RF exposure calculations for Sierra Wireless MINI-PCI Express card CDMA when its antennas collocated with Cisco 802.11 a/b/g/n AP802 module antennas inside Cisco Router according FCC 47 CFR 1.307(b)(1).

The following RF exposure calculation made for Mini-PCI Express card, model: MC5728V (Sierra Wireless Inc., FCC ID: N7N-MC5728) when his antenna collocated with antennas from 802.11 a/b/g/n module, model: AP802 (Cisco Systems Inc., FCC ID: LDKTG2050).

Both devices are embedded into the Cisco 800 series model Router and have been evaluated and complied with FCC RF exposure requirements separately, however in case of Cisco 800 series model Router, these antennas are collocated less than 20 cm from each other and therefore cumulative RF exposure evaluation is required.

This device will be only used with a separation of 20 cm or greater between the antennas and the user or nearby person. Device will be deployed in the fixed locations only but for purpose of this calculation will be consider as a mobile transmitter per 47 CFR 2.1091(b), and therefore has to comply with Maximum Permissible Exposure (MPE) limits. UMTS transmitter (FCC ID: N7N-MC5728) operates under Part 24E and 22H of FCC Rules in cellular and PCS bands and has the transmitting characteristics which are showing in Table1.

Table1

FCC Part No.	Frequency Range (MHz)	Maximum output power (mW)	Duty Cycle	Peak Antenna Gain for calculation MPE (dBi)	Numeric Peak Antenna Gain for calculation MPE
24E	1850- 1910	814.7	100%	1	1.2589
22H	824 - 849	959.4	100%	1	1.2589

a) 802.11 a/b/g/n transmitter (FCC ID: LDKTG2050) operates under Part 15C and 15E of FCC Rules in ISM and U-NII bands and has transmitting characteristics which are showing in Table2.

Table2

FCC Part No.	Modulation	Frequency Range (MHz)	Maximum output power (mW)	Duty Cycle	Peak Antenna Gain for calculation MPE (dBi)	Numeric Peak Antenna Gain for calculation MPE
15C	802.11n HT40	2412.0 - 2462.0	215.77	100%	4.0[1]	2.5119
15C	802.11n HT40	5745.0 - 5825.0	328.1	100%	6.0[1]	3.9811
15E	802.11n HT40	5180.0 - 5240.0	24.66	100%	6.0[1]	3.9811
15C	802.11n HT40	2412.0 - 2462.0	215.77	100%	1.6[2]	1.4454
15C	802.11n HT40	5745.0 - 5825.0	328.1	100%	5.0[2]	3.1623
15E	802.11n HT40	5180.0 - 5240.0	24.66	100%	5.0[2]	3.1623

1. WiFi antenna type 1 PIFA antenna
2. WiFi antenna type 2 Dipole antenna

According 47 CFR 1.1310 FCC MPE limits for General population/Uncontrolled Exposure are showing in the Table3

Table3

Frequency Range (MHz) Electric Field	Strength [E] (V/m)	Magnetic Field Strength [H](A/m)	Power density [S] (mW/cm^2)	Averaging time (min)
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	30

f = frequency in MHz
* = Plane-wave equivalent Power Density

Based on FCC Bulletin OET 65, the MPE calculations in case of multiple transmitters have been e performed on the following and assumptions and equations:

1. For transmitters which operate in the frequency band with a same MPE limit the Power Densities are summed. The Total Power Density shall not exceed the Limit for this band
2. For transmitters which operate in frequency bands with a different MPE the Power Densities are calculated separately for each band, and then divided by Limit for each band. The sum of these ratios shall not exceed 1.
3. The calculation of the Power Density based on equation given in OET 65:

$$E = \sqrt{(30 \times P \times DC \times G) / d} \quad \text{(Eq.1)}$$

and

$$S = E^2 / 3770 \quad \text{(Eq.2)}$$

Where:
E = field strength in volts/meter
P = power in watts
DC = numeric duty cycle
G = numeric antenna gain
d = distance in meters
S = power density in milliwatts / square centimeter

Combining (Eq.1) and (Eq.2), S may be calculated as:

$$S = (30 \times P \times DC \times G) / (3770 \times d^2) \quad \text{(Eq.3)}$$

By changing units for P to mW and distance to cm, (Eq.3) can be written as:

$$S = [30 \times (0.001 \times P) \times DC \times G] / [3770 \times (0.01 \times d)^2] \quad \text{(Eq.4)}$$

Or:

$$S = (0.0795756 \times P \times DC \times G) / d^2 \quad \text{(Eq.4)}$$

Where:
P = power in mW
DC = numeric duty cycle
G = numeric antenna gain
d = distance in cm
S = power density in mW/cm^2

4. According Table3, limit for EV-DO transmitter in 824.7 – 848.31 MHz band shall be calculated at the lowest frequency (worst case) as:

    i. 824.7 / 1500 = 0.5498 mW/cm^2

5. For the all frequency bands the highest level (worst case) of conducted power and antennas gain was used for calculation. The results of calculations are showing in Table 4.

Table 4

Device (transmitter)	Transmitting frequency bands (MHz)	Transmitting conductive power (mW)	Transmitter duty cycle	Antenna gain (dBi)	Numeric antenna gain	Power density at 20 cm from antennas (mW/cm^2)	Ratio of the power density to its limit
EVDO	824-849	814.7	100%	1	1.2589	0.1291	0.2348
EVDO	1850- 1910	959.4	100%	1	1.2589	0.3800	0.3800
802.11 a/b/g/n	2412.0-2462.0	215.77	100%	4.0[1]	2.5119	0.1078	0.1078
802.11 a/b/g/n	5745.0 - 5825.0	328.1	100%	6.0[1]	3.9811	0.2598	0.2598
802.11 a/b/g/n	5180.0 - 5240.0	24.66	100%	6.0[1]	3.9811	0.0195	0.0195
802.11 a/b/g/n	2412.0-2462.0	215.77	100%	1.6[2]	1.4454	0.0620	0.0620
802.11 a/b/g/n	5745.0 - 5825.0	328.1	100%	5.0[2]	3.1623	0.2064	0.2064
802.11 a/b/g/n	5180.0 - 5240.0	24.66	100%	5.0[2]	3.1623	0.0155	0.0155

1. WiFi antenna type 1, PIFA antenna
2. WiFi antenna type 2, Dipole antenna

6. Finally, the sum of ratios according (1.) and (2.) based on values in Table4.

For WiFi antenna type1, PIFA antenna:
EVDO (850) + WiFi (2.4G) = 0.2348 + 0.1078= 0.3426 < 1
EVDO (1900) + WiFi (2.4G) = 0.3800 + 0.1078 = 0.4878 < 1
EVDO (850) + WiFi (5G ISM band) = 0.2348 + 0.2598= 0.4946< 1
EVDO (1900) + WiFi(5G ISM band) = 0.3800 + 0.2598 = 0.6398 < 1
EVDO (850) + WiFi (5G U-NII band) = 0.2348 + 0.0195= 0.2543< 1
EVDO (1900) + WiFi(5G U-NII band) = 0.3800 + 0.0195 = 0.3995 < 1

For WiFi antenna type2, Dipole antenna:
EVDO (850) + WiFi (2.4G) = 0.2348 + 0.0620= 0.2968 < 1
EVDO (1900) + WiFi (2.4G) = 0.3800 + 0.0620 = 0.4420 < 1

EVDO (850) + WiFi (5G ISM band) = 0.2348 + 0.2064= 0.4412< 1
EVDO (1900) + WiFi(5G ISM band) = 0.3800 + 0.2064 = 0.5864 < 1
EVDO (850) + WiFi (5G U-NII band) = 0.2348 + 0.0155= 0.2503< 1
EVDO (1900) + WiFi(5G U-NII band) = 0.3800 + 0.0155 = 0.3955 < 1

Conclusion:

The Sierra Wireless Mini-PCI Express card: MC5728V (FCC ID: N7N-MC5728), when device transmitting antenna collocated with antennas connected to Cisco Wi-Fi module: AP802 (FCC ID: LDKTG2050) at the distance less than 20 cm and both devices are integrated into the Cisco 800 series model Router, is in compliance with FCC MPE limits for General Population/Uncontrolled Exposure as a mobile device (d>20cm).