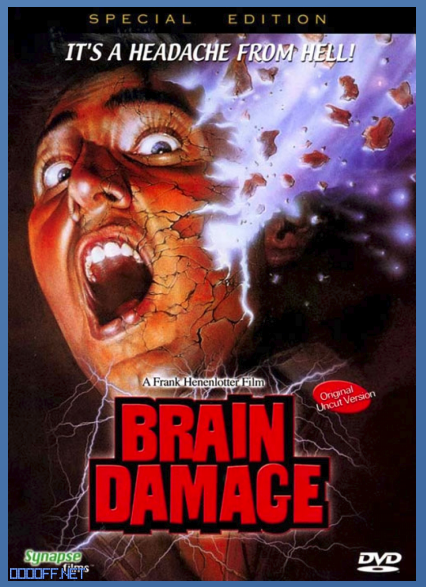
RF Exposure program - RARC

- Example of calculating whether or not you are damaging your neighbors' brains with RF from your radio
- (No one wants brain-damaged neighbors next door, even if your radio damaged them)



Featuring
Bruce MacAlister, W4BRU
with
Ken Leidner, WV0L
14 May 2021

Status of this presentation

- This is preliminary, I'm not done yet
- Unless someone rats you to the FCC, no one will know whether or not you have done this safety survey
- Usually only a problem if you live in the ghetto or are spewing out 1-kilowatt
- The deadline is May 3, 2023

The frequencies of concern

- The danger of certain frequencies has been known at least since WWII
- This table is all over the ham radio websites
- This example came from a *QST* article

Table B

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)	Non-building-mounted antennas:

Demonstration

- Lake Washington radio club RF calculator www.lakewashingtonhamclub.org/resources/rf-exposure-calculator/

- Google maps distance measurer www.google.com/maps/

Actual Wattage – Duty Cycle

- Digital & FM assume 100% duty cycle
- SSB usually 50%
- Watts entered into calculator are reduced by duty cycle

Mar 2009 *QST* - Copyright © 2014 A

Table 3

Fraction of PEP Transmitted using Different Modes while in Transmit Mode

Mode	*Duty Factor (%)*
CW	40
SSB (no processing)	20
SSB (heavy processing)	40
SSB (digital modes)	100
AM Voice (50% modulation)	50
FM Voice	100
ATV (Image)	60
ATV (black screen)	80

Controlled v Uncontrolled

Controlled: You have the right to fry your brain and the brains of your family and your pets

Uncontrolled: It is illegal to fry the brains of your neighbor or your neighbor's pets

Controlled and Uncontrolled Environments

There are two kinds of exposure defined in the rules, *controlled* and *uncontrolled*. Controlled space refers to areas under the control of the operator. This includes the actual station location, as well as any surrounding property under your control, such as your house or apartment and occupied by you and your family but not any adjacent or common areas that could be occupied by other members of the public. Uncontrolled areas include sidewalks at the edge of your property, and your neighbor's apartment or yard. The requirements for uncontrolled space are more stringent since you can't

Gain – dBi, dBd, etc

- dBi = decibels compared to theoretical isotropic antenna
- dBd = decibels compared to dipole antenna
- Dipole = 2.15 dBi gain over isotropic antenna

Antenna measurements [edit]

dBi

dB(isotropic) – the forward gain of an antenna compared with the hypothetical isotropic antenna, which uniformly distributes energy in all directions. Linear polarization of the EM field is assumed unless noted otherwise.

dBd

dB(dipole) – the forward gain of an antenna compared with a half-wave dipole antenna. 0 dBd = 2.15 dBi

dBiC

dB(isotropic circular) – the forward gain of an antenna compared to a circularly polarized isotropic antenna. There is no fixed conversion rule between dBiC and dBi, as it depends on the receiving antenna and the field polarization.

dBq

dB(quarterwave) – the forward gain of an antenna compared to a quarter wavelength whip. Rarely used, except in some marketing material. 0 dBq = −0.85 dBi

dBsm

dB(m^2) – decibel relative to one square meter: measure of the antenna effective area.[65]

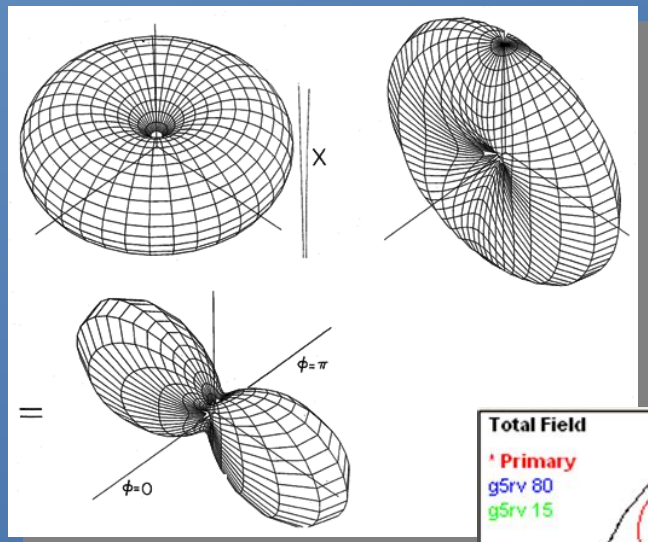
dBm^{-1}

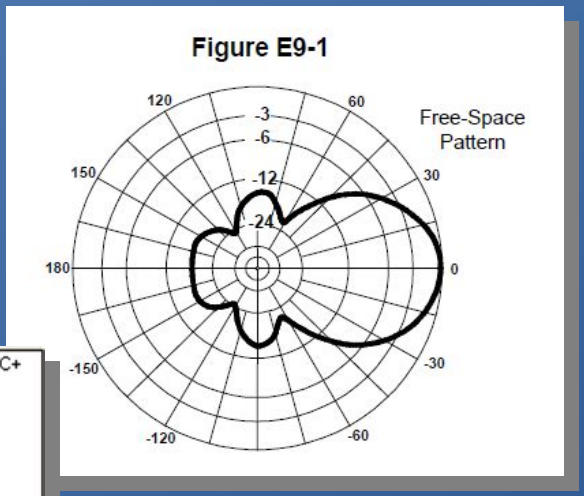
dB(m^{-1}) – decibel relative to reciprocal of meter: measure of the antenna factor.

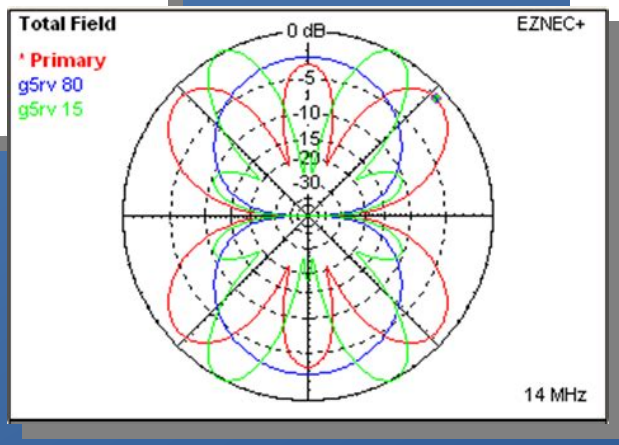
Gain Radiation Pattern

Search

antenna radiation pattern [your-antenna]







W4BRU QTH Challenges

- 40-meter horizontal loop
- 4-feet above “flat” roof
- 3-feet between houses

The test - 10m

- Power at Antenna: (Need help with this?) 100 (watts)
- Mode duty cycle: FSK/RTTY (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 5 minutes (and repeat).
- Antenna Gain (dBi): 2
- Operating Frequency (MHz): 29

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0702

Minimum Safe Distance (feet): 5.2022

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 0.2140

Minimum Safe Distance (feet): 9.0105

- Power at Antenna: (Need help with this?) 50 (watts)
- Mode duty cycle: FSK/RTTY (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 5 minutes (and repeat).
- Antenna Gain (dBi): 2
- Operating Frequency (MHz): 29

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 1.0702

Minimum Safe Distance (feet): 3.6785

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 0.2140

Minimum Safe Distance (feet): 6.3714

RADIO CLUB

40m, 20mm

- Power at Antenna: (Need help with this?) 100 (watts)
- Mode duty cycle:
  For all others, or if unknown, assume worst case scenario (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 5 minutes (and repeat).
- Antenna Gain (dBi): 2
- Operating Frequency (MHz): 7.251

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 17.1178

Minimum Safe Distance (feet): 1.3007

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 3.4236

Minimum Safe Distance (feet): 2.2529

- Power at Antenna: (Need help with this?) 100 (watts)
- Mode duty cycle:
  For all others, or if unknown, assume worst case scenario (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 5 minutes (and repeat).
- Antenna Gain (dBi): 2
- Operating Frequency (MHz): 14.07

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2): 4.5463

Minimum Safe Distance (feet): 2.5240

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 0.9093

Minimum Safe Distance (feet): 4.3716

The maximum gain

- Power at Antenna: (Need help with this?) 100 (watts)
- Mode duty cycle:
  For all others, or if unknown, assume worst case scenario (duty cycle=100%)
- Transmit duty cycle: (time transmitting)
  You transmit for 5 minutes then receive for 5 minutes (and repeat).
- Antenna Gain (dBi): 8
- Operating Frequency (MHz): 14.07

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm^2):

Minimum Safe Distance (feet): 5.0360

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm^2): 0.9093

Minimum Safe Distance (feet): 8.7225

For an uncontrolled environment:

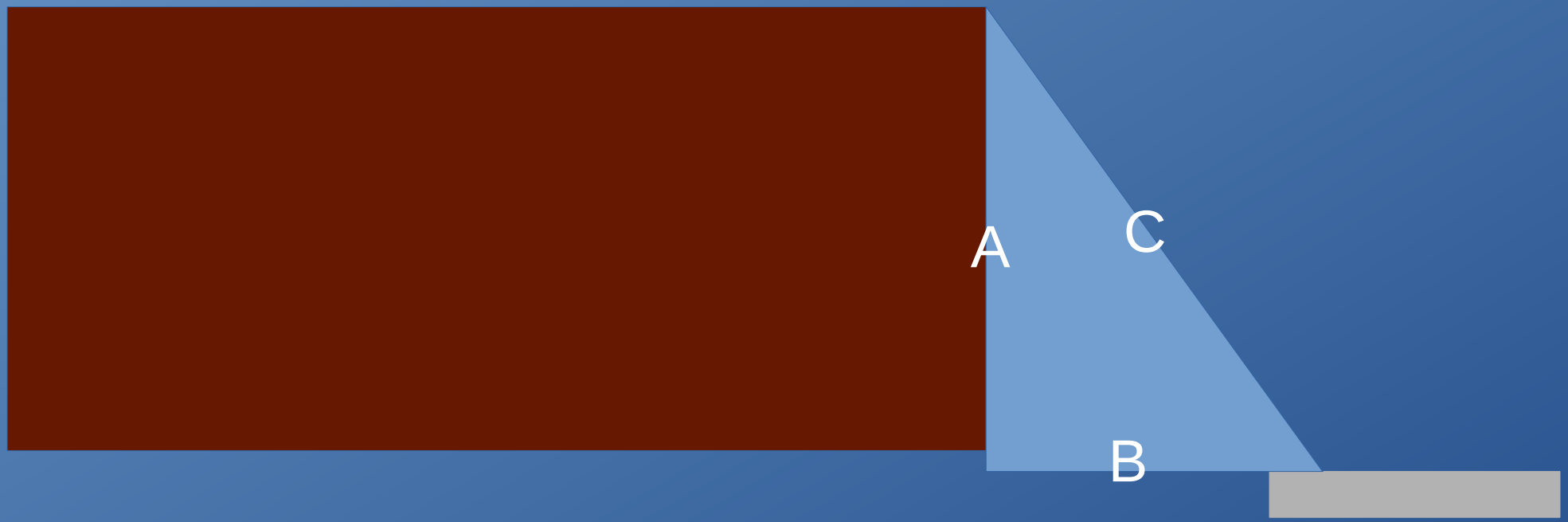
Maximum Allowed Power Density (mw/cm^2): 0.9093

Minimum Safe Distance (feet): 8.7225

Measure via Google Maps

To the sidewalk

C = sqrt (A*A + B*B) = 33ft

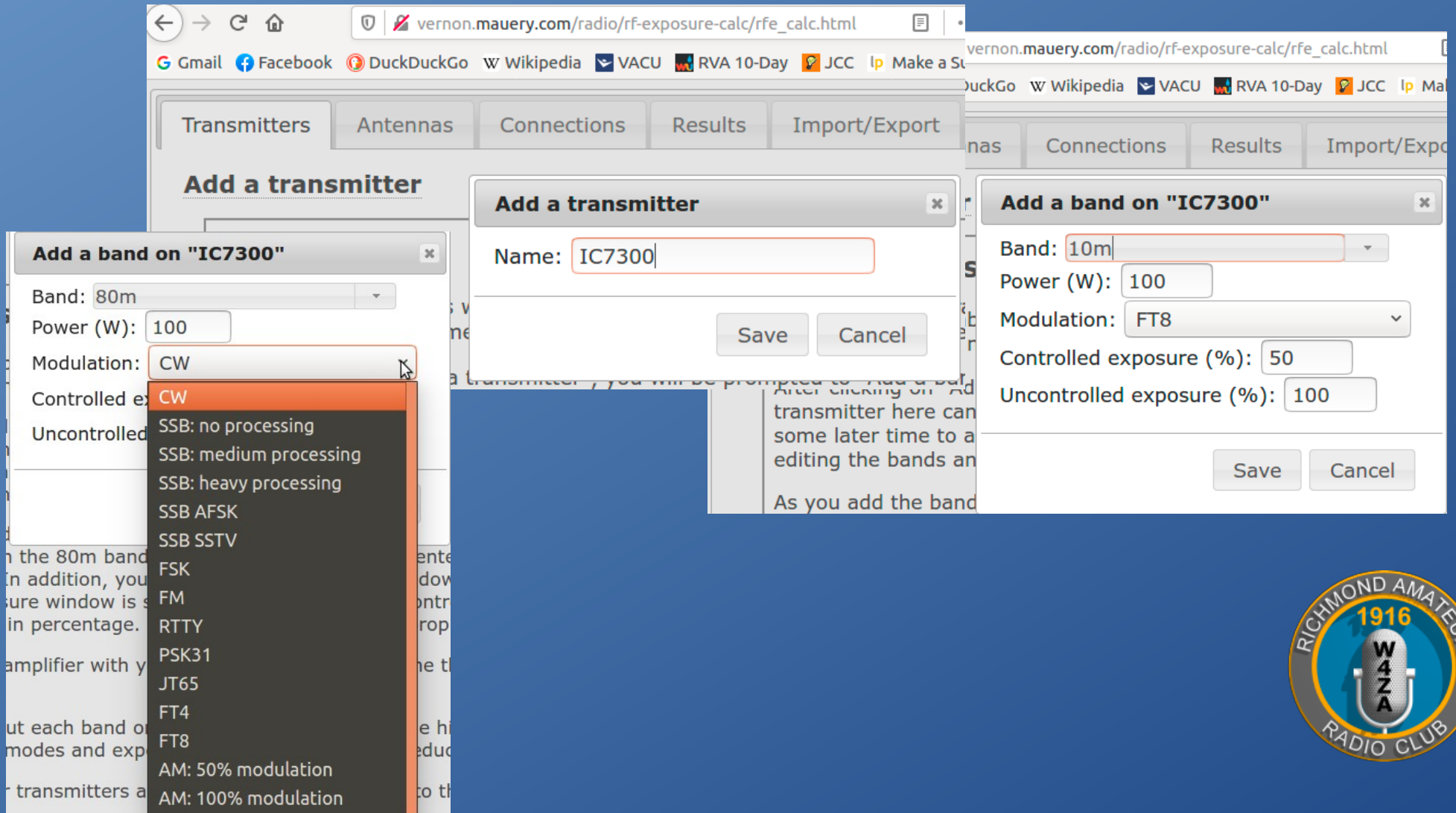


Lessons for my QTH

- Digital: 40w safe 40m – 20m
- SSB: 100w safe 40m – 20m
- SSB: 20w safe 15m - 10m
- Do new antenna model
- Map highest gain pattern to map image

For tougher cases, alternate calculator

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



RARC Remote Station

'ICOM 7100' to 'Long Wire' via 20 ft of 'LMR-400'

Controlled distance: 30 ft., Uncontrolled distance: 10 ft

Band	Power (W)	Line Losses (dB)	Total Gain (dB)	EIRP (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	0.03381	1.966	157.3	19.66	100.0	0.004789	0.2076	Yes	39.32	49.86	0.08621	0.4158	Yes
80m	100	0.04756	1.952	156.8	19.60	64.00	0.004774	0.2591	Yes	39.19	12.80	0.08594	0.8194	Yes
60m	100	0.05694	1.943	156.4	19.55	31.24	0.004764	0.3705	Yes	39.11	6.248	0.08575	1.172	Yes
40m	100	0.06577	1.934	156.1	19.51	17.60	0.004754	0.4930	Yes	39.03	3.521	0.08558	1.559	Yes
30m	100	0.07835	1.922	155.7	19.46	8.779	0.004741	0.6971	Yes	38.91	1.756	0.08533	2.205	Yes
20m	100	0.09282	1.907	155.1	19.39	4.479	0.004725	0.9744	Yes	38.78	0.8958	0.08505	3.081	Yes
17m	100	0.1050	1.895	154.7	19.34	2.742	0.004712	1.244	Yes	38.68	0.5483	0.08481	3.933	Yes
15m	100	0.1138	1.886	154.4	19.30	1.998	0.004702	1.455	Yes	38.60	0.3996	0.08464	4.602	Yes
12m	100	0.1234	1.877	154.0	19.26	1.447	0.004692	1.708	Yes	38.51	0.2894	0.08445	5.402	Yes
10m	100	0.1329	1.867	153.7	19.21	1.081	0.004681	1.974	Yes	38.43	0.2163	0.08427	6.242	Yes
6m	100	0.1791	1.821	152.1	19.01	1.000	0.004632	2.042	Yes	38.02	0.2000	0.08337	6.457	Yes

'ICom 7100 Half Power' to '2meter' via 20 ft of 'LMR-400'

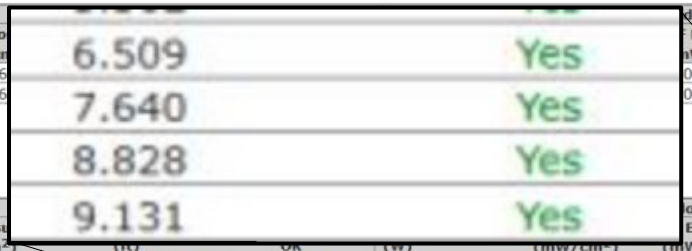
Controlled distance: 15 ft., Uncontrolled distance: 10 ft

Band	Power (W)	Line Losses (dB)	Total Gain (dB)	EIRP (W)	Controlled Exposure (6 minute window)					Uncontrolled Exposure (30 minute window)				
					Time Ave Power (W)	MPE (mW/cm^2)	RF Expo (mW/cm^2)					Exposure (mW/cm^2)	Minimum Distance (ft)	Distance OK
2m	50	0.3031	1.847	76.50	38.25	1.000	0.01456					06553	5.724	Yes
440 MHz	35	0.5327	1.617	50.79	25.40	1.450	0.00966					04351	3.873	Yes

'ICOM 7100 Digital Mode' to 'Long Wire' via 20 ft of 'LMR-400'

Controlled distance: 30 ft., Uncontrolled distance: 10 ft

Band	Power (W)	Line Losses (dB)	Total Gain (dB)	EIRP (W)	Controlled Exposure (6 minute window)					Uncontrolled Exposure (30 minute window)				
					Time Ave Power (W)	MPE (mW/cm^2)	RF Exposu (mW/cm^2)					Exposure (mW/cm^2)	Minimum Distance (ft)	Distance OK
160m	100	0.03381	1.966	157.3	39.32	100.0	0.009579	0.2936	Yes	78.63	49.86	0.1724	0.5880	Yes
80m	100	0.04756	1.952	156.8	39.19	64.00	0.009549	0.3664	Yes	78.38	12.80	0.1719	1.159	Yes
60m	100	0.05694	1.943	156.4	39.11	31.24	0.009528	0.5239	Yes	78.21	6.248	0.1715	1.657	Yes
40m	100	0.06577	1.934	156.1	39.03	17.60	0.009509	0.6972	Yes	78.05	3.521	0.1712	2.205	Yes
30m	100	0.07835	1.922	155.7	38.91	8.779	0.009481	0.9859	Yes	77.83	1.756	0.1707	3.118	Yes
20m	100	0.09282	1.907	155.1	38.78	4.479	0.009450	1.378	Yes	77.57	0.8958	0.1701	4.357	Yes
17m	100	0.1050	1.895	154.7	38.68	2.742	0.009423	1.759	Yes	77.35	0.5483	0.1696	5.562	Yes
15m	100	0.1138	1.886	154.4	38.60	1.998	0.009404	2.058	Yes	77.20	0.3996	0.1693	6.509	Yes
12m	100	0.1234	1.877	154.0	38.51	1.447	0.009383	2.416	Yes	77.02	0.2894	0.1689	7.640	Yes
10m	100	0.1329	1.867	153.7	38.43	1.081	0.009363	2.792	Yes	76.86	0.2163	0.1685	8.828	Yes
6m	100	0.1791	1.821	152.1	38.02	1.000	0.009264	2.887	Yes	76.04	0.2000	0.1667	9.131	Yes



Summation

- You don’t have to love your neighbor but you must not irradiate him-her
- It’s pretty easy to find the frequencies of potential risk
- Figure out which frequencies need lower power
- Write it down and date it in case your enemies rat you out to the FCC
- Do it by May 3, 2023

Resources

www.arrl.org/news/updated-radio-frequency-exposure-rules-become-effective-on-may-3

www.arrl.org/files/file/Technology/RFsafetyCommittee/RFXFAQ.pdf

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

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