Radio frequency

From Wikipedia, the free encyclopedia

Radio frequency (**RF**) is any of the electromagnetic wave frequencies that lie in the range extending from around 3 kHz to 300 GHz, which include those frequencies used for communications or radar signals.[1] RF usually refers to electrical rather than mechanical oscillations. However, mechanical RF systems do exist (see mechanical filter and RF MEMS).

Although radio *frequency* is a rate of oscillation, the term "radio frequency" or its abbreviation "RF" are used as a synonym for radio – i.e., to describe the use of wireless communication, as opposed to communication via electric wires. Examples include:

- Radio-frequency identification
- ISO/IEC 14443-2 *Radio frequency power and signal interface*[2]

Contents

Special properties of RF current

Electric currents that oscillate at radio frequencies have special properties not shared by direct current or alternating current of lower frequencies.

- The energy in an RF current can radiate off a conductor into space as electromagnetic waves (radio waves); this is the basis of radio technology.
- RF current does not penetrate deeply into electrical conductors but tends to flow along their surfaces; this is known as the skin effect. For this reason, when the human body comes in contact with high power RF currents it can cause superficial but serious burns called *RF burns (Note that RF burns result from electrical energy, while Radiation burns result from electromagnetic energy)*.
- RF currents applied to the body often do not cause the painful sensation of electric shock as do lower frequency currents.[3][4] This is because the current changes direction too quickly to trigger depolarization of nerve membranes.

- RF current can easily ionize air, creating a conductive path through it. This property is exploited by "high frequency" units used in electric arc welding, which use currents at higher frequencies than power distribution uses.
- Another property is the ability to appear to flow through paths that contain insulating material, like the dielectric insulator of a capacitor. This is because capacitive reactance in a circuit decreases with frequency.
- In contrast, RF current can be blocked by a coil of wire, or even a single turn or bend in a wire. This is because the inductive reactance of a circuit increases with frequency.
- When conducted by an ordinary electric cable, RF current has a tendency to reflect from discontinuities in the cable such as connectors and travel back down the cable toward the source, causing a condition called standing waves. Therefore, RF current must be carried by specialized types of cable called transmission line.

Radio communication

To receive radio signals an antenna must be used. However, since the antenna will pick up thousands of radio signals at a time, a radio tuner is necessary to *tune into* a particular frequency (or frequency range).[5] This is typically done via a resonator – in its simplest form, a circuit with a capacitor and an inductor form a tuned circuit. The resonator amplifies oscillations within a particular frequency band, while reducing oscillations at other frequencies outside the band. Another method to isolate a particular radio frequency is by oversampling (which gets a wide range of frequencies) and picking out the frequencies of interest, as done in software defined radio.

The distance over which radio communications is useful depends significantly on things other than wavelength, such as transmitter power, receiver quality, type, size, and height of antenna, mode of transmission, noise, and interfering signals. Ground waves, tropospheric scatter and skywaves can all achieve greater ranges than line-of-sight propagation. The study of radio propagation allows estimates of useful range to be made.

Frequency bands

Frequency	Wavelength	Designation	Abbreviation[6]
3–30 Hz	10^5–10^4 km	Extremely low frequency	ELF
30–300 Hz	10^4–10^3 km	Super low frequency	SLF
300–3000 Hz	10^3–100 km	Ultra low frequency	ULF
3–30 kHz	100–10 km	Very low frequency	VLF
30–300 kHz	10–1 km	Low frequency	LF
300 kHz – 3 MHz	1 km – 100 m	Medium frequency	MF
3–30 MHz	100–10 m	High frequency	HF
30–300 MHz	10–1 m	Very high frequency	VHF
300 MHz – 3 GHz	1 m – 10 cm	Ultra high frequency	UHF
3–30 GHz	10–1 cm	Super high frequency	SHF
30–300 GHz	1 cm – 1 mm	Extremely high frequency	EHF
300 GHz – 3 THz	1 mm – 0.1 mm	Tremendously high frequency	THF

In medicine

Radio frequency (RF) energy, in the form of radiating waves or electrical currents, has been used in medical treatments for over 75 years,[7] generally for minimally invasive surgeries using radiofrequency ablation including the treatment of sleep apnea.[8] Magnetic resonance imaging (MRI) uses radio frequency waves to generate images of the human body.

Radio frequencies at non-ablation energy levels are sometimes used as a form of cosmetic treatment that can tighten skin, reduce fat (lipolysis), or promote healing.[9]

RF diathermy is a medical treatment that uses RF induced heat as a form of physical or occupational therapy and in surgical procedures. It is commonly used for muscle relaxation. It is also a method of heating tissue electromagnetically for therapeutic purposes in medicine. Diathermy is used in physical therapy and occupational therapy to deliver moderate heat directly to pathologic lesions in the deeper tissues of the body. Surgically, the extreme heat that can be produced by diathermy may be used to destroy neoplasms, warts, and infected tissues, and to cauterize blood vessels to prevent excessive bleeding. The technique is particularly valuable in neurosurgery and surgery of the eye. Diathermy equipment typically operates in the short-wave radio frequency (range 1–100 MHz) or microwave energy (range 434–915 MHz).

Pulsed electromagnetic field therapy (PEMF) is a medical treatment that purportedly helps to heal bone tissue reported in a recent NASA study. This method usually employs electromagnetic radiation of different frequencies - ranging from static magnetic fields, through extremely low frequencies (ELF) to higher radio frequencies (RF) administered in pulses.

Effects on the human body

Extremely low frequency RF

High-power extremely low frequency RF with electric field levels in the low kV/m range are known to induce perceivable currents within the human body that create an annoying tingling sensation. These currents will typically flow to ground through a body contact surface such as the feet, or arc to ground where the body is well insulated.[10][11]

Microwaves

Microwave exposure at low-power levels below the Specific absorption rate set by government regulatory bodies are considered harmless non-ionizing radiation and have no effect on the human body. However, levels above the Specific absorption rate set by the U.S. Federal Communications Commission are considered potentially harmful (see Mobile phone radiation and health).

Long-term human exposure to high-levels of microwaves is recognized to cause cataracts according to experimental animal studies and epidemiological studies. The mechanism is unclear but may include changes in heat sensitive enzymes that normally protect cell proteins in the lens. Another mechanism that has been advanced is direct damage to the lens from pressure waves induced in the aqueous humor.

High-power exposure to microwave RF is known to create a range of effects from lower to higher power levels, ranging from unpleasant burning sensation on the skin and microwave auditory effect, to extreme pain at the mid-range, to physical burning and blistering of skin and internals at high power levels (see microwave burn).

General RF exposure

The 1999 revision of Canadian Safety Code 6 recommended electric field limits of 100 kV/m for pulsed EMF to prevent air breakdown and spark discharges, mentioning rationale related to auditory effect and energy-induced unconsciousness in rats.[12] The pulsed EMF limit was removed in later revisions, however.[13]

For health effects see electromagnetic radiation and health.

For high-power RF (electromagnetic, not electrical) exposure see radiation burn.

For low-power RF exposure see radiation-induced cancer.

As a weapon

A heat ray is an RF harassment device that makes use of microwave radio frequencies to create an unpleasant heating effect in the upper layer of the skin. A publicly known heat ray weapon called the Active Denial System was developed by the US military as an experimental weapon to deny the enemy access to an area. A death ray is a weapon that delivers heat ray electromagnetic energy at levels that injure human tissue. The inventor of the death ray, Harry Grindell Matthews, claims to have lost sight in his left eye while developing his death ray weapon based on a primitive microwave magnetron from the 1920s (note that a typical microwave oven induces a tissue damaging cooking effect inside the oven at about 2 kV/m.)

Measurement

Since radio frequency radiation has both an electric and a magnetic component, it is often convenient to express intensity of radiation field in terms of units specific to each component. The unit *volts per meter* (V/m) is used for the electric component, and the unit *amperes per meter* (A/m) is used for the magnetic component. One can speak of an electromagnetic field, and these units are used to provide information about the levels of electric and magnetic field strength at a measurement location.

Another commonly used unit for characterizing an RF electromagnetic field is *power density*. Power density is most accurately used when the point of measurement is far enough away from the RF emitter to be located in what is referred to as the far field zone of the radiation pattern. In closer proximity to the transmitter, i.e., in the "near field" zone, the physical relationships between the electric and magnetic components of the field can be complex, and it is best to use the field strength units discussed above. Power density is measured in terms of power per unit area, for example, milliwatts per square centimeter (mW/cm^2). When speaking of frequencies in the microwave range and higher, power density is usually used to express intensity since exposures that might occur would likely be in the far field zone.

See also

- Amplitude modulation
- Electromagnetic Interference
- Electromagnetic radiation
- Electromagnetic spectrum
- EMF measurement
- Frequency allocation
- Frequency bandwidth
- Frequency modulation
- Plastic welding
- Pulsed electromagnetic field therapy
- Spectrum management

References

1. "Definition of RADIO FREQUENCY". *Merriam-Webster*. Encyclopædia Britannica. n.d. Retrieved 6 August 2015.
2. "ISO/IEC 14443-2:2001 Identification cards — Contactless integrated circuit(s) cards — Proximity cards — Part 2: Radio frequency power and signal interface". Iso.org. 2010-08-19. Retrieved 2011-11-08.
3. Curtis, Thomas Stanley (1916). *High Frequency Apparatus: Its Construction and Practical Application*. USA: Everyday Mechanics Company. p. 6.
4. Mieny, C. J. (2003). *Principles of Surgical Patient Care* (2nd ed.). New Africa Books. p. 136. ISBN 9781869280055.
5. Brain, Marshall (2000-12-07). "How Radio Works". HowStuffWorks.com. Retrieved 2009-09-11.
6. Jeffrey S. Beasley; Gary M. Miller (2008). *Modern Electronic Communication* (9th ed.). pp. 4–5. ISBN 978-0132251136.
7. Ruey J. Sung & Michael R. Lauer (2000). *Fundamental approaches to the management of cardiac arrhythmias*. Springer. p. 153. ISBN 978-0-7923-6559-4.
8. Melvin A. Shiffman, Sid J. Mirrafati, Samuel M. Lam and Chelso G. Cueteaux (2007). *Simplified Facial Rejuvenation*. Springer. p. 157. ISBN 978-3-540-71096-7.
9. Noninvasive Radio Frequency for Skin Tightening and Body Contouring, Frontline Medical Communications, 2013 (http://www.skinandallergynews.com/fileadmin/content_pdf/san/scms_pdf/SCMS_Vol_32_No_1_Skin_Tightening.pdf)
10. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz (http://www.euitt.upm.es/estaticos/catedra-coitt/web_salud_medioamb/Informes/informes_PDF/rf/HealthCanada/99ehd237.pdf), Canada Safety Code 6, page 63
11. Extremely Low Frequency Fields Environmental Health Criteria Monograph No.238 (http://www.who.int/peh-emf/publications/elf_ehc/en/index.html), chapter 5, page 121, WHO
12. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz (http://www.euitt.upm.es/estaticos/catedra-coitt/web_salud_medioamb/Informes/informes_PDF/rf/HealthCanada/99ehd237.pdf), Canada Safety Code 6,page 62
13. http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radio_guide-lignes_direct/index-eng.php Safety Code 6: Health Canada's Radiofrequency Exposure Guidelines - Environmental and Workplace Health - Health Canada

External links

- Definition of frequency bands (VLF, ELF … etc.) IK1QFK Home Page (vlf.it) (http://www.vlf.it/frequency/bands.html)
- Radio, light, and sound waves, conversion between wavelength and frequency (http://www.sengpielaudio.com/calculator-wavelength.htm)
- RF Terms Glossary (http://www.sunmantechnology.com/resources_gls_rfts.html)

Categories: Radio spectrum | Radio technology | Waves | Electromagnetic spectrum | Television terminology

---