Calculating RF exposure

How to stay safe

Dangers of RF

- RF Burn -- Not tonight's topic
  - Bad, Nasty, deep burns
  - Keep people from touching antennas
- RF Heating
  - Gentle warming of polar molecules
  - Cook things
    - Microwave oven is extreme example
- NOT IONIZING RADIATION!!!
  - Can’t mess with DNA, etc

It’s about heat

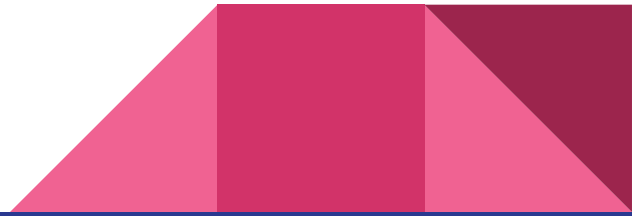
- Heat things too much, can ‘cook’ flesh
- Body most sensitive to frequencies 30-300 MHz
- Heating flesh takes time
  - Body tends to average heat input
  - Different Modes have less average energy (SSB)
    - FM the worst
  - How long are you transmitting

Two limits

1. Controlled -- YOU know where the antenna is, you keep folks at a safe distance
    a. Smallest possible distance
2. Uncontrolled -- Others just happen by near the antenna
    a. Has a larger distance to be safe

What goes into an RF evaluation

- Transmitter power
- Feedline loss
- Antenna gain/loss
- Frequency
- Transmitting mode
- Transmitting duty cycle



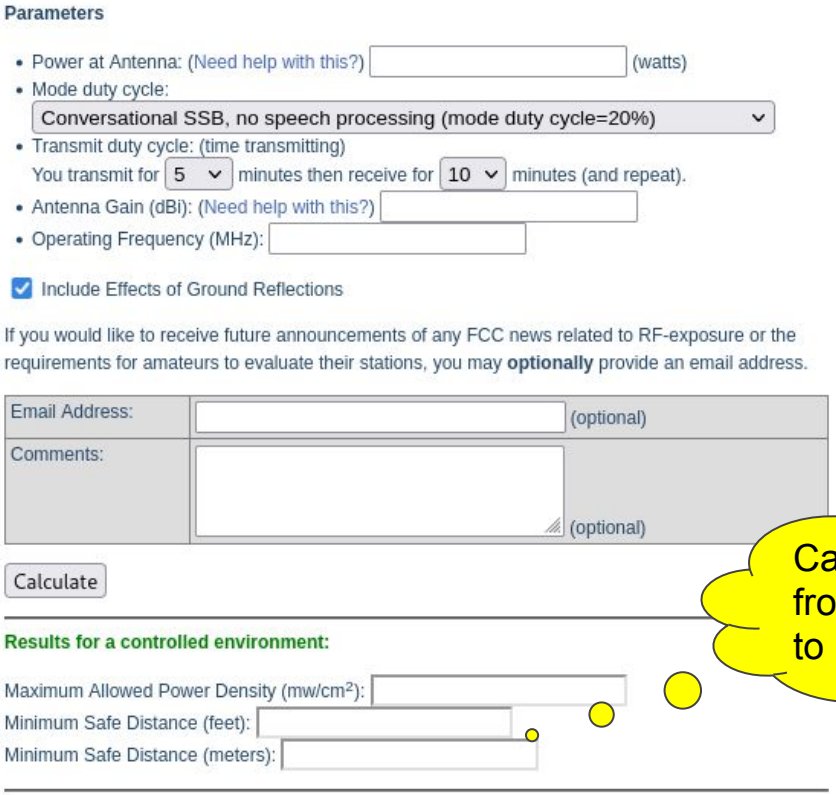
What comes out of an RF Evaluation

Minimum safe distance from antenna to people/pets.

Involves lots of fun math

- Don’t worry, there is an online calculator
- http://www.arrl.org/rf-exposure-calculator
  - Learn how to use this tonight

What does the Website Calculator need



Power at Ant

Mode

Duty Cycle

Ant Gain

Frequency

Supply these 5 items
For calculation

Calculates how far from the antenna to be safe

5 Items

- Power at antenna
  - Assume rated power for HT
- Mode
  - Use FM for HTs and 2M/440
- Duty Cycle
  - Use 1:1 for very chatty
- Antenna Gain
  - Use 2.15 for dipole/Jpole, -2 to 0 for standard HT antenna
- Frequency
  - Use 146 (HT transmits on 146.055 to repeater)

Stock HT Antennas estimated gains

“the average dual-band helical antenna delivers a gain of **minus 5 – 6 dBd** on 2 meters, and something in the range of **minus 3 dBd** on 70 centimeters.”

https://hamgear.wordpress.com/2012/07/17/something-about-antennas-and-gain/

dBi = dBd + 2.15

2 M ht rubber duck = -5+2.15 → -2.85 dBi

440 ht rubber duck = -3+2.15 → -0.85 dBi

Examples use 0 dBi to be conservative

Try a 5W HT with rubber ducky antenna chatty mode

Parameters

- Power at Antenna: (Need help with this?) 5 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 2 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 0
- Operating Frequency (MHz): 146

☐ 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

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²): 1.0000
Minimum Safe Distance (feet): 0.5343
Minimum Safe Distance (meters): 0.1629

For 5W HT talking 2 minutes out of 4

Hold 6-7” from your face

How about a check-in 2 min xmit, 18 min recv

- Power at Antenna: (Need help with this?) 5 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 18 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 0
- Operating Frequency (MHz): 146

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Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²): 1.0000
Minimum Safe Distance (feet): 0.3778
Minimum Safe Distance (meters): 0.1152

4-5 inches away from face is safe

More accuracy -- Measure HT Power output

Good activity for a meeting when we can get together

Licensed for 5W. Being 70% of max is within spec.

This Baofeng is 4.11 watts on our 146.505MHz simplex.

They are all different. It’s manufacturing variance.

At the actual power 4.11W

- Power at Antenna: (Need help with this?) 4.11 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 18 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 0
- Operating Frequency (MHz): 146

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Comments:	(optional)

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0000
Minimum Safe Distance (feet): 0.3426
Minimum Safe Distance (meters): 0.1044

4 inches from your body. A little better, but not a lot

Try the HT on low power

1.25W (Typical Low Power)

UV5R LP (1.25W)

- Power at Antenna: (Need help with this?) 1.25 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 18 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 0
- Operating Frequency (MHz): 146

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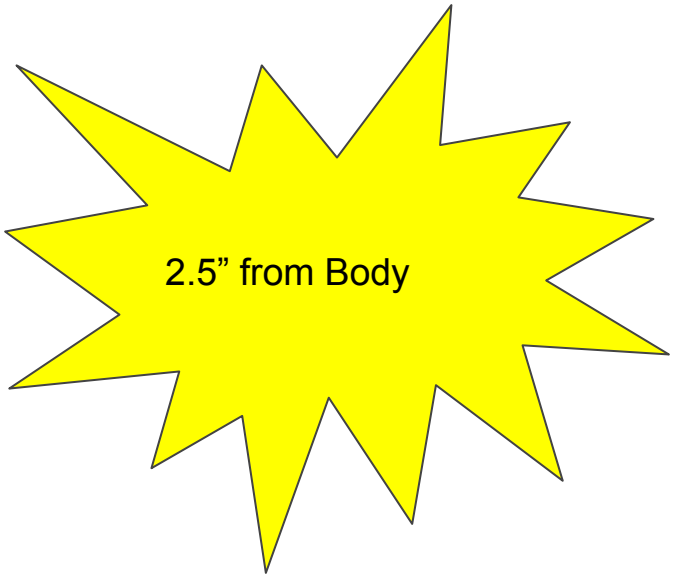
Comments:	(optional)

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0000
Minimum Safe Distance (feet): 0.1889
Minimum Safe Distance (meters): 0.0576



Low Pwr Rubber ducky Ant. 2 out of 20 minutes talking

- Power at Antenna: (Need help with this?) 1.25 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 18 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) -2.85
- Operating Frequency (MHz): 146

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Comments:	(optional)

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²): 1.0000
Minimum Safe Distance (feet): 0.1361
Minimum Safe Distance (meters): 0.0415

About 1.6” from body
Not hard to manage

It’s time for a Demo

Advanced -- Gain Antennas -- Approx 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

* Source: RSGB EM Field Exposure web site at https://rsgb.org/main/technical/emc/emf-exposure/

Jpole is ½ wave dipole

⅝ mobile gain is about 3.7 dBi

50W into a Jpole

- Power at Antenna: (Need help with this?) 50 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 18 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 2.15
- Operating Frequency (MHz): 146

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Email Address:	(optional)
Comments:	(optional)

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0000
Minimum Safe Distance (feet): 1.5304
Minimum Safe Distance (meters): 0.4665

Stay 1.5 feet from Jpole
(Most have 6-10’ cables)

Advanced -- Coax Feed line loss

Attenuation (dB per 100 feet)										
	MHz:	30	50	100	146	150	440	450	1000	2400
#2632	**RG-174**	5.5	6.6	8.8	13.0		25.0		30.0	75.0
#0985	**LMR-100A®**	3.9	5.1		8.8	8.9	15.6	15.8		
#2619	**RG-58A/U**	2.5	4.1	5.3	6.1	6.1	10.4	10.6	24.0	38.9
#3603	**LMR-200®**	1.8	2.3		3.9	4.0	6.9	7.0		16.5
#2910	**RG-59**		2.4	3.5			7.6		12.0	
#2247	**RG-8X**	2.0	2.1	3.0	4.5	4.7	8.1	8.6		21.6
#3604	**LMR-240®**	1.3	1.7		3.0	3.0	5.2	5.3		12.7
#3605	**LMR-240 Ultra®**	1.3	1.7		3.0	3.0	5.2	5.3		12.7
#2248	**RG-8/U FOAM**		1.2	1.8					7.1	
#2929	**RG-213**		1.5	2.1	2.8	2.8	5.1	5.1	8.2	
#0390	**RG-214**	1.2	1.6	1.9	2.8	2.8	5.1	5.1	8.0	13.7
#3606	**LMR-400®**	0.7	0.9		1.5	1.5	2.7	2.7		6.6
#3607	**LMR-400 Ultra®**	0.7	0.9		1.5	1.5	2.7	2.7		6.6
#6512	**DRF-400**	0.7	0.9		1.5			2.7		6.7
#5297	**Bury-FLEX™**		1.1	1.5					4.8	
#0812	**9086**			1.4			2.8	2.8		
#0075	**9913**	0.8			1.5		2.8			7.5

Values indicated are *approximate* and for comparison purposes only.
LMR® is a registered trademark of Times Microwave Systems.

Use a coax Calculator

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

I will use Beldon 9913-f7 as an example. My shack to antenna -- 30 feet

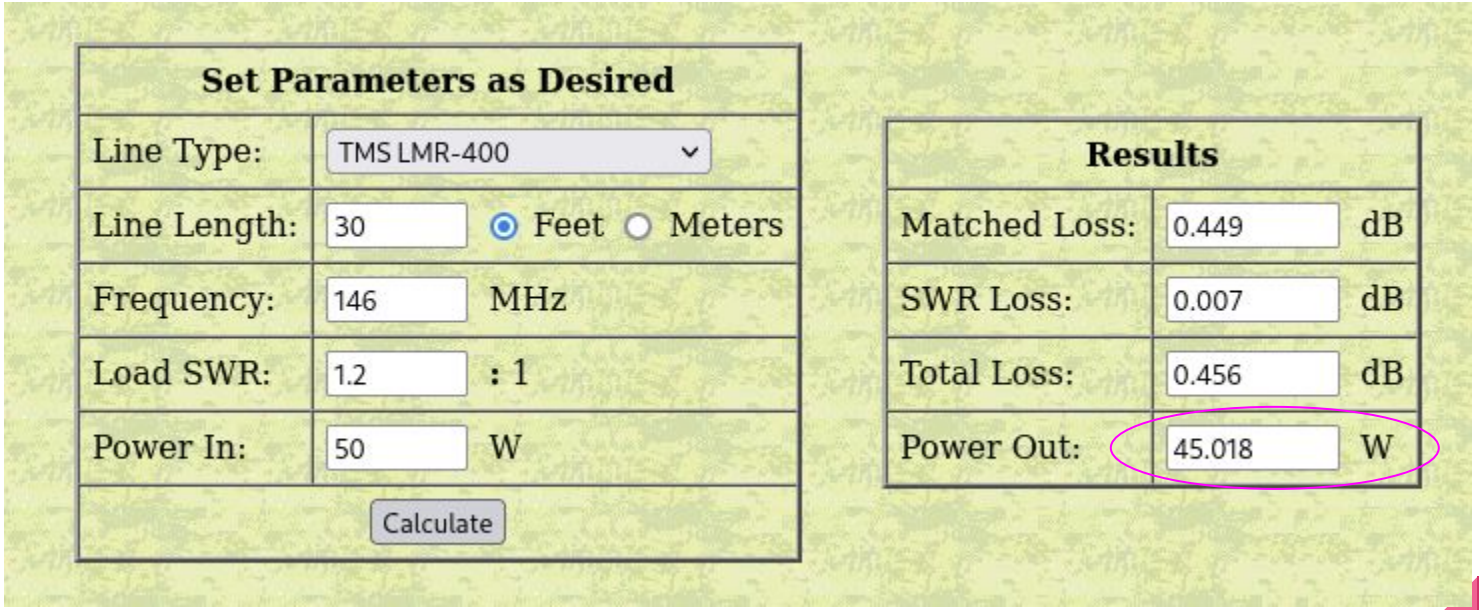
(Same Data as LMR-400, but more flexible)

Connects radio to a Comet CX-333 antenna. (Outdoors, up 15 feet)

6.5 dBi on 2M

9 dBi on 440

Calculate 30 feet Coax 9913-f7 (like LMR-400)



Set Parameters as Desired		
Line Type:	TMS LMR-400	
Line Length:	30	(•) Feet ( ) Meters
Frequency:	146	MHz
Load SWR:	1.2	: 1
Power In:	50	W
	Calculate	

Results		
Matched Loss:	0.449	dB
SWR Loss:	0.007	dB
Total Loss:	0.456	dB
Power Out:	45.018	W

Base Station setup

Parameters

- Power at Antenna: (Need help with this?) 45 (watts)
- Mode duty cycle:
  FM (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 2 minutes then receive for 2 minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?) 6.5
- Operating Frequency (MHz): 146

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Comments:	(optional)

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0000
Minimum Safe Distance (feet): 3.3880
Minimum Safe Distance (meters): 1.0327

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 0.2000
Minimum Safe Distance (feet): 6.7760
Minimum Safe Distance (meters): 2.0653

Safe distance 4’ controlled
7’ uncontrolled

Base of antenna is up 15’.

RF Evaluation is OK.

Discussion