Power Line EMFs, Harmonics, and their Health Impacts

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EMFs Overview

EMFs, or electric and magnetic fields, are found around all electronic devices. Although electric fields are generated by voltage and magnetic fields are generated by current, they are similar in many regards.

- The strength of both decrease with distance
- Both can be shielded by many materials

EMFs have varying levels of intensity. At higher frequencies (encountered with things such as sun exposure), well-documented health issues can occur. In lower, more commonly encountered frequencies, such as those from household appliances and radio waves, the results are less certain.

Lots of research has been done into the long-term health effects of these waves. Over 2,900 studies have been done into them over the past 44 years, totaling over $490 million spent.

Health Effects of EMFs

The WHO currently cannot confirm any links between low-level EMF exposure and long-term health effects. A 1979 study inconclusively tried to link living near power lines and childhood leukemia, although recent studies refuted this, showing a link only in houses with extreme levels of magnetic fields, which is very rare in the United States and cannot be linked to common sources such as Wi-Fi, power lines, or household electrical appliances.

It has been suggested by the FDA that low-level magnetic frequencies can affect the operation of certain models of pacemakers. These levels are again not likely to be encountered in daily life, although certain occupations may create magnetic fields powerful enough.

In addition, health guidelines in the US exist created by the National Institute of Environmental Health Sciences (a subgroup of the National Institute of Health) for acceptable amounts of EMF exposure. These differ by state, and also differ between the general public and occupational exposure.

Internationally, the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) have also created guidelines based on the same thing.

Environmental Impact of EMFs

The European Health Commission has identified certain animals that may be more susceptible to negative impacts from EMFs. These include:

- Animals reliant on magnetic fields for navigation, such as migratory birds, certain fish, and certain insects
- Animals possessing electric sense organs, such as sharks and rays
- Animals with a limited ability to regulate body functions such as temperature

They have also noted that these issues are minor and local, and no significant environmental effects could be conclusively identified as coming from EMFs.

Acceptable EMF levels (as specified by the ICNIRP), Occupational

Table 6. Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	1.63×10^5	2×10^5	—
1–8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8–25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025–0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82–65 kHz	610	24.4	30.7	—
0.065–1 MHz	610	$1.6/f$	$2.0/f$	—
1–10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10–400 MHz	61	0.16	0.2	10
400–2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2–300 GHz	137	0.36	0.45	50

[a] Note:

1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment.

Acceptable EMF levels, General Public

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:

1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

Additional Guidelines

Table 8. Reference levels for time varying contact currents from conductive objects.[a]

Exposure characteristics	Frequency range	Maximum contact current (mA)
Occupational exposure	up to 2.5 kHz	1.0
	2.5–100 kHz	$0.4f$
	100 kHz–110 MHz	40
General public exposure	up to 2.5 kHz	0.5
	2.5–100 kHz	$0.2f$
	100 kHz–110 MHz	20

[a] f is the frequency in kHz.

Table 9. Reference levels for current induced in any limb at frequencies between 10 and 110 MHz.[a]

Exposure characteristics	Current (mA)
Occupational exposure	100
General public	45

[a] Note:

1. The public reference level is equal to the occupational reference level divided by $\sqrt{5}$.
2. For compliance with the basic restriction on localized SAR, the square root of the time-averaged value of the square of the induced current over any 6-min period forms the basis of the reference levels.

2016 WHO Study on Daily Exposure vs. Accepted Levels

The Federal Office for Radiation Safety in Germany recently measured the daily exposure to magnetic fields of about 2000 individuals across a range of occupations and public exposures. All of them were equipped with personal dosimeters for 24 hours. The measured exposure varied widely but gave an average daily exposure of 0.10 µT. This value is a thousand times lower that the standard limit of 100 µT for the public and five thousand times lower than the 500 µT exposure limit for workers. Furthermore, the exposure of people living in the centres of cities showed that there are no drastic differences in exposure between life in rural areas and life in the city. Even the exposure of people living in the vicinity of high voltage power lines differs very little from the average exposure in the population.

Harmonics Overview

Harmonics are additional frequencies that are a multiple of the fundamental frequency of an electrical system. They are introduced to electrical systems via external factors, such as interference from other electronic devices (computers, phones, etc.). The presence of these in an electrical system can lead to poorer energy system performance, with inconsistent voltage levels and flickering.

There are much fewer studies in existence as to the wider health and environmental impacts of harmonics, although indirect ones certainly exist.

Health Effects of Harmonics

Very few studies, if any, exist on the health effects of harmonics specifically. They can affect human health indirectly, via decreasing efficiency of medical equipment or other beneficial electronic devices.

Environmental Impact of Harmonics

Similarly to the health effects of harmonics, the proven environmental impact of them is indirect. If harmonics decrease the efficiency of electric operations, then unnecessary electrical resources would be used, which would harm the environment in the long run.

Sources

- NIEHS, NIH, Electric and Magnetic Fields Associated with the Use of Electric Power (.pdf)
- EMF information brochure, accessed from ITC Holdings, the largest independent electricity transmission company in the United States (.pdf)
- NIH, National Cancer Institute, Electromagnetic Fields and Cancer
- Biosystems & Agricultural Engineering Department, Michigan State University, Electromagnetic Field Basics (EMFs) (.pdf)
- European Commission of Public Health, Electromagnetic Fields
- WHO
- ICNIRP Limiting Exposure Guidelines (.pdf)