Transmitters for radio and TV programmes are usually placed at elevated locations outside residential areas. Although amateur radio transmitters are located in residential areas, they are only used for limited periods. Point-to point microwave links only transmit in very narrow cones.

The majority of broadcast transmitters emit radiation outside residential areas

Contents

Broadcasting

Broadcasting transmission installations serve the purpose of transmitting radio and TV programmes through the air. They are usually placed at elevated locations, e.g. on hilltops or in the mountains. Some large-scale facilities are named after the mountain peak they are situated on, e.g. La Dôle, Chasseral, Rigi, Säntis, Monte San Salvatore, and in addition there are numerous smaller installations. In Switzerland, approximately 400 radio and 600 TV stations broadcast programmes. Their locations and details concerning their transmitting power and programmes broadcast can be found at **www.funksender.ch**.

Broadcasting stations on the Rigi, canton of Schwyz (left) and Bantiger, canton of Bern (above). The directional dishes in the lower section of the towers link the station with other transmitters. The antennae for broadcasting TV and radio programmes are at the top.

Transmitting power

Broadcasting installations that cover a large area use high transmitting power. Due to Switzerland's topography, most of these high-output systems are installed at elevated locations, and this means that there are usually no residential buildings in their immediate vicinity. The radiation from these transmitters is narrowly focused vertically and directed slightly downwards while it is omnidirectional hor-

Radio

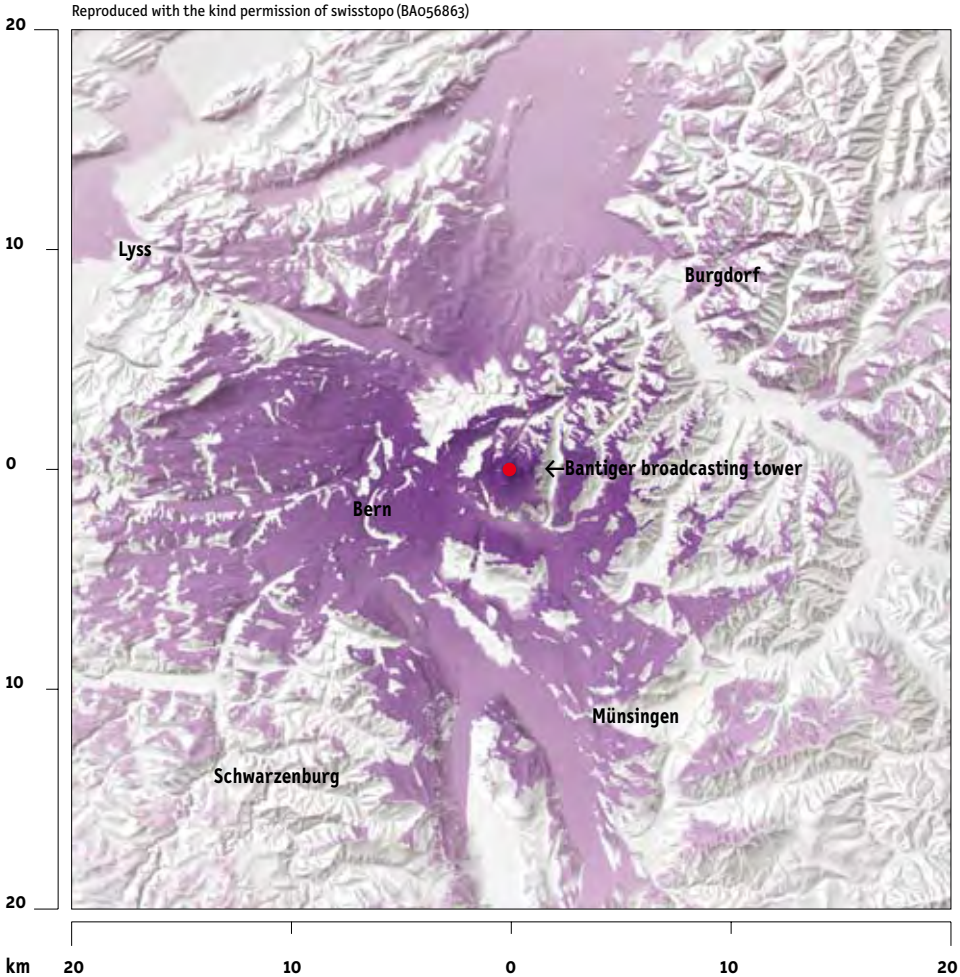
Radio programmes are broadcast at a variety of frequencies. Each frequency range is named after the corresponding wavelength.

Medium wave (MW): Medium wave is the name given to the range from 300 kHz to 3 MHz. It was this frequency range that was used to broadcast the first radio programmes in Switzerland in the 1920s, and was later also used by national stations such as Beromünster, Sottens and Monte Ceneri. After the introduction of VHF (very high frequency), medium wave began to lose ground due to its inferior sound quality. Since the mid-1990s, only two stations have continued to use medium wave ("Option musique" and "Musigwälle 531").

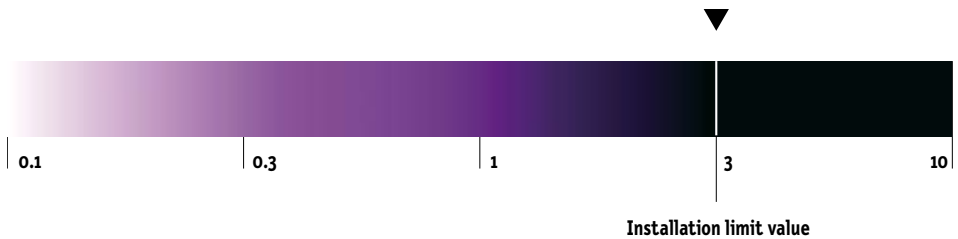
Very high frequency (VHF): Nowadays, most radio programmes are broadcast on VHF. This frequency range is between 30 and 300 MHz, and within this range the band from 87.5 to 108 Hz is reserved for radio programmes. VHF has been in use in Switzerland since the 1950s. Its sound quality is better than that of medium wave, and it is possible to broadcast in stereo.

T-DAB digital radio: This is intended as a medium-term extension of VHF. T-DAB stands for terrestrial digital audio broadcasting. It was introduced in Switzerland in 1999. In addition, digital radio programmes are also broadcast via cable and satellite.
With DAB, the sound signal is digitised before it is broadcast, i.e. it is converted to a numerical sequence based on 1 and 0 similar to the method of storing data on a music CD. The receiver then converts the digital data back into words and music. Thanks to this technology it is now possible to listen to the radio while driving, without the problem of interference. DAB is primarily used in the VHF range between 223 and 230 MHz.

izontally. There are also fill-in transmitters that supply valleys via antennae with low transmitting power.
Outside of cities and urban centres, broadcasting transmitters usually account for the largest proportion of high-frequency background radiation. But in densely populated areas, it is often signals from base station antennae that predominate.
At present it is difficult to assess the impact of the changeover from analogue to digital transmission technology on radiation exposure. Although digital technology requires fewer frequencies for transmitting a certain number of TV programmes than analogue technology, this advantage would be lost again if more programmes were to be transmitted using wireless technology in the future.
Digital transmission requires lower transmission power than analogue technology for the same reception quality, but this advantage, too, would be lost again if TV signals were also to be designed for reception by mobile (portable indoor) TV sets equipped with a smaller antenna, instead of for fixed outdoor reception (i.e. via an aerial on the roof). In this case, the attenuation of the building shell would have to be offset by using a correspondingly higher transmitting power. Whether digital TV (DVB-T) will lead to lower transmission power, and thus to lower radiation exposure, therefore depends on the number of programmes to be transmitted in the future, and on requirements relating to reception quality.



Depiction of electric field strength in the surroundings of the Bantiger broadcasting tower (canton of Bern). The calculations are based on simplified assumptions that do not take diffraction and reflection into account. Due to the topography of the region, there is no visual contact with the transmitter in the areas shown in white. Although the electric field strength here is very low (less than 0.1 V/m), it is usually still possible to receive radio and TV signals.



Scale of electric field strength in volts per metre (V/m).

Designation	Wavelength	Frequency	Frequencies used in Switzerland
Long wave (LW)	1 – 10 km	30 – 300 kHz	Not used
Medium wave (MW)	100 – 1000 m	300 kHz – 3 MHz	531 kHz – 1.5 MHz (MW radio)
Short wave (SW)	10 – 100 m	3 – 30 MHz	Discontinued as of the end of 2004
Very high frequency (VHF)	1 – 10 m	30 – 300 MHz	47 – 68 MHz (analogue TV) 87.5 - 108 MHz (VHF radio) 174 - 230 MHz To date: analogue TV and digital radio In future: digital radio and TV
Microwaves	1 mm – 1 m	300 MHz – 300 GHz	470 – 862 MHz To date: analogue TV, in future digital TV 1452 - 1492 MHz In future: to be considered for transmission of local digital radio programmes

Precautionary regulations of the ONIR

At places of sensitive use, broadcasting transmission installations are required to comply with the installation limit value specified by the ONIR. An installation comprises all broadcasting antennae on the same mast or otherwise located closely together.
The installation limit value must be complied with at maximum transmitting power, and is as follows:
– 8.5 volts per metre (V/m) for medium wave transmitters
– 3.0 V/m for all other transmitting installations

Since most broadcasting installations are located outside of residential areas, they can usually comply with the installation limit value without difficulty. The only exception here concerns some mountain restaurants or cable car/railway stations located close to a transmitter. Here it is possible that the limit value may be exceeded. Unlike mobile phone base stations for which compliance with the installation limit value is compulsory, in certain exceptional cases the authorities may allow broadcasting installations to exceed their installation limit value.

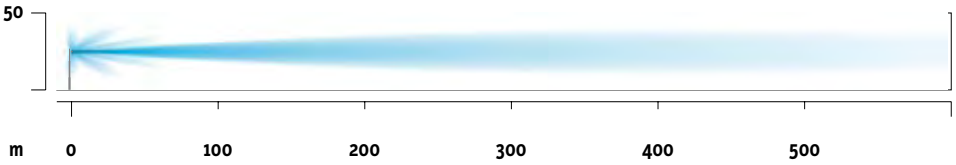
Television

Nowadays we receive most TV programmes viacable or satellite. However, the programmes of Swiss TV are also broadcast via terrestrial transmitters using frequencies in the VHF range (47 to 68 MHz and 174 to 230 MHz) as well as higher frequencies (470 to 862 MHz).

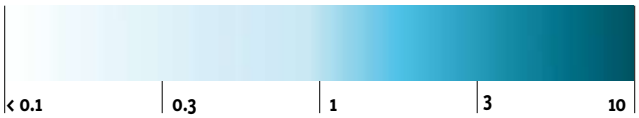
DVB-T: At the end of 2001, TV also began converting from conventional analogue technology to DVB-T (which stands for digital video broadcasting terrestrial). This new technology offers higher sound and picture quality as well as the advantage of broadcasting additional data. It also uses frequencies more efficiently. For example, with DVB-T it is possible to simultaneously transmit two to six digital programmes (depending on the desired quality) on one conventional analogue channel.

The city of Zurich is served by the broadcasting tower at nearby Üetliberg. Since the majority of broadcasting transmitters are located in mountains or on hilltops, residential areas are seldom exposed to intensive radiation.

Point-to-point microwave links



Depiction of the radiation of a point-to-point microwave link. The significance of the colours is indicated in the colour scale below.



Scale of electric field strength in volts per metre (V/m).

These directional antennae on the Jakobshorn (canton of Grisons) link mobile phone base stations and switching centres over relatively short distances.

Point-to-point microwave links in Switzerland

In Switzerland there is a nation-wide point-to-point microwave network with typical distances of 50 to 70 kilometres between the transmission and reception antennae. These distances are bridged with frequencies of 4 to 13 gigahertz (GHz). The required parabolic antennae have a diameter of up to several metres and are usually installed on high towers in exposed locations (e.g. on hilltops).

In addition to the national network, point-to-point microwave links over shorter distances are being used to an increasing extent. These can be used to connect mobile phone base stations with their switching centre. To cover shorter distances of a few hundred metres up to a few kilometres, frequencies in the range from 18 to 38 GHz are used. The respective parabolic antennae have a correspondingly smaller diameter of several dozen centimetres.

Strongly focused radiation

Parabolic antennae focus the radiation to such an extent that it is confined within a narrow beam propagating linearly between the transmitting and receiving stations. Thanks to this property, point-to-point transmitters can work with very low transmitting power compared with broadcasting transmitters. For longer distances, all they require is a few hundred milliwatts per frequency, and for shorter distances this falls to 10 to 100 mW. As a rule, point-to-point microwave installations do not transmit pulsed signals, but rather continually and with constant output power.

Despite the initial narrow focusing of the signal, it nonetheless widens somewhat on its way to the reception antenna. This means that it covers a considerably wider area than that of the targeted parabolic antenna. The further the two stations are apart, the wider the covered area.

Apart from the main beam, parabolic antennae also produce a variety of significantly weaker secondary beams, referred to as side lobes. Since these leave the transmitter at a different angle than the main beam, they can also reach the ground beside and beneath the antenna. Measurements carried out near a powerful transmitter within the national network have yielded scattered radiation readings of between 0.03 and 0.15 volts per metre (V/m). If any exposure is measured in the vicinity of point-to-point transmitting antennae, this can be attributed to side lobes.

Limit values for point-to-point microwave transmitters

Stationary point-to-point transmitting installations are covered by the ONIR. They have to comply with the exposure limit values, and are usually able to do so without difficulty. The only exception that might arise here is if someone stands close to the antenna directly in the main beam. In such cases the human body would considerably attenuate or even interrupt the signal, and for this reason, such situations are of course undesirable for operational reasons. Point-to-point microwave link antennae are therefore installed at elevated locations and if necessary are fenced in so that no one is likely to block the signal. This also ensures that the exposure limit values are complied with. The Ordinance does not specify any installation limit values for point-to-point transmitting facilities.

Point-to-point microwave links

Point-to-point microwave links are used for wireless transmission of phone calls, data and radio and TV programmes between two points with direct visual contact. They support and complement data transmission via the cable network. In difficult terrain they are easier to install and more economical to operate than cable systems. Point-to-point microwave systems comprise a parabolic antenna at both locations (transmission and reception).

Amateur radio

In Switzerland there are approximately 5,000 amateur radio users, and throughout the world there are more than a million. In most cases, the required equipment is installed in private homes, though it is also possible to operate amateur radio from a car, ship or aircraft. For amateur radio, numerous frequencies are available, ranging from long wave to microwave.
The necessary antennae are often installed on the roof or in the immediate vicinity. Since do-it-yourself and experimentation are an important aspect of this hobby, there are numerous different constructions. For low frequencies, fixed wire antennae are usually used, and for shortwave frequencies, many people use vertical aerials and directional antennae, while in the VHF and microwave ranges, directional antennae, vertical aerials and parabolic antennae are common.
By contrast with mobile communication or broadcasting, amateur radio systems are not permanently in use and therefore do not generate permanent radiation, since they only do so when they are actually transmitting. An amateur radio licence permits a maximum transmitting power of 1,000 watts, but in practice, many systems only have an output of up to 100 watts.
Since the antennae are often located in residential areas, their distance from other residential buildings is relatively short. For this reason, amateur radio equipment can account for the main proportion of exposure to high-frequency radiation in their immediate vicinity when they are in use. All stationary installations are subject to the ONIR and must comply with the defined limit values.

Amateur radio aerials can take very different forms. The one shown here is a Yagi roof aerial.

Limit values for amateur radio installations

Amateur radio installations have to comply with the exposure limit values specified by the ONIR. These are between 28 and 87 volts per metre, depending on the frequency used. Otherwise no installation limit value has to be complied with as long as the system is not in operation for more than 800 hours a year. This is almost always the case with hobby users. However, if a system exceeds the above threshold, it has to comply with the applicable installation limit value at places of sensitive use. This limit value is 8.5 V/m for long wave and medium wave transmitters and 3.0 V/m for all other frequency bands. The cantons or municipalities are responsible for the enforcement of the ONIR in the area of amateur radio.

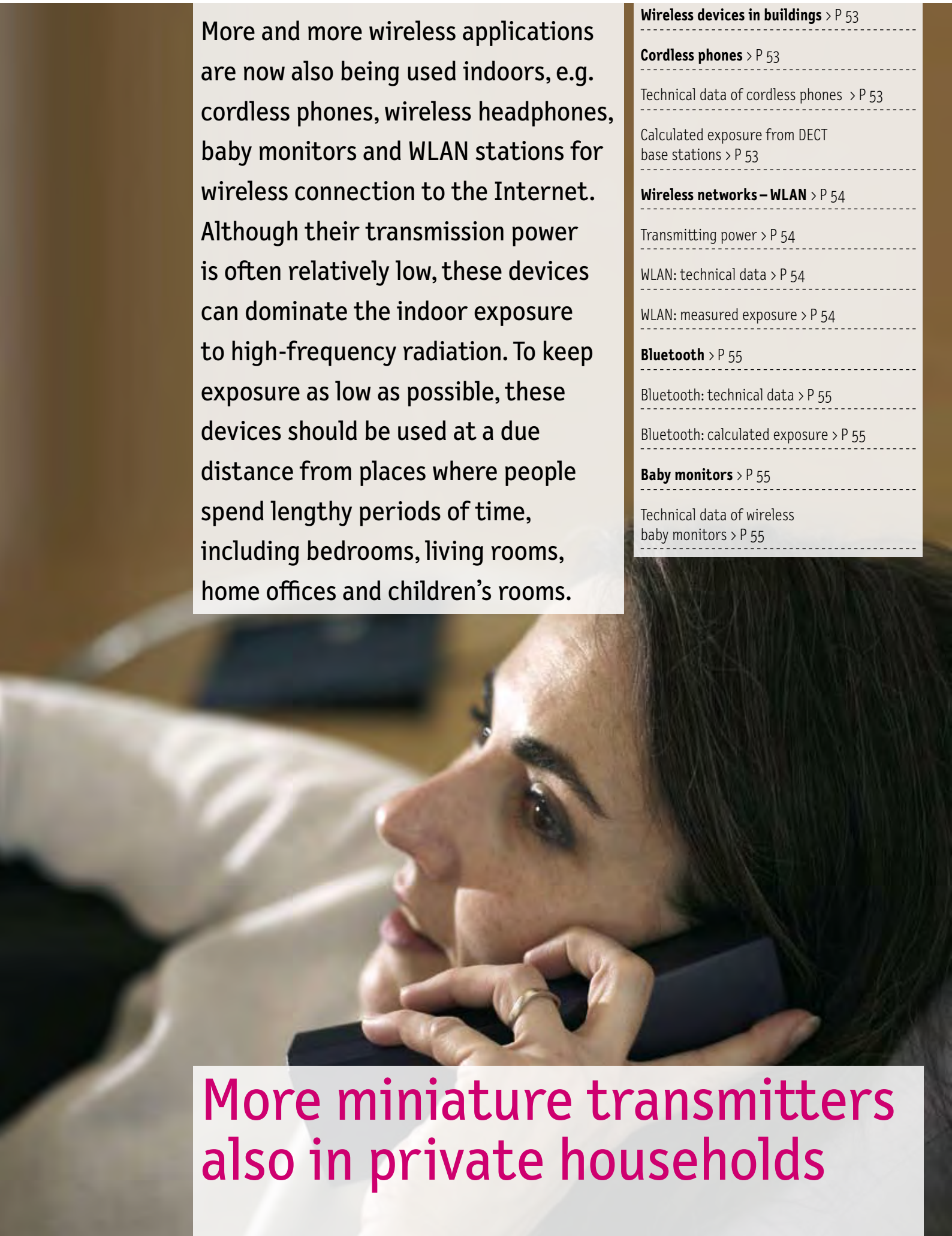
Amateur radio equipment

Amateur radio frequencies

Frequency range	Frequencies used in Switzerland for amateur radio
Long wave	135.7 - 137.8 kHz
Medium wave	1.81 - 2 MHz
Short wave	Several bands between 3.5 and 29.7 MHz
VHF	50 - 52 MHz 144 - 146 MHz
Microwave	Several bands between 430 MHz and 250 GHz

Contents

More and more wireless applications are now also being used indoors, e.g. cordless phones, wireless headphones, baby monitors and WLAN stations for wireless connection to the Internet. Although their transmission power is often relatively low, these devices can dominate the indoor exposure to high-frequency radiation. To keep exposure as low as possible, these devices should be used at a due distance from places where people spend lengthy periods of time, including bedrooms, living rooms, home offices and children's rooms.



More miniature transmitters also in private households

Wireless devices in buildings

Mobile phone base stations, broadcasting transmitters and other wireless systems operated outdoors are not the only sources of high-frequency radiation. An increasing variety of wireless devices are now being used indoors, too, e.g. wireless networks (WLAN), cordless phones and baby monitors. Some of these technologies use similar frequencies to those used by mobile communication systems, others make use of higher frequencies. They operate with relatively low transmitting power, but because they are used indoors, they are often located very close to spots frequently occupied by the inhabitants.
Most of these technologies work with pulsed transmission, though the pulse patterns vary considerably.

Cordless phones

Cordless phones comprise a base station connected to the fixed phone network, plus one or more handsets for cordless phoning. Most devices in use today are based on the DECT standard and operate in a frequency range from 1,880 to 1,900 MHz. DECT stands for digital enhanced cordless telecommunications.

The signal pulses at 100 Hz. The transmitting power during a single pulse is 250 milliwatts (mW), and the time averaged level is 10 mW. This means it is lower than that of a GSM mobile phone operating under poor reception conditions, which in this case transmits with a pulse power of 1,000 or 2,000 mW, corresponding to a time averaged output of 125 or 250 mW. But unlike a cordless phone, a mobile phone adjusts its transmitting power to the reception conditions, and in ideal circumstances can reduce it thousandfold.
The transmitting power from DECT base stations is also 250 mW in the pulse and the average level is 10 mW for each handset served by the base station. DECT base stations are available on the market with up to six handsets.
While the latter only transmit during a call, the DECT base station transmits permanently, i.e. even when no call is in progress (in which case the average transmitting power is 2.5 mW). To minimise exposure, the base station should be kept as far away as possible from places where people spend lengthy periods of time, e.g. beds, armchairs, workdesks.
As an alternative to DECT phones, there are some cordless phones on the market that are based on the CT1+ standard. Here the base station only transmits during a call, and the signal is not pulsed. However, the frequency bands used by such models will be attributed to mobile telephony as of the end of 2005. This means that, under unfavourable circumstances, interference-free operation will no longer be possible. CT1+ phones, which in turn interfere with mobile phone communications, have to be put out of operation.

Calculated exposure from DECT base stations

Distance from DECT base station	Calculated electric field strength (time averaged) (source: Federal Office of Communications)
0.5 m	0.7 – 4.9 V/m
1.5 m	0.2 – 1.6 V/m
3 m	0.1 – 0.8 V/m
7 m	0.05 – 0.4 V/m

Technical data of cordless phones

	DECT Base station	DECT Handset	CT1+ Base station	CT1+ Handset
Frequency	1880 – 1900 MHz	1880 – 1900 MHz	930 – 932 MHz	885 – 887 MHz
Pulse	100 Hz	100 Hz	none	none
Maximum transmitting power	250 mW	250 mW	10 mW	10 mW
Mean transmitting power during call	10 mW (per handset)	10 mW	10 mW	10 mW
Mean transmitting power without call	2.5 mW (per handset)	0 mW	0 mW	0 mW
Transmission status	Transmits permanently	Only transmits during a call	Only transmits during a call	Only transmits during a call
Range	Approx. 50 m indoors, approx. 300 m outdoors			

Unlike conventional telephones with cords, DECT cordless phones and their base stations emit pulsed radiation.

Wireless networks – WLAN

WLAN stands for Wireless Local Area Network. This technology is used for connecting several computers to one another without the need for cables. It can also be used for transferring data to peripheral devices such as printers, scanners and beamers. It enables connections both inside buildings and in the public zone, and also permits wireless access to the Internet or a company intranet.

Hot spots: One example of use of WLAN in the public zone is wireless broadband Internet access from highly frequented locations such as railway stations, airports, restaurants, universities, etc. At a hot spot, the laptop establishes contact by means of its wireless card with a fixed transmission and reception station that is connected to the Internet via a server. These WLAN base stations are called access points. A fee may or may not be charged for Internet access, depending on the hot spot.

WLAN at home and in the office: Wireless Internet access can also be set up at home. Here the WLAN base station is connected via the phone line or TV cable. Within companies, computers and peripheral devices can be connected both to the Internet and to an intranet via access points.

WLAN applications operated via an access point are referred to as infrastructure networks. If no access point is available, end devices can communicate directly with one another, thus forming an ad hoc network.

Transmitting power

In Switzerland, WLAN applications operate in the frequency bands of 2.4 or 5.2 to 5.7 gigahertz, depending on the relevant standard.

Access points transmit not only during data transfer, but also in standby mode. The corresponding control signal is pulsed with a frequency of 10 to 100 hertz (Hz). During data transfer, both the access point and the communication card of the computer transmit signals that have a higher pulse frequency – up to 250 Hz, depending on the quality of the wireless connection and the number of involved stations.

With 100 mW, 200 mW or 1 W, the maximum WLAN transmitting power is often higher than that of DECT base stations and phones. Compared with the WLAN base station (access point), the radiation exposure caused by the WLAN wireless card of the computer is usually higher, since the latter is normally located closer to the user.

WLAN: technical data

Standard	IEEE 802.11b	IEEE 802.11h
Frequency	2.4 - 2.4835 GHz	5.15 - 5.35 GHz, 5.47 - 5.725 GHz
Maximum transmitting power	100 mW	200 mW - 1 W (power control as required)
Pulse in standby mode	10 - 100 Hz	10 - 100 Hz
Pulse during data transfer	10 - 250 Hz	10 - 250 Hz
Range	~30 m indoors ~300 m outdoors	~30 m indoors ~300 m outdoors

WLAN: measured exposure

Access points in public areas (100 mW/200 mW)	
Distance to access point	Measured maximum electric field strength
1 m	0.7 – 3 V/m
2 m	0.4 – 1.5 V/m
5 m	0.1 – 0.7 V/m
10 m	0.05 – 0.4 V/m

Access points at home (100 mW/200 mW)	
Distance to access point	Measured maximum electric field strength
1 m	0.7 – 1.3 V/m
5 m	0.1 – 0.3 V/m

WLAN wireless cards for computers (100 mW/200 mW)	
Distance to WLAN card	Measured maximum electric field strength
50 cm	1.1 – 4.9 V/m
1 m	0.7 – 2.8 V/m

Stationary WLAN installations in areas accessible to the public have to comply with the exposure limit values specified by the ONIR. Due to the low transmitting power, this is generally the case already. By contrast with mobile phone base stations, the Ordinance does not specify any precautionary limit values for WLAN.

Bluetooth

Bluetooth devices operate at relatively low levels of transmitting power, and this means that radiation exposure is also low.

Bluetooth is a standard for wireless data transfer over short distances, e.g. between a computer and a printer, or between headphones and a mobile phone. It differs from WLAN technology in that the range is shorter and it uses a different transmission protocol. For data transfer, Bluetooth uses 79 different frequency channels around 2.4 GHz. The frequencies are changed 1,600 times a second (and the signal therefore is pulsed at a frequency of 1,600 hertz).

Three performance categories exist for Bluetooth devices, with maximum transmitting power of 1 mW, 2.5 mW or 100 mW (i.e. lower than those for DECT and WLAN).

Bluetooth: technical data

Frequency	Transmitting power	Pulse frequency	Range
2.4 - 2.4835 GHz	1 mW	1,600 Hz	approx. 10 m
2.4 - 2.4835 GHz	2.5 mW	1,600 Hz	approx. 15 m
2.4 - 2.4835 GHz	100 mW	1,600 Hz	approx. 100 m

Bluetooth: calculated exposure

Transmitting power (power control as required)	Maximum electric field strength at a distance of 50 cm	Maximum electric field strength at a distance of 1 m
1 mW	approx. 0.4 V/m	approx. 0.2 V/m
2.5 mW	approx. 0.6 V/m	approx. 0.3 V/m
100 mW	approx. 3.5 V/m	approx. 2 V/m

Baby monitors

Baby monitors are devices for acoustic monitoring of babies and small children. The transmitter picks up sounds via a microphone and transmits them to a receiver that plays back the sounds via a loudspeaker. The two devices can be connected via a dedicated cable, the electricity supply in the house or via a wireless system. Wireless baby monitors are operated at 27.8 or 40.7 MHz. Some models transmit permanently and therefore also generate radiation continuously, while others only transmit when a sound is emitted. Electrosmog exposure can be reduced by choosing the right device:

- Baby monitors that transfer sounds via the power supply do not generate any significant electrosmog exposure.
- The wireless monitors that generate the lowest radiation exposure are those that only transmit when a sound is made.
- Regardless of the type of device, wireless monitors should be kept at a minimum distance of 1.5 to 2 metres from the baby.

Technical data of wireless baby monitors

Frequency	Transmitting power	Range
27.8 MHz	100 mW	approx. 400 metres
40.7 MHz	10 mW	approx. 400 metres

Index

Glossary

Frequency: Frequency refers to the number of oscillations per second, and it is measured in hertz (Hz) (1 Hz = 1 oscillation per second). In the field of wireless communication, kilohertz (1,000 Hz), megahertz (1,000,000 Hz) and gigahertz (1,000,000,000 Hz) are widely used units.

High-frequency radiation: Non-ionising radiation with a frequency of 30 kilohertz to 300 gigahertz is referred to as high-frequency radiation. Here, the electric and magnetic field are coupled and can propagate in the form of a wave. Mobile telephony, various wireless applications, radar systems and radio and TV use this property for wireless transmission of data.

Ionising radiation: Ionising radiation refers to electromagnetic radiation in the highest frequency range. It possesses enough energy to release electrons from atoms and molecules, and thus to alter the basic constituents of living organisms. Well-known examples of this include gamma radiation and x-rays.

Low-frequency fields: By contrast with high-frequency radiation, the electric and magnetic fields in the frequency range from 0 Hz to 30 kHz are decoupled. This is why we tend to speak of fields rather than radiation. The sources of these fields include contact lines of railways (catenaries), high-voltage transmission lines, other systems used in electricity distribution (e.g. transformer stations and sub-stations), and electrical appliances.

Non-ionising radiation: Non-ionising radiation does not possess enough energy to alter the constituents of living organisms. It encompasses ultraviolet radiation, visible light, heat radiation, high-frequency radiation and all low-frequency electric and magnetic fields. Artificially produced low-frequency and high-frequency radiation are also widely referred to as "electrosmog".

ONIR: Ordinance relating to Protection from Non-Ionising Radiation: The Ordinance entered into effect on 1 February 2000. Its legal basis is the Swiss Federal Law relating to the Protection of the Environment. The federal government issued this Ordinance in order to protect the population against harmful and annoying effects of non-ionising radiation.

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- www.environment-switzerland.ch > Publications > Electrosmog

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- www.environment-switzerland.ch/electrosmog
- www.bag.admin.ch/themen/strahlung/00053/index.html (in German and French)
- www.bakom.ch > Topics > Technology
- www.mobile-research.ethz.ch
- www.aefu.ch > Themen > Elektrosmog (in German)
- www.icnirp.de
- www.who.int/peh-emf/en

For further information, please contact:
Swiss Federal Office for the Environment
Non-Ionising Radiation Section
CH 3003 Bern
Switzerland

Phone +41 31 322 93 12
Fax +41 31 324 01 37
E-Mail: nis@bafu.admin.ch
Internet:
www.environment-switzerland.ch/electrosmog

Swiss Agency for the Environment, Forests and Landscape SAEFL