The Nebraska Center for Excellence in Electronics
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RF Exposure

Reference: CFR 47 FCC Part 1.1310
               RSS-102. Issue 5

Description:

All measurements were peak power readings taken from test reports from accredited test labs. Antenna gains were taken from the manufacturer's specifications where applicable.

Limits: Maximum exposure limits from CFR 47, FCC Part 1.1310:

Table 1 - 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
300-1,500			f/300	6
1,500-100,000			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
300-1,500			f/1500	30
1,500-100,000			1.0	30

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RF Exposure

Occupational/Controlled	0
General Population/uncontrolled	1

Transmitter	Frequency	Antenna Gain	Power	Power +10% for tolerance	Power Density	Limit at specified distance	% of limit	Highest	Total
	MHz	numerical	mW	mW	mW/cm^2	mW/cm^2			
1	2412	1.74	180.00	198.00	0.06857	1.00	6.86%		
1	2442	1.74	190.00	209.00	0.07238	1.00	7.24%	1	7.24%
1	2462	1.74	173.00	190.30	0.06591	1.00	6.59%		
2	2407	1*	1.97	2.16	0.00043	1.00	0.04%	1	0.04%
2	2440	1*	1.85	2.04	0.00041	1.00	0.04%		
2	2480	1*	1.74	1.92	0.00038	1.00	0.04%		
3	2405	1*	38.82	42.70	0.00850	1.00	0.85%	1	0.85%
3	2440	1*	27.48	30.23	0.00602	1.00	0.60%		
3	2480	1*	16.44	18.08	0.00360	1.00	0.36%		
								TOTAL	8.13%

Distance	20	cm

PASS?	YES

Calculations:

Table 2 - Calculations according to CFR 47, Part 1.1310, Table 1(B)

*Note: when antenna gain = 1, the power was measured as EIRP. In all other cases, power was measured conducted.

Transmitter 1: Murata 1DX module on Hunter Douglas Wireless Hub, worse-case mode shown
Transmitter 2: Nordic NRF52832, 2.4 GHz band – 3 channels, 1 mode

Transmitter 3: Silicon Labs EFR32MG1 - 3 channels, 1 mode

All transmitters cold be transmitting simultaneously.

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Table 3 - From Table 4 of RSS-102 Issue 5

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m²)	Reference Period (minutes)
$0.003\text{-}10^{21}$	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\,f^{0.3417}$	$0.008335\,f^{0.3417}$	$0.02619\,f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\,f^{0.5}$	$4.21 \times 10^{-4}\,f^{0.5}$	$6.67 \times 10^{-5}\,f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

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Table 4 - Calculation according to Industry Canada RSS-102, Table 6

Occupational/Controlled	0
General Population/uncontrolled	1

Transmitter	Frequency	Antenna Gain	Power	Power +10% for tolerance	Power Density	Limit at specified distance	% of limit	Highest	Total
	MHz	numerical	mW	mW	W/m^	W/m^2			
1	2412	1.74	180.00	198.00	0.686	5.37	12.78%		
1	2442	1.74	190.00	209.00	0.724	5.41	13.38%	1	13.38%
1	2462	1.74	173.00	190.30	0.659	5.44	12.11%		
2	2407	1*	1.97	2.16	0.004	5.36	0.08%	1	0.08%
2	2440	1*	1.85	2.04	0.004	5.41	0.08%		
2	2480	1*	1.74	1.92	0.004	5.47	0.07%		
3	2405	1*	38.82	42.70	0.085	5.36	1.59%	1	1.59%
3	2440	1*	27.48	30.23	0.060	5.41	1.11%		
3	2480	1*	16.44	18.08	0.00036	5.47	0.66%		
								TOTAL	15.04%

Distance	20	cm

PASS?	YES

*Note: when antenna gain = 1, the power was measured as EIRP. In all other cases, power was measured conducted.

Notes: The minimum separation distance was defined as the closest point from the transmitting antenna to any part of the body or extremity of a user or bystander.

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The limit was converted from W/cm^2 to mW/m^2 by dividing by 10
 (W→mW = .001) × (/cm^2→/m^2 = 100) = 0.1 = /10
The power density is calculated as shown below:

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RF Exposure

$S = (P \times G)/(4 \times \pi \times d^2)$ – used to calculate exposure at 20 cm

$d = \sqrt{(S/(P \times G) \times 4 \times \pi)}$ – used to calculate minimum distance to meet limits

$1\ mW/cm^2 = 10\ W/m^2$

S = power density
P = transmitter conducted power (in mW)
G = antenna numeric gain
D = distance to radiation center