Basic RF Safety for Amateur Radio

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Topics

- Why RF Safety Concerns?
- Important Definitions
- IEEE Standard
- OET Standard
- Safe Levels
- Station Evaluation
- Wrap Up
- Useful Web Sites

Why RF Safety Concerns?

- Damage: RF radiation can cause thermal heating of bodily tissue that can be painful or cause tissue damage
  - For example, there can be RF burns, like a bad sun burn, if the exposure level is too high
- According to FCC Part 97, we must always operate our station in a proper manner, including not being a safety threat to ourselves, our family, or the general public.
  - Note: All services regulated by the FCC, for example unlicensed devices on the 2.4 or 5 GHz ISM band, must comply. The RF emission profile is part of the FCC certification data for devices made available to the general public.

Why RF Safety Concerns?

- FCC Requirements (Part 97)
  - Before causing or allowing an amateur station to transmit from any place where the operation of the station could cause human exposure to RF electromagnetic field levels in excess of those allowed under §1.1310 of this chapter, the licensee is required to take certain actions.
    - (1) The licensee must perform the routine RF environmental evaluation prescribed by §1.1307(b) of this chapter, if the power of the licensee's station exceeds the limits given in the [safe emissions table]:
    - (2) If the routine environmental evaluation indicates that the RF electromagnetic fields could exceed the limits contained in §1.1310 of this chapter in accessible areas, the licensee must take action to prevent human exposure to such RF electromagnetic fields. Further information on evaluating compliance with these limits can be found in the FCC's OET Bulletin Number 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields."

Important Definitions

- Radiation Types
  - Ionizing: radiation capable of knocking electrons free in atoms and molecules – can cause genetic damage
  - Non-Ionizing: radiation not capable of knocking electrons free in atoms and molecules – can cause burns like a sunburn
- Bodily Absorption
  - Maximum Permitted Exposure (MPE): The rms and peak electric and magnetic field strength, their squares, or the plane-wave equivalent power densities associated with these fields to which a person may be exposed without harmful effect and with an acceptable safety factor.
  - Specific Absorption Rate (SAR): the rate at which the body absorbs radiation
  - Duty Cycle: Percentage of the time for receiving radiation exposure computed over a standard averaging interval (usually 6 or 30 minutes)

Important Definitions

- Environments
  - Controlled: Human exposure to RF fields when persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and ***can exercise control over their exposure***.
  - Uncontrolled: Human exposure to RF fields when the general public is exposed. Therefore, members of the general public would always be considered under this category when exposure is not employment-related, for example, in the case of a telecommunications tower that exposes persons in a nearby residential area.
  - Restricted: Environment in which human exposure may exceed safe limits; generally, ***requires a safety protocol to protect occupants***
  - Unrestricted: Environment in which human exposure will not exceed safe limits; safe for the general public and the operator

IEEE Standard

IEEE Std C95.1TM-2019/Cor.2-2020
IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz—Corrigenda 2

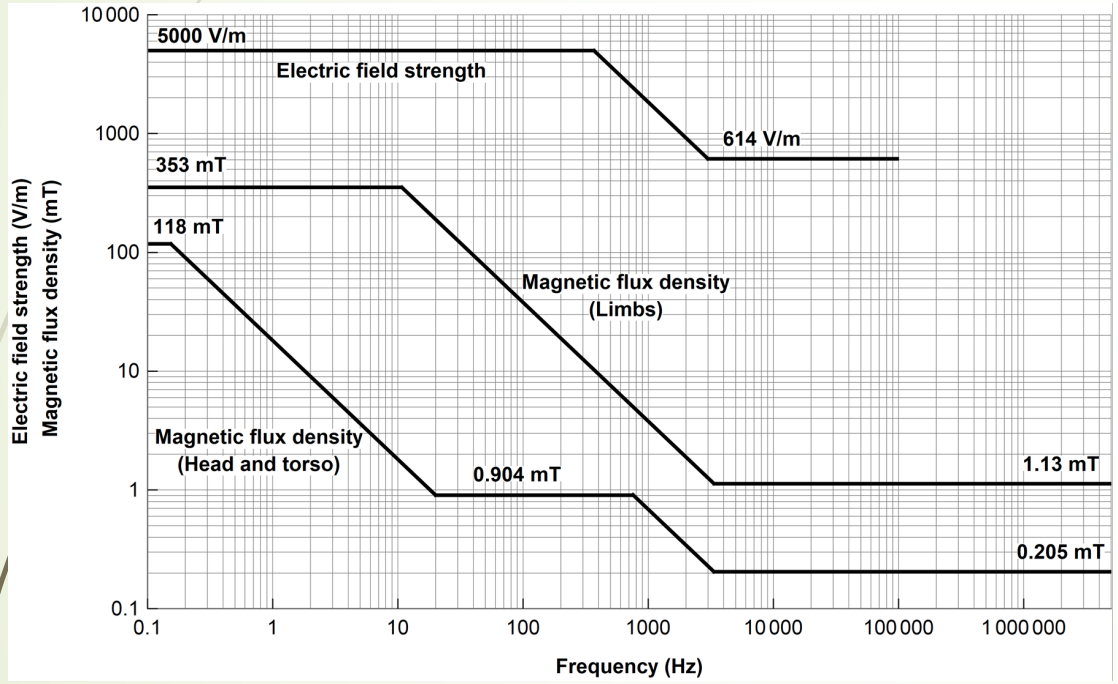

Figure 1—Graphical representations of the ERLs of Table 2, Table 3, and Table 4 for electric and magnetic fields—persons in unrestricted environments

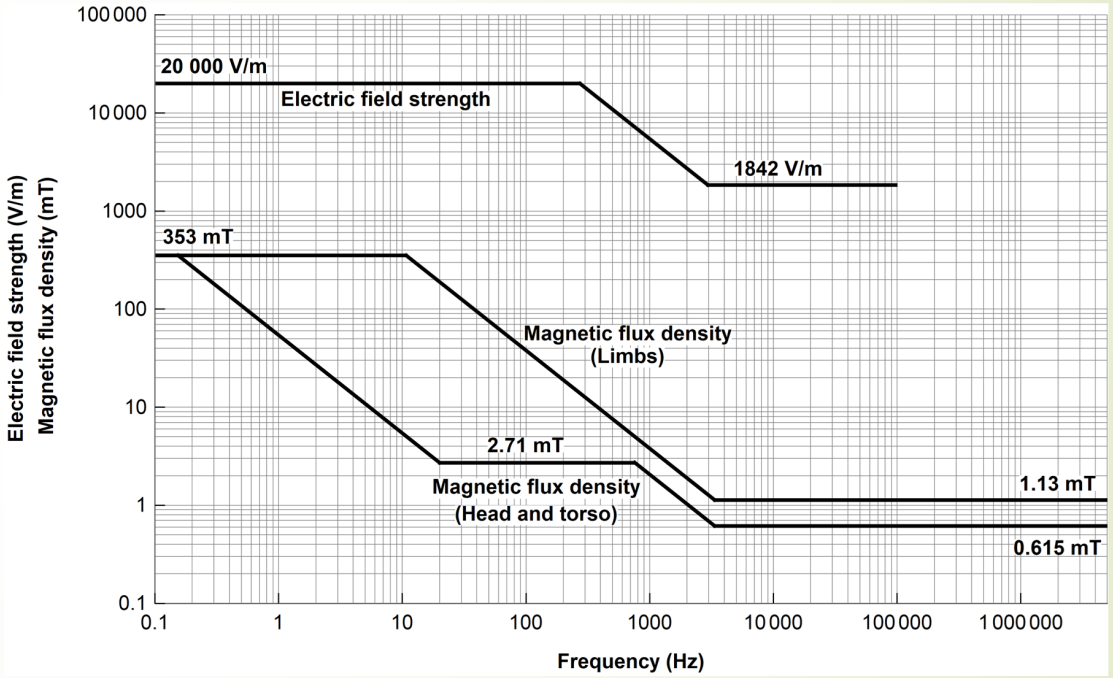

Figure 2—Graphical representations of the ERLs of Table 2, Table 3, and Table 4 for electric and magnetic fields—persons in restricted environments

IEEE Standard

TCB

GRANT OF EQUIPMENT
AUTHORIZATION
Certification
Issued Under the Authority of the
Federal Communications Commission
By:

ACB, Inc.
6731 Whittier Avenue Suite C110
McLean, VA 22101

Futaba Corporation
1080 Yabutsuka,chosei-mura
chosei-gun, Chiba-ken, 299-4395
Japan

Attention: Satoshi Inokoshi , General Manager

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER:	AZPT14SG-24G
Name of Grantee:	Futaba Corporation
Equipment Class:	**Part 15 Spread Spectrum Transmitter**
Notes:	**Radio Control**

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequenc Tolerance
CC	**15C**	**2403.25 - 2447.5**	**0.03621**	

Power Output listed is conducted. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and not be co-located with any other transmitters except in accordance with FCC multi-transmitter product procedures. Only those antenna(s) tested with the device or similar antenna(s) with equal or lesser gain may be used with this transmitter. End-users and installers must be provided with transmitter operating conditions for satisfying RF exposure compliance.

CC: This device is certified pursuant to two different Part 15 rules sections.

Project:	uAvionix ping2020i		
Evaluator:	S. Horan		
Date:	November 25, 2020		
Transmission Frequency:	978.0	MHz	Enter a frequency between 30 and 100,000 MHz
XMIT Output:	20.0E+0	W	Enter the transmitter's output power (W)
XMIT Output:	13.0E+0	dBW	
Cabling Loss:	0	dB	Enter cabling loss expected between the transmitter output and the antenna (dB)
Antenna Gain:	4	dB	Enter the antenna gain (dB)
EIRP:	17.0E+0	dBW	
EIRP:	50.2E+0	W	
Controlled Duty Cycle:	100%		Maximum percent time transmitter is ON during any 6-minute period
General Public Duty Cycle:	100%		Maximum percent time transmitter is ON during any 30-minute period
Max. Power Density:	32.60	W/m^2	Assumes an Occupational/Controlled Environment (IEEE C95.1-2005)
Minimum Safe Range:	350.2E-3	m	Minumum safe distance between control operators and the antenna
Max. Power Density:	4.89	W/m^2	Assumes General Public Environment
Minimum Safe Range:	904.2E-3	m	Minumum safe distance between the general public and the antenna

OET Standard

Table 10.1: Maximum Exposure Limits for Occupational/Controlled Exposure. (OET Bulletin 65, August 1997)

Frequency (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time (minutes)
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 – 100,000	—	—	5	6

Safe Levels

Wavelength band	Evaluation required if power[1] (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:* height above ground level to lowest point of antenna <10 m *and* power >500 W ERP *building-mounted antennas:* power >500 W ERP

Evaluation is ***not required*** if the station's PEP power to the antenna is below these levels.

Station Evaluation

- The evaluation process can be done in several ways
  - Direct measurements of the signal strength at key locations
  - Detailed computer modeling, e.g., with NEC
  - Using the evaluation tables from ARRL
- Not every station needs a formal evaluation. For example, a 100W rig operating on 15m through 160m does not need a formal evaluation, but still must be operated safely.
- Antenna feed line loss, transmission duty cycle, and similar factors also enter the evaluation if the transmitter power is above the minimum levels in the table. For example, a feedline loss of 3 dB when using FT8 with a 50% duty factor reduces the effective emitted power to 25% of the rig output level in the evaluation period.

Station Evaluation

Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations				
1	Call Sign:	NM4SH		User Data
2	Wavelength band:	40	m	
3	Exact operating frequency	7.074	MHz	
4	Setup #:	1		
5	Station Location:	11 Thomas Drive		
6	Evaluated by:	Stephen Horan		
7	Date:	2/3/21		
I. Initial Determination as to whether a Routine Evaluation is required by FCC Rule Section 97.13 for this amateur radio station setup.				
8	Transmitter Description:	IC-746	If known, add FCC ID	
9	External amplifier description (if used):	None		
A.	Peak Envelope Power (PEP) output, in Watts:	100	W	
B.	PEP output, converted to dBW:	20.00	dBW	Computed Data
	Calculate Total Feedline Loss			
	Feedline type	Bury Flex		
C1	Feedline loss/100 ft @ operating band	0.57		
D1	Feedline length	50	ft	
	Feedline type	RG-58		
C2	Feedline loss/100 ft @ operating band	1.1	dB	
D2	Feedline length	50	ft	
E	Feedline loss:	0.835	dB	
F	Other feedline losses (if known):	0	dB	
G	PEP input to antenna, in dBW: (B - E - F)	19.17	dBW	
H	PEP input to antenna, Watts:	82.5	W	
	Max. PEP for this band:	500	W	
	Is an evaluation required?	**No**		

Station Evaluation

	Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations				
1	Call Sign:	NM4SH			
2	Wavelength band:	40	m		
3	Exact operating frequency	7.074	MHz		
4	Setup #:	1			
5	Station Location:	11 Thomas Drive			
6	Evaluated by:	Stephen Horan			
7	Date:	2/3/21			
	II. Routine Evaluation of amateur radio station setup.				
27	Antenna description:	MFJ 2010 OCFD mounted as an invertd Vee			User Data
M	Antenna height above ground level at lowest point:	2.44	m		
N	Lossless antenna gain (directivity only)	6.00	dBi		
	Emission type:	FT8			
O	Emission type factor Table 2 on Tables tab:	1.00			
	Transmit duty cycle (controlled or uncontrolled):	50%	Asume the transmitting percentage time over averaging time is the same for both environments		
P	Duty cycle factor:	0.50		Computed Data	
Q	Average power input to the antenna: (H x O x P)	41.25	W		
	Antenna Efficiency:	100%			
R	Antenna Efficiency factor:	1.00			
S	Average power radiated (EIRP): (Q x R)	41.25	W		

	Minimum necessary distance from radiating part of antenna to controlled/uncontrolled areas:				
	Maximum MPE for Uncontrolled Environment 30-minute averaging time:	3.60	mW/cm^2		
	Maximum MPE for Controlled Environment 6-minute averaging time:	17.99	mW/cm^2		
T	Minimum distance when the Public may be present (uncontrolled):	0.30	m		
U	Minimum distance when the Amateur radio operator may be present (controlled):	0.14	m		
	Actual distance from radiating part of antenna to nearest place where the				
V	Public may be present (uncontrolled):	9.4	m		
W	Amateur radio operator may be present (controlled):	9.4	m		
	Is the configuration Safe?	**YES**	Both public and operator safe?		

Station Evaluation

Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations				
1	Call Sign:	NM4SH		User Data
2	Wavelength band:	10	m	
3	Exact operating frequency	28.074	MHz	
4	Setup #:	1		
5	Station Location:	11 Thomas Dr. Poquoson, VA		
6	Evaluated by:	Stephen Horan		
7	Date:	1/12/21		
I. Initial Determination as to whether a Routine Evaluation is required by FCC Rule Section 97.13 for this amateur radio station setup.				
8	Transmitter Description:	Icom IC-746	FCC ID: AFJIC-746	
9	External amplifier description (if used):	None		
A.	Peak Envelope Power (PEP) output, in Watts:	100	W	
B.	PEP output, converted to dBW:	20.00	dBW	Computed Data
	Calculate Total Feedline Loss			
	Feedline type	BuryFlex		
C1	Feedline loss/100 ft @ operating band	0.95		
D1	Feedline length	50	ft	
	Feedline type	RG-58		
C2	Feedline loss/100 ft @ operating band	2.5	dB	
D2	Feedline length	50	ft	
E	Feedline loss:	1.725	dB	
F	Other feedline losses (if known):	0	dB	
G	PEP input to antenna, in dBW: (B - E - F)	18.28	dBW	
H	PEP input to antenna, Watts:	67.2	W	
	Max. PEP for this band:	50	W	
	Is an evaluation required?	**YES**		

Station Evaluation

	Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations				
1	Call Sign:	NM4SH			
2	Wavelength band:	10	m		
3	Exact operating frequency	28.074	MHz		
4	Setup #:	1			
5	Station Location:	11 Thomas Dr. Poquoson, VA			
6	Evaluated by:	Stephen Horan			
7	Date:	1/12/21			
	II. Routine Evaluation of amateur radio station setup.				
27	Antenna description:	MFJ 2010 OCFD moutned as an inverted vee from a tree			User Data
M	Antenna height above ground level at lowest point:	2.44	m		
N	Lossless antenna gain (directivity only)	6.00	dBi		
	Emission type:	FT8			
O	Emission type factor Table 2 on Tables tab:	1.00			
	Transmit duty cycle (controlled or uncontrolled):	50%	Asume the transmitting percentage time over averaging time is the same for both environments		
P	Duty cycle factor:	0.50		Computed Data	
Q	Average power input to the antenna: (H x O x P)	33.61	W		
	Antenna Efficiency:	100%			
R	Antenna Efficiency factor:	1.00			
S	Average power radiated (EIRP): (Q x R)	33.61	W		

	Minimum necessary distance from radiating part of antenna to controlled/uncontrolled areas:				
	Maximum MPE for Uncontrolled Environment 30-minute averaging time:	0.23	mW/cm^2		
	Maximum MPE for Controlled Environment 6-minute averaging time:	1.14	mW/cm^2		
T	Minimum distance when the Public may be present (uncontrolled):	1.08	m		
U	Minimum distance when the Amateur radio operator may be present (controlled):	0.48	m		
	Actual distance from radiating part of antenna to nearest place where the				
V	Public may be present (uncontrolled):	9.4	m		
W	Amateur radio operator may be present (controlled):	9.4	m		
	Is the configuration Safe?	**YES**	Both public and operator safe?		

Wrap Up

- The station evaluation is an important part of overall RF safety for the amateur.
- Other things to consider
  - Use lightening arrestors where the feedline enters the shack
  - Proper grounding and shielding for both the antenna and the rig
  - Antenna placement so that it cannot be touched accidently or for curiosity
  - Antenna placement at sufficient distance from hazards such as overhead electrical poles and wires
  - Remove any shields or covers (hats) before operating
  - Do not look into the open end of a microwave feed horn antenna
  - Keep the HT antenna away from head and eyes

Useful Web Sites

- ARRL:
  - RF Exposure Station Evaluation and Exemption Worksheets http://www.arrl.org/files/file/Technology/tis/info/pdf/rfex1_2.pdf
  - RF Exposure and You (evaluation worksheet aids) http://www.arrl.org/files/file/Technology/RFsafetyCommittee/RF%20Exposure%20and%20You.pdf
  - Ed Hare, *RF Exposure and You*
- FCC:OET 65 Bulletin https://transition.fcc.gov/bureaus/oet/info/documents/bulletins/oet65/oet65.pdf
- IEEE: C95.1-2019 – "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz," https://ieeexplore.ieee.org/document/8859679