Smart Grid Node Model: X-3100-xxx
RF exposure calculations for Qcom 802.11 b/g/n module with PIFA antennas with 3.6 dBi gain according FCC 47 CFR 1.307(b)(1).

Module type:
- 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 802.11 b/g/n module Model: Q802XKN (Qcom Technology Inc.) when this module attached to PIFA antennas with max gain 3.6 dBi. Previously this module has been evaluated and comply with FCC RF exposure requirements when it connected to PIFA antenna with gain 1.3 dBi.

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) 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 for calculation MPE (dBi)	Numeric Peak Antenna Gain for calculation MPE
15C	802.11b OFDM	2412.0 - 2462.0	64.417	1	3.6	2.2909
15C	802.11g DSSS	2412.0 - 2462.0	50.35	1	3.6	2.2909
15C	802.11n OFDM	2412.0 - 2462.0	50.882	1	3.6	2.2909
15C	802.11n OFDM	2412.0 - 2462.0	50.88	1	3.6	2.2909

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/cm²

4. For the all frequency bands the highest level (worst case) of conducted power and antennas gain has been 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/cm²)
802.11 b/g/n	2412.0-2462.0	64.417	1	3.6	2.2909	0.0294

5. Finally, the MPE comparison to the limit for 802.11 b/g/n module with antennas with of max gain of 3.6dBi dare shown in the Table 5

Table 5

Power density worst cases	MPE 802.11 b/g/n (mW/cm²)	Limit (mW/cm²)	Margin (mW/cm²)	Pass/ Fail
Worst case power density	0.0294	1	- 0.9706	**PASS**

7. Conclusion.

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