the transmission protocol is available to the user, e.g. in the form of a standard, e.g. KNX [3], and closed systems, in which the transmission protocol is only known to the system manufacturer, e.g. LCN [4]. Another division is based on the control method, in which we divide systems into decentralised ones and those with a central unit.

The simplest version of building automation consists of a minimum of two devices: a device that converts signals from the environment into electrical quantities (sensors, buttons, etc.) and a device that converts these electrical quantities into the execution of a given command (lighting controllers, roller shutters, etc.). In the case of wireless systems, a controller is still required, which controls the transmission of the telegrams [5]. Since we want as many functions as possible to be performed automatically, the number of devices is usually in the order of several dozen for single-family houses. As for the maximum number of devices, the only limitation is the investor's imagination, as currently manufactured building automation systems are capable of handling up to tens of thousands of devices [6].

In the literature, information can be found on how to protect building automation equipment from electromagnetic fields. However, there is no information available on the results of tests on building automation devices regarding their emissions in accordance with EN 55014 [7] or the conducted disturbances described in EN 55022 [8].

Every electronic device emits electromagnetic radiation. Due to the large number of building automation devices, even though these values are small, they can pose a threat to the health and life of the building's occupants.

The aim of this study is to investigate the electromagnetic compatibility of a few selected building automation devices and to compare these values with the applicable standards.

Test stand and methodology

The GTEM cell can be used as an alternative measurement environment to the open-area test site (OATS) [9,10,11]. The GTEM cell method of emission measurement uses a mathematical model of the radiation of the test device (EUT) in the form of a system of three equivalent mutually orthogonal electric dipoles, three equivalent mutually orthogonal magnetic dipoles and one quadrupole (ignored for “electrically “small” devices). Since the moments of the equivalent dipoles (their modules and phases) are known for each frequency, the values of the field strength radiated by the EUT in free space or over a reference surface are numerically determined.

Following the standardisation recommendations [9], the measurement of the emissivity of the devices is reduced to the measurement of the power at the entrance of the cell for the positions of the device under test in the three orthogonal axes only, assuming that emission in all directions is measured in this way. At the end of the measurement, the resultant value is calculated, which, after applying the conversion algorithm from GTEM to OATS, gives the equivalent measurement on the open measurement area.

The power emitted by a device under test is defined as [9]

$$P_0 = \frac{\eta_0}{3\pi} \frac{\cdot k_0^2}{e_0^2 \, Z_c} \cdot S^2 \tag{1}$$

where: η_0 – wave impedance in free space ($120\pi\ \Omega$), k_0–$2\pi/\lambda$ – wave coefficient in 1/m, λ – wavelength in m, Z_C – characteristic impedance of the waveguide in Ω, e_{0y} – normalised field factor in $\Omega^{0,5}$□m^{-1}, S – the resultant of the measured voltages at the three orthogonal positions in V.

The quantity *S* is expressed as follows

(2) $$S=\sqrt{U_{1p}^2+U_{2p}^2+U_{2p}^2}$$

where: U_{p1}, U_{p2}, U_{p3} – respectively measured voltages for the three object positions in V.

The value of the maximum electric field strength for the OATS conditions is then determined from formula [9]

(3) $$E_{max}=g_{max}\cdot\frac{\eta_0 k_0}{3\pi e_0}\cdot\frac{S}{\sqrt{Z_c}}$$

where: g_{max} – coefficient related to the geometry of the test equipment (EUT) and the antenna in the open air test site (OATS).

The radiated emission measurement stand consists of a GTEM 1000 cell from TESEQ, a TDEMI 1G spectrum analyser from Gauss Instruments and software for automatic control of the analyser and collection of data from individual measurement series. Measurements were carried out with the analyser connected directly to the input connector of the GTEM cell, without a preamplifier (Fig. 1).

Fig. 1. Radiated disturbance test stand

The generation and propagation of conducted disturbances depends on the structure and electrical parameters of the equipment in the high frequency range and on the impedance loading the disturbance source [12]. The disturbance level measurements should be carried out under clearly defined operating conditions of the device under test, as far as possible corresponding to normal operating conditions. Measurements of conducted disturbances in both power and signal circuits are reduced to determining the voltage present at the input of the disturbance meter. The object to be measured is connected to a so-called artificial network, which represents for the disturbing quantity a defined load impedance.

Measuring stands for conducted disturbance analysis do not require a location in a shielded room, although it is recommended. A reference plane in the form of a metal plate is used at each test stand to stabilise the measurement conditions.

The conducted emission measurement stand consists of an NSLK 8127 artificial line impedance stabilisation network (from Schwarzbeck Mess-Elektronik), located between the mains and the device under test (EUT), a TDEMI 1G spectrum analyser and software for automatic analyser control and data collection (Fig. 2).

The following building automation equipment was used for the study:

- power supply – ZPS640HIC230 without load and working with a laptop and the 6 txa 206A switch output contacts, as well as with the universal dimming module DIMinBOX DX2,
- router N301,
- central unit for intelligent home management, Fibaro Home Centre 3.

Measurements were made for two types of disturbances:

- – Radiated emission in the frequency range from 30 MHz to 1 GHz. Measurements were made for two distances of 3 m and 10 m, using the OATS as the reference method.
- Conducted emission in the frequency range from 150 kHz to 30 MHz. In this case, an artificial network was used. This was to filter the power supply and ensure that the results were reproducible at all stands.

Fig. 2. Transmitted disturbance test stand

Radiated disturbance measurement results

Measurement of radiated interference was performed in accordance with the guidelines contained in PN-EN55014 in the frequency range from 30 MHz to 1 GHz using a quasi-peak detector and a bandwidth of 120 kHz.

The results of the measurements of the radiated disturbances generated by the tested building automation devices are shown in Figures 3 to 6.

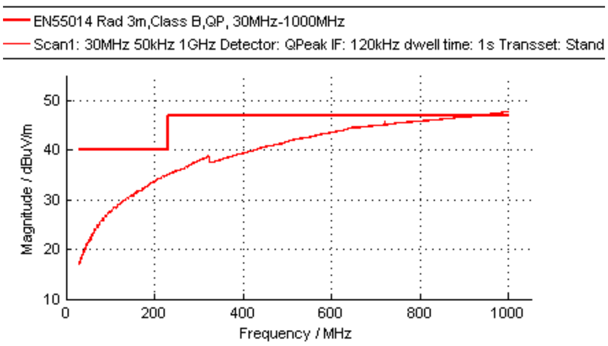
The test results show that the permissible level of radiated disturbances for the ZPS640HIC230 power supply in the no-load condition exceeds the permissible limit of 47 dB µV/m at frequencies from 939.64 kHz and higher at the distance of 3m, while at the distance of 10m the limit of 37 dB µV/m is exceeded at frequencies from 815.88 kHz and higher. (Fig. 3).

On the other hand, the ZPS640HIC230 power supply in cooperation with a laptop and the txa206A 6-output switching circuit, as well as with the DIMinBOX universal dimming module at distances of 3m and 10m respectively, does not show any exceeding of the permissible disturbances level (Fig. 4).

The results of measurements of the disturbance radiated by the central unit for intelligent home management, Fibaro Home Centre 3, are shown in Figure 5.

The tested central unit indicates exceedance of the radiated disturbance level at a distance of 3m and in the frequency interval from 869.71 kHz to 870.06 kHz. The maximum exceedance value is 45.46 dB µV/m at 869.908 kH. However, at a distance of 10 m the limit of 37 dB µV/m is not exceeded. The results of the disturbance measurements radiated by router N301 are shown in Figure 6. The N301 router tested has a radiated emission level below the limits specified in the standard.

a)



b)

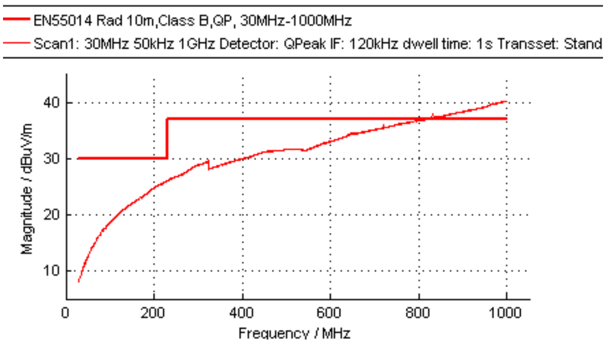
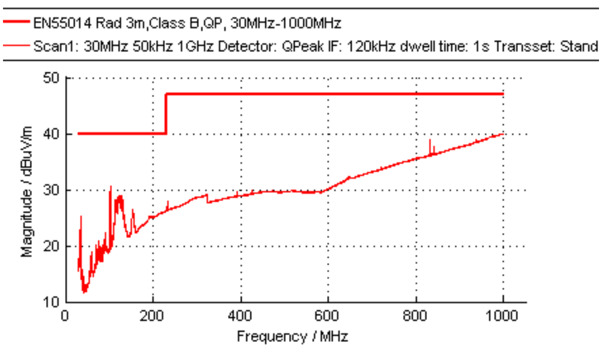


Fig. 3 Measurement results of radiated disturbances for the ZPS640HIC230 power supply in the no-load condition at the following distances: 3m (a) and 10m (b), respectively

a)



b)

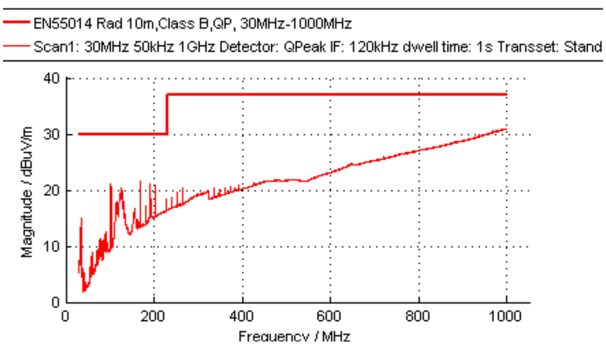
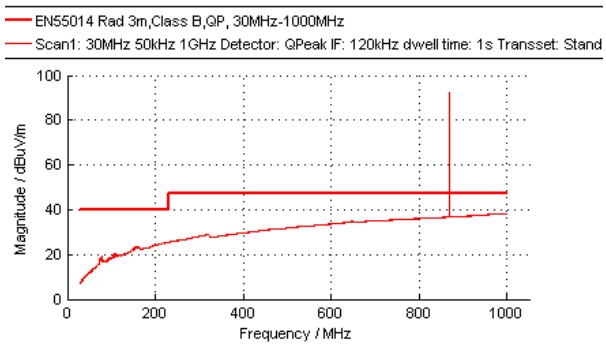


Fig. 4 Radiated disturbances measurement results for the ZPS640HIC230 power supply in the operation mode with a laptop and the txa206A 6-output switching system, as well as with the DIMinBOX universal dimming module at the following distances: 3m (a) and 10m (b), respectively

a)



b)

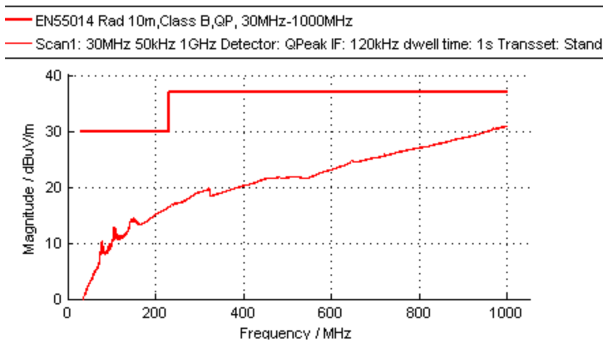
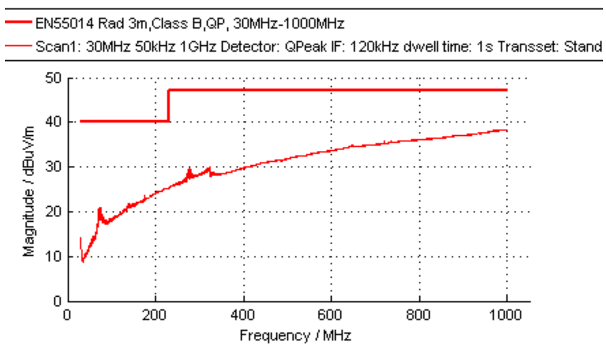


Fig. 5 Measurement results of radiated disturbances for the central unit for intelligent home management, Fibaro Home Centre 3, at distances of: a) 3m and b) 10m, respectively

a)



b)

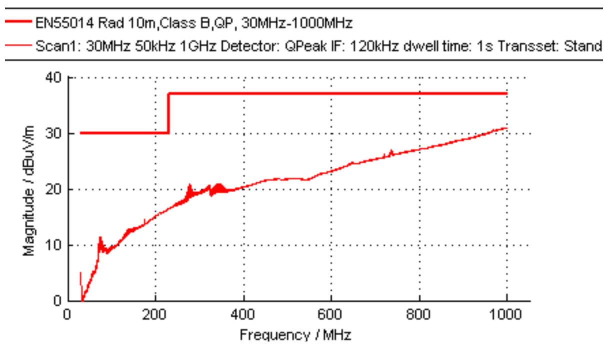


Fig. 6 Measurement results of radiated disturbances for the N301 router at distances of: a) 3m and b) 10m, respectively

Conducted disturbance measurement results

Conducted disturbances were measured according to the guidelines in EN55022, in the frequency range from 150kHz to 30 MHz. The results of the disturbance tests are shown in Figures 7 to 9. The devices tested do not exceed the limits specified in the standard.

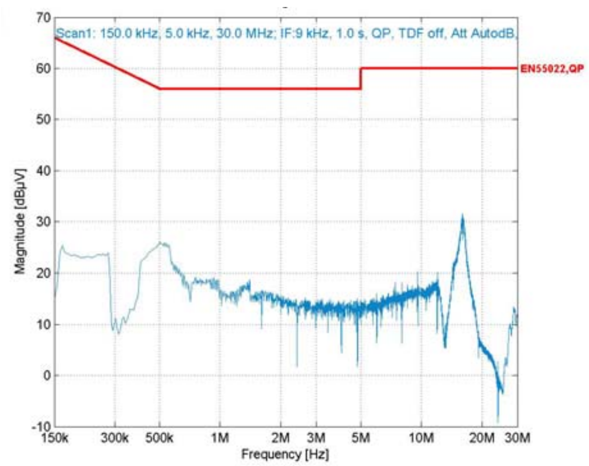


Fig. 7. Measurement results of conducted disturbances for the power supply ZPS640HIC230 in the mode of operation with a laptop and the 6-output switching system txa206A, as well as with the universal dimming module DIMinBOX

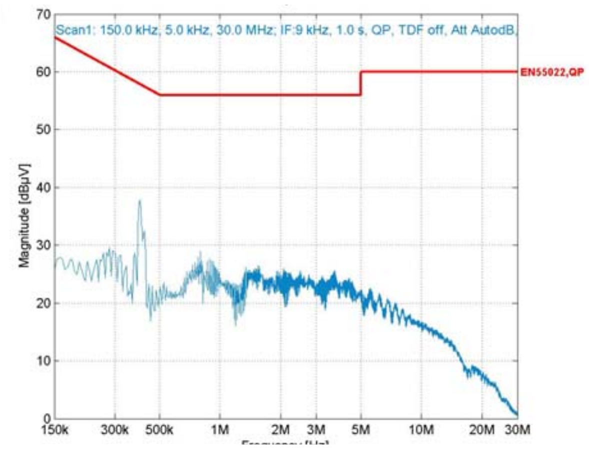


Fig. 8. Measurement results of conducted disturbances for the central unit for intelligent home management, Fibaro Home Centre 3

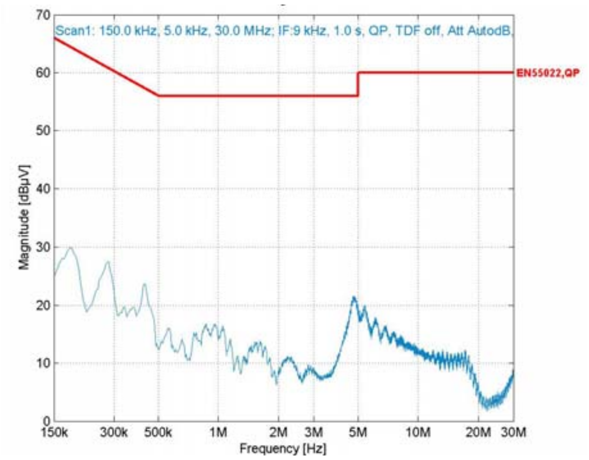


Fig. 9 Measurement results of conducted disturbances for the N301 router

Conclusions

The results of measurements of radiated and conducted disturbances of the tested building automation devices indicate that the levels of radiated emissions are exceeded by the ZPS640HIC230 power supply unit in the no-load condition, as well as by the Fibaro Home Centre 3 unit for intelligent home management in a narrow frequency range. They also allow to determine the difference between the level of emission of these devices and the permissible limits specified by the standard. However, the devices tested do not exceed the limits for conducted disturbances set out in the standard. The selected EMC test results presented here show that only devices that are properly designed and constructed will be safe to operate.

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