FCC REPORT AND ORDER GOVERNING RF EXPOSURE

WHY SHOULD YOU CARE?

LOREN ANDERSON, KEØHZ

FCC HAS ISSUED NEW REQUIREMENTS TO ASSURE RF EXPOSURE SAFETY

FCC Report and Order 19-126 (new)

- Rules for RF exposure (not just Amateur)
- Active as of May 3, 2021
- Past exposure standards maintained
- Automatic exemptions essentially eliminated

OET Bulletin 65 (not new)

- How to determine RF exposure compliance
- Not just for hams
- OET-65B tuned for hams

From ARRL presentation

https://www.youtube.com/watch?v=7dSieKF3rm0&t=1802s

IS IT POSSIBLE THE FCC COULD COME KNOCKING AT YOUR DOOR?

NOT LIKELY, BUT….

An interfering signal gets reported and investigated (first hand story)

A neighbor might be experiencing some sort of interference, see your antennas, and make a complaint

WHY IS RF EXPOSURE A CONCERN?

Radiofrequency (RF) radiation, which includes radio waves and microwaves, is at the low-energy end of the electromagnetic spectrum. It is a type of non-ionizing radiation. Non-ionizing radiation does not have enough energy to remove electrons from an atom. Visible light is another type of non-ionizing radiation. RF radiation has lower energy than some other types of non-ionizing radiation, like visible light and infrared, but it has higher energy than extremely low-frequency (ELF) radiation.

If RF radiation is absorbed by the body in large enough amounts, it can produce heat. This can lead to burns and body tissue damage. Although RF radiation is not thought to cause cancer by damaging the DNA in cells the way ionizing radiation does, there has been concern that in some circumstances, some forms of non-ionizing radiation might still have other effects on cells that might somehow result in cancer.

https://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html

IMPORTANT FOR YOU, YOUR FAMILY, & YOUR NEIGHBOR'S SAFETY!

Radio Amateurs – Occupational/ controlled-higher threshold, shorter time

General Population/uncontrolled-lower threshold, longer time

WHAT DOES THE REPORT AND ORDER SAY?

https://docs.fcc.gov/public/attachments/FCC-19-126A1.pdf

- Document is 159 pages long
- Effective as of May 3, 2021

The exposure limits have not changed

Exemptions are not automatic. You must perform calculation that you are entitled to exemption from performing calculation to determine exposure level.

2-year transition period for existing stations.

Required immediately if you make changes (e.g., new antenna installation)

WHY SHOULD I TAKE THIS SERIOUSLY?

To become a licensed Amateur Radio Operator we had to demonstrate knowledge of rules and operating procedures when we took the exam(s). It is a privilege accorded us and our responsibility to comply.

There are safety considerations!

- RF exposure in your home
- RF exposure to family and public outside your home

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

WHAT DO WE NEED TO DO?

Perform analysis and verify compliance with limits set by FCC.

Document the analysis and file it where you can find it again should the need arise – this is optional but if you go to the trouble why not?

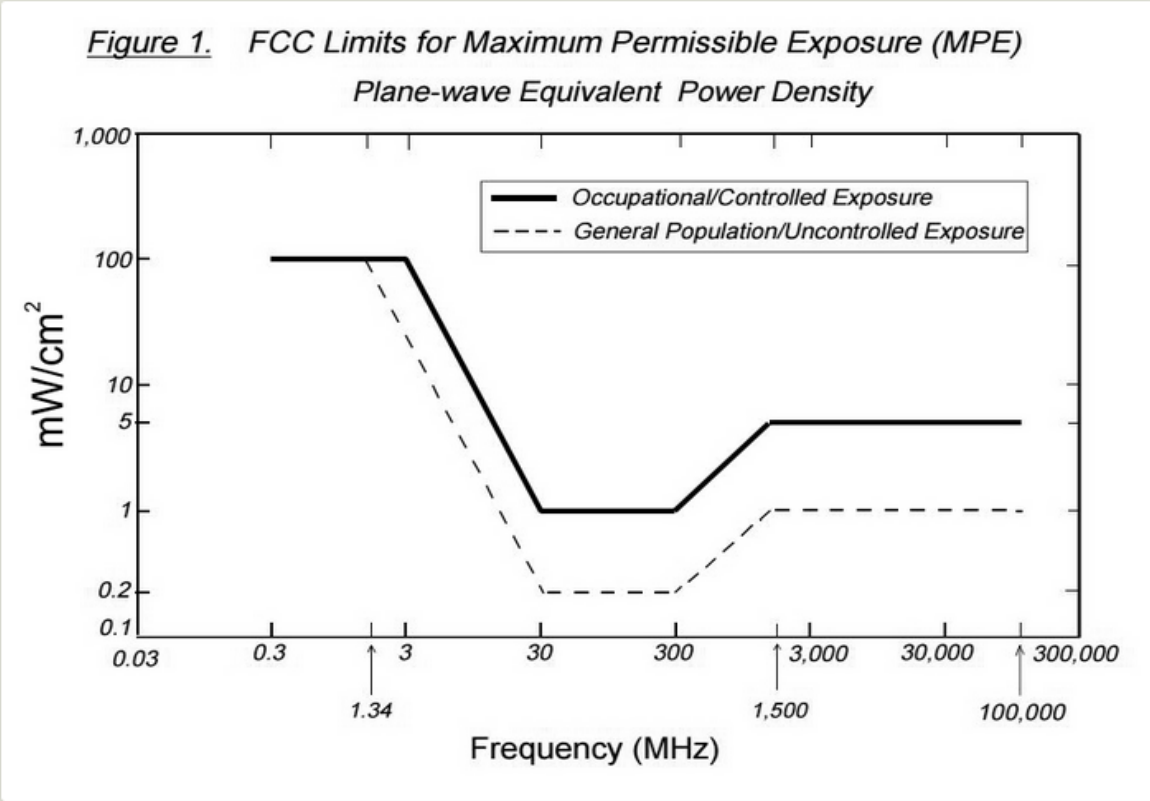
If out of compliance – CORRECT the situation

You do NOT need to file it with the FCC!

You would need to prove compliance to the FCC should they come calling.

It may also be useful if you are in discussion with a neighbor that is concerned with your operation.

MAXIMUM PERMISSIBLE EXPOSURE (MPE)



Maximum Permissible Exposure limits by frequency. Extracted from FCC OET Bulletin 65.

WHAT ARE THE EXEMPTIONS?

and why would there be an exemption?

- You operate at an insignificant power level.
- No one is able to get close enough to RF radiation source for it to be a factor.

EXEMPTIONS, CONT'D

W0TLM Amateur Radio Club

New Exemptions

- The new **Exemptions** are based on three things:
  - Frequency
  - Maximum ERP (taking into account feedline loss and antenna gain)
  - Distance between a person and any part of the antenna
  - **Exemptions** do not apply to distances less than $\lambda/2\pi$ (reactive near-field)
- **Exemptions** require less calculation than a full exposure analysis.
- If you don't quality for an exemption, you can still perform the full analysis, which takes into account T/R duty cycle.

ARRL The national association for AMATEUR RADIO

New Exemptions

RF Environmental Evaluation must be performed if any person will be closer than R meters to any radiating part of the antenna and the **ERP** exceeds the values calculated from the following table:

Frequency (MHz)	Threshold ERP (watts)
0.3-1.34	$1920\ R^2$
1.34-30	$3450\ R^2 / f^2$
30-300	$3.83\ R^2$
300-1500	$0.0128\ R^2\ f$
1500-100000	$19.2\ R^2$

f is in MHz, R is in meters and must be > $\lambda/2\pi$

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N9GL - FCC Exposure Ru

ERP is not the specified power output in your transmitter specifications!

EXEMPTIONS, CONT'D

W0TLM Amateur Radio Club

Exemption Minimum Distances (λ/2π)

Exemptions cannot be taken if the distance between the antenna and a human is less than these distances:

160 m (1.8-2.0 MHz) ..... 82.8 feet
80 m (3.5-3.75 MHz) ..... 41.3 feet
75 m (3.75-4.0 MHz) ..... 38.8 feet
40 m (7.0-7.3 MHz) ..... 20.7 feet
30 m (10.1-10.15 MHz) ..... 15.5 feet
20 m (14.0-14.35 MHz) ..... 10.3 feet
17 m (18.068-18.168 MHz) ..... 8.8 feet
15 m (21.0-21.45 MHz) ..... 7.8 feet

12 m (24.89-24.99 MHz) ..... 6.2 feet
10 m (28.0-29.7 MHz) ..... 5.2 feet
6 m (50-54 MHz) ..... 3.1 feet
2 m (140-144 MHz) ..... 1.0 feet
1.25 m (222-225 MHz) ..... 7.8 inches
For higher frequencies, λ/2π is less than 20 cm
SAR Exemption or Testing is required.
70 cm (420-450 MHz) ..... 4.3 inches
33 cm (902-928 MHz) ..... 2.0 inches

ARRL The national association for AMATEUR RADIO

HOW DO I PERFORM THE ANALYSIS?

There are online tools that make it quite easy

IF

you understand a few important items!

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

https://hamradioschool.com/rf-exposure-evaluating-your-station/

TECHNICAL DETAILS

We’ll not go into excruciating detail

But, there may be a few things here that will help if you’re planning to upgrade your license anytime soon.

CALCULATION

Exposure limits vary dependent on frequency.

Calculation must be performed for each operating band.

PEP Input to antenna X Duty Factor

X Operating Time % = Average Power

Average Power X Antenna Gain = Effective Radiated Power (ERP)

WHAT IS AVERAGE POWER?

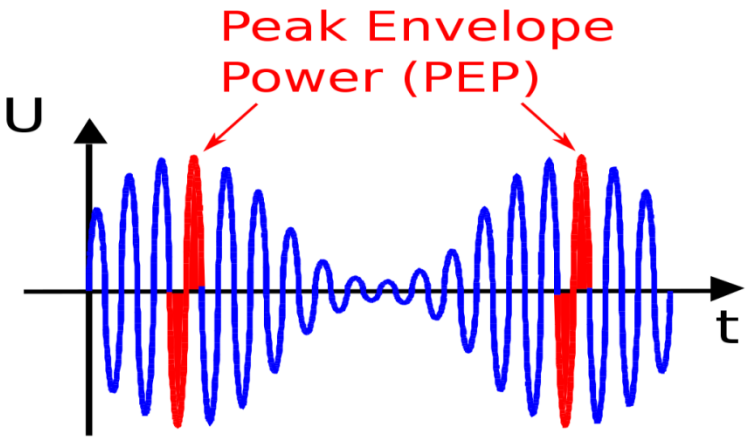
Start with maximum output from transmitter

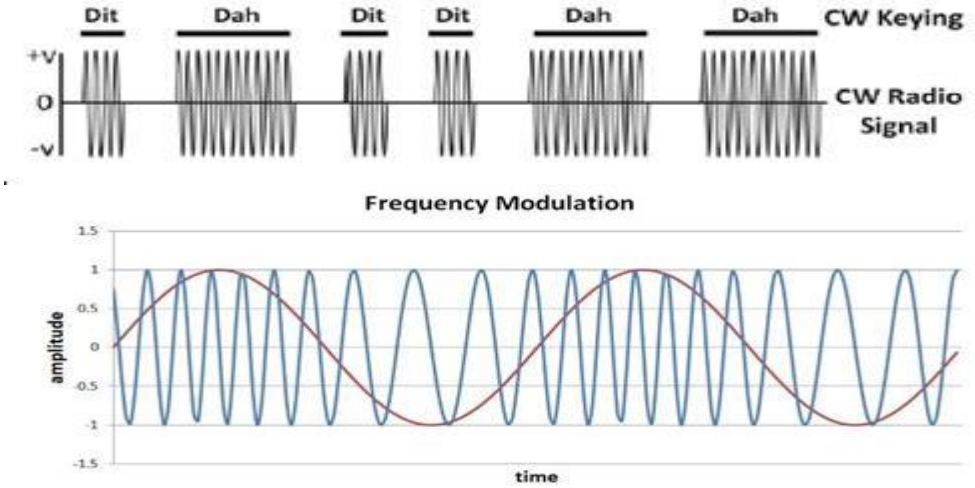
IC-7300 - 100W PEP

TM-V71A - 50W PEP

WHAT IS PEP?

Peak Envelope Power (PEP)





Your transmitter power rating is at its antenna connector.

DUTY FACTOR

Table 5.4

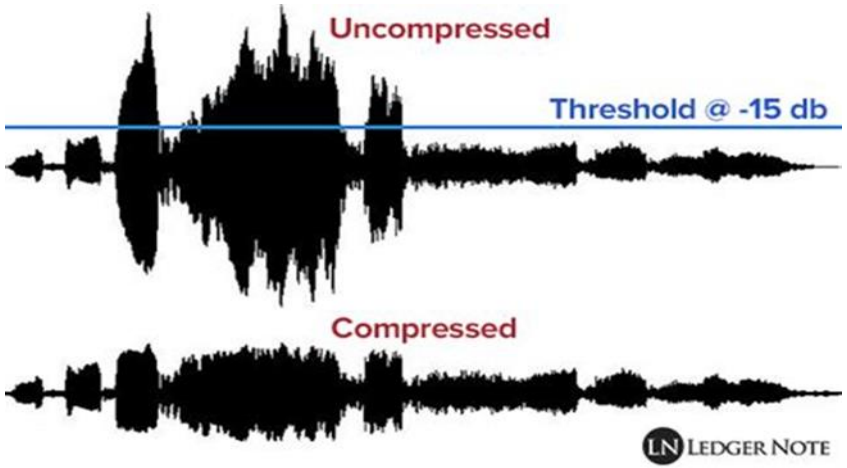
Operating Duty Factor of Modes Commonly Used by Amateurs

Mode	*Duty Cycle*	*Notes*
Conversational SSB	20%	1
Conversational SSB	40%	2
SSB AFSK	100%	
SSB SSTV	100%	
Voice AM, 50% modulation	50%	3
Voice AM, 100% modulation	25%	
Voice AM, no modulation	100%	
Voice FM	100%	
Digital FM	100%	
ATV, video portion, image	60%	
ATV, video portion, black screen	80%	
Conversational CW	40%	
Carrier	100%	4

Note 1: Includes voice characteristics and syllabic duty factor. No speech processing.
Note 2: Includes voice characteristics and syllabic duty factor. Heavy speech processor employed.
Note 3: Full-carrier, double-sideband modulation, referenced to PEP. Typical for voice speech. Can range from 25% to 100%, depending on modulation.
Note 4: A full carrier is commonly used for tune-up purposes

From ARRL “RF Exposure and You”, 1998

SSB DUTY FACTOR
AND EFFECT OF SPEECH PROCESSING



Mic gain is too high. The ALC goes into action and your transmitted speech is likely distorted. Reducing the mic gain reduces the audio power that modulates the SSB signal. (20% duty factor)

The speech processor compresses the audio waveform eliminating the signal peaks while adding minimal distortion. This eliminates the need to reduce the mic gain resulting in higher average power (40% duty factor)

SIGNALS WITH 100% DUTY FACTOR

RTTY

PSK31

FT-8

FM

CALCULATE AVERAGE POWER

PEP Input to antenna X Duty Factor

X Operating Time % = Average Power

But wait

It's PEP input to antenna, not PEP out of transmitter!

There is loss in the transmission line (coax, balanced line, connectors)

CALCULATE TRANSMISSION LINE LOSS

Assume 75 ft run of RG-213 from transmitter (or amplifier) to feed point at antenna

1.2 dB X .75 = 0.9 dB

https://www.qsl.net/co8tw/Coax_Calculator.htm

	LMR-1200	LMR-900	LMR-600	1/2" Superflex	LMR-400	Belden 9913F7	9914	RG214 RG213	LMR-240	Belden RG8X	LMR-200	LMR-195	RG-58/U
Frequency/Size	1.200"	0.870"	0.590"	0.520"	0.405"	0.405"	0.400"	0.405"	0.240"	0.242"	0.195"	0.195"	0.195"
30 MHz	0.209	0.288	0.421	0.561	0.7	0.8	0.8	1.2	1.3	2.0	1.8	1.8	2.5
50 MHz	0.272	0.374	0.547	0.730	0.9	1.1	1.1	1.6	1.7	2.5	2.3	2.3	3.1
150 MHz	0.481	0.658	0.964	1.29	1.5	1.7	1.7	2.8	3.0	4.7	3.9	4.0	6.2
220 MHz	0.589	0.803	1.18	1.58	1.8	2.1	2.1	3.5	3.7	6.0	4.8	4.8	7.4
450 MHz	0.864	1.17	1.72	2.32	2.7	3.1	3.1	5.2	5.3	8.6	6.9	7.0	10.6
900 MHz	1.27	1.70	2.50	3.41	3.9	4.4	4.5	8.0	7.6	12.8	9.9	9.9	16.5
1,500 MHz	1.69	2.24	3.31	4.57	5.1	6.0			9.9		12.7	12.9	

Loss per 100'

AVERAGE POWER AT ANTENNA

PEP Input to antenna X Duty Factor

X Operating Time % = Average Power

dB loss calculator (at 14.25 MHz):

https://kv5r.com/ham-radio/coax-loss-calculator/

100 W – .807 dB = 100 / 10^0.0807 = 100 / 1.204 = 83.1 W PEP Input

X 100% Duty Factor X 50% Operating Time

=

41.5 W Average Power

AND FINALLY ERP!

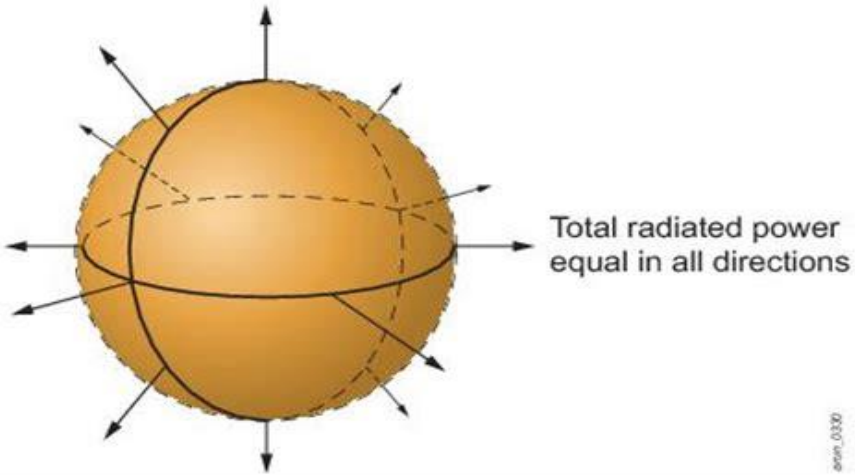
Effective Radiated Power (ERP) =

Average Power X Antenna Gain (dBi) =

41.5 W X ????

What is my Antenna Gain expressed in dBi?

ISOTROPIC ANTENNA (HYPOTHETICAL)



The ultimate omnidirectional antenna

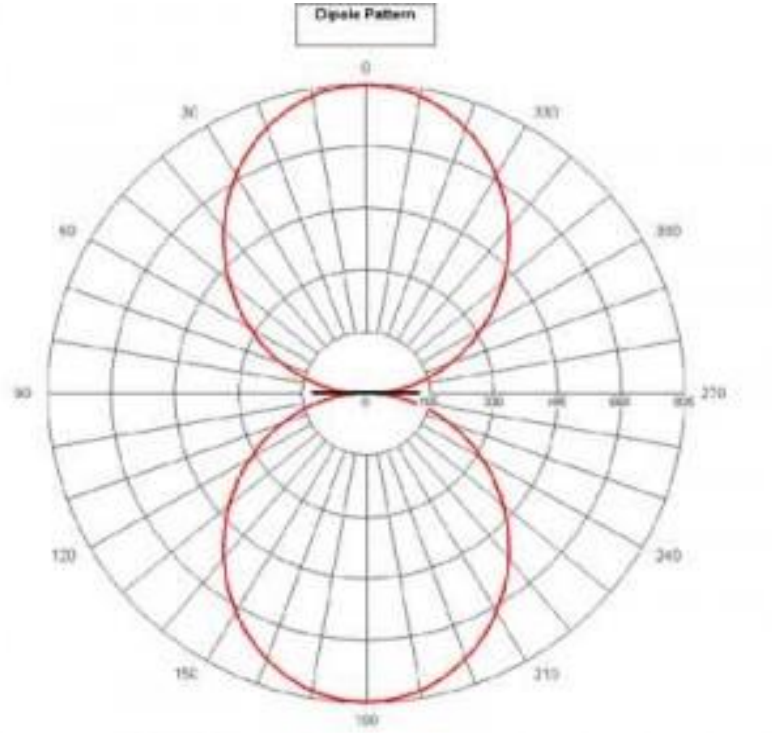
The measured the power density (watts/area) at any location the same distance from the antenna would be identical

This antenna is theoretical – it doesn't actually exist

DIPOLE ANTENNA

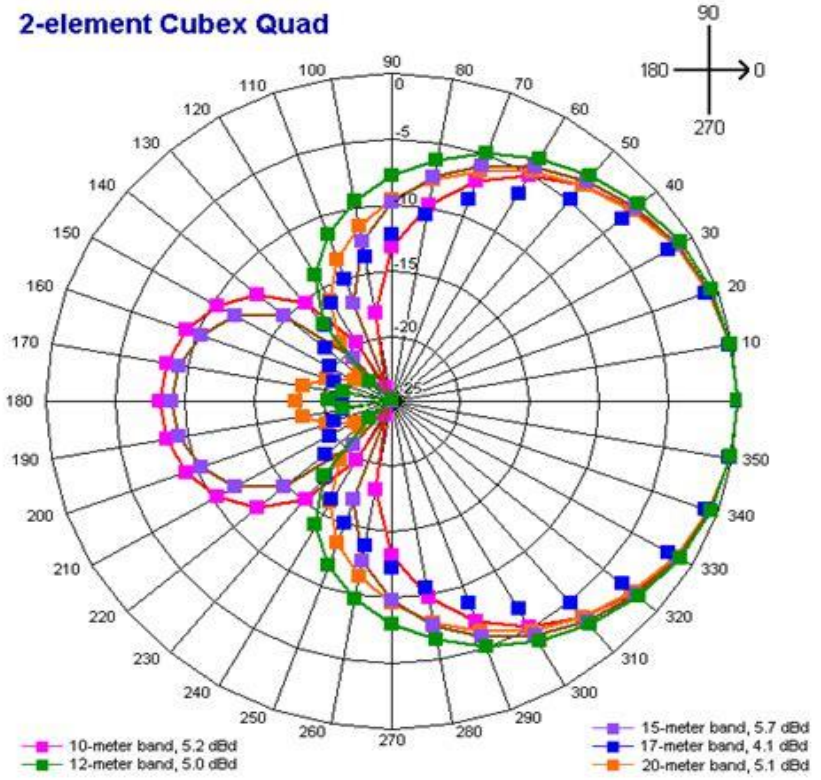
An ideal dipole antenna has a gain of 2.2 dB greater than the Isotropic antenna.

This is expressed as 2.2 dBi or 0 dBd



DIRECTIONAL ANTENNA

Yagi parameters expressed as gain (dBi or dBd (dBi + 2.2)), front-to-back ratio, & take-off angle (not considered in our analysis)



GAIN OF VARIOUS ANTENNAS

Table 3
Typical Antenna Gains in Free Space

Antenna	*Gain*	
	dBi	*dBd*
Quarter-wave ground plane or vertical	1.0	-1.1
Half-wavelength dipole	2.15	0.0
2-element Yagi array	6.0	3.9
3-element Yagi array	7.2	5.1
5-element Yagi array	9.4	7.3
8-element Yagi array	13.2	11.1
10-element Yagi array	14.8	12.7
17-element Yagi array	16.8	14.7

The tables derived from formulas do have advantages: they generally offer conservative estimates and they are easy to use. If a ham "passes" using these conservative tables, the evaluation is complete. Doing a station evaluation can be just that simple!

Table from https://hamwaves.com/vertical-horizontal/en/

ERP CALCULATION

ERP = 41.5W + 1dB gain = 52.3W

There are online calculators but if you want do it yourself:

1dB = 10log (Pout/Pin) = 10log (Pout/41.5)

.1 = log(Pout) – log(41.5) = log(Pout) – 1.62

1.72 = log(Pout)

10^1.72 = Pout = 52.48W

https://www.rapidtables.com/convert/electric/db-converter.html

NOW WHAT?

Remember the table to see if you qualify for the exemption?

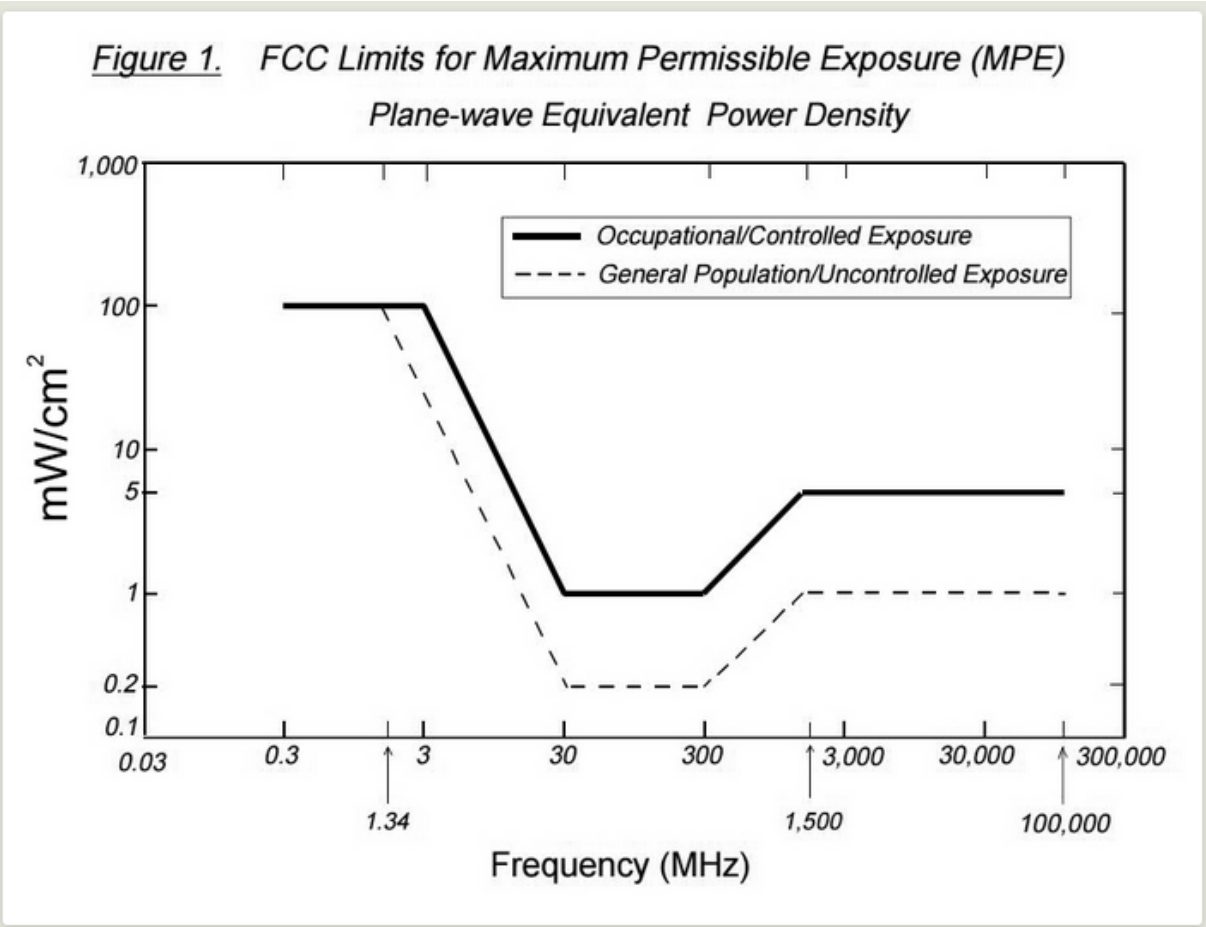
Is your uncontrolled area closer than the exception minimum distance at operating frequency?

Does your ERP exceed the exemption limit?

If yes to either you must calculate the RF exposure to verify it does not exceed the Maximum Permissible Exposure limits.

You’re already there. The rest is easy.

Stu and HamRadioSchool.com to the rescue.



Maximum Permissible Exposure limits by frequency. Extracted from FCC OET Bulletin 65.

HF to VHF Exposure Calculator:

Enter values in the bordered green cells below. Power density is calculated in the blue cells both with and without reflection factor. MPE for both controlled and uncontrolled population is calculated and compliance is determined by comparison in the beige cells.

Enter Values:		
Transmitter PEP output (W)	100	watts
Feedline length (ft)	75	feet
Feedline loss / 100 ft (dB)	1.076	dB
Operating Mode (select)	Digital	mode
Transmit On Percentage (0 to 1)	0.5	
Transmitting Frequency (MHz)	28.5	MHz
Average Power into Antenna = (Calculated -- no value entry)	41.52	watts
Antenna Gain (dBi)	1	dBi
Distance to Area of Interest (ft)	20	feet

Accurate calculations are performed for HF to VHF frequencies only (3 - 300 MHz). Calculations are performed using formulas prescribed in FCC OET Bulletin 65 for far-field power density estimates. These formulas may overestimate field strength of high-gain antennas in the near field (within several wavelengths). These formulas may underestimate the strength of fields within "hot spots" in the near field. No Warranties: This information is provided "as is" without any warranty, condition, or representation of any kind, either express or implied, including but not limited to, any warranty respecting non-infringement, and the implied warranties of conditions of merchantability and fitness for a particular purpose. In no event shall we be liable for any direct, indirect, special, incidental, consequential or other damages howsoever caused whether arising in contract, tort, or otherwise, arising out of or in connection with the use or performance of the information contained on this spreadsheet.

		Controlled MPE	Uncontrolled MPE	
Power Density =	**0.0112** mW/cm^2	1.1080	0.2216	mW/cm^2
	In compliance?	Yes	Yes	
Power Density with Reflection =	**0.0287** mW/cm^2	1.1080	0.2216	mW/cm^2
	In compliance?	Yes	Yes	

HTTPS://HAMRADIOSCHOOL.COM/RF-EXPOSURE-EVALUATING-YOUR-STATION/

WHAT DO I DO IF I EXCEED THE MPE?

Calculations may be looking at worst case parameters. I selected 100% duty cycle and an excessive operating time. Make them more realistic to the way you operate.

- **Evaluate using modeling software (EZNEC) for a more accurate assessment**
- **Alter your antenna – the location of my vertical antenna is exposed. For 10 meters I may need to use a dipole that's elevated**
- **Cut back on your power. There may be situations where you can't fire up that 1.5KW space heater**
- **Decrease your talk time – listen more**
- **Put up a fence and warning signs to keep people greater distance away**
- **Don't operate when people are around**

WHAT ABOUT MY HANDHELD?

Human tissue is most sensitive to VHF

- Older HTs grandfathered
- Newer HTs need modeling (may result in higher prices in future)

Your 75cm HT antenna is within 20cm of your body. The FCC requires specific absorption rate (SAR) testing above 300MHz

- Impractical for hams

ADDITIONAL RESOURCES

RF Exposure and You (ARRL)

- http://www.arrl.org/files/file/Technology/RFsafetyCommittee/RF+Exposure+and+You.pdf

  Note: *Worksheet A: Categorical Exemption for Station Evaluation Worksheet* can be used for informational purposes but the exemption is no longer valid.

http://www.arrl.org/rf-exposure

- ARRL website has a lot of information on the subject

https://youtu.be/_R6MQD-WZiA

- ARRL presentation to RATPAC

MORE RESOURCES

EZNEC

- https://www.eznec.com
- Might be needed for more accurate results

Online calculators

- https://hamradioschool.com/rf-exposure-calculator/
- http://www.lakewashingtonhamclub.org/resources/rf-exposure-calculator/
- https://www.hintlink.com/power_density.htm

QUESTIONS?