

Intro to RF Safety

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Introduction

- Because of fears of the effects of RF, the FCC put in place, in 1996, rules to protect people from the "hazards" of RF
- As hams, most of us were exempt from the RF safety analysis,
- Effective May3, 2021 the FCC adopted new rules on RF Safety Analysis
 - that change the ways that radio stations can determine whether they are exempt from the need to do a routine RF-exposure station evaluation
- We will watch a video by Ria Jairam, N2RJ, about the new rules and how we can meet them
- After the video,
 - I will do my best to answer any questions
- If someone needs help reach out to either:
 - Paul Newland, AD7I, or
 - Joe Wilkes, WA2SFF
 - We will help, but we will not do the evaluations
- For more information <http://www.arrl.org/rf-exposure>

Ria's video

- <https://www.youtube.com/watch?v=kyLDC-H8kb0>



Table 2. Single RF Sources Subject to Routine Environmental Evaluation under MPE-Based Exemptions, $R \geq \lambda/2\pi$

Transmitter Frequency	Threshold ERP
0.3 – 1.34	1,920 R ²
1.34 – 30	3,450 R ² /f ²
30 – 300	3.83 R ²
300 – 1,500	0.0128 R ² f
1,500 – 100,000	19.2 R ²
<i>Note:</i> Transmitter Frequency is in MHz, Threshold ERP is in watts, R is in meters, f is in MHz.	

49. Single RF sources are exempt if, using Table 2 above, for the frequency (f in MHz) and separation distance (R in meters) at which the source operates, the ERP (in watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 2 to apply, the separation distance in meters, R,¹⁴⁶ must be at least $\lambda/2\pi$, where λ is the free-space operating wavelength. If the ERP of a single RF source is not easily obtained, then the available maximum (source-based) time-averaged power may be used in lieu of ERP if the device antenna(s) or radiating structure(s) do not exceed the electrical length of $\lambda/4$. If the ERP of the single RF source and transmitting antenna(s) (including coherent array) exceeds the ERP threshold, then the RF source is not exempt and the applicant must prepare an evaluation.¹⁴⁷

<http://www.arrl.org/files/file/Technology/RFsafetyCommittee/RFXFAQ.pdf>

Power levels for exemption

Distance in feet	10	16	22	29	45	87	100	120		
Distance in meters	3	4.9	6.7	8.8	13.7	26.5	30.5	36.6		
frequency (MHz)	If Average Power in Watts is greater than this number you must do an analysis								near field boundary (ft)	
1.8	Analysis Required						989245	1424513	87	
3.5	Analysis Required					198039	261645	376769	45	
5.4	Analysis Required			9244	22258	83196	109916	158279	29	
7	Analysis Required		3166	5501	13246	49510	65411	94192	22	
10	Analysis Required	821	1551	2696	6490	24260	32052	46154	16	
14	Analysis Required	419	791	1375	3311	12377	16353	23548	11	
18	96	253	479	832	2003	7488	9892	14245	9	
21	70	186	352	611	1472	5501	7268	10466	7	
24	54	142	269	468	1127	4212	5565	8013	7	
28	40	105	198	344	828	3094	4088	5887	6	
50	34	91	172	299	721	2693	3558	5124	3	
146	34	91	172	299	721	2693	3558	5124	1.07	
222	34	91	172	299	721	2693	3558	5124	0.71	
432	50	132	249	432	1040	3888	5137	7398	0.36	
908	105	276	523	908	2187	8173	10798	15548	0.17	
1296	149	395	746	1296	3121	11665	15411	22193	0.12	

Gain of Common Antennas

• Antenna Type	Gain (dBi)	Directionality *	• Antenna Type	Gain (dBi)	Directionality *
• Half wave dipole	2.2 dBi	Slightly	• Four Square	5.2 dBi	Moderately
• 0.3m dish	22.0 dBi	Highly	• G5RV	1.0 dBi	Slightly
• 0.6m dish	24.0 dBi	Highly	• Helix	14.1 dBi	Highly
• 1.0m dish	34.0 dBi	Highly	• Hex Beam	5.0 dBi	Moderately
• 1.5m dish	38.0 dBi	Highly	• Horn (typical)	22.0 dBi	Highly
• 10 element Yagi	15.1 dBi	Highly	• Log Periodic	6.0 dBi	Highly
• 2 element Yagi	5.9 dBi	Moderately	• Longer Yagi	19 dBi	Highly
• 3 element Yagi	8.1 dBi	Highly	• Longwire	2.0 dBi	Slightly
• 4 element Yagi	9.1 dBi	Highly	• Moxon	6.0 dBi	Moderately
• 5 element Yagi	10.1 dBi	Highly	• Quad	9.1 dBi	Highly
• 6 element Yagi	11.1 dBi	Highly	• Quarter Wave Vertical	1.5 dBi	Omni
• 8 element Yagi	13.1 dBi	Highly	• Slotted Waveguide	12.0 dBi	Highly
• Alford Slotg	9.0 dBi	Slightly	• SteppIR	7.1 dBi	Moderately
• Big Colinear	8.2 dBi	Highly	• Vertical Dipole	4.2 dBi	Omni
• Colinear	5.2 dBi	Moderately	• Windom (OCD)	2.0 dBi	Slightly
• Delta	5.2 dBi	Medium	• ZS6BKW (G5RV type)	5.0 dBi	Slightly
• Flat Panel (typical)	24.0 dBi	Highly			
• Four Square	5.2 dBi	Moderately			

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

Averaging Factor for Different Modes

Table 2
Operating Duty Factors by Mode

<i>Mode</i>	<i>Duty Factor</i>	<i>Notes</i>
Conversational SSB	20%	Note 1
Conversational SSB	40%	Note 2
Voice FM	100%	
FSK/RTTY	100%	
AFSK	100%	
Conversational CW	40%	
Carrier	100%	Note 3

Note 1: Includes voice characteristics and syllabic duty factor. No speech processing.

Note 2: Moderate speech processing employed.

Note 3: A full carrier is commonly used for tune-up purposes.

<http://www.arrl.org/fcc-rf-exposure-regulations-the-station-evaluation>

Two Web Calculators

- <http://www.lakewashingtonhamclub.org/resources/rf-exposure-calculator/>
- http://hintlink.com/power_density.htm
- Notes on Near Field vs. Far Field
- From Lake Washington ham club
 - The calculator is based on the published FCC exposure guidelines, which doesn't distinguish between near and far fields.
 - The results are shown as the max allowable power density for the provided frequency and power, and the minimum safe distance for that density.
- From the ARRL
 - The calculators are all far-field calculators, but the current FCC material does indicate that they can be used. In actuality, these far-field calculators are actually conservative for all but very small antennas such as 1-meter loops, etc, if you take the distance to be from any part of the antenna. So for halfwave dipoles, verticals, Yagis, etc., they can be accurately used as a worst-case estimate.

References

- Ria's videos on RF Safety
- <https://www.youtube.com/watch?v=kyLDC-H8kb0>
- <https://www.youtube.com/watch?v=Jx8JeiywYyI>
- On line calculators
- <http://www.lakewashingtonhamclub.org/resources/rf-exposure-calculator/>
- http://hintlink.com/power_density.htm
- ARRL links
- <http://www.arrl.org/rf-exposure>
- <http://www.arrl.org/tis>
- American Cancer Society on RF and cancer
- <https://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html>

Example

Antenna Layout



Assumptions

- Assume SSB
- Power 80-6 meters 100 watts (ICOM 756ProIII)
- Power 2 meters, $\frac{3}{4}$ meters 50 watts (Yaesu 991A)
- Neglect feed line loss
- HF Antenna G5RV \rightarrow gain same as dipole (2.2 dBi)
- 6 Meter vertical AR-50 gain 3.75 (assumed dBi)
- 2 meter vertical AR270 gain 3.7 (assumed dBi)
- $\frac{3}{4}$ meter vertical AR270 gain 5.5 (assumed dBi)
- Station is on the second floor in the back of the house and about 10 feet from each antenna
- Based on tables, I need to do a calculation for 80-20 meters, 6 meters, 2 meters

Note: Most manufacturers when specifying gain without a dBd or dBi notion are using dBi to make the number look better $0 \text{ dBd} = 2.2 \text{ dBi}$

RF Calculator- 80 meters

<http://www.lakewashingtonhamclub.org/resources/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):
- Operating Frequency (MHz):

☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

RF Calculator- 20 meters

- 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):
- Operating Frequency (MHz):

☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

RF Calculator- 10 meters

- 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):
- Operating Frequency (MHz):

☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

RF Calculator- 6 meters

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):
- Operating Frequency (MHz):

☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

RF Calculator- 2 meters

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):
- Operating Frequency (MHz):

☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

RF Calculator $\frac{3}{4}$ meters

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):
 - Operating Frequency (MHz):
- ☒ Include Effects of Ground Reflections

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²):

Minimum Safe Distance (feet):

Conclusion

- For all bands:
- Minimum safe distance for controlled and uncontrolled exposure is less than 10 feet
- No problem with this station and RF exposure with its current antennas, antenna layout, and current equipment
- If the station did not pass, then operator would:
do calculations for CW, FT8 and SSB to see if stations passes
- If it still doesn't pass, then operator would:
 - move antennas
 - lower power on bands where it does not pass