ECOLOG
INSTITUT FÜR SOZIAL - ÖKOLOGISCHE
FORSCHUNG UND BILDUNG gGmbH

Measuring Report

High frequency emissions of radio switches of Enocean Co.

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Customer	Enocean Co., Oberhaching
Tasks	• Measurement of the electromagnetic high-frequency fields emitted by the radio switch of Enocean Co. • Comparison of the emissions of the radio switch with the emissions of other high-frequency sources in homes and offices • Assessment of the exposures caused by the radio switch
Description of the device	The radio switch is used to switch lighting on and off by means of a radio signal. It replaces conventional light switches. It is no longer necessary to install electric cables to the light switch and from there to the consumer. The piezoelectric effect is utilized to supply the radio switch with energy. The transmitter frequency of the radio switch is approximately 868 MHz. According to the manufacturer's specifications, the transmitter power is 10 mW. The switch has a range of around 30 m inside buildings.
Measurements performed	• Frequency resolved measurement of the switching pulse of the radio switch • Frequency resolved measurement of high-frequency fields emitted when a conventional light switch is operated.
Measuring devices used	Spectrum analyzer Rohde & Schwarz FSH3 Antenna module 0.5 to 3.0 GHz (measurement of radio switch, measurement of conventional switch), 20 to 200 MHz and 200 to 500 MHz (measurement of conventional switch)
Measurement setup	All measurements were performed under real conditions in offices and homes. Two double radio switch units were available for measurements. The radio switches were mounted on a wall for the measurements and the measuring probes were placed so that their center lines were located level with the radio switches or other sources to be measured. The distance between measuring probes and sources varied between 0.1 and 4.9 m.
Course of measurements	The switches were operated several times while the frequency spectrum was recorded in max-hold operation.
Measurement results	**Switching pulse of the radio switch** Figure 1 shows an example for a measured frequency spectrum of the electromagnetic field of the radio switch in the range of 865.5 to 870.5 MHz. The maximum lies around a frequency of 868.28 MHz. The maximum value of 87.2 dBµV/m measured 1 m from the switch corresponds toan electrical field strength of 0.02 V/m or a power flux density of 1.4 10^{-6} W/m^2. In Figure 2, the decline of the power flux density is shown with the distance between radio switch and measuring probe. The bars indicate the bandwidth of the values obtained at various measurements. With measurements at the two available switches and various switching processes, maximum electrical field strengths of 93.9 dBµV/m were measured at a distance of 1 m. Possible measuring uncertainties are taken into account by adding 3 dB. Thus, power flux densities of max. 1.3 10^{-5} W/m^2 are generated at a distance of 1 m.

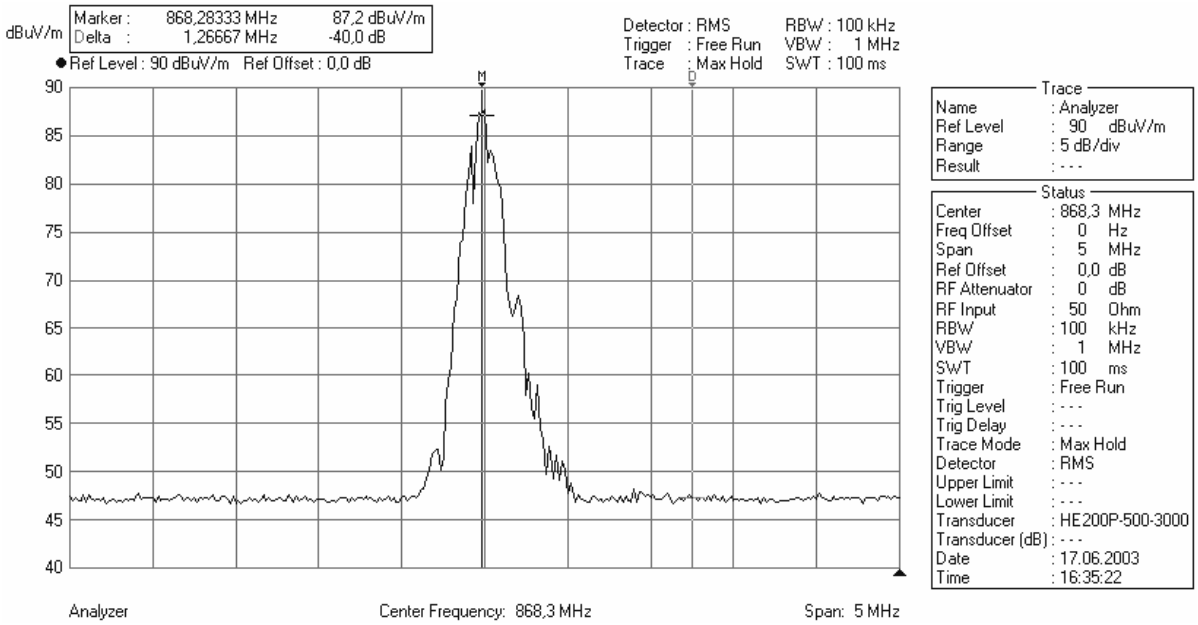

Fig. 1
Frequency spectrum of the electromagnetic field of a radio switch.

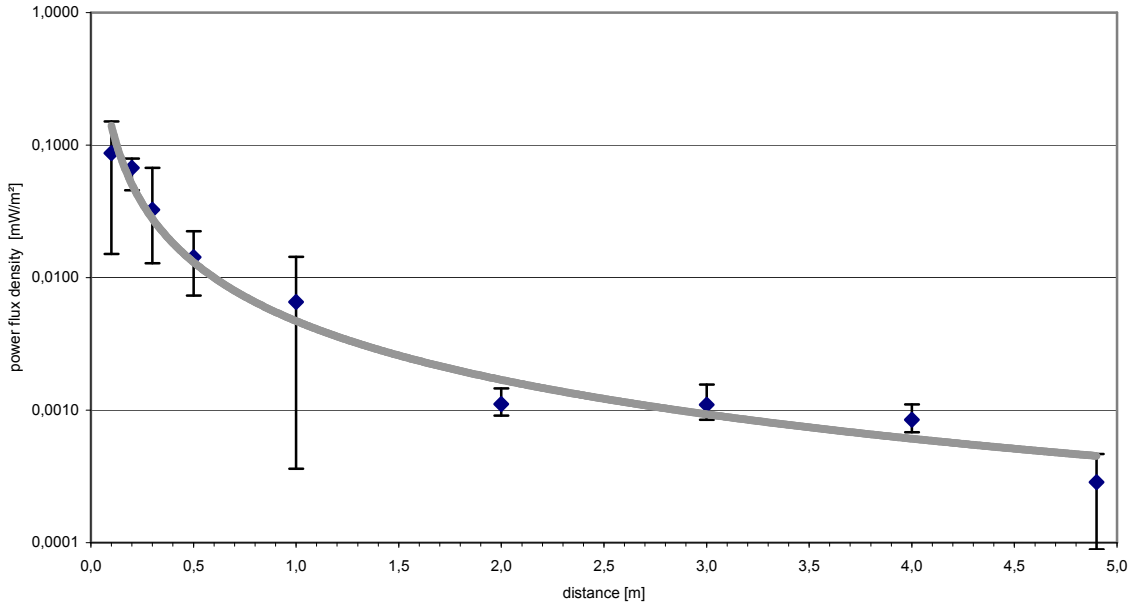

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Fig. 2
Power flux density as a function of the distance between radio switch and measuring probe

High frequency emissions of a conventional light switch
Not only a low frequency magnetic impulse is generated, but high-frequency electromagnetic fields are also emitted when a conventional switch is operated. This is caused by the discharge (spark) generated when the switch is operated. The emissions cover a broad frequency range from the kHz-range to the range of visible light. Field strengths with an average of 80 dBµV/m were measured for the conventional switch at a distance of 1 m in the frequency range of the radio switch. With an allowance of 3 dB, this corresponds to a power flux density of

5.3 10^{-7} W/m^2. The maximum emitted intensity may vary greatly between different switches.
When evaluating the emissions of the conventional switch in comparison with the radio switch, the total emissions in the frequency range under consideration, that is, the respective bandwidth of the signal, must be taken into account (see below).

Comparison of the emissions of the radio switch with the emissions of other high-frequency sources in homes and offices

Table 1 shows the maximum power flux densities measured for the radio switch at a distance of 1 m compared with the power flux densities caused by other devices and equipment in homes and offices and by mobile radio systems in the surrounding areas at the same distance. For DECT base stations, DECT phone and mobile W-LAN units (Neitzke H.-P. & Voigt H. 2003), the exposure of persons at a distance of 1 m from the devices is 1500 times higher than that of a radio switch. Measurements by the ECOLOG Institute and by other measuring laboratories (Neitzke & Voigt 2002, Bornkessel et al. 2002) in homes in the surrounding areas of mobile radio installations yielded power flux density values between 0.00001 to 0.1 W/m^2 caused by these installations.

Table 1
Power flux densities of installations and devices in homes and offices

Device/System	**Frequency (range) [MHz]**	**Maximum power flux density at a distance of 1 m [W/m^2]**
Radio switch	868 MHz	1.3 10^{-5}
Conventional switch	kHz to THz	at 868 MHz: 5.3 10^{-7}
DECT base station	1880 to 1900	0.02
DECT phone	1880 to 1900	0.02
W-LAN (mobile)	2400.0 to 2483.5	0.02
		Typical power flux densities [W/m^2]
Mobile radio installations	935 to 960 1805 to 1880	0.00001 to 0.1 W/m^2

It must be noted in the case of emissions from conventional switches, that they have a very large frequency bandwidth. To allow a comparison with the emissions of the radio switch, the integral in both power flux density spectra was formed via the frequency range from 100 MHz to 3 GHz in which one can assume similar biological effects of the electromagnetic fields. The results of this calculation are shown in Table 2. Although the peak value of the power flux density of the radio switch is roughly 25 times greater than that of a conventional switch, the total power flux density of the conventional switch is, however, 100 times higher than that of the radio switch.

Table 2
Integrated power flux densities in the frequency range 100 MHz to 3.0 GHz

Device/System	**Integrated power flux density [W/m^2]**
Radio switch	1.3 10^{-5}
Conventional switch	1.5 10^{-3}

In addition to this, the magnetic flux density in the low frequency range was measured at lines leading to and away from conventional

switches. Values between 0.2 and 0.4 nT were measured at a distance of 1 m from lines supplying 100 W lamps each. If higher outputs are switched, the magnetic flow density increases proportionally. In addition to this, it depends to a large extent on the type of power line and line arrangement.

Assessment of the exposures caused by the radio switch

For reasons of precaution, the ECOLOG Institute recommends that electromagnetic field exposures are kept as low as possible. As a minimum standard for long lasting exposures to high-frequency electromagnetic fields, a precautionary value of 0.01 W/m^2 should not be exceeded. This recommendation of the ECOLOG Institute refers to exposures due to outdoor installations. High-frequency electromagnetic fields in the frequency range of the radio switch are as a rule dampened by reflection and absorption by 3 to 10 dB during the transition from outside to interior rooms. Therefore, a value reduced by the factor of 10, that is 0.001 W/m^2, is used as a reference value for the power flux density caused by installations and devices in interior rooms.
At a distance of 1 m, the exposure caused by the examined radio switch lies below the reference value of 0.001 W/m^2 by a factor of 76. In addition, it must be noted that the precautionary value recommended by the ECOLOG Institute and the reference value derived from it refer to permanent exposures. These conditions are not given when the radio switch is used to operate lighting. Furthermore, the power flux densities caused by the radio switch are significantly below the power flux densities that may arise from the operation of a conventional light switch. From the perspective of health protection and the reduction of exposures to electromagnetic fields, the radio switch has another advantage over conventional switches: when installing a radio switch, the length of lines conducting power is reduced and, thus, the potential exposures to low-frequency magnetic fields are minimized. This is especially interesting when higher currents are carried by the lines, e.g., for supplying the lighting in open plan offices and when permanent work places are located near the lines.

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Literature

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