How Safe Is Your Ham Shack?

Part 1: We'd all like to be safe, but often don't know how to prepare for apparent — or subtle — hazards. This series will explore the dangers to hams from radiation, chemicals and electricity, and how you can deal with them. Subject of this first part — nonionizing radiation.

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Strong rf fields, which many amateurs encounter almost daily, can be harmful. How harmful? That has not been fully resolved, and recent media coverage of the subject has served only to alarm the public, often needlessly. A member of the IEEE's Committee on Man and Radiation (COMAR), Dr. John M. Osepchuk, recently told the U.S. Senate Committee on Commerce, Science and Transportation that the mass media have often exhibited serious misinformation and embellishments of the truth that tend to highly exaggerate the degree and nature of the hazard. The two articles that follow discuss the nature and extent of the hazards — to amateurs as well as their neighbors — of nonionizing radiation. They agree that commonsense precautions can virtually eliminate its effects.

How safe is your amateur station? No, I am not talking about how well-grounded your station is. The question here is concerned with your exposure to radio waves. Throughout the history of radio communication, most sources of radio waves were thought to be harmless (unless you foolishly touched the antenna). This view has been changing with growing concern about the health impact of radio waves, or nonionizing radiation.

The spectrum of nonionizing radiation is essentially bounded on one side by 60 Hz, the frequency of household electricity, and on the other side by optical frequencies corresponding to infrared and visible light. The chart on this page shows where the amateur bands — as well as the greatest potential hazards — lie in the wide spectrum between these limits.

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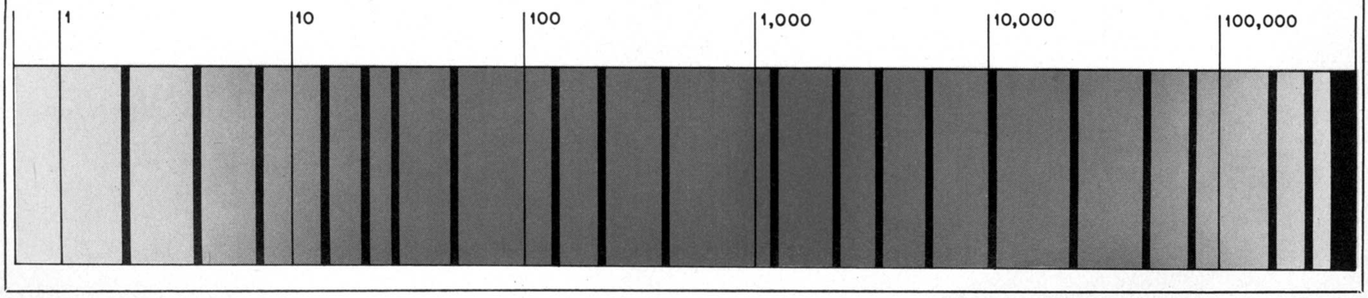
Cause of Biological Damage

The mechanism by which strong radio waves can cause biological damage is dielectric heating. In this process, the molecules of the body are agitated by the rapidly changing electric field of the radio wave. This agitation causes the body to heat up. This is the physical principle that is used in microwave ovens, most of which operate on a frequency of 2450 MHz. For this heating to be noticeable, the radio waves have to be quite strong.

The biological research community agrees that dielectric heating damage of the body can occur at power densities well above 10 milliwatts for each exposed square centimeter of surface area (10 mW/cm^2). However, there is a great controversy about possible biological effects of weaker power densities. The Soviet Union and the Eastern European Nations

Electromagnetic spectrum, with the amateur bands designated by vertical bars. The frequency range of maximum deep heating is colored red and decreases in intensity as you go higher or lower. The actual frequency range of absorption of electromagnetic energy will also vary with body size and shape — the smaller the body, the higher the frequency. The scale is semi-logarithmic and calibrated in MHz.



report physiological and psychological effects at much weaker power densities which have not yet been widely accepted by western researchers.[1] This disagreement on the biological impact of non-ionizing radiation is reflected in the different national standards for radio wave exposure. For example, the Soviets have a standard of 0.01 mW/cm^2 for people who work with radio; the U.S. occupational standard[2] is 10 mW/cm^2.

Radio Waves in the Environment

As a result of the increasing interest in the ecological impact of radio waves, the FCC, the Bureau of Radiological Health (HEW), and the Environmental Protection Agency have made surveys of radio wave exposure. EPA has made surveys in seven cities using a mobile receiving system that sums up signal strengths over many frequency bands within the radio spectrum.[3] This system thus allows them to compute the total exposure of citizens to radio signals of many frequencies.

The total strength of the signals reaching the population as a whole is very weak. Indeed, the EPA reports[4] that for 99 percent of the urban population the total exposure is less than 0.001 mW/cm^2. That is, the exposure is less than one-millionth of a watt for each square centimeter of area. This is low compared to the current U.S. occupational standard of one one-hundredth of a watt for each square centimeter of area (10 mW/cm^2).

Broadcast stations (fm and TV) were found to be the most significant sources. The nearest stations contribute almost all of the ambient exposure. This is to be expected in view of the rapid weakening of radio signals with distance. Radar stations were found to be very weak sources of ambient radio frequency energy.[5] This was somewhat surprising in view of the high peak power of a radar transmitter. Two factors weaken the strength of the radar signals. Most of the time the radar set is not transmitting at all but rather, it is looking for radio echoes. When it is transmitting it is powerful but the long periods of silence reduce the *average* power to a low level.

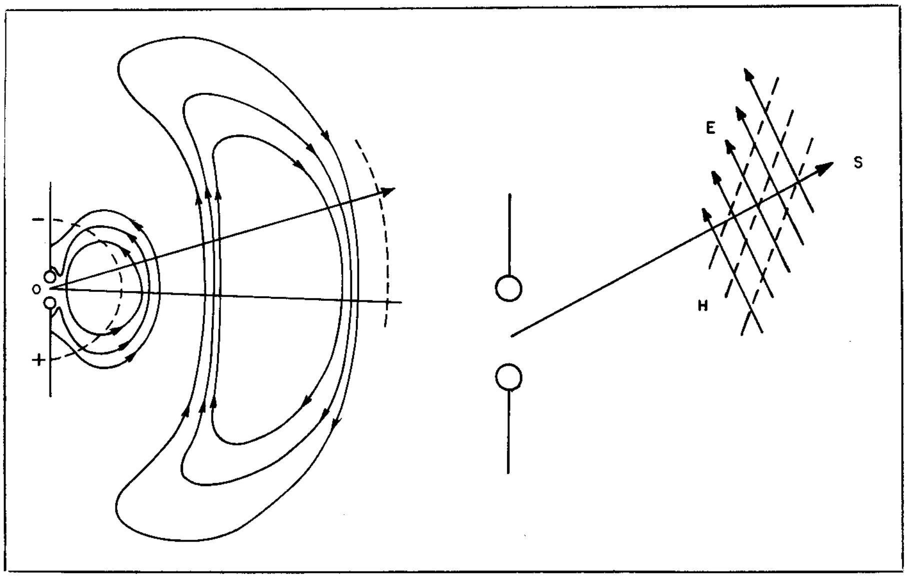
Exposures Close to the Antenna

The above findings do not mean that all exposures to radio waves are harmless. The situation of very low signal strengths does not necessarily hold for locations that are very close to a source of radio waves. If you are very close to an operating broadcast antenna, you can receive an exposure that greatly exceeds the U.S. occupational limit[6] of 10 mW/cm^2. To become overexposed in this manner, generally one has to be employed in the servicing of such radio equipment.

Amateur Power Density

Obviously, an amateur radio station has

[1]Footnotes appear on page 13.



The near-field (left) and far-field patterns around a vertical dipole are illustrated with an ac voltage applied to its terminals. Near-field power density is difficult to measure due to the disorganized field caused by components moving transversely as well as in the direction of the wave front. In the far field, power density is more easily measured since only the transverse component of either the magnetic (h) or electric field (e) is significant.

a strong field in the immediate proximity of its antenna too. But the extent of the strong field is less because of the much lower output power in the amateur service. In order to examine the strength of this field, it is necessary to distinguish between the *near field* and the *far field* of an antenna.

As shown in the illustration, the near field is the field close to the antenna. The approximate extent of the near field for large antennas can be found by using the simple formula:[7]

$$\text{Distance in meters} = \frac{2\,D^2}{\lambda}$$

where

D = maximum dimension of antenna in meters

λ = wavelength in meters

Using this equation for a half-wave dipole on the popular 2-meter band yields a near field radius of about one meter.

Beyond this one-meter distance is the far field of your antenna. In the far field of your antenna, the familiar inverse square law operates and the strength of the radio waves is easy to calculate. The following equation allows you to compute the power density in the far field.[8]

$$X = \frac{P \cdot G}{4\pi\,R^2}$$

X = power density in mW/cm^2 along the main beam

G = gain of the antenna expressed as a power ratio (i.e., a gain of 5 dB equals a power ratio of 3.162)

P = output power of your transmitter in milliwatts (1000 mW = 1 W)

R = distance from the antenna in centimeters (100 cm = 1 M)

Calculations of approximate far-field power densities for amateur installations are shown in Table 1. The power density is quite low in many amateur stations, but there can be situations where the power density is too high.

The situations where high power densities are involved would usually involve *very* high gain antennas with quite high transmitter output powers. Thus, operators doing high power work should review the cited references and compute their power density. If the power density reaching occupied areas is higher than about 0.5 mW/cm^2, the amateur should consider rearranging the system to lower the exposure. The value of 0.5 mW/cm^2 is chosen to match the probable, future U.S. standard for exposure of the general population to a continuously operating source.

Unfortunately, it is not easy to calculate the near field about an antenna. The near field is complex because of the interference patterns created by signals arriving from different parts of the antenna with differing phase relationships. This complexity is a great limitation because most of the biologically significant exposures will be in the near field. A

Table 1

Approximate far-field densities in milliwatts per square centimeter (mW/cm^2) at a distance of 10 meters from a uhf antenna

Antenna Gain	*Transmitter CW Output Power*		
	10 watts	*50 watts*	*500 watts*
10 dB	0.00796	0.0398	0.398
15 dB	0.0252	0.126	1.26
18 dB	0.0502	0.251	2.51

cautious approach would be to mount your antenna so that people will not be passing through its near field. This precaution should not greatly inconvenience the uhf operator, who more than likely follows it already by mounting his antenna high and clear to get maximum DX. QST

References

[1]Glaser et al., "Biomedical Aspects of Radio Frequency and Microwave Radiation: A Review of Selected Soviet, East European and Western References," *Biological Effects of Electromagnetic Waves*, Vol. 1, U.S. Department of Health, Education and Welfare (Bureau of Radiological Health), Rockville, MD, December 1976.

[2]Tell and Nelson, *Calculated Field Intensities Near a High Power UHF Broadcast Installation*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, July 1974.

[3]Janes, Jr., *The EPA Environmental Radio — Frequency Radiation Program* (Electromagnetic Interference Workshop — National Bureau of Standards, July 1977).

[4]Ibid.

[5]Tell, *An Analysis of Radar Exposure in the San Francisco Area*, U.S. Environmental Protection Agency — Office of Radiation Programs (Electromagnetic Radiation Analysis Branch), Las Vegas, NV, March 1977 (Technical Note ORP/EAD-77-3), p. 8.

[6]Tell, *A Measurement of RF Field Intensities in the Immediate Vicinity of an FM Broadcast Station Antenna*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, January 1976 (Technical Note OPR/EAD-76-2).

[7]Tell, *Reference Data for Radiofrequency Emission Hazard Analysis*, U.S. Environmental Protection Agency — Electromagnetic Radiation Analysis Branch, Silver Spring, MD, June 1972 (ORP/SID-72-3), p. 24.

[8]Ibid., p. 4.