Recent Changes to the FCC RF Safety Qualifications for Amateur Radio Stations

Dennis Silage K3DS

RF Safety Qualifications

RF safety qualification is nothing new! The FCC has required that the Maximum Permissible Exposure (MPE) for Amateur Radio stations be assessed since 1998.

The FCC added a certification statement to Form 605 and Form 610 that had to be affirmed by every Radio Amateur who was issued an FCC license, renewed their license or changed their station address.

I certify that:

- I waive any claim to the use of any particular frequency regardless of prior use by license or otherwise;
- All statements and attachments are true, complete, and correct to the best of my knowledge and belief and are made in good faith;
- I am not a representative of a foreign government;
- I am not subject to a denial of Federal benefits pursuant to Section 5301of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 862;
- The construction of my station will NOT be an action which is likely to have a significant environmental effect [See 47 CFR Sections 1.1301-1.1319 and Section 97.13(a)];
- I have read and WILL COMPLY with Section 97.13(c) of the Commission's Rules regarding RADIO FREQUENCY (RF) RADIATION SAFETY and the amateur service section of OST/OET Bulletin Number 65.

RF Safety Qualifications

Due to the 10-year license period, by 2008, every licensed Radio Amateur in the US had certified that they would comply with the FCC's rules for RF safety.

However, a provision of the rules at that time — Categorical Exemptions in FCC Part §97.13(c)(1) — made it possible for some to avoid evaluating their stations.

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RF Safety Qualifications

In the old rules, there were numerous exemptions from this requirement based on frequency of operation, power level, and the type of operating being done.

For example, mobile and handheld portable transmitters were exempt from the need to evaluate, as were most repeater stations.

QST September 2021

Understanding the Changes to the FCC RF Exposure Rules

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Ed Hare, W1RFI

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Table 1 shows the formulas you can use to determine whether you're exempt from needing to do an evaluation. This table cannot be used for exposure distances $< \lambda/2\pi$ or for distances closer than 20 centimeters.

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Note: Transmitter frequency is in MHz, threshold ERP is in watts, R is in meters, and frequency (f) is in MHz.

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RF Safety Qualifications

The FCC announced new rules for allowable exposure to RF energy in May 2021.

Prior “exemptions” to the rules from 1997 have been removed.

Stations were given until May 2023 to evaluate and comply with the limits to exposure.

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These specific exemptions were replaced in the new rules with simple formula-based methods of determining whether a particular station needs to be evaluated.

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RF Safety Qualifications

Even if your station was exempt from evaluation under the old rules, you will need to assess your station to determine whether or not it needs to be evaluated under the new rules to be in compliance.

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When you complete your evaluation, you have fulfilled the rules requirement.

Unless specifically requested by the FCC, you are not required to submit any paperwork to them. However, it's a good idea for you to keep a copy of your evaluations in your station records.

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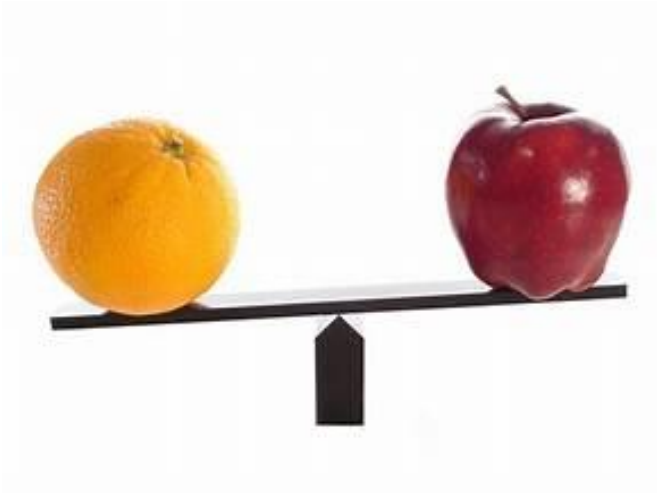
To perform an evaluation, you're going to compare the power density and field strength of your antenna to the limits in the FCC rules.



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This Table 2 shows the limits for the amount of RF exposure that can occur from the operation of any transmitter in any radio service.

Table 2 — Limits for Maximum Permissible Exposure (MPE)				
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	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 – 1500			f/300	< 6
1500 – 100000			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 – 1500			f/1500	< 30
1500 – 100000			1.0	< 30
f = frequency in MHz and * = plane-wave equivalent power density				

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RF Safety Qualifications

Exposure must meet all three limits — power density, electric field, and magnetic field strength.

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(B) Limits for General Population/Uncontrolled Exposure				
(A) Limits for Occupational/Controlled Exposure				

The limits are for exposure averaging over 30 minutes for Uncontrolled and 6 minutes for Controlled.

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To obtain this average exposure, evaluation should determine the average power of the transmitter, using mode duty factors and the on/off duty cycle of the transmitter over the averaging period.

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RF Safety Qualifications

This seems to be incomprehensible and a lot of work!

In·com·pre·hen·si·ble

/ˌinˌkämprəˈhensəb(ə)l/

adjective

1. not able to be understood; not intelligible:
   "a language that is incomprehensible to anyone outside the office"

RF Safety Qualifications

However, the ARRL has simplified this assessment with an RF exposure calculator and you don't need to be a member to use it!

www.arrl.org/rf-exposure-calculator

RF Exposure Calculator

- FCC RF-Exposure Regulations -- the Station Evaluation
- ARRL RF Safety Committee
- **RF Exposure Calculator**
- RF Exposure Calc Instructions
- Changes in the FCC RF Exposure Regulations

The FCC has changed its RF-exposure rules, eliminating service-specific exemptions from the need to do a routine RF-safety evaluation and replacing those exemptions with a formula that applies to all radio services. See the FAQ on the ARRL RF-Exposure page for more information. The rules did not change the exposure limits nor the two-tiered exposure environments for controlled and uncontrolled exposure. The controlled limits generally apply to amateurs and members of their household if those people have been given instructions by the amateur about RF safety. The uncontrolled limits apply in all other circumstances, such as exposure to the general public.

To use the RF Exposure Calculator, fill-in the form below with your operating power, antenna gain, and the operating frequency. Depending on how far above ground the RF source is located, you might want to consider ground reflections — and then click "Calculate".

You may need to run the calculator multiple times to get a complete picture of your situation, i.e. take into account the antenna's lobes and directionality.

This calculator should not be used for antennas that are less than 20 cm (8 in) from a person.

View detailed instructions for each parameter. (opens in new tab/window)

Parameters

- Power at Antenna: (Need help with this?) _____ (watts)
- Mode duty cycle:
  Conversational SSB, no speech processing (mode duty cycle=20%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 10 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) _____
- Operating Frequency (MHz): _____

☑ Include Effects of Ground Reflections

If you would like to receive future announcements of any FCC news related to RF-exposure or the requirements for amateurs to evaluate their stations, you may **optionally** provide an email address.

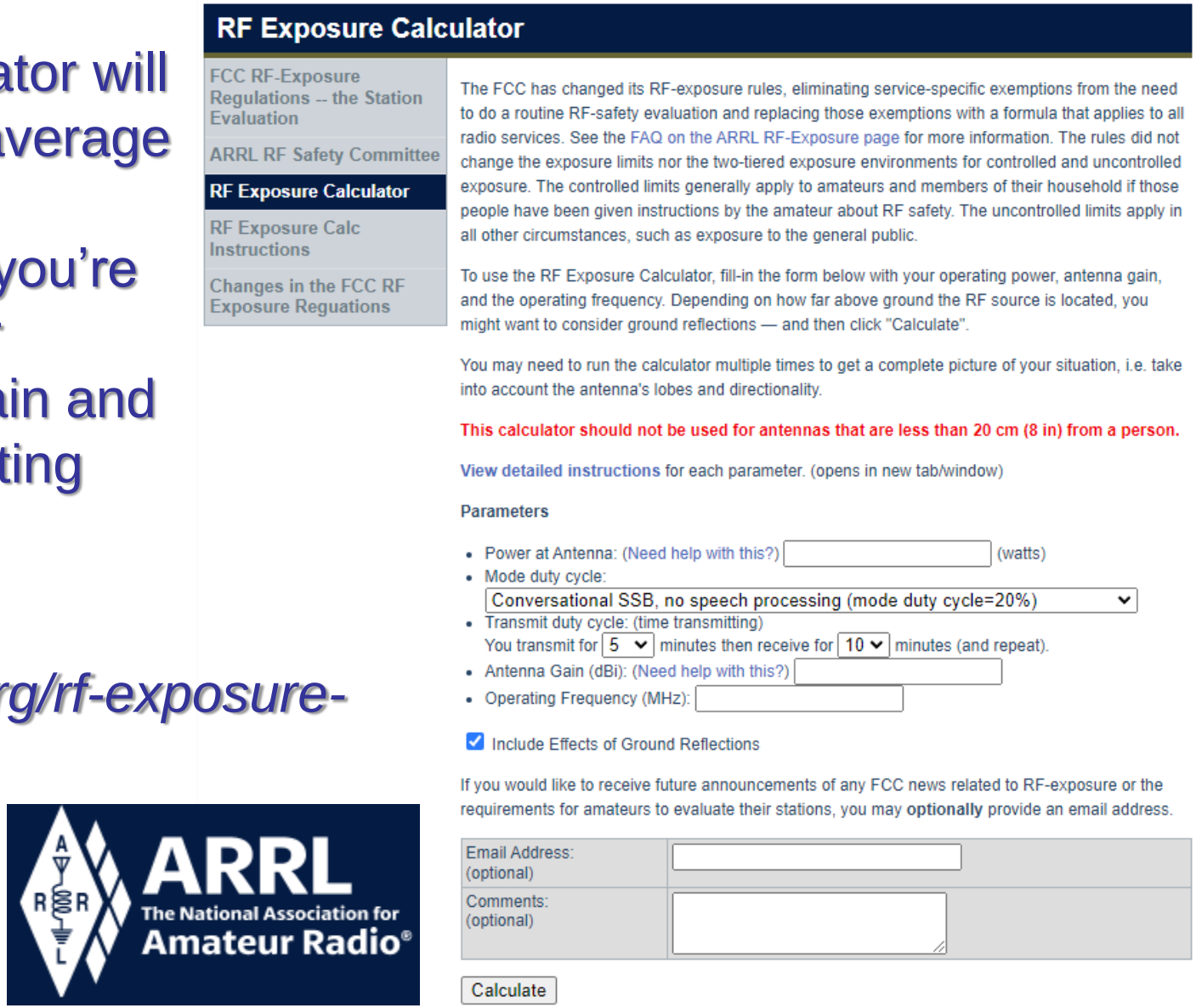
Email Address: (optional)	
Comments: (optional)	

Calculate

RF Safety Qualifications

The calculator will take your average power, the frequency you're using, your antenna gain and your operating mode.

www.arrl.org/rf-exposure-calculator



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You calculate your average power by inputting the mode with the highest duty factor and the on/off operating times.

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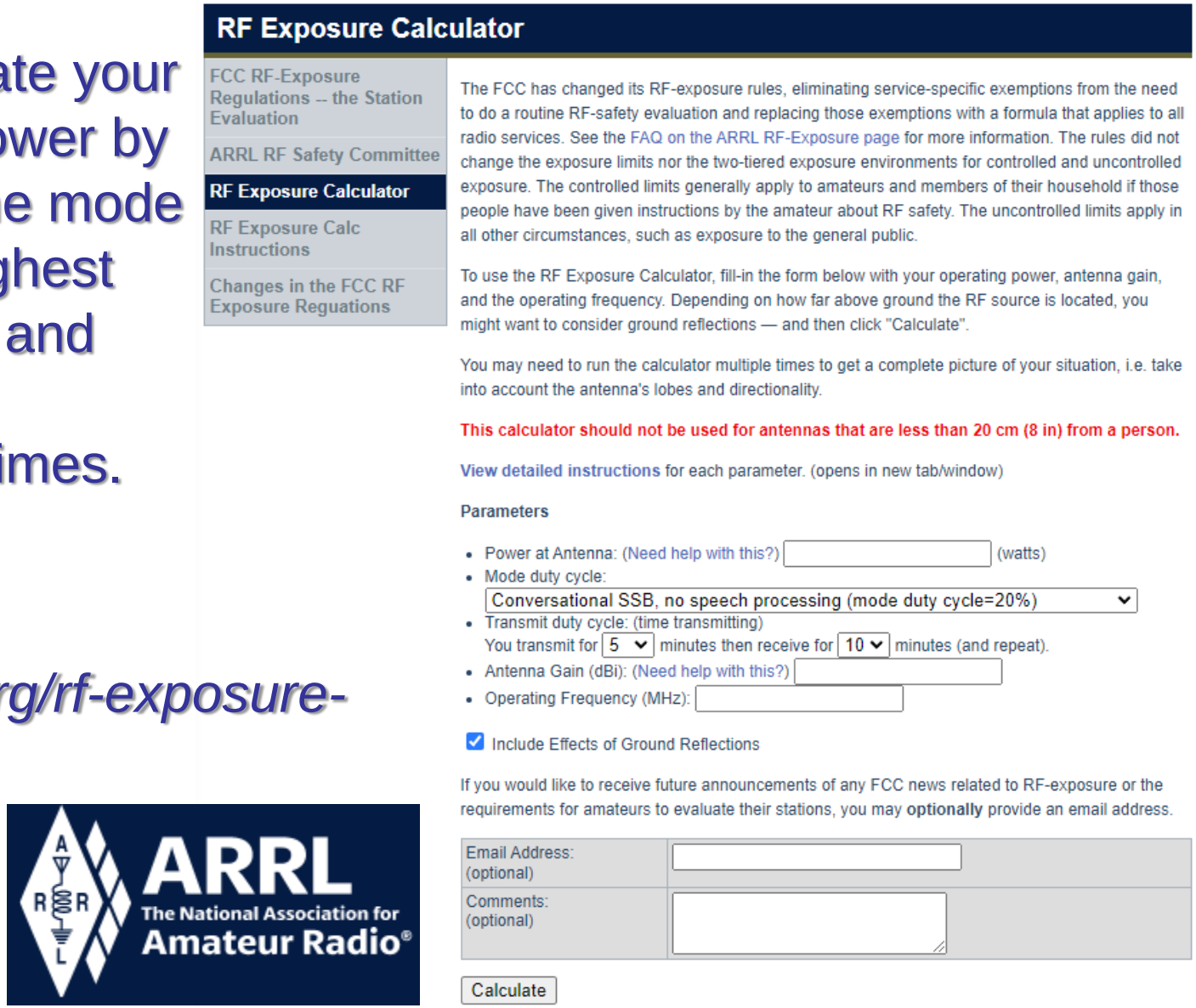

ARRL The National Association for Amateur Radio®

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Enter your parameters into the on-line calculator:

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  Conversational SSB, no speech processing (mode duty cycle=20%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 10 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) _____
- Operating Frequency (MHz): _____

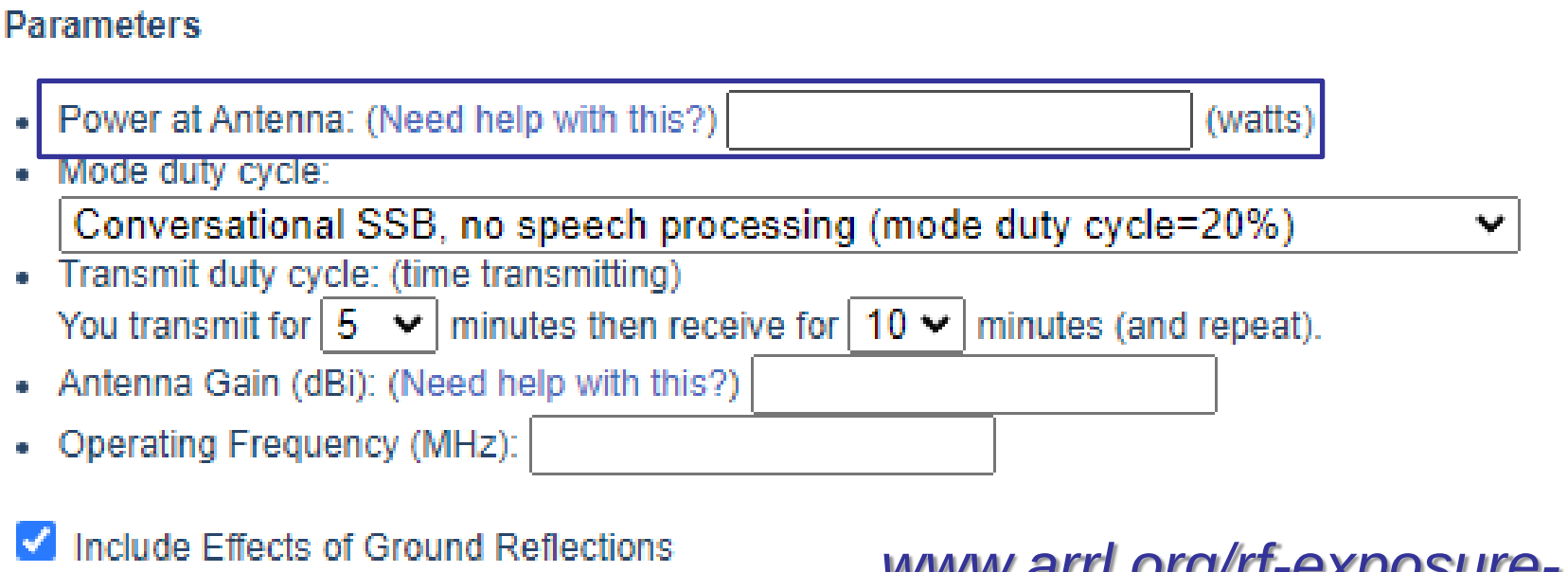
☑ Include Effects of Ground Reflections

ARRL The National Association for Amateur Radio®

www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

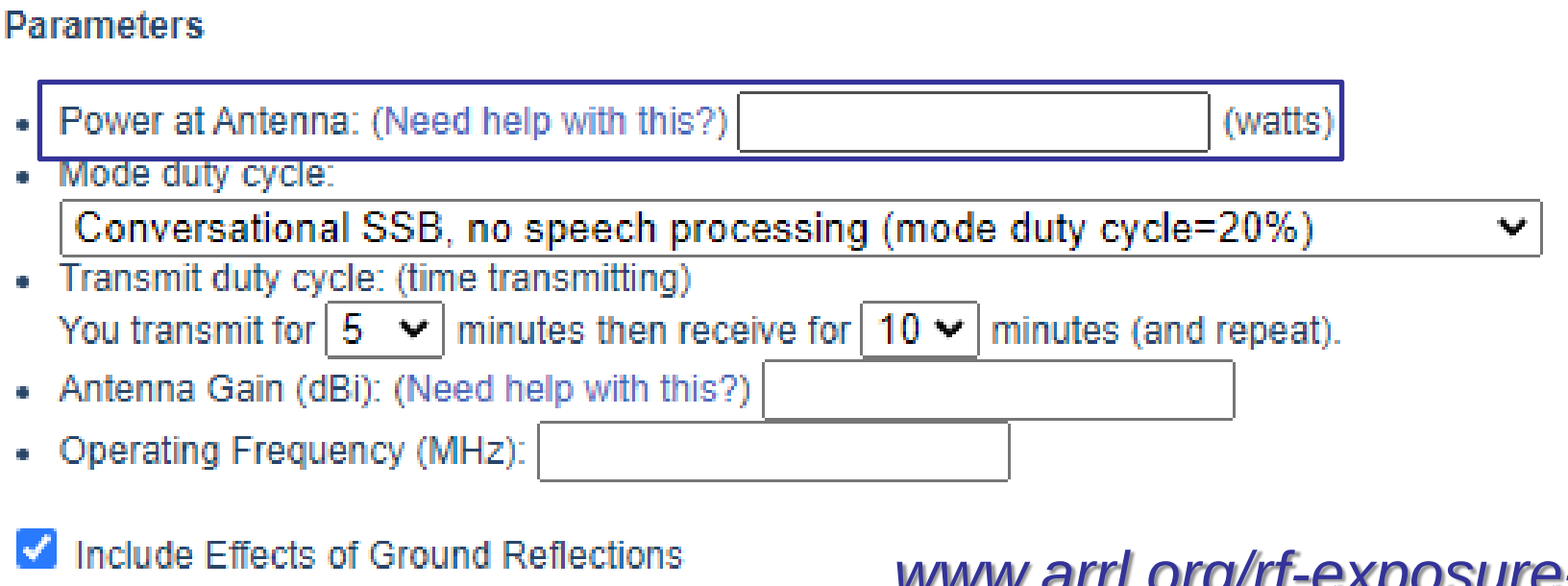
Power at Antenna. This is the transmitter power minus feedline losses. At VHF/UHF frequencies, the feedline loss can result in significantly less power applied to the antenna compared to the transmitter power.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

Power at Antenna. You can use a coax loss calculator or you can be conservative and enter the transmitter's output power.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

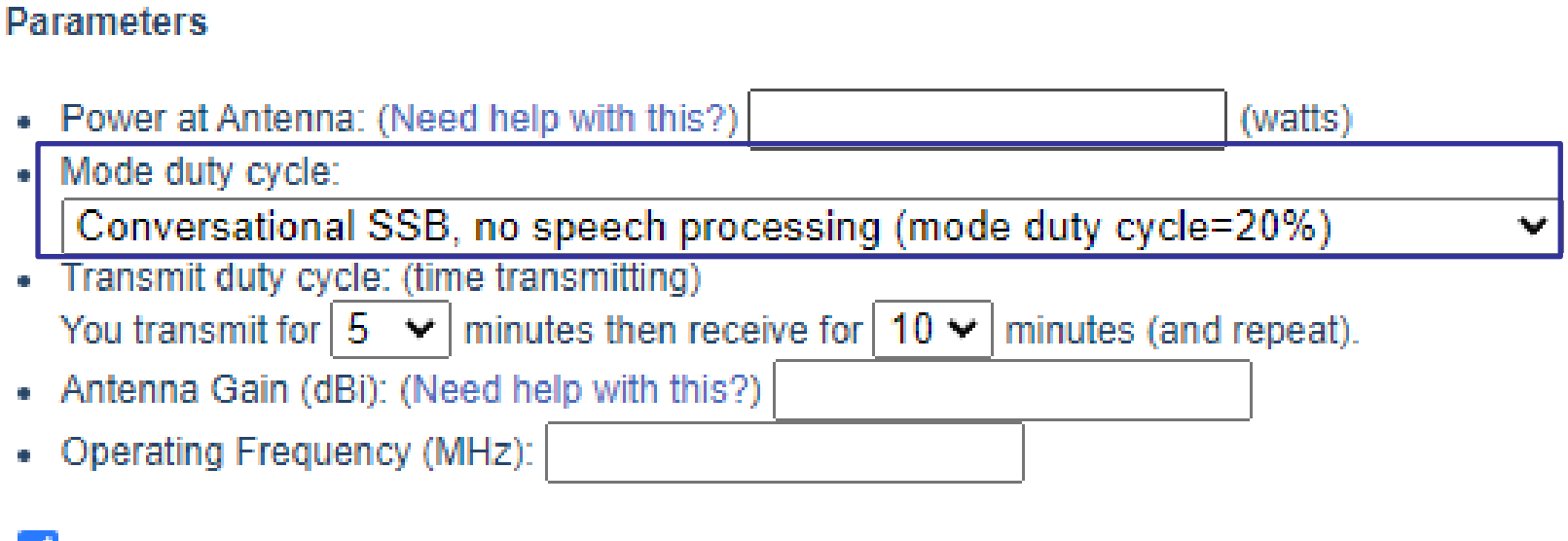
Power at Antenna. Coax loss calculator at:
qsl.net/co8tw/Coax_Calculator.htm

Set Parameters as Desired		
Line Type:	Belden 9913 (RG-8)	
Line Length:	100	◉ Feet ○ Meters
Frequency:	144	MHz
Load SWR:	1	: 1
Power In:	100	W
Calculate		

Results		
Matched Loss:	1.541	dB
SWR Loss:	0	dB
Total Loss:	1.541	dB
Power Out:	70.129	W

RF Safety Qualifications

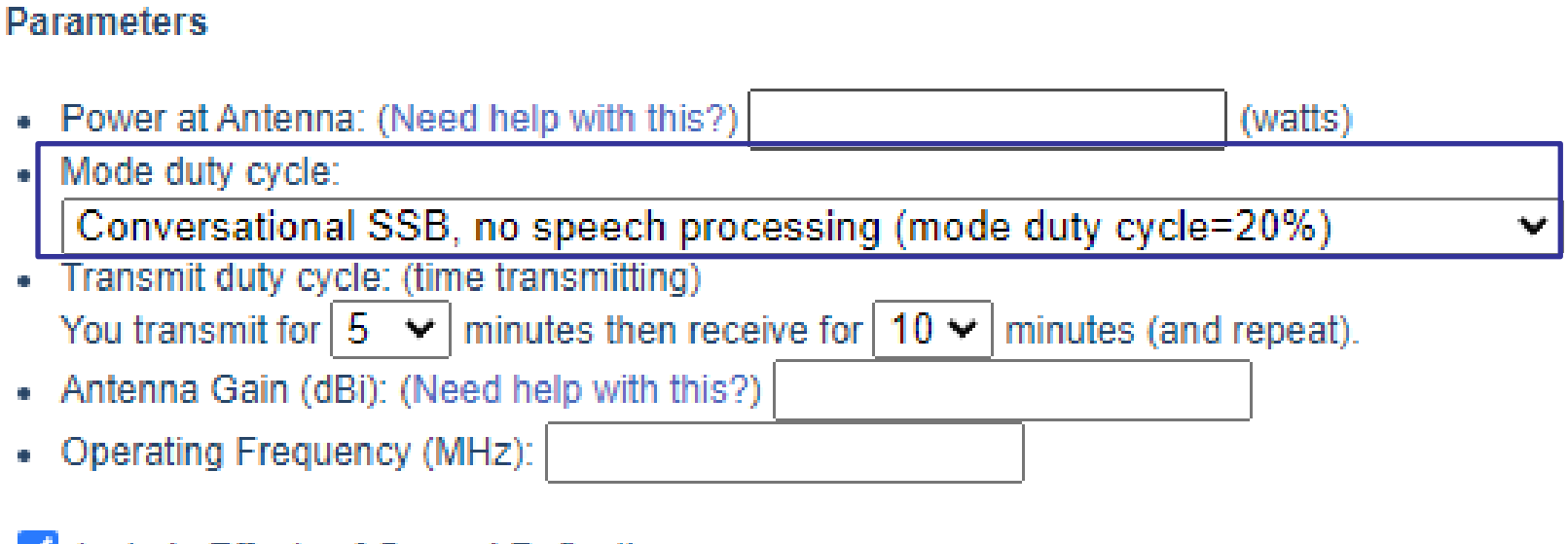
Mode duty cycle: There is a pull-down list. Conversational SSB with no speech processing, uses a 20% duty cycle which includes voice characteristics and syllabic duty factor.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

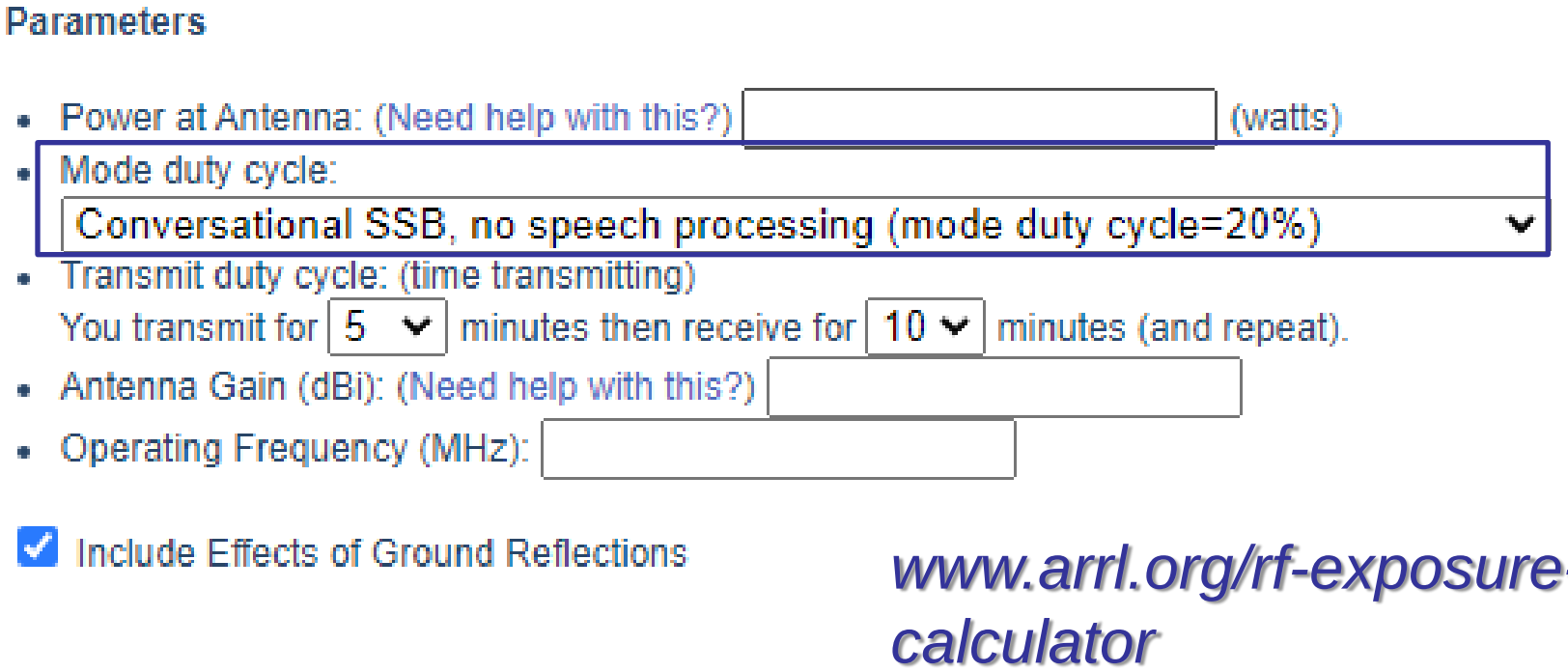
Mode duty cycle: Conversational SSB with heavy speech processing, uses a 50% duty cycle which includes voice characteristics and syllabic duty factor. Voice FM uses a 100% duty cycle. AFSK SSB uses a 100% duty cycle.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

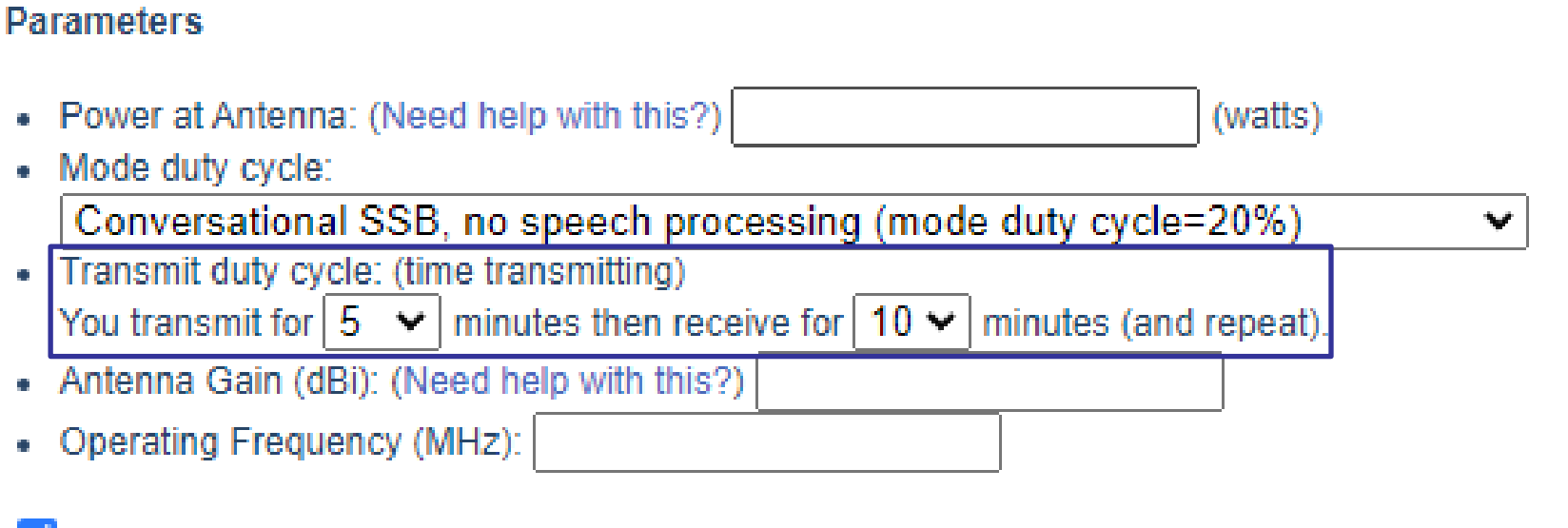
Mode duty cycle: Conversational CW uses a 40% duty cycle. Carrier always on (commonly used for tune-up purposes) uses a 100% duty cycle. For all others or if unknown use a 100% duty cycle as a worst case.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

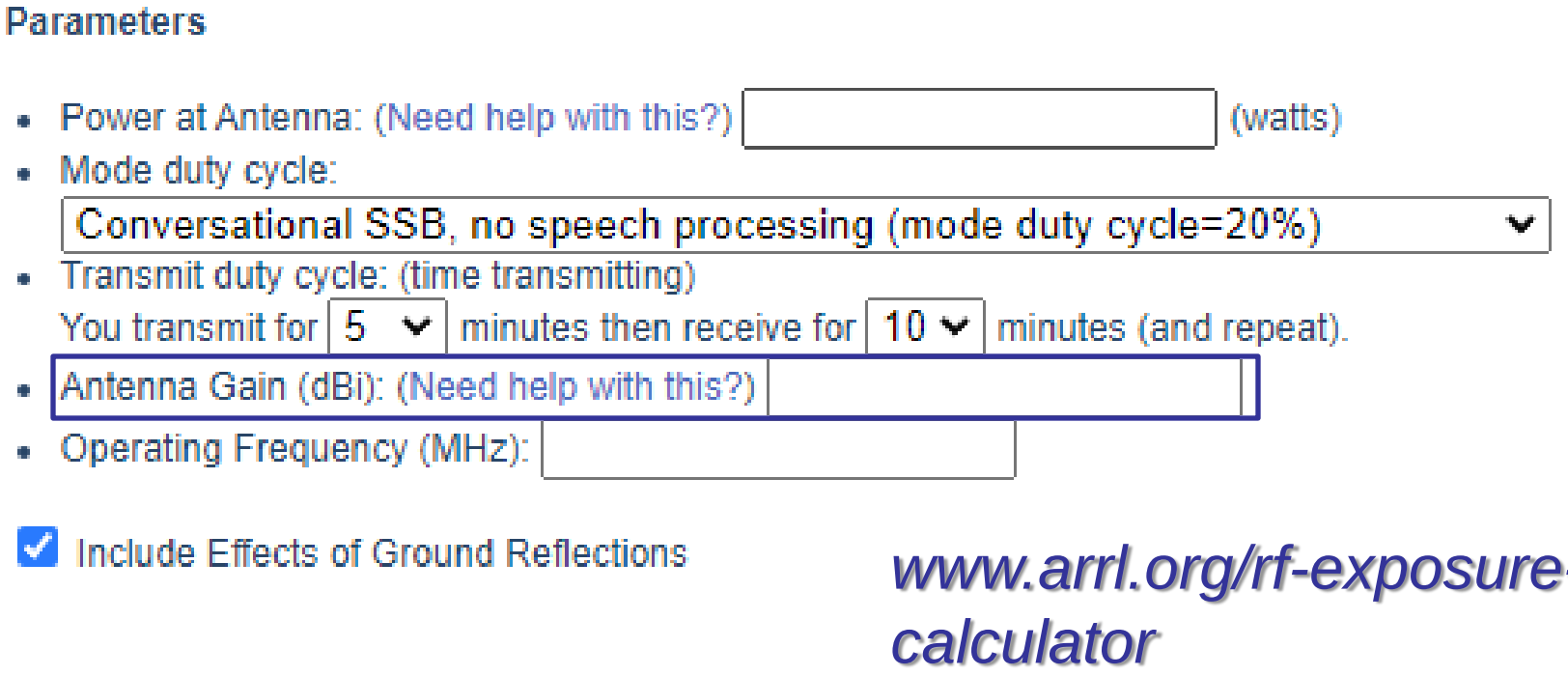
Transmit duty cycle: To figure out your percentage of transmitting, enter the number of minutes you usually transmit, followed with the number of minutes you usually receive. This affects the average output power.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

Antenna Gain (dBi): Enter your antenna gain in dBi. You can use the manufacturer's free space gain in dB referenced to isotropic (dBi) if available. You can also use your own or the manufacturer's antenna model.



www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

Antenna Gain (dBi): Finally, if you have no idea what your antenna's radiation pattern looks like, use this Table as a first approximation.

Refine your input as you research your situation over time.

www.arrl.org/rf-exposure-calculator

rsgb./org/main/technical/emc/emf-exposure

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

RF Safety Qualifications

Operating Frequency (MHz):
Enter your operating frequency in MHz.

Parameters

- Power at Antenna: (Need help with this?) _____ (watts)
- Mode duty cycle:
  Conversational SSB, no speech processing (mode duty cycle=20%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 10 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) _____
- Operating Frequency (MHz): _____

☑ Include Effects of Ground Reflections

www.arrl.org/rf-exposure-calculator

RF Safety Qualifications

RF safety qualifications are presented for a *controlled* and an *uncontrolled* environment.

The FCC has determined that Amateur Radio operators and the members of their households can be evaluated to the higher or *controlled* exposure limits if the Amateur has provided them with RF safety instruction and training.

The *uncontrolled* exposure limits are for every else, like your neighbors.

RF Safety Qualifications

Example 1: 40 meter. half wave dipole with 100 feet of RG-58C coax, running 50 W with FT8 on 7.074 MHz.

Power at the antenna is about 37.4 W

Set Parameters as Desired	
Line Type:	Belden 8259 (RG-58C)
Line Length:	100 ◉ Feet ○ Meters
Frequency:	7.074 MHz
Load SWR:	1 : 1
Power In:	50 W
Calculate	

Results		
Matched Loss:	1.265	dB
SWR Loss:	0	dB
Total Loss:	1.265	dB
Power Out:	37.369	W

RF Safety Qualifications

Example 1: FT8 is AFSK SSB with a duty cycle of 100%. At the worst case, you normally transmit 15 seconds on and 15 seconds off. Here we'll use 1 minute on and 1 minute off from the pull-down list.

The 40 meter, half wave dipole has a gain of 2.15 dBi from the chart.

Parameters

- Power at Antenna: (Need help with this?) 37.4 (watts)
- Mode duty cycle:
  AFSK SSB (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 1 minutes then receive for 1 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 2.15
- Operating Frequency (MHz): 7.074

RF Safety Qualifications

Example 1: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(A) Limits for Occupational/Controlled Exposure				
3.0 – 30	1842/f	4.89/f	*(900/f^2)	< 6

900/(7.074^2) = 17.9851

Results for a controlled environment:

Maximum Allowed Power Density (mW/cm^2): 17.9851

Minimum Compliance Distance (feet): 0.6116

Minimum Compliance Distance (meters): 0.1864

RF Safety Qualifications

Example 1: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(B) Limits for General Population/Uncontrolled Exposure				
1.34 – 30	824/f	2.19/f	*(180/f^2)	< 30

180/(7.074^2) = 3.5970

For an uncontrolled environment:

Maximum Allowed Power Density (mW/cm^2): 3.5970

Minimum Compliance Distance (feet): 1.3676

Minimum Compliance Distance (meters): 0.4168

RF Safety Qualifications

Example 1: These results indicate that there is no problem with the example of a 40 meter, half wave dipole with 100 feet of RG-58C coax, running 50 W with FT8 on 7.074 MHz. The compliance distance is greater than 1.37 feet (0.42 m) in the worst case.

Results for a controlled environment:

Maximum Allowed Power Density (mW/cm^2):	17.9851
Minimum Compliance Distance (feet):	0.6116
Minimum Compliance Distance (meters):	0.1864

For an uncontrolled environment:

Maximum Allowed Power Density (mW/cm^2):	3.5970
Minimum Compliance Distance (feet):	1.3676
Minimum Compliance Distance (meters):	0.4168

RF Safety Qualifications

Example 2: 10 meter, 3 element Yagi with 100 feet of RG-8 coax, running 100 W with CW on 28.5 MHz.

Power at the antenna is about 85.9 W

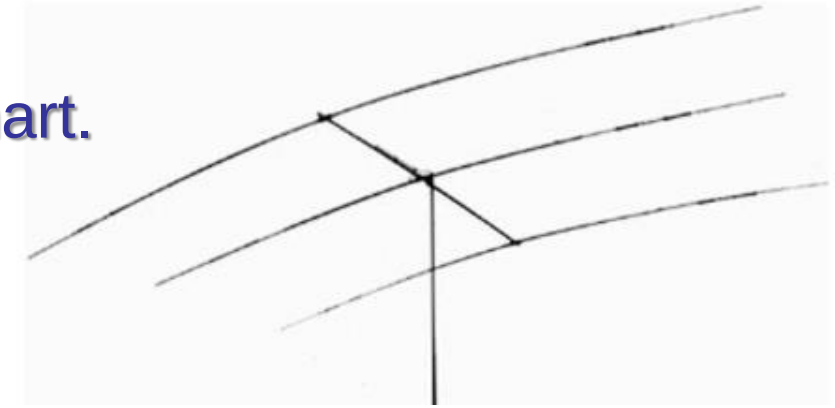
Set Parameters as Desired		
Line Type:	Belden 9913 (RG-8)	
Line Length:	100	◉ Feet ○ Meters
Frequency:	28.5	MHz
Load SWR:	1	: 1
Power In:	100	W
	Calculate	

Results		
Matched Loss:	0.662	dB
SWR Loss:	0	dB
Total Loss:	0.662	dB
Power Out:	85.86	W

RF Safety Qualifications

Example 2: Conversational CW has a duty cycle of about 40%. You might transmit 2 minutes on and 2 minutes off.

The 3 element Yagi has a gain of 8.1 dBi from the chart.



Parameters

- Power at Antenna: (Need help with this?) 100 (watts)
- Mode duty cycle:
  Conversational CW (duty cycle=40%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 2 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 8.1
- Operating Frequency (MHz): 28.5

RF Safety Qualifications

Example 2: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(A) Limits for Occupational/Controlled Exposure				
3.0 – 30	1842/f	4.89/f	*(900/f^2)	< 6

We need to be about 5.84 feet (1.78 m) away.

900/(28.5^2) = 1.1080

Results for a controlled environment:

Maximum Allowed Power Density (mW/cm^2):	1.1080
Minimum Compliance Distance (feet):	5.8372
Minimum Compliance Distance (meters):	1.7792

RF Safety Qualifications

Example 2: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(B) Limits for General Population/Uncontrolled Exposure				
1.34 – 30	824/f	2.19/f	*(180/f^2)	< 30

We need to be about 11.7 feet (3.56 m) away.

180/(28.5^2) = 0.2216

For an uncontrolled environment:

Maximum Allowed Power Density (mW/cm^2):	0.2216
Minimum Compliance Distance (feet):	11.6745
Minimum Compliance Distance (meters):	3.5584

RF Safety Qualifications

Example 3: However, another example that operates at UHF with high power produces much worse results: a 10 element Yagi with 100 feet of LMR-600 coax, running 500 W with CW on 432.1 MHz.

Power at the antenna is about 339.3 W.

Set Parameters as Desired		
Line Type:	TMS LMR-600	
Line Length:	100	Feet / Meters
Frequency:	432.1	MHz
Load SWR:	1	: 1
Power In:	500	W
Calculate		

Results		
Matched Loss:	1.684	dB
SWR Loss:	0	dB
Total Loss:	1.684	dB
Power Out:	339.253	W

RF Safety Qualifications

Example 3: Conversational CW has a duty cycle of about 40%. You might transmit 2 minutes on and 2 minutes off.

The 10 element Yagi has a gain of 15.1 dBi from the chart.

Parameters

- Power at Antenna: (Need help with this?) 500 (watts)
- Mode duty cycle:
  Conversational CW (duty cycle=40%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 2 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 15.1
- Operating Frequency (MHz): 432.1

RF Safety Qualifications

Example 3: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(A) Limits for Occupational/Controlled Exposure				
300 – 1500			f/300	< 6

We need to be about 25.6 feet (7.81 m) away.

432.1/300 = 1.4403

Results for a controlled environment:

Maximum Allowed Power Density (mW/cm^2):	1.4403
Minimum Compliance Distance (feet):	25.6294
Minimum Compliance Distance (meters):	7.8118

RF Safety Qualifications

Example 3: The calculated results are shown: Calculate

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
(B) Limits for General Population/Uncontrolled Exposure				
300 – 1500			f/1500	< 30

We need to be about 51.3 feet (15.62 m) away.

432.1/1500 = 0.2881

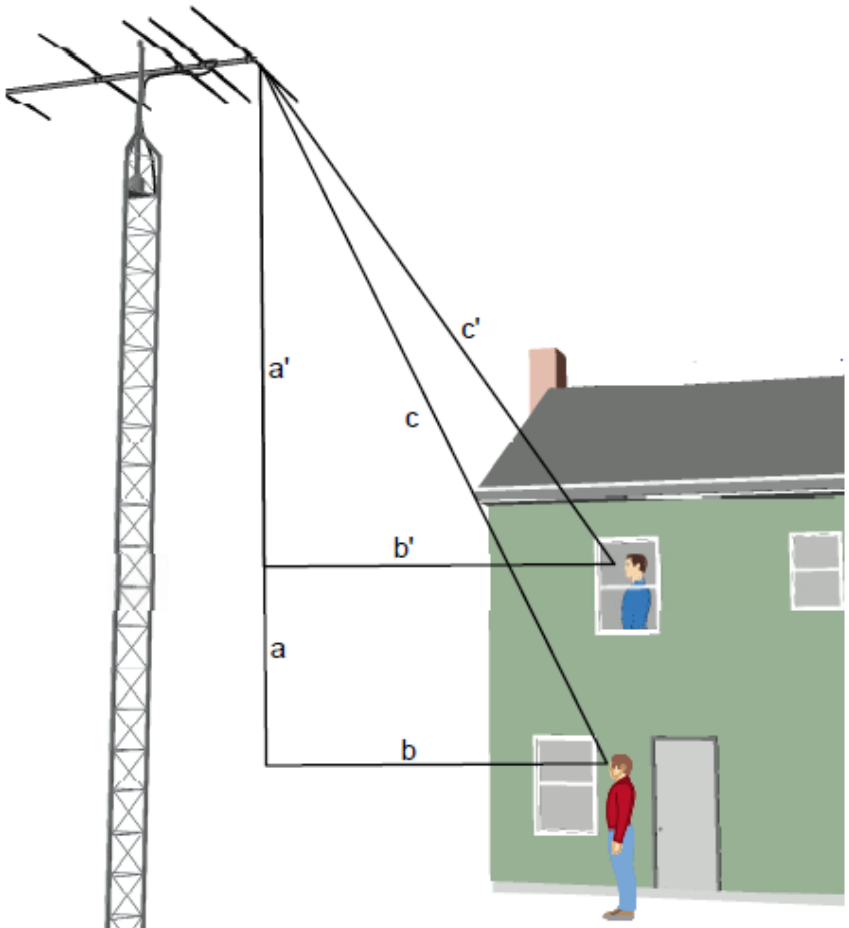
For an uncontrolled environment:

Maximum Allowed Power Density (mW/cm^2):	0.2881
Minimum Compliance Distance (feet):	51.2587
Minimum Compliance Distance (meters):	15.6237

RF Safety Qualifications

The RF safety qualification minimum compliance distance must consider the layout of the antenna system in the environment.

You would include the antenna height, the nearest point of the person being exposed, and the horizontal distance between the antenna and the exposure point to find the compliance distance (c or c’ as shown).



RF Safety Qualifications

The FCC also requires *positive access control* which becomes the responsibility of all affected Radio Amateurs under the new rules.

The ARRL reiterated these new rules at the end of the 2-year transition in *QST* May 2023.

FCC Exposure Rules Soon to Affect Every US Radio Amateur

As the 2-year transition period comes to an end, the ARRL RF Safety Committee Chair discusses the rules and how to evaluate your station's RF exposure to ensure compliance.

Gregory Lapin, PhD, PE, N9GL

On May 3, 2021, new FCC rules governing RF exposure went into effect. A 2-year transition period was implemented to allow existing stations to make any necessary changes. On May 3, 2023, the transition period ends, and all transmitters operating in the US are expected to comply with the exposure rules.

A Brief History

FCC RF exposure rules aren't new to radio amateurs. In 1996, the FCC enacted the first exposure regulations that affected the Amateur Radio Service, and all amateur radio stations were expected to comply by 1998. In addition to rules governing Maximum Permissible Exposure (MPE) for amateur radio stations, some procedural rules were applied. For the FCC to be assured that radio amateurs understood the important aspects of RF exposure to humans, they required that every amateur radio examination contain at least one question related to exposure. In order to correctly answer that question, the entire question pool had to be studied and, in doing so, every licensed amateur radio operator would be assumed to have knowledge about the subject.

The FCC also added a certification statement to Form 605 and Form 610 that had to be affirmed by every radio amateur who was issued an FCC license, renewed their license, or changed their station address. Due to the 10-year license period, by 2008, every licensed radio amateur in the US had certified that they would comply with the FCC's rules for RF safety.

Many radio amateurs determined that their stations complied with the FCC exposure regulations by 1998. However, a provision of the rules at that time — Categorical Exemptions in FCC Part §97.13(c)(1) — made it possible for some to avoid evaluating their stations.

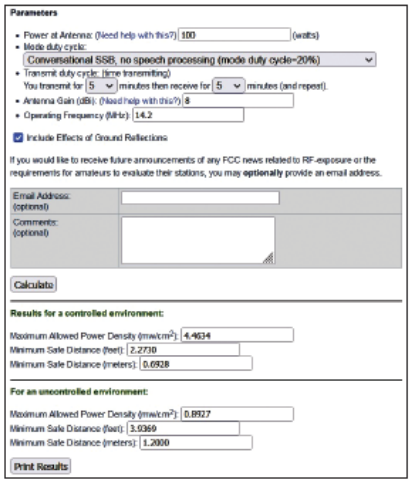


Figure 1 — The ARRL RF Exposure Calculator, showing a sample analysis for a 100 W transmitter with no feed-line loss and normal (non-compressed) SSB modulation into a 20-meter Yagi. The closest that any part of a person can be to any part of the antenna is 0.7 meter (2.3 feet) for the occupational population, or 1.2 meters (3.9 feet) for the general population. Note that this calculator is not valid for exposure distances less than 20 centimeters (8 inches) from a person.

To simplify the determination of human exposure compliance for many radio amateurs, the FCC set up some operating conditions that would preclude amateurs who operated under those limits from being required to assess their stations. For instance, if a transmitter produced less than 225 W on 20 meters, no further assessment would be required for that band. The conditions for categorical exemption were based on power and frequency. In addition, all mobile

RF Safety Qualifications

If a location is identified as causing excessive exposure to people within it, the FCC expects every Amateur Radio station to prevent access by unauthorized persons to that location and to post warning signs about potential high RF exposure.

RF Safety Qualifications

However, it does seem that a typical Amateur Radio station operating conservatively would be in compliance, but you must have the documentation available, if requested.

The ARRL has made the September 2021 and May 2023 *QST* articles and other materials available for download.

www.arrl.org/rf-exposure

Understanding the Changes to the FCC RF Exposure Rules

Learn whether these changes affect your station, and how you can easily evaluate it to comply with FCC regulations.

Ed Hare, W1RFI

On May 3, 2021, the new FCC ru
sure to RF energy went into effec
under the exemptions included in
comply with the rules changes by
article provides a historical backg
teur rules for RF exposure, as we
about the exposure limits, other re
amateur stations, and changes to
can continue to be exempt from th
evaluate their stations.

Recent Changes to the R

When the FCC first introduced re
human exposure to RF energy in
was included. The first RF exposu
human exposure to radio transmi
limits applied to amateur radio, ar
required to evaluate their stations

In 2020, the FCC finalized signific
rules. Under the new rules, amate
required to comply with the expos
amateur stations are required to c
station evaluation" to determine th
plies with the limits for human exp
rules, there were numerous exem
requirement based on frequency
level, and the type of operating be
handheld portable transmitters th
(PTT) were exempt from the need
most repeater stations. These ser
tions were replaced in the new ru
formula-based methods of detern
particular station needs to be eva

Determining If Your Stati Needs an Evaluation

If you performed an evaluation of
the old rules, you don't need to to
you make a change that could inc

of RF energy present near your station, such as in-

FCC Exposure Rules Soon to Affect Every US Radio Amateur

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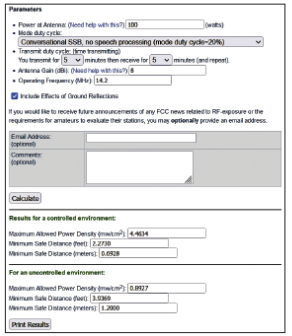

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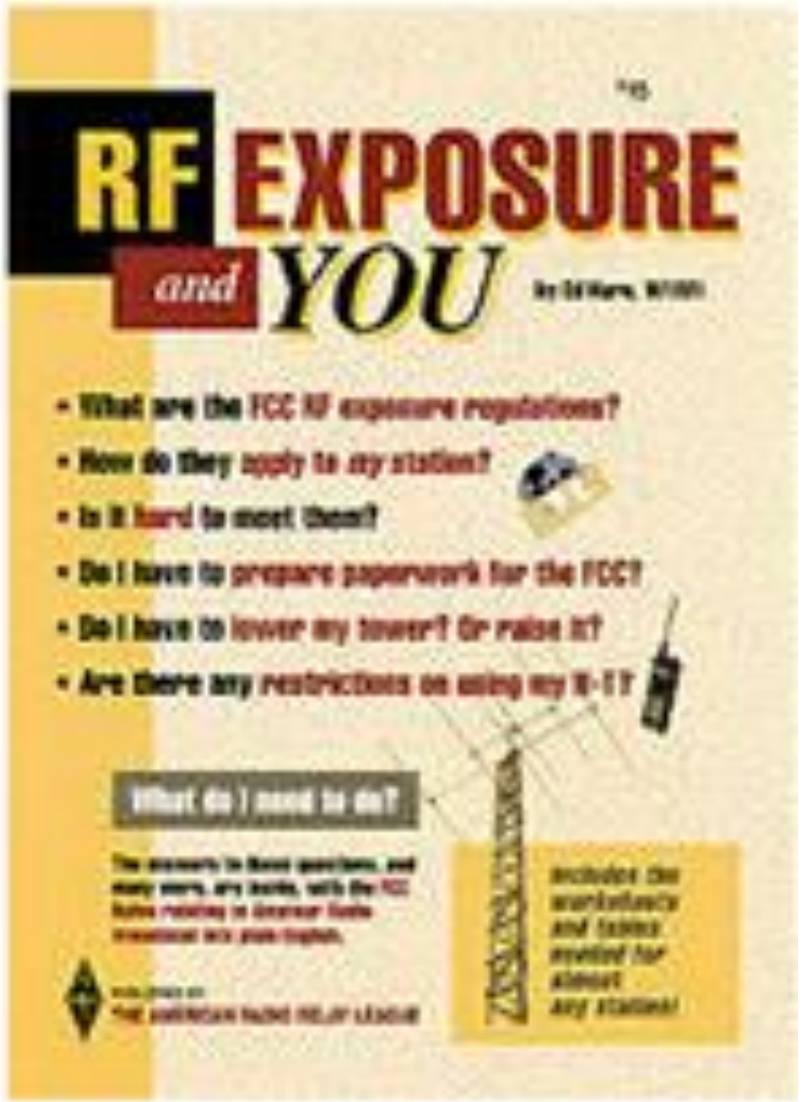
RF Safety Qualifications

Finally, there is a *free book* from the ARRL on RF exposure with more technical information. The book is 316 pages!



www.arrl.org/files/file/Technology/RFsafetyCommittee/RF+Exposure+and+You

Recent Changes to the FCC RF Safety Qualifications for Amateur Radio Stations

Dennis Silage K3DS

Questions?

Recent Changes to the FCC RF Safety Qualifications for Amateur Radio Stations

Dennis Silage K3DS