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Test report No:
NIE: 77535RAN.002

Assessment report
RF EXPOSURE REPORT ACCORDING TO
FCC 47 CFR Part 2.1091; FCC 47 CFR Part 1.1307
FCC 47 CFR Part 1.1310

(*) Identification of item under evaluation	nRF91
(*) Trademark	nRF91
(*) Model and /or type reference	nRF9151
(*) Other identification of the product	IMEI TAC : 35502593 FCC ID : 2ANPO00nRF9151 IC ID : 24529-NRF9151 HW version : nRF9151 LACA AA SW Version : mfw_nrf91x1_2.0.0
(*) Features	LTE Cat-M1, LTE NB1&NB2
(*) Manufacturer	NORDIC SEMICONDUCTOR ASA Otto Nielsens Veg 12, 7052 Trondheim, Norway
Test method requested, standard	FCC 47 CFR Part 2.1091 Radiofrequency radiation exposure evaluation: mobile devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Miguel Lacave Antennas Lab Manager  2024.02.27 11:04:19 +01'00'
Date of issue	2024-02-27
Report template No	FAN36_01 (*) "Data provided by the client"

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Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item under evaluation", "Trademark", "Model and/or type reference", “General description of the device”, “Other identification of the product”).
2. Maximum output power, antenna gain and request for evaluation under mobile exposure conditions.
3. The device under evaluation consists of a development kit that has nRF9151 IOT module and GPS. The nRF9151 is capable of LTE Cat-M1, Cat-NB1&NB2 and GPS. The development kit contains antennas for cellular and GPS.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Identification of the client

NORDIC SEMICONDUCTOR ASA

Otto Nielsens Veg 12, 7052 Trondheim, Norway

Document history

Report number	Date	Description
77535RAN.002	2024-02-27	First release

Appendix A: FCC RF Exposure assessment result

General description of the equipment under evaluation

Table 1 shows information used for the RF Evaluation, taking into account the following declared specifications for the device:

Description and technologies: the device under evaluation consists of a module that have two antenna options, an integrated antenna or an external antenna, with the following features: LTE Cat-M1, LTE NB1&NB2. For RF Exposure evaluation, only transmission technologies: LTE Cat-M1, LTE NB1&NB2 are taken into account.

For the external antenna, a Maximum Antenna Gain determination for RF Exposure compliance has been evaluated, and for the integrated antenna, a RF Exposure Assessment result and verdict has been evaluated.

Evaluation Distance: a conservative evaluation distance of 20 cm has been used to perform the assessment.

Maximum output power:

- Values corresponding to maximum output power have been declared by the device manufacturer (maximum output power values stated in module manufacturer´s datasheet.
- Values corresponding to the integrated antenna gain have been declared by the device manufacturer (maximum peak gain stated in antenna manufacturer´s datasheet).

The following table shows the information provided above:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Maximum Conducted Output Power (Incl. Tune-Up) (dBm)	Integrated Antenna peak gain (dBi)	Maximum E.R.P. (dBm)	Maximum E.R.P. (mW)	Maximum E.I.R.P. (dBm)	Maximum E.I.R.P. (mW)
LTE Cat-M1	2	1850 - 1910	24.00	4.40	26.25	421.70	28.40	691.83
LTE Cat-M1	4	1710 - 1755	24.00	4.40	26.25	421.70	28.40	691.83
LTE Cat-M1	5	824 - 849	24.00	2.60	24.45	278.61	26.60	457.09
LTE Cat-M1	8	897.5 - 900.5	24.00	2.60	24.45	278.61	26.60	457.09
LTE Cat-M1	12	699 - 716	24.00	2.60	24.45	278.61	26.60	457.09
LTE Cat-M1	13	777 - 787	24.00	2.60	24.45	278.61	26.60	457.09
LTE Cat-M1	25	1850 - 1915	24.00	4.40	26.25	421.70	28.40	691.83
LTE Cat-M1	26	814 - 849	24.00	2.60	24.45	278.61	26.60	457.09
LTE Cat-M1	66	1710 - 1780	24.00	4.40	26.25	421.70	28.40	691.83
LTE Cat-M1	85	698 - 716	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	2	1850 - 1910	24.00	4.40	26.25	421.70	28.40	691.83
LTE NB-IoT	4	1710 - 1755	24.00	4.40	26.25	421.70	28.40	691.83
LTE NB-IoT	5	824 - 849	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	8	897.5 - 900.5	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	12	699 - 716	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	13	777 - 787	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	17	704 - 716	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	25	1850 - 1915	24.00	4.40	26.25	421.70	28.40	691.83
LTE NB-IoT	26	814 - 849	24.00	2.60	24.45	278.61	26.60	457.09
LTE NB-IoT	65	1920 - 2010	24.00	4.40	26.25	421.70	28.40	691.83
LTE NB-IoT	66	1710 - 1780	24.00	4.40	26.25	421.70	28.40	691.83
LTE NB-IoT	85	698 - 716	24.00	2.60	24.45	278.61	26.60	457.09

Table 1: Equipment specifications

Maximum Antenna Gain determination for RF Exposure compliance

Summary of maximum antenna gain values:

Maximum antenna gain for mobile operation to comply with MPE and EIRP limits (see Appendix B) shall not exceed the following values:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Max Gain to comply with RF Exp Limits (dBi)	Max Gain to comply with EIRP Limits (dBi)	Maximum allowed Gain (worst case) (dBi)
LTE Cat-M1	2	1850 - 1910	13.01	9.00	9.00
LTE Cat-M1	4	1710 - 1755	13.01	6.00	6.00
LTE Cat-M1	5	824 - 849	10.41	16.60	10.41
LTE Cat-M1	8	897.5 - 900.5	10.78	12.92	10.78
LTE Cat-M1	12	699 - 716	9.70	12.92	9.70
LTE Cat-M1	13	777 - 787	10.16	12.92	10.16
LTE Cat-M1	25	1850 - 1915	13.01	9.00	9.00
LTE Cat-M1	26	814 - 849	10.36	16.60	10.36
LTE Cat-M1	66	1710 - 1780	13.01	6.00	6.00
LTE Cat-M1	85	698 - 716	9.69	12.92	9.69
LTE NB-IoT	2	1850 - 1910	13.01	9.00	9.00
LTE NB-IoT	4	1710 - 1755	13.01	6.00	6.00
LTE NB-IoT	5	824 - 849	10.41	16.60	10.41
LTE NB-IoT	8	897.5 - 900.5	10.78	12.92	10.78
LTE NB-IoT	12	699 - 716	9.70	12.92	9.70
LTE NB-IoT	13	777 - 787	10.16	12.92	10.16
LTE NB-IoT	17	704 - 716	9.73	12.92	9.73
LTE NB-IoT	25	1850 - 1915	13.01	9.00	9.00
LTE NB-IoT	26	814 - 849	10.36	16.60	10.36
LTE NB-IoT	65	1920 - 2010	13.01	9.00	9.00
LTE NB-IoT	66	1710 - 1780	13.01	6.00	6.00
LTE NB-IoT	85	698 - 716	9.69	12.92	9.69

Table 2: Maximum Antenna Gain values

Maximum Gain to meet FCC Radiofrequency radiation exposure limits:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Distance (cm)	Power density for Gain = 0 dBi (mW/cm²)	FCC General Population Limit (mW/cm²)	Maximum Gain to comply with RF Exposure Limits (dBi)
LTE Cat-M1	2	1850 - 1910	20.00	0.05	1.00	13.01
LTE Cat-M1	4	1710 - 1755	20.00	0.05	1.00	13.01
LTE Cat-M1	5	824 - 849	20.00	0.05	0.55	10.41
LTE Cat-M1	8	897.5 - 900.5	20.00	0.05	0.60	10.78
LTE Cat-M1	12	699 - 716	20.00	0.05	0.47	9.70
LTE Cat-M1	13	777 - 787	20.00	0.05	0.52	10.16
LTE Cat-M1	25	1850 - 1915	20.00	0.05	1.00	13.01
LTE Cat-M1	26	814 - 849	20.00	0.05	0.54	10.36
LTE Cat-M1	66	1710 - 1780	20.00	0.05	1.00	13.01
LTE Cat-M1	85	698 - 716	20.00	0.05	0.47	9.69
LTE NB-IoT	2	1850 - 1910	20.00	0.05	1.00	13.01
LTE NB-IoT	4	1710 - 1755	20.00	0.05	1.00	13.01
LTE NB-IoT	5	824 - 849	20.00	0.05	0.55	10.41
LTE NB-IoT	8	897.5 - 900.5	20.00	0.05	0.60	10.78
LTE NB-IoT	12	699 - 716	20.00	0.05	0.47	9.70
LTE NB-IoT	13	777 - 787	20.00	0.05	0.52	10.16
LTE NB-IoT	17	704 - 716	20.00	0.05	0.47	9.73
LTE NB-IoT	25	1850 - 1915	20.00	0.05	1.00	13.01
LTE NB-IoT	26	814 - 849	20.00	0.05	0.54	10.36
LTE NB-IoT	65	1920 - 2010	20.00	0.05	1.00	13.01
LTE NB-IoT	66	1710 - 1780	20.00	0.05	1.00	13.01
LTE NB-IoT	85	698 - 716	20.00	0.05	0.47	9.69

Table 3: Maximum Antenna Gain values based on FCC MPE limits

Maximum Gain to meet FCC EIRP limits

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Maximum Output power (dBm)	EIRP Limits (dBm)	Maximum Gain to meet EIRP Limits (dBi)
LTE Cat-M1	2	1850 - 1910	24.00	33.00	9.00
LTE Cat-M1	4	1710 - 1755	24.00	30.00	6.00
LTE Cat-M1	5	824 - 849	24.00	40.60	16.60
LTE Cat-M1	8	897.5 - 900.5	24.00	36.92	12.92
LTE Cat-M1	12	699 - 716	24.00	36.92	12.92
LTE Cat-M1	13	777 - 787	24.00	36.92	12.92
LTE Cat-M1	25	1850 - 1915	24.00	33.00	9.00
LTE Cat-M1	26	814 - 849	24.00	40.60	16.60
LTE Cat-M1	66	1710 - 1780	24.00	30.00	6.00
LTE Cat-M1	85	698 - 716	24.00	36.92	12.92
LTE NB-IoT	2	1850 - 1910	24.00	33.00	9.00
LTE NB-IoT	4	1710 - 1755	24.00	30.00	6.00
LTE NB-IoT	5	824 - 849	24.00	40.60	16.60
LTE NB-IoT	8	897.5 - 900.5	24.00	36.92	12.92
LTE NB-IoT	12	699 - 716	24.00	36.92	12.92
LTE NB-IoT	13	777 - 787	24.00	36.92	12.92
LTE NB-IoT	17	704 - 716	24.00	36.92	12.92
LTE NB-IoT	25	1850 - 1915	24.00	33.00	9.00
LTE NB-IoT	26	814 - 849	24.00	40.60	16.60
LTE NB-IoT	65	1920 - 2010	24.00	33.00	9.00
LTE NB-IoT	66	1710 - 1780	24.00	30.00	6.00
LTE NB-IoT	85	698 - 716	24.00	36.92	12.92

Table 4: Maximum Antenna Gain values based on FCC EIRP limits

RF Exposure Assessment result

RF Exposure Exemption evaluation:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Distance (cm)	Maximum E.R.P. (mW)	§1.1307(b)(3).i.(C) Exposure Limit (mW)	Verdict for exemption § 1.1307(b)(3).i
LTE Cat-M1	2	1850 - 1910	20.00	421.70	768.00	Pass
LTE Cat-M1	4	1710 - 1755	20.00	421.70	768.00	Pass
LTE Cat-M1	5	824 - 849	20.00	278.61	421.89	Pass
LTE Cat-M1	8	897.5 - 900.5	20.00	278.61	459.52	Pass
LTE Cat-M1	12	699 - 716	20.00	278.61	357.89	Pass
LTE Cat-M1	13	777 - 787	20.00	278.61	397.82	Pass
LTE Cat-M1	25	1850 - 1915	20.00	421.70	768.00	Pass
LTE Cat-M1	26	814 - 849	20.00	278.61	416.77	Pass
LTE Cat-M1	66	1710 - 1780	20.00	421.70	768.00	Pass
LTE Cat-M1	85	698 - 716	20.00	278.61	357.38	Pass
LTE NB-IoT	2	1850 - 1910	20.00	421.70	768.00	Pass
LTE NB-IoT	4	1710 - 1755	20.00	421.70	768.00	Pass
LTE NB-IoT	5	824 - 849	20.00	278.61	421.89	Pass
LTE NB-IoT	8	897.5 - 900.5	20.00	278.61	459.52	Pass
LTE NB-IoT	12	699 - 716	20.00	278.61	357.89	Pass
LTE NB-IoT	13	777 - 787	20.00	278.61	397.82	Pass
LTE NB-IoT	17	704 - 716	20.00	278.61	360.45	Pass
LTE NB-IoT	25	1850 - 1915	20.00	421.70	768.00	Pass
LTE NB-IoT	26	814 - 849	20.00	278.61	416.77	Pass
LTE NB-IoT	65	1920 - 2010	20.00	421.70	768.00	Pass
LTE NB-IoT	66	1710 - 1780	20.00	421.70	768.00	Pass
LTE NB-IoT	85	698 - 716	20.00	278.61	357.38	Pass

Table 5: FCC Exemption Evaluation Results for integrated antenna

The computed value(s) are below the exemption limit(s), so these modes meet the requirements stated in FCC 47 CFR Part 1.1307.

Appendix B: FCC RF Exposure information

FCC RF Exposure evaluation

Devices operating in standalone mobile device exposure conditions may contain a single transmitter or multiple transmitters that do not transmit simultaneously. A minimum test separation distance ≥ 20 cm is required between the antenna and radiating structures of the device and nearby persons to apply mobile device exposure limits. The distance must be at least 20 cm and fully supported by the operating and installation configurations of the transmitter and its antenna(s), according to the source-based time-averaged maximum power requirements of § 2.1091(d)(2). In cases where cable losses or other attenuations are applied to determine compliance, the most conservative operating configurations and exposure conditions must be evaluated. The minimum test separation distance required for a device to comply with mobile device exposure conditions must be clearly identified in the installation and operating instructions, for all installation and exposure conditions, to enable users and installers to comply with RF exposure requirements. For mobile devices that have the potential to operate in portable device exposure conditions, similar to the configurations described in § 2.1091(d)(4), a KDB inquiry is required to determine the SAR test requirements for demonstrating compliance.

When a device qualifies for the categorical exclusion provision of § 2.1091(c), the minimum test separation distance may be estimated, when applicable, by simple calculations according to plane-wave equivalent conditions, to ensure the transmitter and its antenna(s) can operate in manners that meet or exceed the estimated distance. The source-based time-averaged maximum radiated power, according to the maximum antenna gain, must be applied to calculate the field strength and power density required to establish the minimum test separation distance. When the estimated test separation distance becomes overly conservative and does not support compliance, MPE measurement or computational modeling may be used to determine the required minimum separation distance.

According to §1.1310 Radiofrequency radiation exposure limits, paragraph (e), the limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields are:

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*100	6
3.0–30	1842/f	4.89/f	$*900/f^2$	6
30–300	61.4	0.163	1.0	6
300–1,500	.....	.....	f/300	6
1,500–100,000	.....	.....	5	6
(B) 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
300–1,500	.....	.....	f/1500	30
1,500–100,000	.....	.....	1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

Each supported transmission technology will be evaluated to determine if it is in compliance with limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

In order to perform the assessment, the following equations have been used for the calculations; these equations are accurate in the far-field of an antenna and will over-predict power density in the near field, where they could be used for making a "worst-case" or conservative prediction:

Power density: $S[mW/cm^2] = \frac{P_{E.I.R.P.}[mW]}{4\Pi R[cm]^2}$

Where:

S = power density

$P_{E.I.R.P.}$ = Equivalent isotropically radiated power

R = distance to the center of radiation of the antenna (evaluation distance)

$P_{E.I.R.P.}$ = P_T + G_T - L_C

Where:

P_T= transmitter time-averaged output power (including Duty Cycle and tune-up tolerance, if applicable)

G_T= gain of the transmitting antenna

L_C = signal attenuation in the connecting cable between the transmitter and the antenna if applicable

FCC MPE Evaluation

Each supported transmission technology will be evaluated to determine if it is in compliance with limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.
In order to perform the assessment, the following equations have been used for the calculations; these equations are accurate in the far-field of an antenna and will over-predict power density in the near field, where they could be used for making a "worst-case" or conservative prediction:

Power density: $S[mW/cm^2] = \frac{P_{max}[mW]}{4\Pi R[cm]^2}$

Maximum gain to meet the MPE limit: $G_{max}[dBi] = (10 * \log[S[mW/cm^2] * 4\Pi R[cm]^2) - P_{max}[dBm]$

S = power density

P_{max} = power input to the antenna

R = distance to the center of radiation of the antenna (evaluation distance)

G_{max} = power gain of the antenna in the direction of interest relative to an isotropic radiator

FCC Cellular bands limits

Maximum FCC EIRP limits are frequency-dependent and are stated into the FCC standards shown in the following table:

Standard	Frequency Band (MHz)	EIRP limit (W)	EIRP limit (dBm)
FCC 47 CFR §27.50 (c)	600-746	4.92	36.92
FCC 47 CFR §27.50 (b)	776-787	4.92	36.92
FCC Clause 90.542 (a) (7)	788-798	4.92	36.92
FCC 47 CFR §22.913	814-849	11.48	40.6
FCC 47 CFR §27.50 (d)	1710-1780	1.0	30.0
FCC 47 CFR §24.232	1850-1915	2.0	33.0
FCC 47 CFR §24.232	1920-2010	2.0	33.0
FCC 47 CFR §27.50 (a)	2305-2315	0.25 (average EIRP)	23.9
FCC 47 CFR §27.50 (h) (2)	2496-2690	2.0	33.0
FCC 47 CFR §96.41 (b)	3550-3700	0.2	23
FCC 47 CFR §27.5 (j)	3700-3980	1	30