MICROWAVE HAZARDS: SAFETY RECOMMENDATIONS

1. Introduction

RF and microwave energy is absorbed by the human body, the energy being dissipated as heat. Excessive heating may cause damage to body tissues. At VHF and UHF there is usually little danger because the power density of the radiation is low and antennas carrying high power are almost always mounted well above head height.

Equipment for the higher frequencies, however, tends to be operated near ground level in order to facilitate pointing the highly directive antennas and to minimise feeder losses. The additional potential hazard that this way of operating produces is compounded by the increase in power density with decreasing wavelength for equipment with a given output power.

The guidelines listed below should minimise the risk to both bystanders and operators. These precautions are based on a power density reference level of 50 W/sq m, as advised in the UK National Radiological Protection Board publication GS-11 [1] for the frequency range 2 - 300 GHz. The corresponding value for 1.3 GHz is 32.5 W/sq m.It should be noted that these values are for continuous whole-body exposure; practical amateur operations are unlikely to give rise to such exposure conditions.

The basis for restriction of exposure has focussed on the concept of absorbed energy rate in the body. Since this is difficult to implement in practical situations, advised reference levels of maximum power density are still used, on the understanding that they are not limits. Adherence to the reference levels will ensure that basic restrictions on absorbed energy rate are met.

2. Guidelines for Protection against Microwave Hazards

Very high RF power densities are acceptable provided they are contained within the equipment. Loose connectors or waveguide flanges, for example, can represent a hazard. The operator must take steps to ensure that the equipment is RF-tight at all times. An open waveguide represents the greatest potential hazard in most Amateur stations, since the temptation to look down the guide is great.

It should be recognised that low power devices do not represent a hazard. For example, a 10 mW Gunn oscillator is incapable of depositing enough energy in any practical situation to be considered a hazard.

High RF power densities can exist anywhere within the physical structure of an antenna. Access to the antenna structure should be prevented whilst the antenna is energised, and also for a nominal distance of 1 m to the sides of the antenna, and at least 1 m in front (see below).

The highest power densities outside the structure of the antenna will occur in the forward direction, quite close by. For a given power level, the power density close to the antenna (the near field region) will be smaller, the larger the antenna. The following formula can be used to estimate the maximum power density PD in W/sq m:

$$PD = \frac{4 * W}{A} \quad . \; . \; . \; . \; . \; . \; . \; (1) \; 0$$

where W is the power in W and
A is the aperture area in sq m.

For example, with the commonly-used 0.6 m dishes power densities will not exceed 50 W/sq m at powers of up to 3.5 W.

In the case of antennas which do not have a physical aperture, such as Yagis, an equivalent aperture can be obtained from gain or beamwidth information. The equivalent aperture for a given gain is:

$$A = \frac{G * l^2}{4 * p} \; . \; . \; . \; . \; . \; . \; . \; (2)$$ 0whereA is the equivalent aperture in sq m,

G is the linear gain of the antenna over isotropic and
ÿ is the wavelength in m.

For example a 23 cm Yagi with a gain of 18 dBi (linear ± 63 times) has an equivalent aperture of about 0.26 sq m. If this antenna was fed with 100 W then the maximum power density, obtained from equation (1) above, would be about 1500 W/sq m.

The above power density formula (1) provides a pessimistic estimate, and can be used at the system planning stage to determine desirable antenna gains or maximum transmitter powers for various situations.

If the estimated peak power density is less than 50 W/sq m then no further action is needed, apart from restricting access to the antenna structure itself. It is expected that the majority of amateur microwave operations will fall into this category.

If the estimated peak power density is more than 50 W/sq m then the distance D in m to the 50 W/sq m point can be found from :

$$D = \sqrt{\frac{W * A}{PD * l^2}} \; . \; . \; . \; . \; . \; . \; . \; (3)$$ 0whereW is the power in W,

A is the aperture area in sq m,
ÿ is the wavelength in m and
PD is the power density wanted, in this case 50 W/sq m.

For example, for a 25 * 25 cm horn antenna fed with 25 W at 10 GHz, the 50 W/sq m point will be about 6 m away.

For the 23 cm Yagi discussed earlier, the distance to the 32.5 W/sq m point is about 4 m.

Access should be prevented within this range in the direction of the main lobe of the antenna. Since in the majority of amateur microwave installations using antennas close to the ground, the operator will be very close by, satisfactory protection can be achieved very simply. If this is not possible, then any of the following steps could be taken:

a) Raise antennas above ground level in order to reduce power densities at head height.

b) Keep outside the projection of the aperture as the decrease in power density outside this is at least -10 dB, if the feed is positioned correctly.

c) Check the power densities by measurement if you have access to the equipment (because the above estimates tend to be pessimistic).

d) Reduce output power until satisfactory protection can be achieved by the above means.

Reference

[1] NRPB-GS11 Guidance as to Restrictions on Exposures to Time Varying Electromagnetic Fields and the 1988 Recommendations of the International Non-Ionizing Radiation Committee. HMSO 1989 ISBN 0 85951 314 9
(Information provided by the RSGB, October 1990)