EMF Safety for Community Wireless Networks

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June 12, 2013

Safety concerns come up from time to time when people put up networks involving radio links. Is microwave radiation harmful? What safety precautions, if any are necessary? Here we examine a few typical scenarios.

The International Commission on Non-Ionizing Radiation Protection is the organisation recognised by the World Health Organisation[6] as responsible for reviewing the scientific literature and setting safe limits for exposure to electro-magnetic fields. The ICNIRP guidelines[1] are recommended by the UK Health and Safety Executive[5].

The radios typically used for community wireless networks operate in the 5 GHz band. The relevant limits are in tables 4 and 5 of the guidelines:

	Occupational Exposure	General Public	Units
Basic limit (10 MHz–10 GHz)	0.4	0.08	W/kg
Power density limit (10 GHz–300 GHz)	50	10	W/m^2

the power density limit is not quoted for frequencies less than 10 GHz, but we will consider them here as though they applied below 5 GHz just for an extra safety margin.

The limits of allowable radiated power in the 5 GHz band are set by Ofcom in their Interface Requirements 2006[3] and 2007[4] documents. The maximum allowable effective radiated power on these bands is 4W.

A creature called *Standard Reference Man* is used to consider the effects of this radiation. It was defined in 1975 by the International Commission on Radiological Protection as, "being between 20-30 years of age, weighing 70 kg, is 170 cm in height, and liv[ing] in a climate with an average temperature of from 10°C to 20°C"[2].

The first thing to note is that even if our Standard Reference Man absorbed the entirety of the radiation emitted at Ofcom's limit, this would work out to 0.057 W/kg, well within the guidelines for the general public. However it should be realised that there are people who do not weigh as much as Standard Reference Man, a newborn baby absorbing all of the radiation might be at some 25 times the general public limit.

But it is not reasonable to suppose that somebody is going to absorb all of the energy from the radio, and in any case the greater concern is the degree to which the radiation is focused at a particular

place.

The power density P at some distance r, is the radiated power, P_0 divided by the area that it is spread over. With a beam width, θ, and assuming a circular cross-section of the radiation pattern, this gives:

$$P = \frac{P_0}{A} \approx \frac{P_0}{\pi \left[r \sin\left(\frac{\theta}{2}\right)\right]^2} \tag{1}$$

Consider a typical piece of equipment used at the customer premises. It is a radio with an output power of 0.5 W and a 60° wide radiation pattern corresponding to a gain of about 16 dBi. At full power this corresponds to an effective radiated power of some 20 W, well in excess of the legal limit. However, this is peak power. The way that 802.11n radios modulate the signal means that the actual RMS average power is significantly lower, by about 10 dB. This means that if we turn this equipment up all the way, the RMS power is only about 2W.

Here are some values for equation 1 worked out with different transmit powers – a reasonably conservative estimate for the RMS output, the regulatory limit, and a larger value, exceeding the regulatory limit by a significant margin:

P_0 \ r	1	2	5	10	20	50	100
2	0.85	0.21	0.034	0.0085	0.0021	0.00034	0.000085
4	1.70	0.42	0.068	0.017	0.0042	0.00068	0.00017
20	8.49	2.12	0.34	0.085	0.021	0.0034	0.00085

Mind that all of these numbers assume that the antenna is pointed directly at the person. The numbers show that standing directly in front of the antenna at a very small distance isn't wise, but even at the regulatory limit, 2m away is within the occupational safety limits an 5m is within the range for the general public. Even the overestimated peak power is within the general public safety limits once one is 10m away.

The front to back ratio of these directional antennas is in the neighbourhood of 24 dB or greater. This means that behind the antenna the field strength is about 250 times weaker than in front of it.

The safety advice is therefore simply:

Do not place antennas where it is likely for people to stand directly in front of them at close range.

For residential installations, no special precautions apart from that need to be taken.

Some extra care is required when working with very directional antennas such as are used for long-distance links. Because the beam is focused so narrowly, extremely high power densities can be observed right by the antennas – especially if the output power is increased beyond the legal limit. When these are installed in places accessible to the general public, measures should be taken to place the antennas such that people are prevented from placing themselves directly in the antenna beam. Placing the antenna up high, above head height and/or pointing out over a cliff are good ways of doing this.

References

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[4] Ofcom. UK interface requirement 2007, fixed broadband services operating in the 5725-5850 MHz band. http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-area/spectrum-management/research-guidelines-tech-info/interface-requirements/uk_interface_2007.pdf.

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[6] World Health Organisation. Electromagnetic fields (EMF): Standards and guidelines. http://www.who.int/peh-emf/standards/en/.