

Updated Radio Frequency Exposure Rules Become Effective on May 3

Prepared for the Valley Amateur Radio Association & the Massanutten Amateur Radio Association
Prepared By Bob McCracken N4JGO

By now most of you have heard that each of us will be required to conduct an RF exposure evaluation of our individual stations. The requirement to conduct an RF exposure evaluation is nothing new. It has been around for quite awhile. The Amateur Radio Community has been excluded in the past, but now each of us is required to perform these tests. If you do not make any changes to your radio, cabling or antenna, you have until May 3, 2023 to do this evaluation. If you do make changes to your radio, cabling or antenna, you are required to perform this evaluation prior to putting the station into service.

The requirement to conduct an RF exposure evaluation is described in FCC regulation §97.13. This regulation provides a table of all amateur radio bands with a transmitted power level in watts for each band (see Table 1). The regulation now states that an RF environmental evaluation must be performed whether the station's PEP power into the antenna exceeds the table value for the band of operation or not.

Table 1. Power Thresholds for Routine Evaluation of Amateur Radio Stations

Wavelength Band	Evaluation Required if Power* (watts) Exceeds:
MF	
160 m	500
HF	
80 m	500
75 m	500
40 m	500
30 m	425
20 m	225
17 m	125
15 m	100
12 m	75
10 m	50
VHF (all bands)	50
UHF	
70 cm	70
33 cm	150
23 cm	200
13 cm	250
SHF (all bands)	250
EHF (all bands)	250
Repeater stations (all bands)	<u>non-building-mounted antennas:</u> height above ground level to lowest point of antenna < 10 m <u>and</u> power > 500 W ERP <u>building-mounted antennas:</u> power > 500 W ERP

* Transmitter power = PEP input to antenna. For repeater stations *only*, power exclusion based on ERP (effective radiated power).

<https://transition.fcc.gov/bureaus/oet/info/documents/bulletins/oet65/oet65b.pdf>

Regulation, §97.13 states that the calculation must be performed as prescribed by §1.1307(b), but for amateur radio stations the *FCC Office of Engineering and Technology (OET) Bulletin 65* provides the best guidance for complying with §1.1307(b) evaluation methods.

This announcement of being compliant with the FCC regulation has raised a lot of questions ranging from what information does the FCC want; am I going to need special equipment to do this work; what values I am supposed to calculate; do I need to send my results to the FCC; and many more. Our intent is to help guide you through these questions and uncover what readily available techniques exist to help us all be compliant.

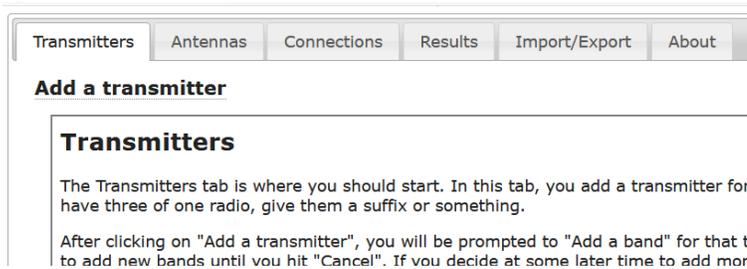
As most of you are aware there are many RF Exposure Calculators on-line. One that we found to be exceptional was one written by Vernon Mauery, N7OH. He utilizes the same formula that is specified in the OET Bulletin 65. The main feature of his application is the ability to enter all of your station equipment one time, edit it, and have it saved or import and export it. The link below is to Vernon's web site. We have been in contact with Vernon N7OH, and he encourages us to use his calculator, as well as, he has no future plans to remove the calculator site. The link below is where you will find the calculator.

http://vernon.mauery.com/radio/rfe/rfe_calc.html.

Once you navigate to the above link you will see that each of the entry tabs on his calculator have a brief help section explaining each of the steps. To compliment those help sections we have compiled a **“basic set of instructions”** that should enable you to get started. *“Once you walk through these instructions you will agree that this calculator program is a very intuitive program, and you will be navigating it in various ways to suit your needs.”*

Open the RF Calculator link to begin your calculations.

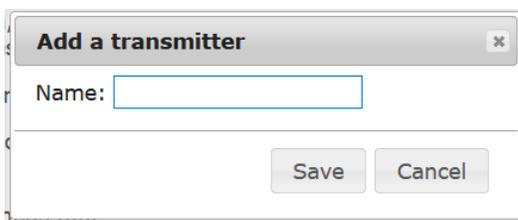
The opening screen will default with the **Transmitters** tab highlighted.



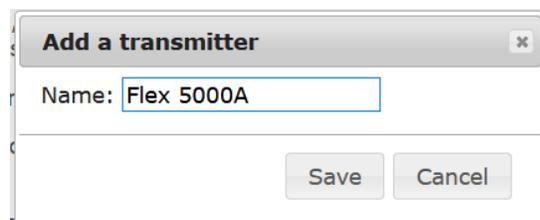
For this basic instruction let's get started by adding all of your transmitters (*not mobile radio's*) and the bands (HF/VHF) that that each transmitter is capable of.

Start by *clicking* the **"Add transmitter"** link at the top left of the page.

A small **"Add a transmitter"** entry box should now appear in the center of your screen.



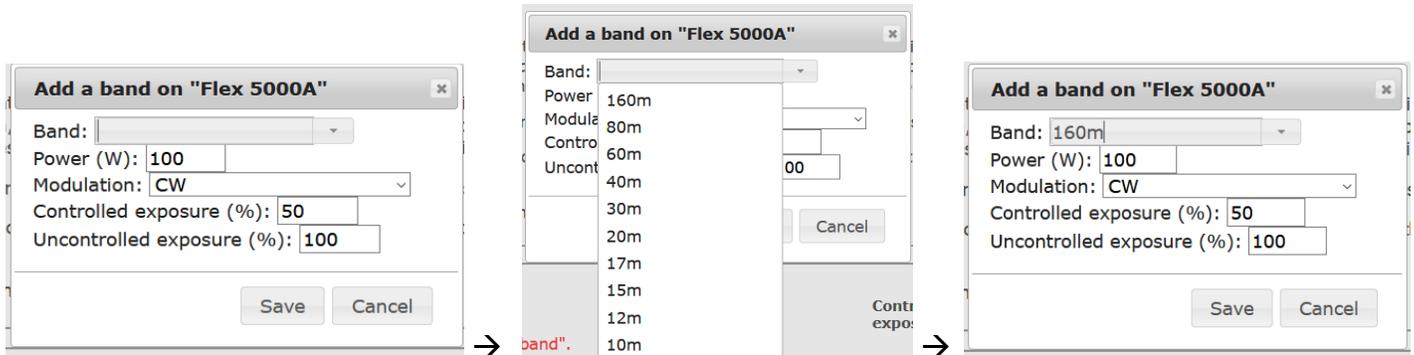
Example →



Type in the model of radio that you are using into the **Name** text box and then *click* the save button. If you have 2 or more of the same type of transmitter, simply add a number to the end of the transmitter name.

Example: Icom 7300-1 and Icom 7300-2 etc.

Next, the "Add a band on your transmitter" entry box appears. Since we are required to do the calculations for all of the bands we will be using, I am going to start with 160m. *Select* 160m from the list in the drop down box.



Next, we will need to enter the rest of the parameters reflecting how you operate on 160m. With this calculator you can only enter one specific band per transmitter. So, it is recommended that you select a **Modulation** entry that has the highest **Duty Factor** that you will be using on that band. (See Table 2). This way you will be within the limits on a lower **Operating Mode**.

Table 2

Operating Mode	Duty Factor
Conversational SSB, no processing	20%
Conversational SSB, with processing	40%
[Voice] FM	100%
FSK or RTTY	100%
AFSK [SSB]	100%
FT4/FT8	50%
Conversational CW	40%
Carrier	100%

Next you will need to *enter* the power you will be using. This calculator uses PEP to do the calculations.

Note: If you are using an amplifier be sure to use that power for your entry.

In my case I use 100 watts PEP; and SSB: no processing.

Next on the list are the exposure entries.

Add a band on "Flex 5000A"

Band: 160m

Power (W): 100

Modulation: SSB: no processing

Controlled exposure (%): 65

Uncontrolled exposure (%): 80

Save Cancel

The **Controlled exposure %** is the percentage of time that you are transmitting in a 6-minute window. This can vary from conversation to conversation, so I like to be a little aggressive on this setting and go for 65% of the 6-minute window.

The **Uncontrolled exposure %** is the percentage of time that you are transmitting in a 30-minute window. Again, this can vary from conversation to conversation, so I like to be a little aggressive on this also and go for 80% of the 30 minutes.

Now *Click* save.

After you click the save, the entry box will refresh to the programs default values and be ready for you to enter the next band and its associated parameters.

Add a band on "Flex 5000A"

Band:

Power (W): 100

Modulation: CW

Controlled exposure (%): 50

Uncontrolled exposure (%): 100

Save Cancel

Continue to add the rest of the bands that you use along with their parameters.

Again, if you have more than one model of transmitter that you use, simply repeat this whole process to enter them in, being sure that you save as you go through the steps.

Don't forget to add your VHF / UHF "shack" transmitters, "not mobile units". HT's and mobile units of 50 watts or less are exempt.

When you have completed and saved your last transmitter entry, simply *click* Cancel to close this entry screen and return to the main screen.

You will notice that the main screen now displays your transmitter entries at the bottom of the screen.

Transmitters Antennas Connections Results Import/Export About

Add a transmitter

Transmitters [Hide help](#)

The Transmitters tab is where you should start. In this tab, you add a transmitter for each one you want to run calculations for. You get to pick the name, but the names must be unique, so if you have three of one radio, give them a suffix or something.

After clicking on "Add a transmitter", you will be prompted to "Add a band" for that transmitter. Just like your real radio, each transmitter here can have its own bands. It will continue to prompt you to add new bands until you hit "Cancel". If you decide at some later time to add more bands, you can manually click on the "Add a band" link inside the transmitter box. Deleting or editing the bands and/or transmitters can be done with those links as well.

As you add the bands, you specify information on how you will be using that band for this calculator. For example, if you typically use 50W on the 80m band while using CW, you should enter that data there. This way, you can model your real-life usage of the radio. In addition, you should enter your usage windows for controlled and uncontrolled exposure. Remember that the controlled exposure window is six minutes long and the uncontrolled window is 30 minutes. These two fields here are not in minutes, but rather in percentage. So fill in the percentages appropriately.

If you are using an amplifier with your radio, you can just assume that the radio is putting out the amplifier's output for the sake of simplification.

You only get to fill out each band once per transmitter, so use the highest power configuration you plan on using. Note that the various modulation modes and exposure percentages will also reduce the total RFE in the calculations.

After adding all your transmitters and transmitter bands, go on to the Antennas tab.

Flex 5000A				
Band	Power (W)	Modulation	Controlled exposure (%)	Uncontrolled exposure (%)
160m	100	SSB: no processing (25%)	65	80

Note: At this point if you notice that you have made an error or need to change / add, or delete an entry, you can hover your mouse pointer over the transmitter entries and use the edit tools on the right side of the box.

Transmitters Antennas Connections Results Import/Export About

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Flex 5000A					Add a band Edit Delete
Band	Power (W)	Modulation	Controlled exposure (%)	Uncontrolled exposure (%)	
160m	100	SSB: no processing (25%)	65	80	Edit Delete

Now let's move to the **Antennas** tab. *click* the "Add an antenna" link.

Transmitters Antennas Connections Results Import/Export About

Add an antenna

Antennas

The Antennas tab is where you enter information about your antennas. This includes entering the gain for each band that the antenna will be used with.

Click on "Add an antenna" to start with and enter the basic information. The "Ground it, but you should refer to Bulletin 65 for what you think you should do. The controller close anyone else can get to it.

After saving the antenna, you will be prompted to add bands until you hit the "Cancel" should be listed as dBi, not dBd. If your antenna specs are in dBd, take the dBd number.

If you need to, you can always go back and add, delete or edit the bands that you have

A small "Add an antenna" entry box will now appear in the center of your screen.

The image shows two side-by-side screenshots of a software dialog box titled "Add an antenna". The left screenshot shows the dialog with empty input fields for "Name:", "Controlled exposure (ft): 0", "Uncontrolled exposure (ft): 0", and a dropdown menu for "Ground reflections:" set to "yes". The right screenshot shows the same dialog with "Name:" filled with "Homebrew OCFD", "Controlled exposure (ft):" filled with "20", "Uncontrolled exposure (ft):" filled with "20", and "Ground reflections:" still set to "yes". Both dialogs have "Save" and "Cancel" buttons at the bottom. An arrow points from the left dialog to the right one.

Type in the name of your antenna into the **Name** text box. Use the manufacturers name whatever name you want to describe your antenna.

Next you will need to *enter* the **Controlled & Uncontrolled exposure** entries in feet.

Basically, these entries are talking about “**how close**” a member of your household or the general public (your neighbor/s) can get to your antenna. In my case the homebrew OCFD is 40 feet in the center and the ends are 20 feet of off the ground.

So, I entered 20 feet for both the **Controlled** and **Uncontrolled exposure**. Please keep in mind that your family knows the antenna is there. The general public and possibly your neighbors may not know.

The **Ground reflections** are a difficult one to accurately calculate in the field because no one can accurately predict where wiring or reflective objects may create reflected hot spots at your location. But it is important we understand them.

Without going into great technical detail, on a ground level vertical HF antenna installation, you will most likely have an elaborate ground system of wires fanning out from the base of the antenna. In a sense this is the other half of your vertical antenna installation. Ground waves will travel half in the ground and half out of the ground along your ground system. Keep in mind that the signal will be attenuated as it goes further out by rocks and dirt and stuff, but they are ground reflections and someone could be exposed to these reflections if they decide to picnic on your ground array while you transmit.

On a horizontal dipole antenna the reflection is less important to the whole system in general. A horizontal antenna without any reflections works just fine. The height above ground as well as configuration (inverted V) will have an effect on ground reflection, the inverted V does add a vertical element into the mix. Theory taught us that on a horizontal antenna there is a 180 deg. out of phase reflection from the ground. In the case of a low dipole, once you get far away, the reflection and the original signal are basically just coming from the same place, so the incident signal and the out-of-phase reflection add up and cancel out. For those of you who have played with NVIS know a dipole at the right height has maximum gain straight up, because that's the direction that maximizes the path length difference between the incident and the reflected signal.

Once you raise the horizontally polarized antenna more than a quarter wavelength above the ground, you make it so that there is some angle where the length of the reflected path to a distant point will be a half wavelength longer than the direct path to the same point. This 180° shift from the path length difference, adds to the 180° shift from the reflection, that gives 360° or 0°, which means the RF signal is increased instead of canceled. By placing an antenna at just the right height, you can make the ground reflection contribute to dipoles performance. How much reflection depends on your ground or earth under your antenna. As I said in the

beginning it is difficult to determine those hot spots. So, to be on the safe side I selected **yes** from the drop down list.

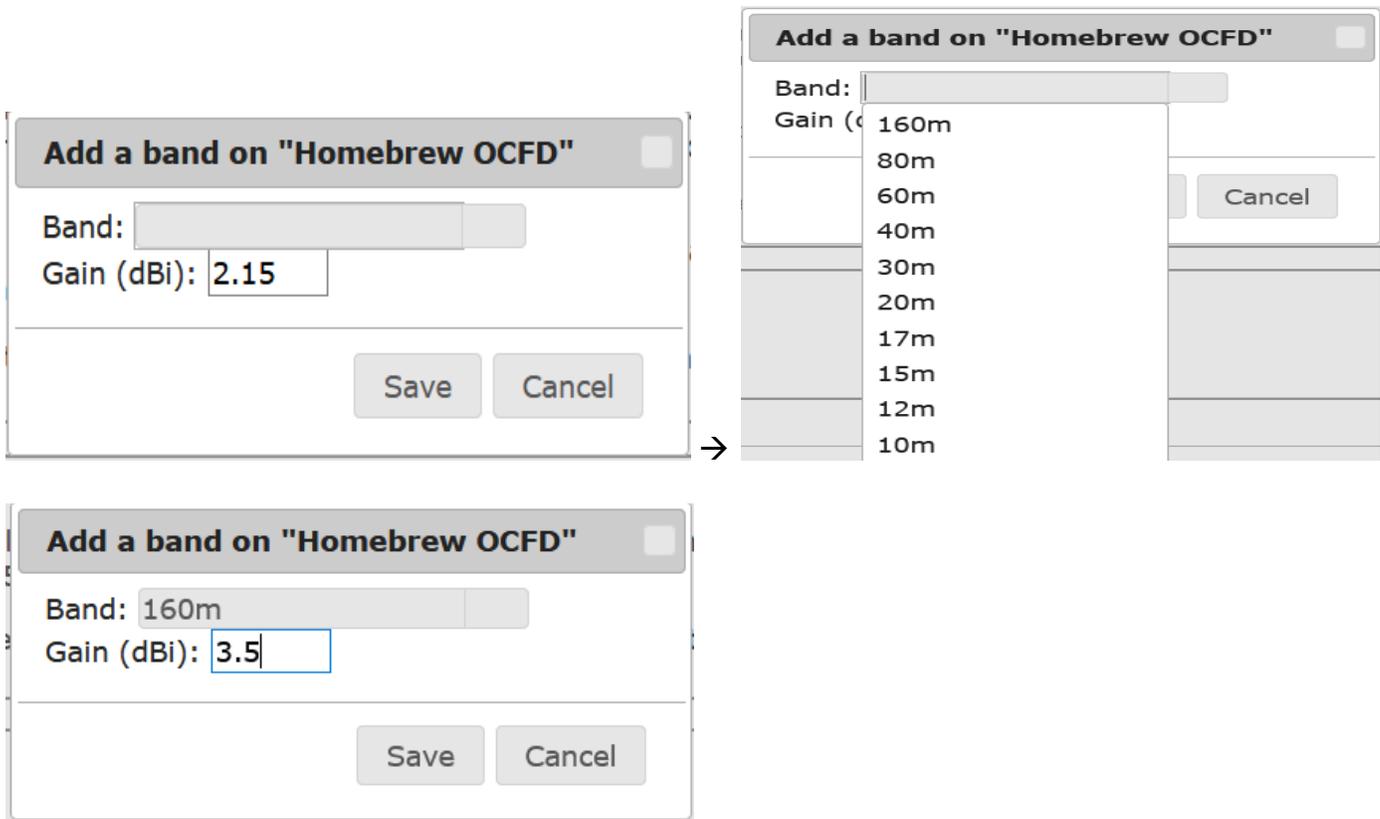
Now *Click* save.

After you *click* the save, the “**Add a band on**” your antenna box will appear. Use the drop down to associate this antenna with the band you will be using.

The **Gain** (dBi) value you add here will be used as part of the calculation for determining RFE by the formula given in the FCC [OET Bulletin No. 65](#). If your antenna specs are in dBd then add 2.15 to it and enter that number.

Use whatever the manufacture specifications are for your particular antenna.

In my case I used MANNA-GL when I designed my antenna. So, I'll be using the parameters the antenna program calculated for my installation, which was a gain of 3.5 dBi.



Now *Click* save.

After you click the save, the entry box will refresh to the programs default values and be ready for you to enter the next Band and Gain for the selected antenna.

Add a band on "Homebrew OCFD"

Band:

Gain (dBi):

When you have completed and saved your last antenna band entry, simply *click* Cancel to close this entry screen and return to the main antennas screen.

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Add an antenna

Antennas Hide help

The Antennas tab is where you enter information about your antennas. This includes the controlled and uncontrolled distances for which we are making calculations. Also, it gives you a chance to enter the gain for each band that the antenna will be used with.

Click on "Add an antenna" to start with and enter the basic information. The "Ground reflections" entry is whether or not to use the formula to incorporate ground reflections in the RFE totals. I use it, but you should refer to Bulletin 65 for what you think you should do. The controlled and uncontrolled distances are basically how close you and your household can get to the antenna and how close anyone else can get to it.

After saving the antenna, you will be prompted to add bands until you hit the "Cancel" button. This allows you to set the gain for each band. This gain is used in the formulas for calculating RFE. It should be listed as dBi, not dBd. If your antenna specs are in dBd, take the dBd number and add 2.15 to it.

If you need to, you can always go back and add, delete or edit the bands that you have created. When you have entered all your antennas, move on to the Connections tab.

Homebrew OCFD

Controlled exposure: 20ft, Uncontrolled exposure: 20ft, Ground reflections: yes

Band	Gain (dBi)
160m	3.5

You will notice that the antennas main screen now displays your antenna entries at the bottom of the screen.

Note: Just like the transmitter screen, if you notice that you have made an error or need to change / add, or delete an entry, you can hover your mouse pointer over the antenna entries and use the edit tools on the right side of the box.

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Add an antenna

Antennas Hide help

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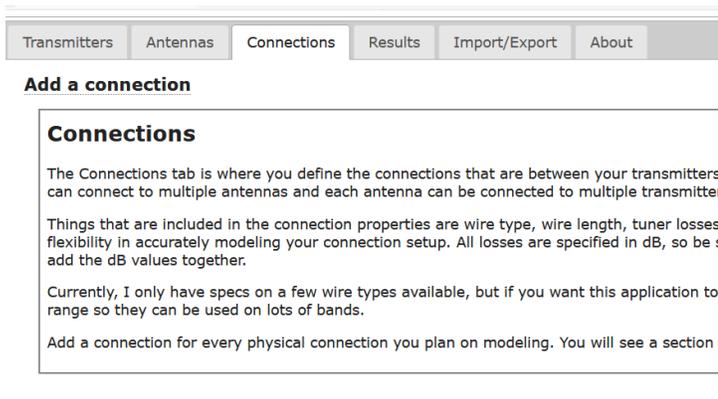
If you need to, you can always go back and add, delete or edit the bands that you have created. When you have entered all your antennas, move on to the Connections tab.

Homebrew OCFD Add a band | Edit | Delete

Controlled exposure: 20ft, Uncontrolled exposure: 20ft, Ground reflections: yes

Band	Gain (dBi)	
160m	3.5	Edit Delete

Next we can move on to the **Connections** tab so *click* the “**Add a connections**” link.



The “Add a connection” box appears in the center of the screen.

The Transmitter drop down box has all the transmitters that you have entered, and the Antenna drop down box has your antenna entries listed. As you can see, they are in the order you entered them with the box already populated with your first entry.

If you do not use a tuner, you can leave the **Tuner losses as 0 (dB)**.

Even if you use a tuner, leave the setting for **Tuner losses as 0 (dB)** at this time.

The limits in the formula are at their maximums, so any setup that is less than the maximum will still be fine when adding a component loss to the path.

At this time, you can ignore items in the path (including the Tuner loss), and that would still give you an absolute maximum. If you fail to meet the limit requirements, then you can return to this screen and start adding in more details like the Tuner loss and Other losses.

The next item to be entered is the **Wire type**. From the drop-down box *select* your type.

Add an connection

Transmitter: Flex 5000a

Antenna: Homebrew OCFD

Tuner losses (dB): 0

Wire type:

Wire length (ft): 0

Other losses (dB): 0

Save Cancel



Add an connection

Transmitter: Flex 5000a

Antenna: Homebrew OCFD

Tuner losses (dB): 0

Wire type:

- Belden 9913
- Belden 84303 (RG303/U)
- Belden 84316 (RG316)
- Belden 9011
- Belden 9204 (RG-59/U)
- Belden 9212 (RG-11/U)
- Belden 9258 (RG-8/X)
- Belden 9269 (RG-62/U)
- Belden 9275
- Belden 9913**
- Belden 9914
- Carol C.1188
- Commscope P3-500 CA
- Commscope P3-750 JCA
- Davis BURY-FLEX

In my case I am using 100 feet of Beldon 9913 coaxial cable.

Add an connection

Transmitter: Flex 5000a

Antenna: Homebrew OCFD

Tuner losses (dB): 0

Wire type: Belden 9913

Wire length (ft): 100

Other losses (dB): 0

Save Cancel

At this time, just like the **Tuner losses**, just leave the **Other losses** 0(dB). You can come back and add other entries to help lower your wattage.

Note: If you cannot find your Wire type in the list here is another link that may help.

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

Once you have entered all of your information *click* the **save** button.

The screen returns back to the Connections main screen. At this point you would continue to add connections for your different modes of operation. For example, if you have a 40-meter beam as well as a 40-meter dipole that you use for a specific transmitter, you would add them here.

Add a connection

Connections

Hide help

The Connections tab is where you define the connections that are between your transmitters and your antennas. Each transmitter/antenna pair can only have one connection, but each transmitter can connect to multiple antennas and each antenna can be connected to multiple transmitters, with each connection having different characteristics.

Things that are included in the connection properties are wire type, wire length, tuner losses, and any other losses (lightning suppressors, line splitters, etc.) This allows you to have a wide range of flexibility in accurately modeling your connection setup. All losses are specified in dB, so be sure to enter them that way. If you need to add multiple losses to put in the other losses field, you just add the dB values together.

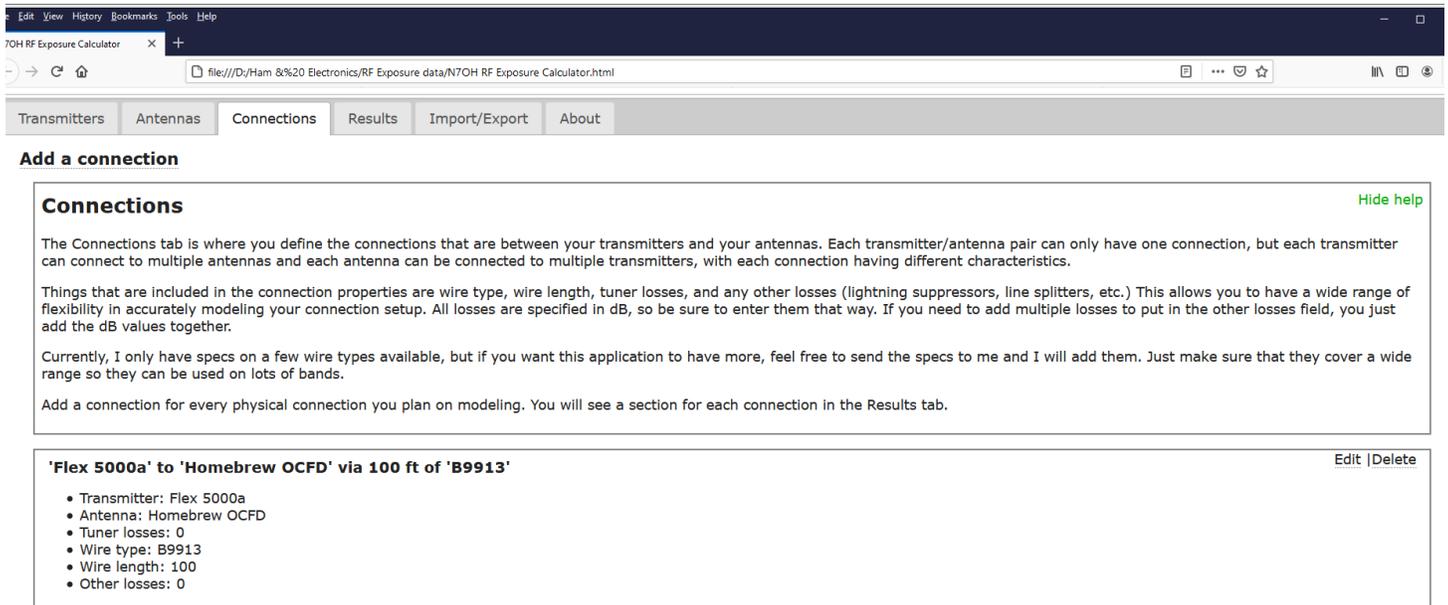
Currently, I only have specs on a few wire types available, but if you want this application to have more, feel free to send the specs to me and I will add them. Just make sure that they cover a wide range so they can be used on lots of bands.

Add a connection for every physical connection you plan on modeling. You will see a section for each connection in the Results tab.

'Flex 5000a' to 'Homebrew OCFD' via 100 ft of 'B9913'

- Transmitter: Flex 5000a
- Antenna: Homebrew OCFD
- Tuner losses: 0
- Wire type: B9913
- Wire length: 100
- Other losses: 0

Note: Again, like the other screens, if you notice that you have made an error or need to change / add, or delete an entry, you can hover your mouse pointer over the connection entries and use the edit tools on the right side of the box.



Now the fun part, seeing if you are RF Exposure compliant.

Click the Results tab.

The Results screen will display, and at the bottom will be the calculated results of your entries. The main one you should be concerned about is the **Distance OK** being a “yes”. This is indicating that your RF Exposure (mW/cm²) is within the required limits.



Results

[Hide help](#)

The Results tab is where all the results of the calculations are shown for each of the radio/connection/antenna groups that you have specified.

Listed in convenient tables, you see the data you entered in the first few columns and then starting with "Power at Antenna", you see the ERP for each band. Then, using that number, the calculations show the RFE at both the controlled and uncontrolled distances, the minimum allowable distance for each band and then whether or not the band is within the limitations set by the FCC.

For each connection shown in the Results tab, and for each band within those connections, you should make sure that both the controlled and uncontrolled exposures are within the limits. There is a box that will say "yes" or "no" for each entry. If any of the boxes say "no", then you need to look into your setup to see what you can do to reduce the RF exposure for that band. Some options are to:

1. Use a lower output power
2. Use a smaller operating window (i.e. transmit for less time in each six or 30 minutes segments)
3. Use a modulation that is less power (FM is 100% modulation whereas CW is only about 40%)
4. Use a lower-gain antenna or a more lossy network (it would be a better idea to just turn down the power)

'Flex 5000a' to 'Homebrew OCFD' via 100 ft of 'B9913'

Controlled distance: 20 ft., Uncontrolled distance: 20 ft

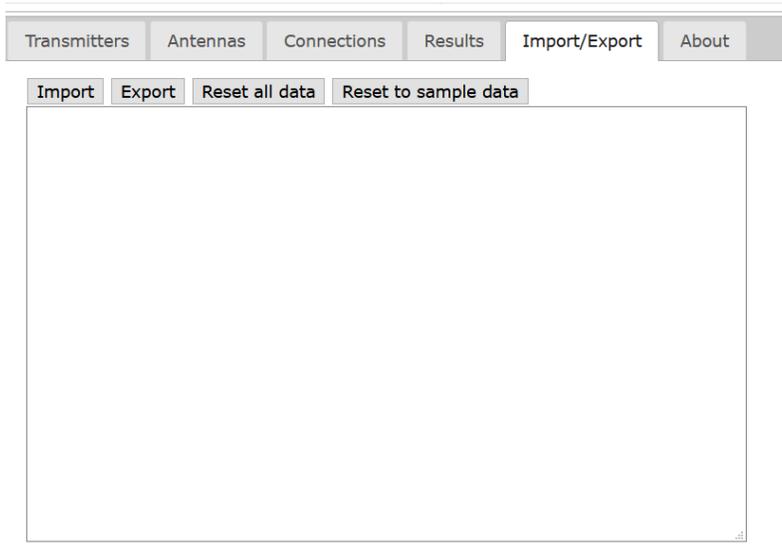
Band	Power (W)	Line Losses (dB)	Total Gain (dB)	ERP (W)	Controlled Exposure (6 minute window)					Uncontrolled Exposure (30 minute window)				
					Time Ave Power (W)	MPE (mW/cm ²)	RF Exposure (mW/cm ²)	Minimum Distance (ft)	Distance OK	Time Ave Power (W)	MPE (mW/cm ²)	RF Exposure (mW/cm ²)	Minimum Distance (ft)	Distance OK
160m	100	0.1572	3.343	215.9	35.09	100.0	0.01923	0.2774	Yes	43.18	49.86	0.02367	0.4358	Yes

If by chance you get a “no” to the **Distance OK**, you can refer to the page help for possible suggestions on how to reduce the level.

At this point you can print this page to keep for your records if you want to.

If you would like to save the data that you have entered, then *click* the **Import/Export** tab.

Next, on the **Import/Export** screen you will need to *click* the **Export** tab.



The **Export** box will be populated with all of the information that you have entered into the calculator.

Transmitters Antennas Connections Results Import/Export About

Import Export Reset all data Reset to sample data

```
{ "schema":2,"antennas":{"Homebrew OCFD":
[{"160m":3.5},20,20,true]},"connections":[[{"Flex 5000a","Homebrew
OCFD",0,"B9913",100,0}],{"transmitters":{"Flex 5000a":{"160m":{100,"SSB: no
processing",65,80}}}}
```

To save your information *highlight* it, and do a *copy*.

Edit View History Bookmarks Tools Help

70H RF Exposure Calculator x +

file:///D:/Ham &%20Electronics/RF Exposure data/N7OH RF Exposure Calculator.html

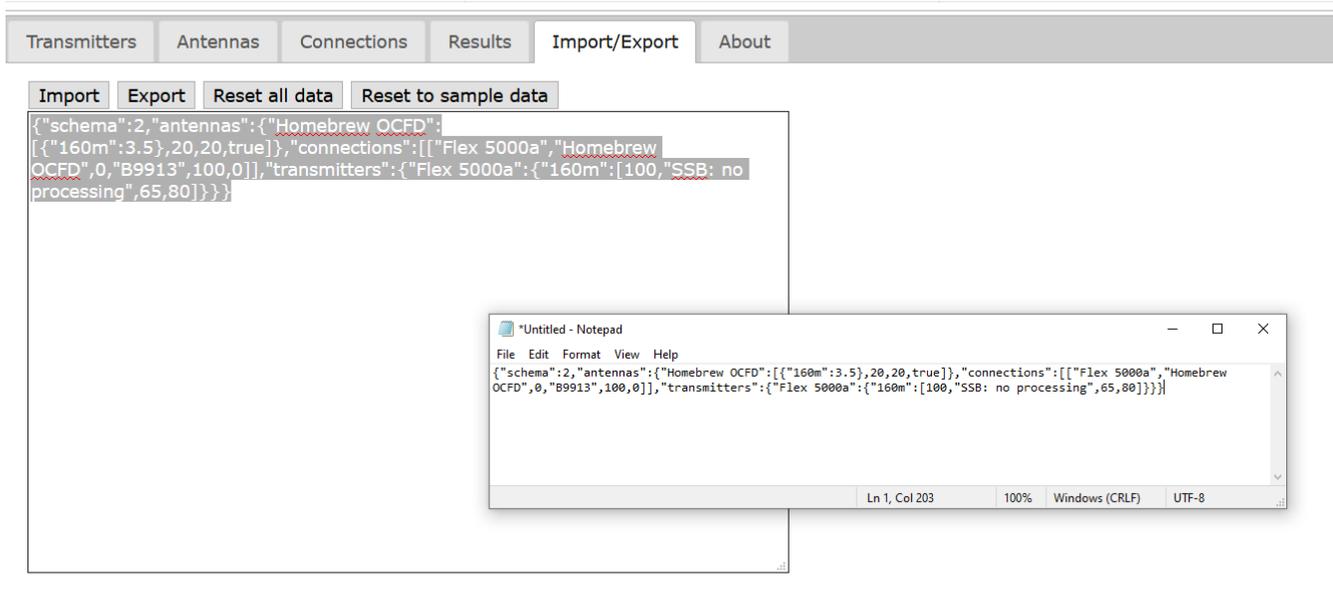
Transmitters Antennas Connections Results Import/Export About

Import Export Reset all data Reset to sample data

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{ "schema":2,"antennas":{"Homebrew OCFD":
[{"160m":3.5},20,20,true]},"connections":[[{"Flex 5000a","Homebrew
OCFD",0,"B9913",100,0}],{"transmitters":{"Flex 5000a":{"160m":{100,"SSB: no
processing",65,80}}}}
```

- Undo
- Cut
- Copy
- Paste
- Delete
- Select All
- Search Google for "[schema":2,"an..."
- ✓ Check Spelling
- Languages >
- Inspect Accessibility Properties
- Inspect Element (Q)
- Take a Screenshot

Open Notepad or Word or whatever text application you like using and paste the information into that application. At this point save it by giving it a name associating it to the RF Calculations.



This way if your browser doesn't store your test results, or you change browsers, you can **Import** your data by opening the application that you used to save the data, select and open your file, highlight the data and copy the data. Then *navigate* to this **Import/Export**, screen and *paste* your data into the box. Once you do that then *click* the **Import** tab. Now when you click the **Results** tab your calculations will be displayed.

Below is a common list of terms and brief definitions that you may encounter.

PEP – Peak Envelope Power - the average power supplied to the antenna by a transmitter during one radio-frequency cycle at the peak of the modulation envelope taken under normal operating conditions. The easiest place to get your transmitter PEP power is from your radio manual.

AVG – Average Power - This is defined as the energy transfer rate average over many radio-frequency cycles.

SAR – Specific Absorption Rate - a measure of the rate at which energy is absorbed per unit mass by a human body when exposed to a radio frequency (RF) electromagnetic field.

MPE - Maximum Permissible Exposure – The OET Bulletin 65 specifies that the maximum allowable power density of any given frequency in milliwatts per square centimeter (mW/cm^2) This is the number in which we want to stay under to be compliant.

dB_i – Antenna Gain

Controlled Environment - Persons exposed are aware of and can take steps to control their exposure - such as the amateur's family members and warned guests on the property. Exposure limits are higher for this category.

Uncontrolled Environment - Persons exposed are unaware of their exposure - such as neighbors, unwarned guests on the property, and the general public. Exposure limits are lower for this category.

Feed Line Loss - Your transmission line causes some power loss over the length of the line, and this loss should be “subtracted” from the transmitter’s output PEP value to determine the PEP input to the antenna.

Appendix

Here are a few more links to help answer questions:

1) Coax loss and ERP calculator: <https://kv5r.com/ham-radio/coax-loss-calculator/>

2) For those who have made home brew antennas you could use one of the antenna programs to help figure out their gain. MMANA-GAL is a "FREE" application, there are some good You Tube Video's by DX Commander on how to set it up and use it. <https://mmana-gal.software.informer.com/3.0/>

3) And for those who want to know how to calculate tuner loss <https://k6jca.blogspot.com/2015/10/notes-on-measuring-antenna-tuner-power.html>