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GLOSSARY

Antenna: Device that serves as a transducer between a guided wave (e.g. via a coaxial cable) and a free space wave, or *vice versa*. It can be used either to emit or to receive a radio signal.

Base station: Wireless communications station installed at a fixed location and used to transmit and receive radio signals to and from mobile-phone users. Also used for DECT phones at home.

Cell phone: See "Mobile phone".

Cellular radio network: Fixed infrastructure comprising multiple base stations deployed across a wide geographical area such that mobile-phone users are able to communicate via the base stations, with the radio signals associated with their calls being transmitted from one base station to another as the users move across cell boundaries.

Conductivity: The ratio of the conduction-current density in a medium to the electric field strength. The unit of conductivity is siemens per metre (S/m).

Cordless phone: (DECT, portable phone) A wireless telephone that communicates via radio waves with a base station connected to a fixed telephone line, usually within a limited range of its base station. The base station is on the premises of the owner, and attached to the wired telephone network in the same way as a corded telephone.

DECT phone: See "Cordless phone"

Effective radiated power (ERP) or **equivalent radiated power:** is a standardized theoretical measurement of radiofrequency (RF) energy using the SI unit watts, and is determined by substracting system losses and adding system gains. ERP is similar to EIRP (see below), but may use some other reference antenna than an isotropic antenna, e.g. a half dipole.

Electric-field strength (E): Magnitude of a field vector at a point that represents the force (F) on a small test charge (q) divided by the charge:

$$\vec{E} = \frac{\vec{F}}{q}$$

The magnetic field strength is expressed in units of volt per metre (V/m).

Equivalent isotropically radiated power (EIRP) or **effective isotropically radiated power**: The amount of power that a theoretical isotropic antenna (which evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum antenna gain. EIRP can take into account the losses in transmission line and connectors and includes the gain of antenna. The EIRP is often expressed in terms of decibels over a reference power emitted by an isotropic radiator with an equivalent signal strength. The EIRP allows comparisons between different emitters regardless of type, size or form. From the EIRP, and with knowledge of a real antenna's gain, it

is possible to calculate real values for power and field strength.

Equivalent plane-wave power density (plane-wave equivalent power density) (S): A commonly used term associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric- (E) or magnetic- (H) field strength. Specifically, the normalized value of the square of the electric- or the magnetic-field strength at a point in the near field of a radiating source. The unit of equivalent plane-wave power density (according to the International System of Units, SI) is the watt per square metre (W/m^2) and is computed as follows:

$$S = \frac{|E|^2}{\eta} = \eta |H|^2$$

where:

E and H are the root-mean-square (rms) values of the electric- and magnetic-field strengths, respectively

η is the wave impedance (≅ 377 ohms in free space).

Note that most field-survey equipment uses this relationship, although it does not apply to the near field. In case of exposure assessment, the independent measurement of E *rms* (or $|E|^2$) and H *rms* (or $|H|^2$) is preferred.

Synonym: **equivalent plane-wave power flux density.**

Far-field region and near-field region: The far-field region is defined when the fields can be well approximated by the radiating fields, i.e. the E-field vector is perpendicular to the H-field vector, and both are orthogonal to the direction of propagation whereby the ratio of the amplitudes of the E- and H-fields is 377 Ohms.

The near-field region is when the above conditions are not met, i.e. when the field is dominated by reactive field components.

Frequency and wavelength: The intensity of electric and magnetic fields can vary periodically over time and space, following a sinusoidal function. In the time domain, the number of cycles of oscillation per second is defined as the frequency, *f*, of the field and is expressed in hertz (Hz). In the spatial domain, the distance between two peaks of one oscillation cycle is called the wavelength. In free space, this is equivalent to:

$$\lambda = \frac{c}{f}$$

where:

c is the velocity of light (≈ 3.10^8 m/s).

Magnetic-field strength (H): The magnitude of a field vector in a point that results in a force (F) on a charge q moving with the velocity v:

$$F = q \ (\mathrm{v} \times \mu \mathrm{H})$$

The magnetic-field strength is expressed in units of ampere per metre (A/m).

Magnetic-flux density (B): The magnitude of a field vector that is equal to the magnetic field strength H multiplied by the permeability (μ) of the medium:

$$B = \mu \, \mathrm{H}$$

Magnetic-flux density is expressed in units of tesla (T).

Mobile phone: (cell phone, hand-held phone) Electronic device used to make and receive phone calls across a wide geographical area allowing the user to be mobile. A mobile phone is connected to a cellular network provided by a mobile-network operator.

Modulation: The process, or result of the process, whereby some characteristic of one wave is varied in accordance with another wave or signal. There are three canonical modulation types:

- AM (amplitude modulation): information is imparted to an electromagnetic wave by varying its amplitude
- FM (frequency modulation): information is imparted to an electromagnetic wave by varying its frequency
- ϕM (phase modulation): information is imparted to an electromagnetic wave by varying its phase

FM and ϕM are actually closely related to each other, e.g. both can be expressed mathematically in terms of a phase modulation.

Multiple access, or channel multiple access: Multiple-access methods are required to allow multiple devices to operate simultaneously. The following multiple-access methods are available for transmitting a set of individual data streams:

- FDMA: frequency-division multiple access splits the communication spectrum into different frequency domain bands that are assigned to the different data streams.
- TDMA: time-division multiple access splits the communication spectrum into periodically repetitive time slots, each terminal or data stream has a fixed periodic time slot during which data may be transmitted.
- CDMA: code-division multiple access allows multiple transmitters to send data simultaneously, theoretically, in the same frequency and time-domain channels. Communication channels are separated in the code domain by multiplying (spreading) the data streams with mutually orthogonal code vectors. Applying the same code vectors at the receiver allows separation of multiple simultaneous data streams due to the orthogonality of the codes.
- SDMA: space-division multiple access separates different data streams in space. A prominent example is directional radio systems.

In principle, the same multiple-access methods can be used to divide the forward and return data stream between two terminals. In practice however only time-division duplex (TDD) and frequency-division duplex (FDD) are applied.

Peak spatial SAR (psSAR): Peak spatial SAR values describe the peak SAR of all sSAR (See specific absorption rate [SAR] and spatially averaged SAR [sSAR]).

Peak-to-average power ratio (PAPR): The probability of peak signal power exceeding the average power level by 0.1%. In the case of non-statistical disruptions, PAPR is equivalent to the crest factor, i.e. 2 for a sinusoidal signal, 8.7 for GSM, 3.1–3.3 for UMTS-FDD, 10–20 for WLAN, etc. In the case of pulsed signals, the peak pulse amplitude is PAPR multiplied by the average power.

Penetration depth: For a plane electromagnetic wave incident on the boundary of a medium, the distance from the boundary into the medium along the direction of propagation in the medium, at which the field strengths of the wave have been reduced to 1/e (around 37%) of their boundary values. Penetration depth is expressed in metres (m).

Permittivity: The ratio of the electric-flux density in a medium to the electric-field strength at a point. The permittivity of biological tissues is dependent on frequency. Permittivity is expressed in units of farad per metre (F/m).

Polarization: The property of a radiated electromagnetic wave describing the time-varying direction and amplitude of the electric-field vector; specifically, the figure traced as a function of time by the extremity of the E-field vector at a fixed location in space, as observed along the direction of propagation.

Power density (Pd): The radiant power incident perpendicular to a surface, divided by the area of the surface. The power density is expressed in units of watt per square metre (W/m^2). Power density can be determined from the field strengths as follows:

$$P_d = E \times H = \frac{E^2}{377\Omega} = 377\Omega\ H^2$$

Also written as:

$$P_d = E \times H = E^2|377\Omega = 377\Omega\ H^2$$

Radiation: The emission and propagation of energy in the form of waves or particles through space.

Radiofrequency: Any frequency in the range of 30 MHz to 300 GHz.

Receiver: A device that detects radio signals and extracts useful information that has been encoded onto them through modulation, such as speech, music, data or pictures.

Resonance: The tendency of an object to oscillate with a larger amplitude at certain frequencies.

Root-mean-square (rms): The rms value or effective value is the square root of the mean of the squares of a continuous function:

$$f_{rms} = \sqrt{\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} [f(t)]^2 dt}$$

where:
T is period
t is time
f is frequency
The rms values are important in the context of expressing exposure values averaged over time (see also specific absorption rate, SAR).

Root-sum-square (rss): The rss value is the root of the sum of the squares of the components of a vector.

Sidelobes: Antennae designed to radiate a main beam in particular angular direction also produce weaker beams known as sidelobes in other angular directions.

Spatially averaged SAR (sSAR:): Spatially averaged SAR (sSAR) values have been defined to better characterize SAR with respect to potential hazards. Technically, each location of the body is represented with a spatially averaged SAR. Different definitions have been proposed for standard settings and are commonly applied:

- **sSAR-1 g**: spatially averaged SAR values over a mass of 1 g of tissue in the shape of a cube. Special evaluation conditions are applied in case of air interfaces (IEEE C95.3). In practice, each local SAR value in the body is represented by the sSAR-1 g value whereby the cube is grown symmetrically around that location. At higher frequencies, sSAR-1 g is approximately twice the value of sSAR-10 g due to the reduced penetration depth.
- **sSAR-10 g**: spatially averaged SAR values over a mass of 10 g of tissue in the shape of a cube.
- **sSAR-10 g c**: spatially averaged SAR values over a mass of 10 g of contiguous tissue.

Specific absorption rate (SAR): The time derivative of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of given density (ρ):

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{pdV}\right)$$

The SI unit of SAR is the watt per kilogram (W/kg).

NOTE: SAR can be related to the electric field at a point by:

$$SAR = \frac{\sigma |E|^2}{\rho}$$

where:
σ is conductivity of the tissue (S/m)
ρ is mass density of the tissue (kg/m^3)
E is rms electric field strength in tissue (V/m)
NOTE: SAR can be related to the increase in temperature at a point by:

$$SAR = \frac{c\Delta T}{\Delta t}\Big| \quad t = 0$$

where:
ΔT is the change in temperature (°C)
Δt is the duration of exposure (s)
c is the specific heat capacity (J/kg °C)
This assumes that measurements are made under "ideal" non-thermodynamic circumstances, i.e. no heat loss by thermal diffusion, radiation, or thermoregulation (blood flow, sweating, etc.). Therefore, the third equation is only valid if the exposed body is in thermal equilibrium or a steady thermal state at the beginning of the exposure and either heat exchange processes can be neglected during the measurement interval or the processes are known and corrected such that dT can be correspondingly corrected.

In other words, SAR is proportional to the absorbed energy, square of the induced E-fields or induced current density. However, SAR is not directly proportional to the induced magnetic field.

Specific tissue-averaged SAR (stSAR): The total electromagnetic power absorbed by a organ or specific tissue.

Standing waves: Standing waves are formed where RF fields are contained by reflection back and forth. Energy is stored in the space where reflection occurs, which leads to high field strengths that are not associated with radiation. Fields associated with standing waves generally deposit much less energy in the body tissues than radiation fields of the same strength.

Time-averaged SAR or **temporal-averaged SAR:** SAR is usually reported as time-averaged SAR, either over the periodicity of the signal or over any 6 minutes.

Transceiver: A device containing both a transmitter and a receiver, such that it forms one terminal in a duplex communications link.

Transmitter: A device that generates and amplifies a carrier wave, modulates it to carry information, and radiates the resulting signal from an antenna, such that it can be received elsewhere.

UMTS (Universal Mobile Telecommunications System): a third-generation mobile telecommunications technology that uses digitally encoded signals to enable user access.

Whole-body SAR or **whole-body averaged SAR (wbSAR):** The whole-body SAR is the total electromagnetic power absorbed by a body divided by its mass.

Wi-Fi: a wireless transmission technique for use in local area networks that works in 2.4 GHz and 5 GHz bands. It is a registered trademark of the WiFi Alliance.

WLAN (wireless local area network): a short-range wireless data communications network linking two or more devices.

WPAN (wireless personal area networks): a short-range wireless communications network for personal devices located near to the individual, e.g. Bluetooth.