

14. Maximum Permissible Exposure (MPE)

14.1. Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended to comply with § 2.1091 radiofrequency radiation exposure evaluation: mobile devices of the FCC CFR 47 Rules, CFR 1.1310 (b) Radio frequency Radiation Exposure Requirement.

14.2. Special Accessories

Not available for this EUT intended for grant.

14.3. Equipment Modifications

Not available for this EUT intended for grant.

14.4. Limitation

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for General Population/Uncontrolled Exposure				
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
1500-15000	/	/	1.0	30

F = frequency in MHz

* = Plane-wave equipment power density

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/f	2.19/f	-	6
10-30	28	2.19/f	-	6
30-300	28	0.073	2*	6
300-1500	1.585 f ^{0.5}	0.0042 f ^{0.5}	f/150	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/f ^{1.2}
150000-300000	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000/f ^{1.2}

Note: f is frequency in MHz.

* Power density limit is applicable at frequencies greater than 100 MHz.

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14.5. Maximum Permissible Exposure (MPE) Evaluation

The evaluation and calculation as deduces below presents only worst-case that produces highest value of the result:

Operation Configuration of the Worst-Case picked up to evaluate:

GSM 850 / 1900, HSDPA II, HSUPA V

LTE BAND 2

Transmission Band Width: 1.4M, Modulation: 16QAM, RB allocation: 1 offset: 5

LTE BAND 5

Transmission Band Width: 1.4M, Modulation: 16QAM, RB allocation: 1 offset: 5

LTE BAND 4

Transmission Band Width: 15M, Modulation: QPSK, RB allocation: 1 offset: 0

LTE BAND 7

Transmission Band Width: 5M, Modulation: 16QAM, RB allocation: 1 offset: 24

LTE BAND 17

Transmission Band Width: 5M, Modulation: 16QAM, RB allocation: 1 offset: 0

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Operation in GSM850 band (824.2 – 848.8 MHz)

The ERP of NB105 NGFF WWAN MODULE in GSM850 band is 28.19dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	ERP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
GSM 850	824.2	128	V	27.02	3.91	-3.03	27.89	38.45
			H	19.47	3.91	-3.03	20.35	38.45
	836.6	190	V	27.37	3.89	-3.07	28.19	38.45
			H	21.52	3.89	-3.07	22.34	38.45
	848.8	251	V	26.96	3.87	-3.11	27.72	38.45
			H	21.47	3.87	-3.11	22.24	38.45

$$\text{ERP} = 28.19\text{dBm} = 659.174\text{mW}$$

$$\begin{aligned} \text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \pi R^2) \\ &= 659.174 \times 0.125 / (4 \pi \times 20^2) = 0.01640\text{mW/cm}^2 \end{aligned}$$

where Duty Cycle is 0.125 for GSM850 band operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 0.5773\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in GSM850 band is compliant with the FCC rules on RF exposure.

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Operation in GSM1900 band (1850.2 – 1909.8 MHz)

The EIRP of NB105 NGFF WWAN MODULE in GSM1900 band is 26.54dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	EIRP	Limit
	MHz		V/H	dBm	dBi	dB	dBm	dBm
GSM 1900	1850.2	512	V	23.58	5.08	-4.67	23.99	33.00
			H	22.10	5.08	-4.67	22.51	33.00
	1880.0	661	V	26.24	5	-4.7	26.54	33.00
			H	21.31	5	-4.7	21.61	33.00
	1909.8	810	V	25.42	4.92	-4.74	25.61	33.00
			H	21.49	4.92	-4.74	21.68	33.00

$$\text{EIRP} = 26.54\text{dBm} = 450.817\text{mW}$$

$$\text{Power Density} = \text{EIRP} \times \text{Duty Cycle} / (4 \times R^2)$$

$$= 450.817 \times 0.125 / (4 \times 20^2) = 0.00685\text{mW/cm}^2$$

where Duty Cycle is 0.125 for GSM1900 band operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 1.0\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in GSM1900 band is compliant with the FCC rules on RF exposure.

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Operation in HSDPA II band (1852.4 – 1907.6 MHz)

The EIRP of NB105 NGFF WWAN MODULE in HSDPA II band is 25.43dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	EIRP	Limit
	MHz		V/H	dBm	dBi	dB	dBm	dBm
HSDPA B2	1852.4	9262	V	25.03	5.07	-4.67	25.43	33.00
			H	19.56	5.07	-4.67	19.96	33.00
	1880.0	9400	V	23.21	5	-4.7	23.51	33.00
			H	18.31	5	-4.7	18.60	33.00
	1907.6	9538	V	22.70	4.93	-4.74	22.90	33.00
			H	18.91	4.93	-4.74	19.10	33.00

$$\text{EIRP} = 25.43\text{dBm} = 349.140\text{mW}$$

$$\begin{aligned} \text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \pi R^2) \\ &= 349.140 \times 1 / (4 \pi \times 20^2) = 0.06949\text{mW/cm}^2 \end{aligned}$$

where Duty Cycle is 1 for HSDPA II band operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 1.0\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in HSDPA II band is compliant with the FCC rules on RF exposure.

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Operation in HSUPA V band (826.4 – 846.6 MHz)

The ERP of NB105 NGFF WWAN MODULE in HSUPA V band is 24.91dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	ERP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
HSUPA B5	826.4	4132	V	23.69	3.9	-3.03	24.56	38.45
			H	20.9	3.9	-3.03	21.77	38.45
	836.6	4183	V	23.85	3.89	-3.07	24.67	38.45
			H	20.54	3.89	-3.07	21.36	38.45
	846.6	4233	V	24.13	3.88	-3.1	24.91	38.45
			H	20.40	3.87	-3.1	21.17	38.45

$$\text{ERP} = 24.91\text{dBm} = 309.742\text{mW}$$

$$\begin{aligned} \text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \pi R^2) \\ &= 309.742 \times 1 / (4 \pi \times 20^2) = 0.06165\text{mW/cm}^2 \end{aligned}$$

where Duty Cycle is 1 for HSUPA V band operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 0.5644\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in HSUPA V band is compliant with the FCC rules on RF exposure.

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Operation in LTE band 2 (1850.7 – 1909.3 MHz)

The EIRP of NB105 NGFF WWAN MODULE in LTE band 2, 1.4MHz /16QAM/RB 1 offset: 5 is 30.74dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	EIRP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
BAND 2 BW: 1.4M 16QAM RB: 1,5	1850.7	18607	V	30.34	5.08	-4.67	30.74	33.00
			H	22.73	5.08	-4.67	23.13	33.00
	1880.0	18900	V	28.82	5	-4.7	29.12	33.00
			H	20.42	5	-4.7	20.71	33.00
	1909.3	19193	V	29.25	4.93	-4.74	29.44	33.00
			H	18.82	4.93	-4.74	19.01	33.00

$$\text{EIRP} = 30.74\text{dBm} = 1185.767\text{mW}$$

$$\begin{aligned}\text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \times R^2) \\ &= 1185.767 \times 1 / (4 \times 20^2) = 0.23602\text{mW/cm}^2\end{aligned}$$

where Duty Cycle is 1 for LTE band 2, 1.4MHz /16QAM/RB 1 offset: 0 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 1.0\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in LTE band 2 is compliant with the FCC rules on RF exposure.

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Operation in LTE band 5 (824.7 – 848.3 MHz)

The ERP of NB105 NGFF WWAN MODULE in LTE band 5, 1.4MHz /16QAM/RB 1 offset: 5 is 26.44dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	ERP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
BAND 5 BW: 1.4M 16QAM RB: 1,5	824.7	20407	V	25.56	3.91	-3.03	26.44	38.45
			H	23.29	3.91	-3.03	24.17	38.45
	836.5	20525	V	24.75	3.89	-3.07	25.57	38.45
			H	22.34	3.89	-3.07	23.17	38.45
	848.3	20643	V	23.83	3.87	-3.1	24.60	38.45
			H	22.82	3.87	-3.1	23.58	38.45

$$\text{ERP} = 26.44\text{dBm} = 440.555\text{mW}$$

$$\begin{aligned}\text{Power Density} &= \text{EIRP} * \text{Duty Cycle} / (4 \pi R^2) \\ &= 440.555 * 1 / (4 \pi * 20^2) = 0.08769\text{mW/cm}^2\end{aligned}$$

where Duty Cycle is 1 for LTE band 5, 1.4MHz /16QAM/RB 1 offset: 0 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 0.5498\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in LTE band 5 is compliant with the FCC rules on RF exposure.

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Operation in LTE band 4 (1717.5 – 1747.5 MHz)

The EIRP of NB105 NGFF WWAN MODULE in LTE band 4, 15MHz /QPSK/RB 1 offset: 0 is 29.17dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	EIRP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
BAND 4 BW: 15M QPSK RB: 1,0	1717.5	20025	V	25.32	5.46	-4.5	26.28	30.00
			H	22.58	5.46	-4.5	23.55	30.00
	1732.5	20175	V	28.27	5.42	-4.52	29.17	30.00
			H	22.69	5.42	-4.52	23.59	30.00
	1747.5	20325	V	26.38	5.38	-4.54	27.22	30.00
			H	22.12	5.38	-4.54	22.96	30.00

$$\text{EIRP} = 29.17\text{dBm} = 826.038\text{mW}$$

$$\begin{aligned}\text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \pi R^2) \\ &= 826.038 \times 1 / (4 \pi \times 20^2) = 0.16442\text{mW/cm}^2\end{aligned}$$

where Duty Cycle is 1 for LTE band 4, 15MHz /QPSK/RB 1 offset: 0 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 1.0\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in LTE band 4 is compliant with the FCC rules on RF exposure.

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Operation in LTE band 7 (2502.5 – 2567.5 MHz)

The EIRP of NB105 NGFF WWAN MODULE in LTE band 7, 5MHz /16QAM/RB 1 offset: 24 is 24.30dBm. max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	EIRP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
BAND 7 BW: 5M 16QAM RB: 1,24	2502.5	20775	V	23.98	5.81	-5.49	24.30	30.00
			H	18.74	5.81	-5.49	19.06	30.00
	2535.0	21100	V	22.81	5.87	-5.53	23.15	30.00
			H	18.88	5.87	-5.53	19.23	30.00
	2567.5	21425	V	23.57	5.93	-5.57	23.93	30.00
			H	16.67	5.93	-5.57	17.03	30.00

$$\text{EIRP} = 24.30\text{dBm} = 269.153\text{mW}$$

$$\begin{aligned} \text{Power Density} &= \text{EIRP} \times \text{Duty Cycle} / (4 \pi R^2) \\ &= 269.153 \times 1 / (4 \pi \times 20^2) = 0.05357\text{mW/cm}^2 \end{aligned}$$

where Duty Cycle is 1 for LTE band 7, 5MHz /16QAM/RB 1 offset: 24 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 1.0\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in LTE band 7 is compliant with the FCC rules on RF exposure.

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Operation in LTE band 17 (706.5 – 713.5 MHz)

The ERP of NB105 NGFF WWAN MODULE in LTE band 17, 5MHz /16QAM/RB 1 offset: 0 is 25.13dBm max. The resulted power density at a distance of 20 cm can be deducted as follows:

EUT			Measurement					
Operation Band	Fundamental Frequency	CH	Antenna Pol.	S.G. Output	Antenna Gain	Cable Loss	ERP	Limit
	MHz		V/H	dBm	dBd	dB	dBm	dBm
BAND 17 BW: 5M 16QAM RB: 1,0	706.5	23755	V	22.30	3.86	-2.75	23.42	34.69
			H	14.92	3.86	-2.75	16.03	34.69
	710.0	23790	V	24.04	3.85	-2.76	25.13	34.69
			H	16.14	3.85	-2.76	17.24	34.69
	713.5	23825	V	22.68	3.84	-2.76	23.76	34.69
			H	15.55	3.84	-2.76	16.62	34.69

$$\text{ERP} = 25.13\text{dBm} = 325.8371\text{mW}$$

$$\text{Power Density} = \text{ERP} \times \text{Duty Cycle} / (4 \times R^2)$$

$$= 325.837 \times 1 / (4 \times 20^2) = 0.064856\text{mW/cm}^2$$

where Duty Cycle is 1 for LTE band 17, 5MHz /16QAM/RB 1 offset: 0 operation and R is 20 cm.

The MPE limit for General Population/Uncontrolled Exposure is referred to in section 14.4, and it is,

$$\text{MPE limit} = 0.47\text{mW/cm}^2$$

The resulted power density is below the limit of MPE, and therefore NB105 NGFF WWAN MODULE in LTE band 17 is compliant with the FCC rules on RF exposure.

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