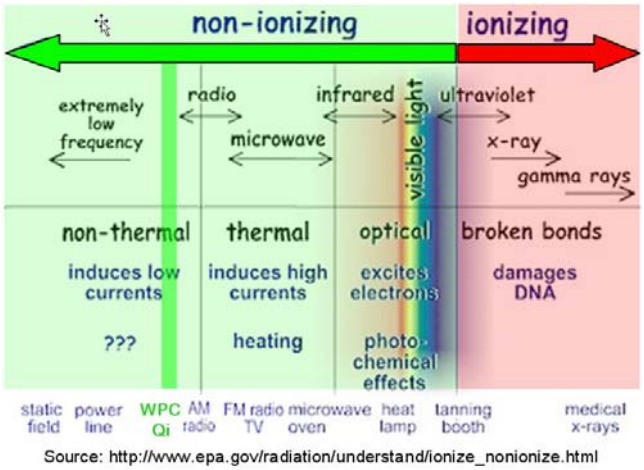
EMF exposure limits – ICNIRP basic restrictions

The acronym EMF (Electromagnetic Fields) is widely used to express the exposure of humans to electromagnetic fields. The exposure to EMF covers a wide frequency range (0 - 300 GHz). EMF is sometimes known as electromagnetic radiation (EMR) or electromagnetic energy (EME).
Electromagnetic fields are present everywhere in our environment – the earth, sun and ionosphere are all natural sources of EMF.
Electric and magnetic fields are part of the spectrum of electromagnetic energy which extends from static electric and magnetic fields, mains power frequencies (50/60Hz) through radiofrequency, infrared, and visible light to X-rays.



Electromagnetic Spectrum - This diagram shows the electromagnetic spectrum with ionising and non-ionising sections. WPC Qi products are using electromagnetic waves within the marked non-ionizing area of the electromagnetic spectrum. Non-ionizing means, that the energy of those waves is too low to ionize tissues. Only electromagnetic waves within the ionizing area can ionize molecules and can cause damage to human tissues.

Electromagnetic fields are also created in any electrical appliance, including many in daily use such as refrigerators, hairdryers and computers.
Many electrical appliances don't just create electromagnetic fields – they rely on them to work. Electrical toothbrushes, rechargeable remote controls and many other aplliances are using EM fields. So do wireless chargers such as those certified by the WPC.

In order to protect against any known kind of health effect, a scientific committee (ICNIRP) [1] has published guidelines (exposure limits) for a maximum exposure. They are based on an extensive number of related scientific publications, evaluated by the authors of the ICNIRP committee and have been reviewd up to today by more than 35 national expert committees.

ICNIRP states that: "There is no substantive evidence that adverse health effects, including cancer, can occur in people exposed to levels at or below the ICNIRP limits"
The ICNRIP guidelines include basic restrictions for the current density in the body of an exposed human. Exposure limits (basic restrictions) are available for "occupational exposure", and for "general public exposure", see table 4. The limits for the general public are applicable for consumer applications.

Reference levels are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded, see table 7. Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference

level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction

[1] International Commission on Non-Ionizing Radiation Protection, [ICNIRP] "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields", Health Physics April 1998, Volume 74, Number 4.

WHO research summary http://www.who.int/peh-emf/research/en/

Table 4 Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 GHz.

Exposure characteristics	Frequency range	Current density for head and trunk (mA m^{-2})(rms)	Whole-body average SAR (W kg^{-1})	Localized SAR (head and trunk) (W kg^{-1})	Localized SAR (limbs) (W kg^{-1})
Occupational exposure	up to 1 Hz	40	—	—	—
	1–4 Hz	$40/f$	—	—	—
	4 Hz–1 kHz	10	—	—	—
	1–100 kHz	$f/100$	—	—	—
	100 kHz–10 MHz	$f/100$	0.4	10	20
	10 MHz–10 GHz	—	0.4	10	20
General public exposure	up to 1 Hz	8	—	—	—
	1–4 Hz	$8/f$	—	—	—
	4 Hz–1 kHz	2	—	—	—
	1–100 kHz	$f/500$	—	—	—
	100 kHz–10 MHz	$f/500$	0.08	2	4
	10 MHz–10 GHz	—	0.08	2	4

Notes:

1. f is the frequency in hertz.
2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm^2 perpendicular to the current direction.
3. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by $\sqrt{2}$ (~1.414). For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$.
4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
5. All SAR values are to be averaged over any 6-minute period.
6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.
7. For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$. Additionally, for pulsed exposures, in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 10 mJ kg^{-1} for workers and 2 mJ kg^{-1} for the general public averaged over 10 g tissue.

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

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
400–2000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

Notes:

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-minute period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding100 kHz see Figures 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 1000 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 $68/f^{1.05}$-minute period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. For most people the annoying 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.