Smart Grid Node Model: X-3100-xxx
RF exposure calculations for Embedded Modules with collocated antennas according FCC 47 CFR 1.307(b)(1).

Modules type:
- Multi-band Radio Module, Sierra Wireless Inc., Mod: MC8355 (FCC ID: N7NMC8355) and
- 802.11 b/g/n: Qcom Technology Inc, Mod: Q802XKN (FCC ID: RUJ-Q802XKN)

The following calculations was made for RF exposure evaluation of the smart grid node Model: X-3100, which equipped with embedded EV-DO module Model: MC8355 (Sierra Wireless Inc.) and 802.11 b/g/n module Model: Q802XKN (Qcom Technology Inc.). Both modules has been evaluated and comply with FCC RF exposure requirements separately, however in case of X- 3100, these antennas are collocated less then 20 cm for each other and therefore X-3100 is a subject to cumulative RF exposure evaluation.

The EUT will be only used with a separation of 20 cm or greater between the antennas and the user or nearby person and therefore can be consider a mobile transmitter per 47 CFR 2.1091(b). Due to deployment conditions, device has to comply with Maximum Permissible Exposure (MPE) limits for General Population/Uncontrolled Exposure.
EUT contains:

a) EV-DO/GPRS transmitter (FCC ID: N7NMC8355) 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 (W)	Duty Cycle	Peak Antenna Gain (cable loss included) for calculation MPE (dBi)	Numeric Peak Antenna Gain (cable loss included) for calculation MPE
24E	1850.2 - 1909.8	1.199	1	3.4	2.19
24E	1850.2 - 1909.8	0.537	1	3.4	2.19
24E	1852.4 - 1907.5	0.294	1	3.4	2.19
24E	1851.25 – 1908.75	0.287	1	3.4	2.19
22H	824.2 – 848.8	2.01	0.25	1.4	1.38
22H	824.2 – 848.8	0.531	1	1.4	1.38
22H	826.4 – 846.6	0.281	1	1.4	1.38
22H	824.7 – 848.31	0.29	1	1.4	1.38

b) 802.11 b/g/n transmitter (FCC ID: RUJ-Q802XKN) 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 (cable loss included) for calculation MPE (dBi)	Numeric Peak Antenna Gain (cable loss included) for calculation MPE
15C	802.11b OFDM	2412.0 - 2462.0	64.417	1	2.6	1.82
15C	802.11g DSSS	2412.0 - 2462.0	51.286	1	2.6	1.82
15C	802.11n OFDM	2412.0 - 2462.0	50.882	1	2.6	1.82
15C	802.11n OFDM	2422.0 - 2452.0	50.88	1	2.6	1.82

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 824.2 – 848.8 MHz band shall be calculated at the lowest frequency (worst case) as:

$$824.2 / 1500 = 0.55 \ mW/cm^2$$

5. For the all frequency bands the worst case combination of conducted power, duty cycle and antennas gain was used for calculation. The results of calculations for these cases are showing in Table 4.

Table 4

Device (transmitter)	Transmitting frequency bands (MHz)	Transmitting conductive power (mW)	Transmitter duty cycle	Peak antenna gain (cable loss included) (dBi)	Numeric peak antenna gain (cable loss included)	Power density at 20 cm from antennas (mW/cm²)	**Ratio of the power density to its limit**
GPRS	824.2-848.8	2010	0.25	1.4	1.38	**0.138**	**0.251**
EV-DO	824.2-848.8	531	1	1.4	1.38	**0.146**	**0.266**
GPRS	1850.2-1909.8	1199	1	3.4	2.19	**0.523**	**0.523**
EV-DO	1850.2-1909.8	537	1	3.4	2.19	**0.234**	**0.234**
802.11 b/g/n	2412.0-2462.0	64.417	1	2.6	1.82	**0.024**	**0.024**

6. Finally, the MPE calculations for collocated EV-DO or GPRS and 802.11 b/g/n are shown in the Table 5

Table 5

Power density worst cases	Active transmitters in frequency bands (MHz):			MPE Total (numerical or mW/cm²)	Limit (numerical or mW/cm²)	Margin (numerical or mW/cm²)	Pass/ Fail
	824.2- 848.8 (EV-DO or GPRS)	1850.2 -1909.8 (EV-DO or GPRS)	2412.0 - 2462.0 (802.11 b/g/n)				
GPRS: worst case power density (fraction of the limit)	0.251		0.024	0.275	1	**-0.725**	**PASS**
EV-DO: worst case power density (fraction of the limit)	0.266		0.024	0.29	1	**-0.71**	**PASS**
GPRS: worst case power density (mW/cm²)		0.523	0.024	0.547	1	**-0.453**	**PASS**
EV-DO: worst case power density (mW/cm²)		0.234	0.024	0.258	1	**-0.742**	**PASS**

7. Conclusion.

Calculated worst case MPE numbers are complying with FCC limits for General population/Uncontrolled Exposure