



Communications for a Smarter Grid

**Smart Grid Node Model: X-320i-xxx/X-32MI**  
**RF exposure calculations for Embedded Modules with different type antenna**  
**according FCC 47 CFR 1.307(b)(1).**

Modules type:

- 802.11 a/b/g/n: Compex Systems Pte Ltd, Mod: WLE200NX  
(FCC ID: TK4-10-WLE200NX)

The following calculations was made for RF exposure evaluation of the smart grid nodes Model: X-320i-xxx or Model: X-32MI that equipped with 802.11 b/g/n module Mod: WLE200NX (Compex Systems Pte Ltd). The evaluation has been made for the case when module will be connected to different type external antenna.

The node 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 a/b/g/n transmitter (FCC ID: TK4-10-WLE200NX) operates under Part 15C of FCC Rules in ISM band and has transmitting characteristics which are showing in Table1

Table1

<b>FCC Part No.</b>	<b>Modulation</b>	<b>Frequency Range (MHz)</b>	<b>Maximum output power (mW)</b>	<b>Duty Cycle</b>	<b>Peak Antenna Gain ( cable loss included) for calculation MPE (dBi)</b>	<b>Numeric Peak Antenna Gain (cable loss included) for calculation MPE</b>
15C	802.11b/g/n	2412.0 - 2462.0	410	1	-0.9	0.82
15C	802.11 b/g/n	2422.0 - 2452.0	240	1	-0.9	0.82
15C	802.11a/n	5745.0 - 5825.0	410	1	2.5	1.78
15C	802.11a/n	5755.0 - 5795.0	300	1	2.5	1.78

According 47 CFR 1.1310 FCC MPE limits for General population/Uncontrolled Exposure are showing in the Table2



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Table2

Frequency Range (MHz)	Electric Field Strength [E] (V/m)	Magnetic Field Strength [H](A/m)	Power density [S] (mW/cm <sup>2</sup> )	Averaging time (min)
0.3 - 1.34	614	1.63	(100)*	30
1.34 - 30	824/f	2.19/f	(180/f <sup>2</sup> )*	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 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:



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

Or:

$$S = (0.0795756 \times P \times DC \times G) / d^2 \quad (\text{Eq.5})$$

Where:

P = power in mW

DC = numeric duty cycle

G = numeric antenna gain

d = distance in cm

S = power density in mW/cm<sup>2</sup>

4. 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 Table3

Table3

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/cm <sup>2</sup> )
802.11 b/g/n	2412.0-2462.0	410	1	-0.9	0.82	0.067
802.11 b/g/n	2422.0-2452.0	240	1	-0.9	0.82	0.04
802.11 a/n	5745.0-5825.0	410	1	2.5	1.78	0.146
802.11 a/n	5755.0-5795.0	300	1	2.5	1.78	0.107



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Finally, the MPE compare to the limit (worst cases) for 802.11 a/b/g/n module is shown in the Table 4

Table4

Power density worst cases	MPE Total (numerical or mW/cm <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )	Margin (mW/cm <sup>2</sup> )	Pass/Fail
2412.0-2462.0 b/g/n (mW/cm <sup>2</sup> )	0.067	1	- 0.933	<b>PASS</b>
5745.0-5825.0 a/n (mW/cm <sup>2</sup> )	0.146	1	- 0.854	<b>PASS</b>

### Conclusion.

**Calculated worst case MPE numbers are complying with FCC limits for General population/Uncontrolled Exposure for a mobile device (d>20cm).**