

RARE, MEDIUM, OR WELL DONE?

RF EXPOSURE AND YOUR SHACK

Presented by

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and

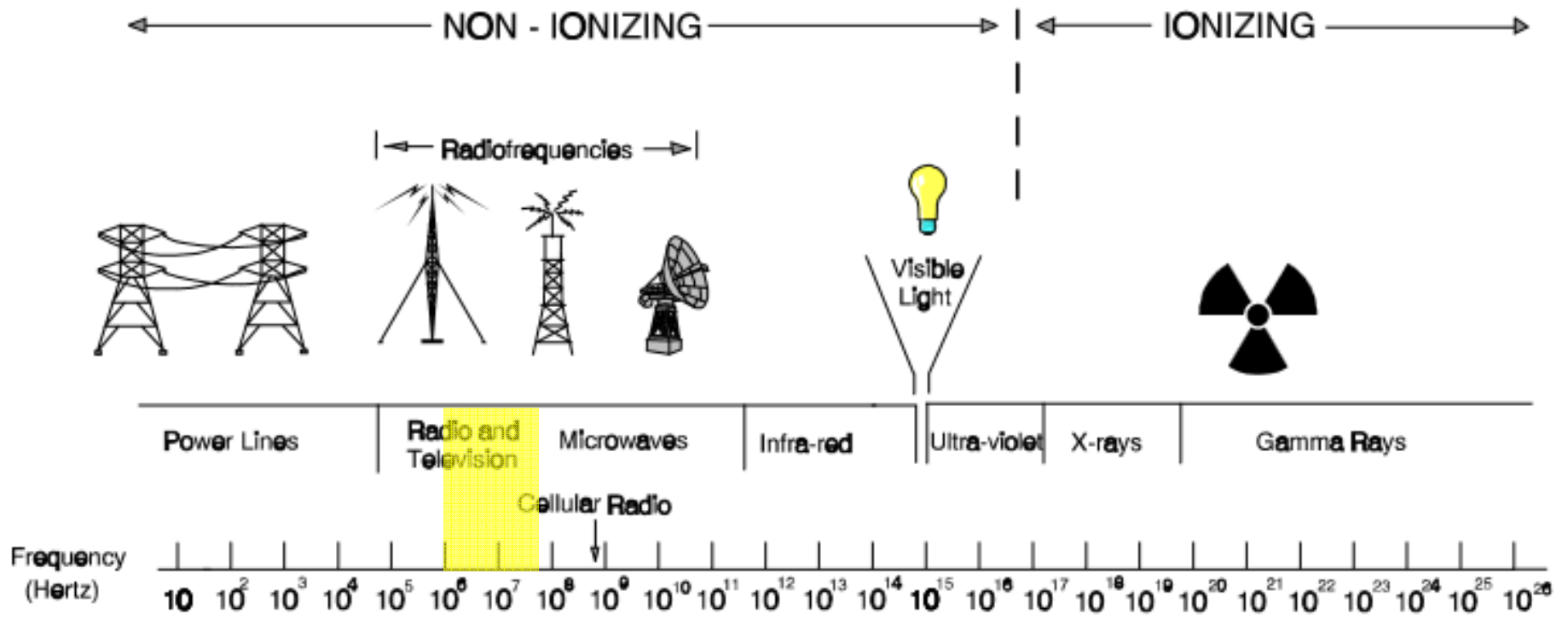
Gary Fritz, WB9LIB

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NEW FCC RULES

- Existing RF exposure (RFE) limits do not change
- For amateur radio stations already in place, an evaluation must be completed by May 3, 2023
- After May 3, 2021, any new station, or any existing station modified in a way that's likely to change its RFE profile — such as different antenna or placement or greater power — must evaluate

THE ELECTROMAGNETIC SPECTRUM



EFFECTS OF RF EXPOSURE

- Biological effects that result from heating of tissue by RF energy are often referred to as **thermal effects**. Exposure to high levels of RF radiation can be harmful due to the ability of RF energy to heat biological tissue rapidly.
- **The eyes and the testes**, are known to be particularly vulnerable to heating by RF energy.

1. Sleeping Problems
2. Fatigue
3. Learning Problems and Concentration
4. Headaches
5. Tinnitus
6. Eye Problems
7. Heart Problems, Heart Palpitations and Heart Arrhythmias
8. Leg Cramps
9. Vertigo (Balance Problems)
10. Cancer
11. Stress, Agitation, Anxiety, Irritability
12. Depression
13. Seizures
14. Arthritis, Sharp Stabbing Pains, Body Pain
15. Nausea, flu-like symptoms
16. Sinus Problems and Nosebleeds
17. Respiratory Problems and Cough
18. Skin Rashes and Facial Flushing
19. Endocrine Disorders, Thyroid Disorders and Diabetes
20. Children Behavior Problems & Mental Effects

EXPOSURE LIMITS

PART 97 – AMATEUR RADIO SERVICE

40. The authority citation for part 97 continues to read as follows:

Authority: [INSERT CURRENT AUTHORITY CITATION].

41. Section 97.13 is amended by revising paragraph (c)(1) to read as follows:

§ 97.13 Restrictions on station location.

* * * * *

(c) * * *

(1) The licensee shall ensure compliance with the Commission's radio frequency exposure requirements in Sections 1.1307(b), 2.1091, and 2.1093 of this chapter, where applicable. In lieu of evaluation with the general population/uncontrolled exposure limits, amateur licensees may evaluate their operation with respect to members of his or her immediate household using the occupational/controlled exposure limits in Section 1.1310, provided appropriate training and information has been accessed by the amateur licensee and members of his/her household. RF exposure of other nearby persons who are not members of the amateur licensee's household must be evaluated with respect to the general population/uncontrolled exposure limits. Appropriate methodologies and guidance for evaluating amateur radio service operation is described in the Office of Engineering and Technology (OET) Bulletin 65, Supplement B.

* * * * *

“... amateur licensees may evaluate their operation with respect to members of his or her immediate household using the occupational/controlled exposure limits...”

“... RF exposure of other nearby persons who are not members of the amateur licensee’s household must be evaluated with respect to the general population/uncontrolled exposure limits...”

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²) <i>S</i>	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f ²	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-3,000,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f ²	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-3,000,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density, electric and magnetic field strengths are root-mean-square (rms)

EXPOSURE CALCULATIONS

$$S = \frac{PG}{4\pi R^2}$$

- where: S = power density (in appropriate units, e.g. mW/cm²)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

when power gain is expressed in logarithmic terms, i.e., dB, a conversion is required using the relation:

$$G = 10^{\frac{dB}{10}}$$

RF EXPOSURE CALCULATOR

Parameters

- Power at Antenna: (Need help with this?) (watts)
 - Mode duty cycle:
 ▾
 - Transmit duty cycle: (time transmitting)
You transmit for minutes then receive for minutes (and repeat).
 - Antenna Gain (dBi): (Need help with this?)
 - Operating Frequency (MHz):
- Include Effects of Ground Reflections

RF EXPOSURE CALCULATOR

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
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30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-3,000,000			1.0	30

$$S = \frac{PG}{4\pi R^2}$$

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²): 4.4321

Minimum Safe Distance (feet): 2.6008

Minimum Safe Distance (meters): 0.7927

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²): 0.8864

Minimum Safe Distance (feet): 4.5047

Minimum Safe Distance (meters): 1.3730

MODE DUTY CYCLE

Conversational SSB, no speech processing (mode duty cycle=20%)

Conversational SSB, heavy speech processing (duty cycle=50%)

Conversational CW (duty cycle=40%)

FM (duty cycle=100%)

AM (duty cycle=100%)

FSK/RTTY (duty cycle=100%)

AFSK SSB (duty cycle=100%)

Carrier Always On, i.e., for Tuning Up (duty cycle=100%)

For all others, or if unknown, assume worst case scenario (duty cycle=100%)

GAIN

Antenna Type	Approx. Gain (dBi) *
Half wave dipole	2.15 dBi
10 element Yagi	15.1 dBi
2 element Yagi	5.9 dBi
3 element Yagi	8.1 dBi
4 element Yagi	9.1 dBi
5 element Yagi	10.1 dBi
6 element Yagi	11.1 dBi
8 element Yagi	13.1 dBi
Delta Loop	5.2 dBi
Four Square	5.2 dBi
G5RV	1.0 dBi
Hex Beam	5.0 dBi
Moxon	6.0 dBi
Quarter Wave Vertical	1.5 dBi
Windom (OCD)	2.0 dBi

<http://www.arrl.org/rf-exposure-calc-instructions#gain>

DIPOLE GAIN

Height, wavelengths	Gain, dBi
4	7.75
3	7.83
2	7.8
1.5	7.72
1	7.64
0.9	7.03
0.8	7.16
0.7	7.95
0.6	8.35
0.5	7.45
0.4	6.06
0.3	5.59
0.2	6.7
0.1	8.21
0.05	9.61

<https://www.qsl.net/aa3rl/ant2.html>

EXAMPLE

100 watts with a dipole antenna @ 0.5λ

G = 7.45 dBi, SSB without speech processing
5 minutes talk, 5 minutes receive

MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
3.75	64	12.8	0.6	0.8
7.25	17	3.4	1.1	1.5
14.25	4.4	0.8	2.1	3.0
21.35	2.0	0.4	3.2	4.5
28.5	1.1	0.2	4.3	6.1
52	1.0	0.2	4.5	6.4
146	1.0	0.2	4.5	6.4
440	1.5	0.3	3.7	5.2

EFFECT OF MODE DUTY CYCLE

100 watts with a dipole antenna @ 0.5λ

G = 7.45 dBi, SSB without speech processing
5 minutes talk, 5 minutes receive

Mode at 14.25 MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
20% (SSB no processing)	4.4	0.9	2.1	3.0
40% (Conversational CW)	4.4	0.9	3.0	4.3
50% (SSB heavy processing)	4.4	0.9	3.4	4.8
100% (FM, AM FSK/RTTY, AFSK SSB, tuning)	4.4	0.9	4.8	6.8

HT

5 watts with a Comet extended antenna (15.75")

G = 2.1/3.5 dBi FM

1 minute talk, 1 minute receive / 10 minute talk, 10 minute receive

MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
Talk 1 minute, receive 1 minute				
146	1.0	0.2	0.9	2.1
440	1.5	0.3	0.9	2.0
Talk 10 minute, receive 10 minute				
146	1.0	0.2	1.3	2.4
440	1.5	0.3	1.3	2.4

MOBILE

50 watts with typical antenna

G = 3.0/5.5 dBi , FM

1 minute talk, 1 minute receive

MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
146	1.0	0.2	3.3	7.4
440	1.5	0.3	3.6	8.1

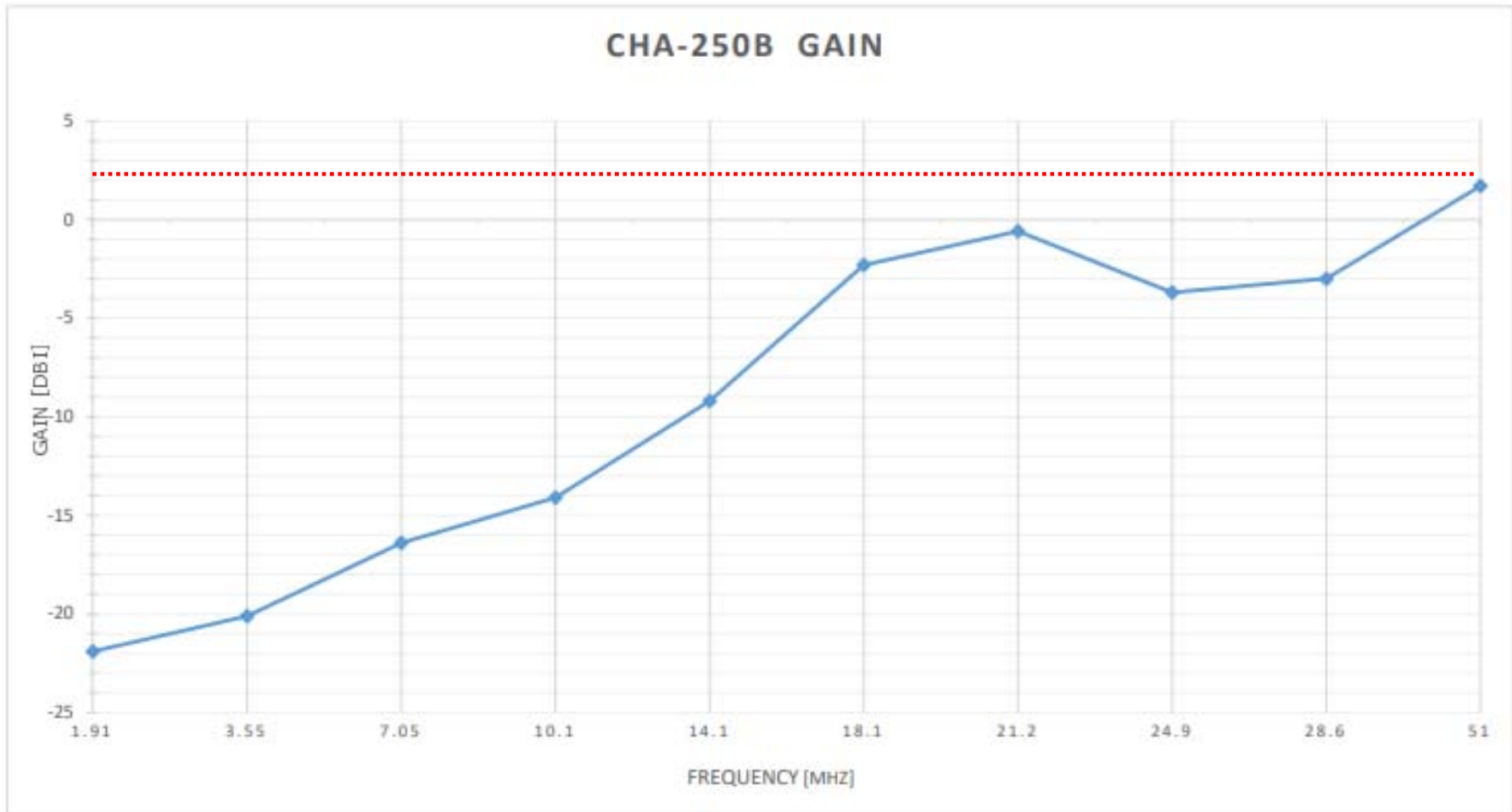
QRO STATION

1500 watts with 5-element yagi antenna

G = 10.1 dBi SSB with heavy processing
5 minutes talk, 5 minutes receive

MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
7.25	17	3.4	9.0	16
14.25	4.4	0.8	18	31
21.35	2.0	0.4	27	46
28.5	1.1	0.2	36	62

Comet CHA-250 B



Information provided by Comet representative, personal communication

COMET CHA-250B

100 watts with Comet CHA-250B antenna

G varies, SSB with no processing
5 minutes talk, 5 minutes receive

MHz	Max allowed power density, mW/cm ²		Minimum safe distance, ft	
	controlled	uncontrolled	controlled	uncontrolled
1.91	100	49	0.02	0.02
3.75	64	12.8	0.02	0.04
7.25	17	3.4	0.07	0.1
14.25	4.4	0.8	0.3	0.5
21.35	2.0	0.4	1.3	2.2
28.5	1.1	0.2	1.3	2.2
52	1.0	0.2	2.3	4

Information provided by Comet representative, personal communication

ARRL CALCULATOR

<http://www.arrl.org/rf-exposure-calculator>