RF exposure calculations for Novatel Wireless EV-DO card when his antennas collocated with Qcom 802.11 b/g/n card antennas inside Ambient X-4000-xxx-xx smart grid node according FCC 47 CFR 1.307(b)(1).

The following RF exposure calculations made for EV-DO card Model: E760 (Novatel Wireless Inc., FCC ID: PKRNVWE760) when device antenna collocated with antennas from 802.11 b/g/n module Model: Q802MKN (Qcom Technology Inc., FCC ID: RUJ-Q802MKN).

Both devices are embedded into the Ambient X-4000-xxx-xx smart grid node and has been evaluated and complied with FCC RF exposure requirements separately, however in case of X-4000-xxx-xx, these antennas are collocated less then 20 cm for 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.

EV-DO transmitter (FCC ID: PKRNVWE760) 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	1851.25 - 1908.75	877	100%	4.9	3.0903
22H	824.7 - 848.31	628	100%	2.2	1.6596

802.11 b/g/n transmitter (FCC ID: RUJ-Q802MKN) operates under Part 15C of FCC Rules in ISM band 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	802.11b/g/n	2412.0 - 2462.0	352	100%	3.6	2.2908

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 er FCC Bulletin OET 65 the MPE calculations in case of multiple transmitters has 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 , 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:

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

and

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

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:

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

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/cm²

4. According Table3, limit for EV-DO transmitter in 824.2 – 848.8 MHz band shall be calculated at the lowest frequency (worst case) as:

   $$824.2 / 1500 = 0.55 \text{ mW/cm}^2$$

5. For the all frequency bands the highest level (worst case) of conducted power and antennas gain used for calculation. The results of calculations are showing in Table4.

Table4

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/cm²)	Ratio of the power density to its limit
EV-DO	824.7-848.31	877	100%	2.2	1.6596	0.2896	0.5265
EV-DO	1851.25-1909.75	628	100%	4.9	3.0903	0.3861	0.3861
802.11 b/g/n	2412.0-2462.0	352	100%	3.6	2.2908	0.1604	0.1604

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

EV-DO (800) + WiFi = 0.5265 + 0.1604 = 0.6869 < 1
EV-DO (1900) + WiFi = 0.3861 + 0.1604 = 0.5465 < 1

Conclusion:

The Novatel Wireless EV-DO card model: E760(FCC ID: PKRNVWE760), when device antenna collocated with antennas connected to Qcom Wi-Fi card model: Q802MKN (FCC ID: RUJ-Q802MKN) at the distance less then 20 cm and both devices are integrated into the Ambient X-4000-xxx-xx smart grid node, is in compliance with FCC MPE limits for General Population/Uncontrolled Exposure as a mobile device (d>20cm).