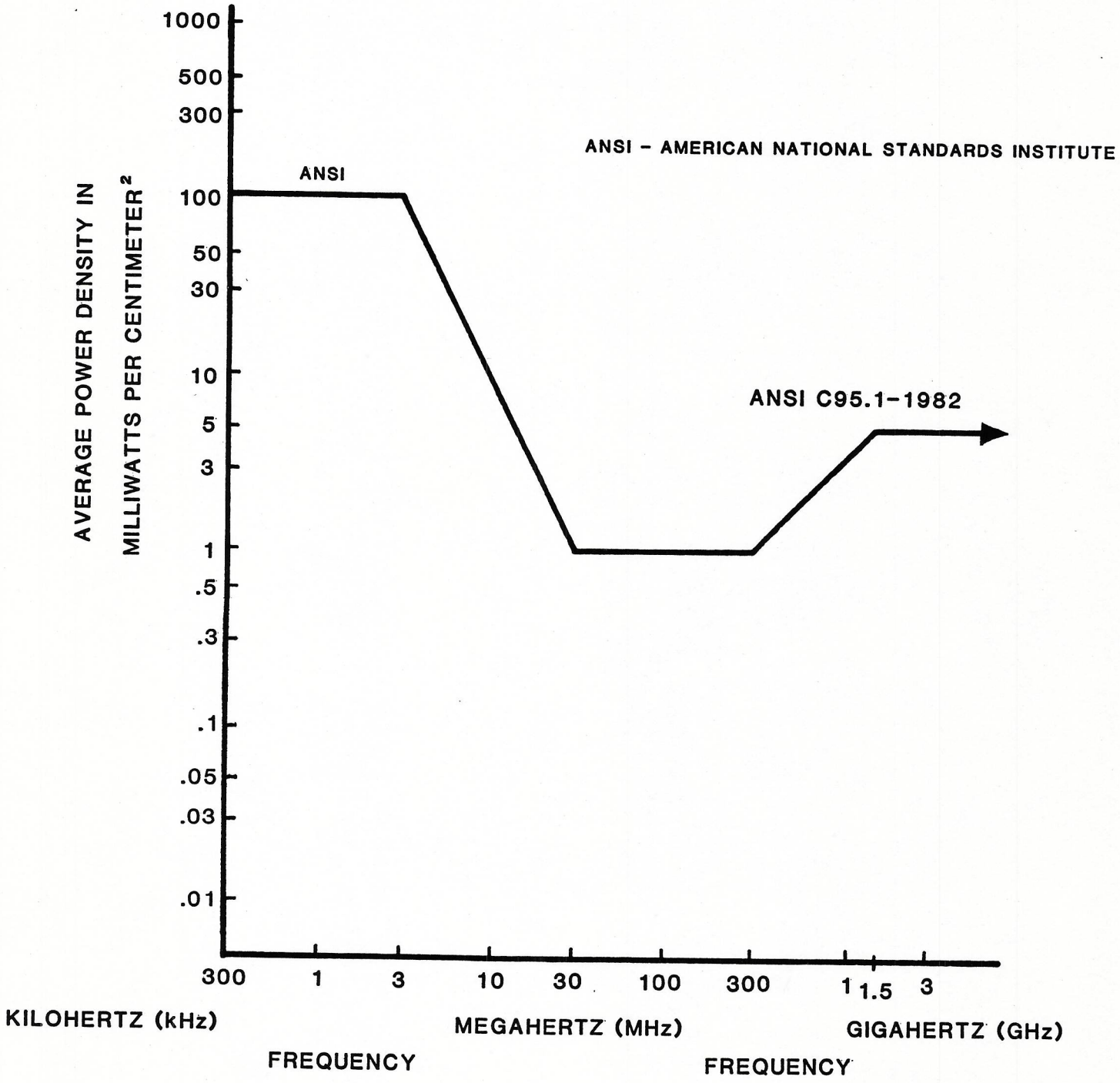
ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE
ANSI
ANSI C95.1-1982
AVERAGE POWER DENSITY IN MILLIWATTS PER CENTIMETER²
1000
500
300
100
50
30
10
5
3
1
.5
.3
.1
.05
.03
.01
300
1
3
10
30
100
300
1
1.5
3
KILOHERTZ (kHz)
FREQUENCY
MEGAHERTZ (MHz)
FREQUENCY
GIGAHERTZ (GHz)

RF RADIATION HAZARDS

Warren 2/27/84

Introduction

This article presents for EMC engineers a brief overview of various types of radiation hazards (RADHAZ) due to high-level RF emissions. Three broad RADHAZ categories are considered:

1. Personnel: direct biological effects and indirect effects resulting from the performance of cardiac pacemakers.
2. Explosives: both munitions and other applications (blasting caps, seat ejectors, etc.), primarily those utilizing electro-explosive (EED) devices.
3. Fuel: ignition due to RF-induced sparks.

RF Radiation Hazards To Personnel

Biological Effects

Biological hazards to personnel due to whole-body radiation are measured by incident power density or energy flux, respectively, in milliwatts or millijoules per square centimeter. Biological damage to living tissue is known to be caused by the heating effect on the tissue. (Some other reversible effects are known or suspected, but are not considered here.) Skin burns, eye cataracts, and overheating of delicate body organs can be caused by radio-frequency (RF) radiation. Organs with limited circulation to dissipate heat, such as the lungs, testicles, and liver, may be damaged by RF radiation. Until recently, the generally accepted threshold level in the United States is a time-averaged power density of 10 milliwatts per square centimeter (10 mW/cm²), for a limited duration of 6 minutes during any hour period, over the frequency range from 10 MHz to 100 GHz.

The new revision to ANSI C95.1[1] decreases the level, presents it in terms of the square of field strength (electric and magnetic), and makes it a function of frequency. These proposed changes are particularly significant since they are likely to be adopted widely by military and civilian organizations. The new limits for ANSI C95.1 are shown below, and plotted in Figure 1.

All values averaged over 0.1-hr. period.

f (MHz)	E^2 (V^2/m^2)	H^2 (A^2/m^2)	P (mW/cm^2)
0.3 - 3	400,000	2.5	100
3 - 30	4,000/(900/f^2)	0.25 (900/f^2)	900/f^2
30 - 300	4,000	0.025	1.0
300 - 1,500	4,000 (f/300)	0.025 (f/300)	f/300
1500 - 100,000	20,000	0.125	5.0

Note that for 300 kHz<f<100 GHz, values may be exceeded provided average whole-body specific absorption rate (SAR)<0.4 W/kg, and peak spatial SAR<8 W/kg averaged over 1 g of tissue.

Some foreign countries identify more stringent limits for continuous exposure to RF radiation. For example, the Academy of Medical Sciences of the USSR specifies 0.01 milliwatt per square centimeter as a level for continuous exposure.[2]

The purpose of the ANSI standard is to recommend maximum radiation levels to prevent harmful effects in human beings exposed to electromagnetic fields. These recommendations are intended to apply to non-occupational, as well as occupational, exposures. The recommendations are not intended to apply to the purposeful exposure of patients under the direction of practitioners of the healing arts.

The proposed standard has several definitions which are of critical importance. There are as follows:

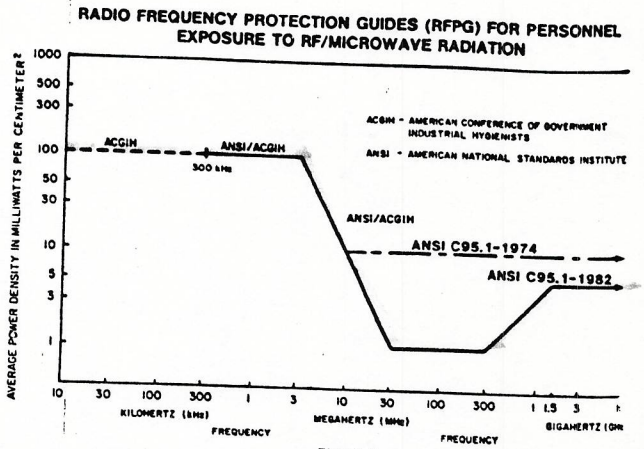

Figure 1.

Radioprotection Guide (RFPG). The radio frequency field strength or equivalent plane wave power density should not be exceeded without (1) careful consideration of the reasons for doing so, (2) careful estimation of increased energy disposition in the human body, and (3) careful consideration of the increased risk of unwanted biological effects.

Specific Absorption Rate (SAR). The time rate at which radio frequency electromagnetic energy is imparted to an element of mass of a biological body.

For human exposure to electromagnetic energy of radio frequencies from 300 kHz to 100 GHz, the Radio Frequency Protection Guide, in terms of equivalent plane wave free-power density is as follows:

FREQUENCY RANGE (MHz)	POWER DENSITY (mW/cm^2)
.03 - 3	100
3 - 30	900/f^2
30 - 300	1.0
300 - 1500	f/300
1500 - 100,000	5.0

For mixed or broadband fields consisting of a number of frequencies for which there are different values of radio frequency protection guide, the fraction of the radio frequency protection guide incurred within each frequency interval should be determined, and the sum of all such fractions should not exceed the unity.

At all frequencies between 300 kHz and 100 GHz, the protection guide may be exceeded if the exposure condition can be shown by laboratory procedures to produce specific absorption rates (SAR) below 0.4 w/kg, as averaged over the whole body, and spartial peak SAR values below 8 w/kg, as averaged over any 1 gram of tissue. Furthermore, at frequencies between 300 kHz and 1 GHz, the protection guide may be exceeded if the radio frequency input power of the radiated device is 7 watts or less.

Both for pulsed and non-pulsed fields, the power density and the values of SAR or input power, as applicable, are averaged over any 0.1-hour period. The time-average values should not exceed either the power densities given above or in the exclusions. Measurements to determine adherence to the recommended protection guides shall be made at a distance of 5 centimeters or greater from any object (refer to ANSI C95.3-1979 for radio frequency measurements).

TION HAZARDS

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RADIO FREQUENCY PROTECTION GUIDES (RFPG) FOR PERSONNEL EXPOSURE TO RF/MICROWAVE RADIATION

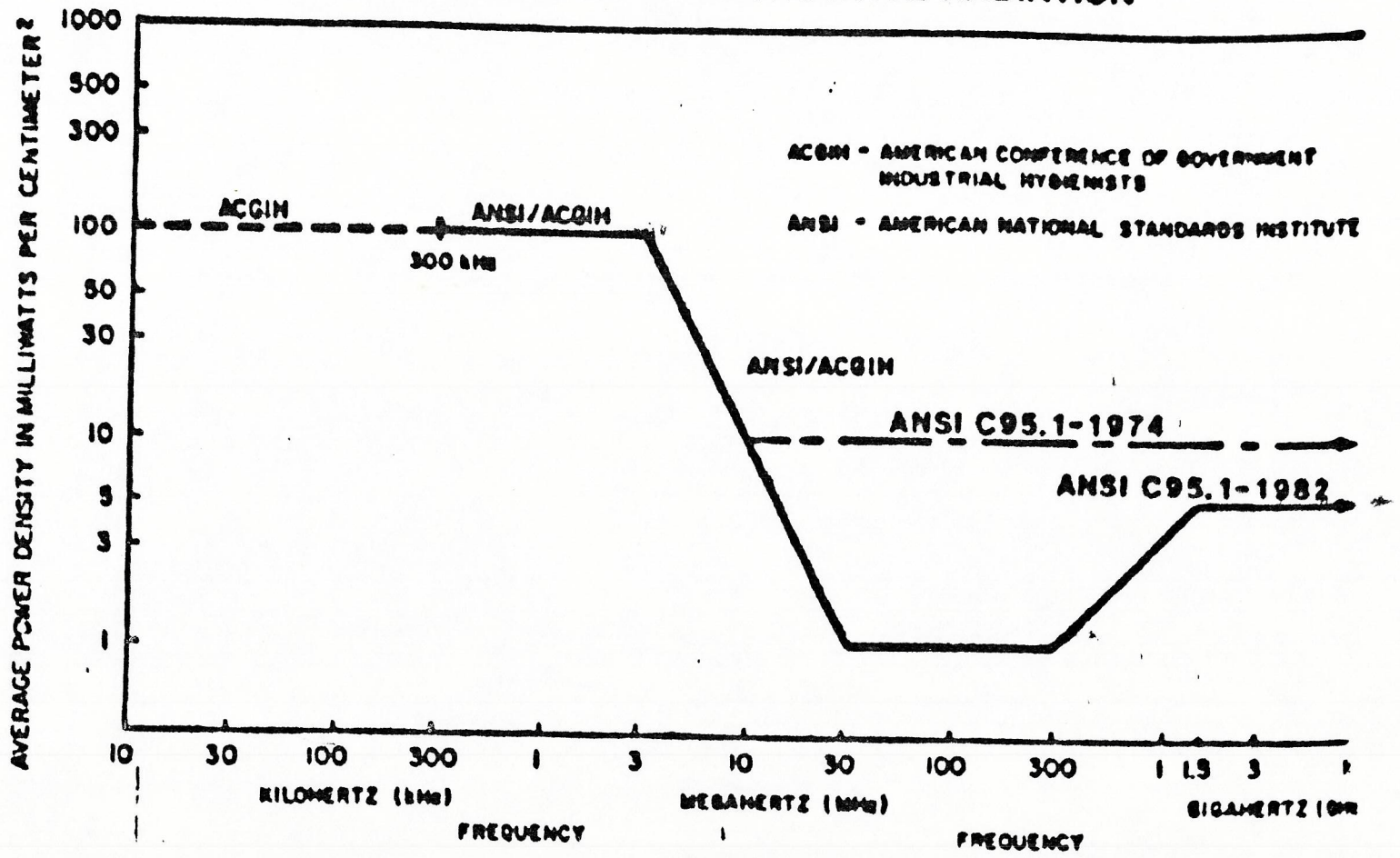

Figure 1.