Collocated MPE Calculations

BCM94311MCAG with N7N-MC5720

Systems operating under the provision of 47 CFR 1.1307(b)(1) shall be operated in a manor that ensures that the public is not exposed to radio frequency energy levels in excess of the FCC guidelines.

The EUT will only be used with a separation of 20 centimeters or greater between the antennas and the body of the user or nearby persons and can therefore be considered a mobile transmitter per 47 CFR 2.1091(b).

The EUT contains a PCS Licensed Transmitter, FCC Identifier N7N-MC5720, covered under FCC parts 24E and 22H of CFR part 47. The details for this transmitter are shown in table

FCC Rule Parts	Range (MHz)	Output Watts	Peak Antenna Gain to be used for collocated MPE, dBi
24E	1851.25 – 1908.75	0.923	3.35
22H	824.7 – 848.31	0.964	3.50

The EUT contains a transmitter, with FCC Identifier BCM94311MCAG, operating in the Unlicensed UNII bands covered under parts 15E of CFR part 47 and also in the Unlicensed IMS bands covered under part 15C of CFR part 47. The details for this transmitter are shown below.

FCC Rule Parts	Range (MHz)	Output Watts	Peak Antenna Gain to be used for collocated MPE, dBi
15C	2412.0 – 2462.0	0.4325	2.00
15E	5180.0 – 5240.0	0.0448	4.00
15C	5745.0 – 5825.0	0.2328	4.00
15E	5260.0 – 5320.0	0.0448	4.00

Equations

The equations used are based on methods described in OET Bulletin 65 and appendices.

Given

$$E = \sqrt{(30 * P * G) / d}$$

And

$$S = E^2 / 3770$$

Where

E = Field Strength in Volts/meter
P = Power in Watts
G = Numeric antenna gain
d = Distance in meters
S = Power Density in milli-watts/square centimeter

Combining equations and rearranging the terms to express the Power Density in terms of the other variables yields,

$$S = (30 * P * G) / (3770 * d^2)$$

Changing the units of Power to mW and Distance to cm, using,

$$P\ (mW) = 1000 * P\ (W)$$
$$d\ (cm) = 100 * d\ (m)$$

Yields,

$$S = (30 * (P/1000) * G) / (3770 * (d/100)^2)$$

Or,

$$S = (0.0795756 * P * G) / (d^2)$$

Where

d = distance in cm
P = Power in mW
G = Numeric antenna gain
S = Power Density in mW/cm^2

FCC Limits for Maximum Permissible Exposure (MPE)

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
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
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

The MPE calculations for d = 20cm are shown below for the possible combinations of transmit frequency bands.

Per OET Bulletin 65, for frequency bands with the same MPE limits, the Power Densities produced by each transmitter are summed. The summation must be under the limit for the band.

Per OET Bulletin 65, for frequency bands with different limits the Power Densities are calculated separately for each band, divided by the limit for the band and the results are then summed. The summation must be less than 1.

For the frequency band 824.7 – 848.31 MHz the worst case (lowest) limit is used. The limit is calculated as follows,

$$824.7 / 1500 = 0.55 \text{ mW/cm}^2$$

For the 5 GHz frequency bands the worse case (highest) conducted power level of 0.2328 Watts is used.

Collocated MPE Calculations

Transmitter Frequency Band, MHz	Power, Watts	Power, milli-Watts	Antenna Gain, dBi	Antenna Gain, Dimensionless	Power Density at 20cm, mW/cm^2 $(0.0795756 * P * G) / (d^2)$	Fraction of Limit, Dimensionless
824.7 – 848.31	0.964	964	3.50	2.24	NA	0.43/0.55 = 0.78
1851.25 – 1908.75	0.923	923	3.35	2.16	0.40	NA
2412.0 – 2462.0	0.4325	432.5	2.00	1.58	0.14	0.14/1 = 0.14
5180.0 – 5240.0 / 5260.0 – 5320.0 / 5745.0 – 5825.0	0.2328	232.8	4.00	2.51	0.12	0.12/1 = 0.12

Active Transmitter Bands, MHz	2412.0 – 2462.0	5180.0 – 5240.0 / 5260.0 – 5320.0 / 5725.0 – 5850.0	Unit	Limit
824.7 – 848.31	0.78+0.14 = **0.92**	0.78+0.12 = **0.90**	**Dimensionless**	**1**
1851.25 – 1908.75	0.40+0.14 = **0.54**	0.40+0.12 = **0.52**	**mW/cm2**	**1**

Calculated worse case MPE numbers are below required limits.