Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Gesundheit BAG

WLAN

Date: 9 August 2019

A WLAN (wireless local area network) is a computer network that transmits data between connected devices using radio-frequency electromagnetic radiation. The networked computers, laptops, smartphones, digital cameras, cordless phones, printers, scanners, projectors, televisions and other devices equipped for this purpose usually communicate with a central switching point, the access point or router. This connects the networked devices to the internet and to each other.

The electromagnetic radiation emitted by WLAN devices depends on the transmission power and the volume of data being transmitted in the network. Even with the greatest possible data volume, the maximum radiation is low. It also rapidly decreases as the distance from the WLAN transmitter increases: it is 10 times lower than the recommended safety level at a distance of 20 cm from the transmitter, and 40 times lower at a distance of 1 metre. So even several WLAN networks operated in the same area cannot cause significantly increased radiation for the general public. A study conducted in the canton of Zurich showed that a person's average radiation exposure from WLAN networks in daily life is 5,000 times lower than the current recommended exposure limit.

Existing studies on high-frequency radiation from WLANs do not provide substantiated findings or plausible evidence of health risks. Protective measures against electromagnetic radiation emitted by WLANs are therefore not necessary for the general public.

The following tips are not protective measures but are intended as advice for people who wish to minimise their personal exposure to high-frequency WLAN radiation:

- Position the access point centrally in the area to be supplied so that all WLAN devices have good reception.
- Switch off the WLAN devices or access point if you are not using them.
- Install the access point one metre away from places where you work, sit or rest for long periods of time to further reduce radiation exposure.
- If the access point allows the power to be adjusted, you can reduce the transmission power of the access point as long as all connected devices can still connect to it.
- Use devices with the latest WLAN standards 802.11n and 802.11ac, which transmit data very efficiently.

Federal Office of Public Health FOPH
Schwarzenburgstrasse 157, CH-3003 Bern

Further tips

- A WLAN device displays all available WLAN networks in the vicinity that emit sufficient radiation for a connection. There is a technology that allows WLAN devices to connect to each other at low radiation intensities. It is therefore not possible to deduce the radiation exposure at the location of the WLAN device on the basis of the number and strength of available WLAN networks displayed.
- Measuring WLAN radiation exposure requires time-consuming and very expensive measuring procedures. Commercially available manual measuring devices are not suitable for measuring radiation exposure from WLAN.
- Activate the power saving setting on battery-operated mobile devices such as smartphones so that the device switches off its WLAN module when the display is not active. This prevents the device constantly searching for WLAN networks and draining the battery unnecessarily.
- WLAN devices should only be used with the inbuilt antenna or one provided for this purpose by the manufacturer. If an unsuitable antenna with an excessive antenna gain is used, the maximum permitted transmission power may be exceeded.

1 Structure and uses

A WLAN or Wifi network usually consists of an access point or router that connects WLAN-enabled products to the internet or to each other via radio links. Products containing WLAN transmission and reception modules can currently be found in the following areas:

- Computer networks: desktop computers, laptops, tablets, WLAN hard drives, printers, scanners, etc.
- Household and leisure: radios and televisions, home cinema systems, audio devices, game consoles, action cameras, web cameras, photo and video cameras, surveillance- and baby monitors, devices for controlling heating and home installations, lighting, some household appliances
- Multimedia: radios and televisions, projectors, e-readers
- Telecommunication: smartphones, cordless phones, Voice over IP (VoIP) telephones

Due to their limited transmission power and range, WLAN networks are mainly suited to supplying small areas, such as apartments, detached houses, means of transport and public places. Larger areas, such as large buildings, universities and schools or whole neighbourhoods can be networked with ‘repeaters’ (also known as extenders or boosters), or through larger network structures containing several access points. Repeaters are either designed as standalone units or integrated in devices such as lamps or base stations for cordless phones.

2 Technical data

The Institute of Electrical and Electronics Engineers, an international professional association, has published a family of 802.11 standards for WLANs. Their output characteristics are shown in Table 1. Modern products work with standards 802.11ac or 802.11n, which enable high data transmission rates.

Table 1: Properties of the various IEEE WLAN standards

IEEE Standard	802.11ac	802.11n	802.11a	802.11 b	802.11g	802.11h
Frequency (MHz)	a) 5150-5350 b) 5470-5825	a) 2400 – 2483.5 b) 5150-5350 c) 5470-5825	5150 – 5250	2400 – 2483.5	2400 – 2483.5	5150 –5350 5470 -5725
Max. transmission power (mW)	a) 200 b) 1000	a) 100 b) 200 c) 1000	200	100	100	200/1000
Max. transmission power (mW) without power control	a) 100 b) 500	a) 100 b) 100 c) 500				
Mean transmission power of beacon (mW)			1	0.5	0.5	0.5
Mean transmission power (max.) (mW)			< 200	< 100	< 100	< 200
Range (m)			50	Up to 200	50	50
Power control	Yes	Yes	No	No	Yes, static	Yes, dynamic
Max. raw data rate (Mbit/s)	866.7 per antenna (max. 8 antennas)	150 per antenna (max. 4 antennas)	54	11	54	54
Proliferation	Current	Current	Outdated	Outdated	Outdated	Outdated

Data rates

The latest WLAN devices operate on the standards 802.11ac and 802.11n. These technologies work with beamforming antennas, which can be directed towards the connected devices. WLAN devices running on these standards can combine several of their antennas using MIMO (multiple-input-multiple-output) technology to increase data rates.

The more recent standards 802.11ac and 802.11ng and h incorporate high data rates. If several devices try to use an access point at the same time (e.g. several computers in a classroom), the transmission capacity of the connection is split, with the data rate for each device dropping accordingly. WLANs are very sensitive, which means that they can still network even if the radiation level is very low.

Radiation

The effective radiated power is determined primarily by the volume of data being transmitted. Even when no data are being transmitted, the access point still sends a signal (beacon) lasting 0.5 ms every 100 ms to enable the other devices to synchronise with it. If a 100 mW access point is only transmitting the beacon, the mean radiated power over time is 0.5 mW. However, if a large volume of data is being transmitted, the mean radiated power can be up to 70 mW.

The radiation pattern is very irregular because a device can transmit as soon as no other data transfer is taking place. The beacon transmitted by the access point produces relatively evenly pulsed energy with a repetition frequency of 10 Hz, for example.

The effect of distance

The radiation emitted by an antenna decreases significantly as distance increases. It can also be weakened or reflected by obstructions such as walls. The data rate can therefore drop if there is a considerable distance between the access point and the networked devices, or if there are obstacles in the way.

3 Limits and measuring exposure

SAR

The best way to describe exposure is in terms of SAR (specific absorption rate). The SAR (in W/kg) shows how much power (W) is absorbed by the human body (kg). This radiation leads to a temperature rise in the body. The SAR thresholds recommended by the ICNIRP (International Commission on Non-Ionizing Radiation Protection) limit this temperature rise to levels that do not endanger human health. They vary depending on whether the exposure is on the whole body, the limbs, or the head and torso. These threshold values comprise a safety factor of 50 in order to protect sensitive populations. The ICNIRP threshold for the torso and head is the strictest and amounts to 2 W/kg, averaged over a 10 g volume of body tissue [1]. This means that in the most heavily exposed 10 g volume of body tissue, the SAR must not exceed the level of 0.02 W/kg. The SAR values of all measured devices are below this recommended threshold.

A number of studies commissioned by the FOPH have measured the SAR and in some cases the electrical field of a tablet, several access points, PC cards and a PDA [2, 3]. Since the radiation emitted by the WLAN depends on the transmission power of the device and the rate at which data are transmitted, all the measurements were carried out at the maximum transmission power and data rate in close proximity to the devices. The various standards use different modulation methods which produce different radiation levels. Although the most recent ac and n standards have a significantly higher data rate than the old a, b and g standards, the use of beamforming technology allows signals to be directed to the connected devices and the signal from several antennas to be combined, so the radiation levels tend to be lower than those produced with the older standards, particularly at access points.

Table 2: Maximum SAR values measured in close proximity to the devices. SAR values were measured in a body phantom [2,3]

maximum SAR values		
Stand-ard	Device	SAR (W/kg)
802.11ac	Access point 5 GHz	0.070
	Tablet 5 GHz	0.511
802.11 n	Access point 2.4 GHz	0.256
	Access point 5 GHz	0.096
	Tablet 2.4 GHz	0.298
	Tablet 5 GHz	0.697
802.11a	Access point	0.54
	PC card	0.07
802.11b	Access point	0.73
	PC card	0.43
	PDA	0.067
802.11g	Access point	0.27
	PC card	0.11

Electrical field

The electrical field can also be measured for devices which are used away from the body. The threshold recommended by the ICNIRP for the frequency range in which WLAN devices transmit is 61 V/m (volts per metre). This value guarantees that the thresholds for the specific absorption rates (SAR) are complied with.

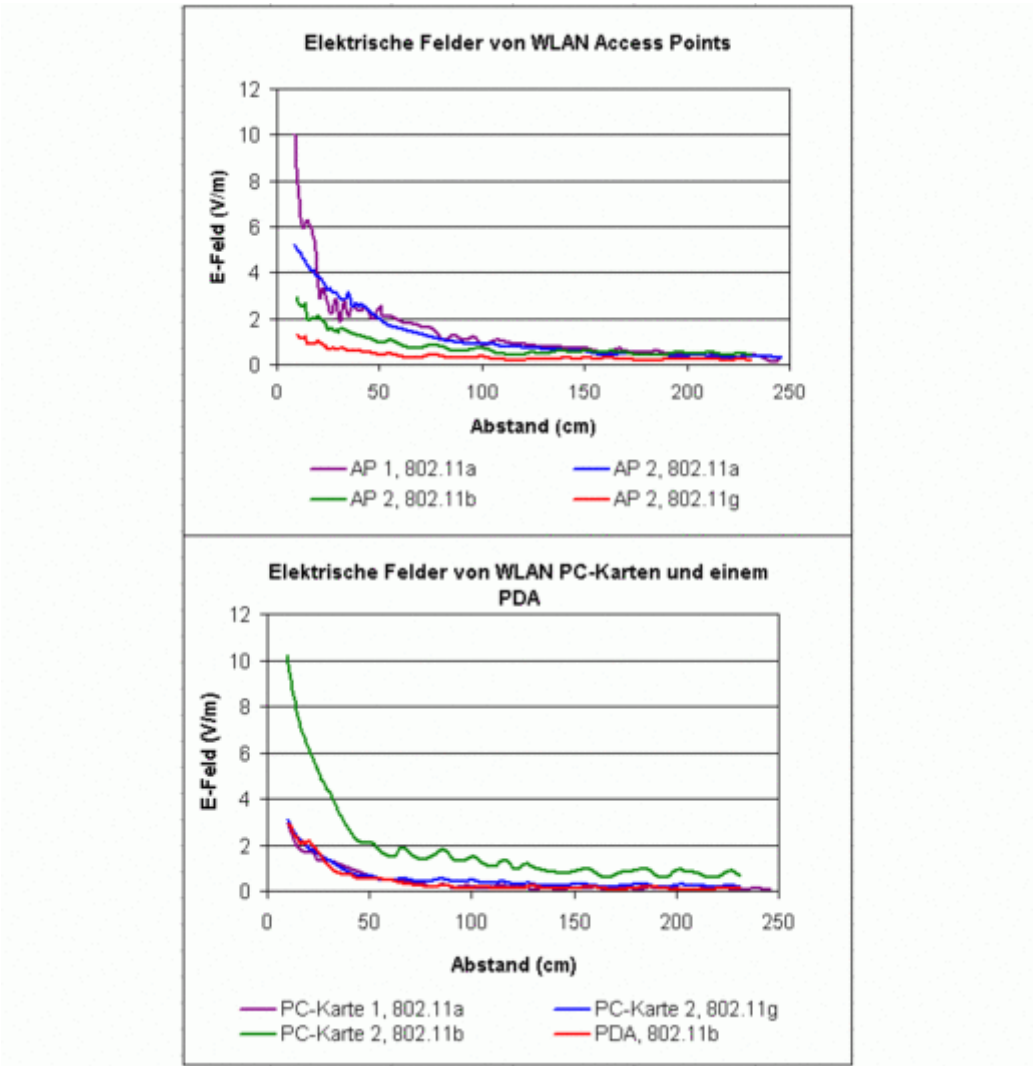

Figure 1: Electrical field (e-field) as a function of distance for two different WLAN access points (AP), two different PC cards and a PDA. Access point 2 can be operated using the 802.11 a, b or g standard, the PC card 2 using 802.11 b or g.

Electrical fields decrease significantly as the distance from the transmitter increases (Figure 1). The values are in all cases below the ICNIRP's recommended threshold of 61 V/m. None of the devices reaches more than 10% of the ICNIRP's recommended threshold at a distance of 20 cm, and they reach less than 2.5% at 1 metre.

Average exposure of the population to radiation from WLAN devices

A number of studies in Switzerland have looked at the mean real exposure of the population to various high-frequency radiation sources. A study conducted in the canton of Zurich [4] involving 115 subjects showed that the overall exposure at 0.18 V/m was very low and amounted to around 3 per mill of the ICNIRP's recommended threshold for radio frequency fields. In the study, subjects wore a dosimeter on their bodies for two or three days to record the high-frequency radiation from individual sources. The main sources were mobile telephony followed by mobile phone base stations. Radiation from

WLAN only contributed 5% of total exposure. This was therefore more than 5,000 times lower than the ICNIRP's recommended threshold. The mean exposures from WLAN devices were 0.04 V/m in households with WLAN and 0.02 V/m in households without WLAN. These exposures were 1,500 and 3,000 times respectively below the ICNIRP's recommended threshold.

Another study conducted in Switzerland involving 90 subjects aged between 13 and 17 shows similar results [5]. The total exposure to high-frequency radiation amounted to 0.15 V/m, with WLAN devices contributing 3.5% of this. The detailed analysis of WLAN radiation shows that the exposure of adolescents to radiation from WLAN was only marginally dependent on whether or not WLAN devices were used at school or at home. In addition, the exposure of adolescents to radiation was only slightly dependent on whether they connected their mobile phones to the internet via WLAN, via mobile internet (mobile phone base stations) or not at all.

WLAN hotspots

An area in which internet access is available via a WLAN is called a hotspot. Hotspots may be accessible to the public (in stations, airports etc.) or limited to a specific set of users (in hotels, for example). Access points in buildings are typically mounted in the ceiling or walls, in rare instances in cavity floors; access points that supply outdoor areas are installed on the façades of buildings or on the roof. Several access points may be installed in one hotspot. The radiation emitted by hotspots is also well below the ICNIRP's recommended maximum level of 61 V/m.

4 Effects on health

Based on the current state of knowledge and available exposure measurements, the high-frequency radiation emitted by WLAN is too weak to have acute health effects due to an increase in body temperature through absorption. Long-term and non-thermal effects have not been sufficiently researched. The available studies on the effects of exposure to high-frequency EMF at low doses below the current thresholds do not suggest any risk to health from WLAN.

Individual WLAN devices, such as WLAN-enabled laptops, mobile phones and PDAs, can lead to longer-term radiation exposure when used closer to the body. At the moment the impact on health of such devices when used close to the body is uncertain; international research is currently investigating them in detail in connection with the effects of radiation emitted by mobile phones. Taking appropriate precautions as described in the introduction to this fact sheet can minimise the exposure.

5 Statutory regulations

WLAN devices

WLAN devices are subject to the Swiss Telecommunications Installations Ordinance (TIO) [6], which sets out the fundamental requirements for protecting the health and safety of persons who use telecommunications installations or are exposed to radiation from such installations. These requirements are substantiated in Swiss-European standards. The limits contained in these standards correspond to

the limits set out in the European Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz - 300 GHz) [7] and which the EU adopted from the ICNIRP recommended exposure limits [1].

Hotspots

The access points of publicly accessible hotspots are stationary transmitters and fall within the scope of the Ordinance on Protection against Non-Ionising Radiation (NIRO) [8].
As the maximum permitted transmission power of WLAN access points is below 6 Watt ERP, they are exempt from a preventive emission limit, i.e. they do not have to comply with an additional reduced installation limit value. However, the less strict emission thresholds of the NIRO must be complied with by hotspots if the whole body is evenly exposed to radiation.

In the case of hotspots where people are so close to the antennas that the body is not evenly exposed, or only parts of the body are exposed, the NIRO exposure limit value is no longer applicable. In this case, the requirements of the Telecommunications Installations Ordinance (TIO) [6], or the ICNIRP threshold of 2 W/kg for the specific absorption rate apply [1].

6 References

1. ICNIRP. Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields up to 300 GHz. Health Phys. 75: 494-521. 1998. ICNIRP. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)
2. Kühn, S et al. Development of Procedures for the EMF Exposure Evaluation from Wireless Devices in Home and Office Environments. Supplement 1: Close-to-Body and Base Station Wireless Data Communication Devices. 2006. IT'IS Report. See "Further documents"
3. Funck, C; Kühn, S; Goren, T; Kuster, N: Dosimetric Evaluation of IEEE 802.11n and 802.11ac Devices. Final Report for Project 644, IT'IS Report. 2017
4. Röösli, M; Struchen, B; Eeftens, M; Roser, K: Persönliche Messungen von hochfrequenten elektromagnetischen Feldern bei einer Bevölkerungsstichprobe im Kanton Zürich (Personal measurements of high-frequency electromagnetic fields in a population sample in the canton of Zurich) on behalf of the WWEA, Office of Waste, Water, Energy and Air in Zurich, March 2016
5. Roser, K; Schoeni, A; Struchen, B; Zahner, M; Eeftens, M; Fröhlich, J; Röösli, M: Personal radiofrequency electromagnetic field exposure measurements in Swiss adolescents. Environment international 99, 2017, 303–314
6. Ordinance of 14 June 2002 on Telecommunications Installations, SR 784.101.2.
7. 1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz - 300 GHz) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31999H0519
8. Ordinance of 23 December 1999 on Protection against Non-Ionising Radiation, SR 814.710 (NIRO).

Specialist staff:
Federal Office of Public Health FOPH
str@bag.admin.ch