

Test report No:
NIE: 72148RAN.001A3

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

(*) Identification of item under evaluation	nRF91
(*) Trademark	nRF91
(*) Model and /or type reference	nrRF9160
(*) Other identification of the product	FCC ID: 2ANPO00NRF9160 IC: 24529-NRF9160
(*) Features	Features: LTE Cat-M1, LTE-NB1 HW version: nRF9160-SICA-B1A SW version: mfw_nRF9160_1.3.2
(*) Manufacturer	NORDIC SEMICONDUCTOR ASA Otto Nielsens Vel 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
Date of issue	2023-06-23
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 and request for evaluation under mobile exposure conditions.
3. The module under evaluation consists of a Development Kit that has nRF9160 IOT Module and nRF52840 BTLE SoC. The nRF9160 is capable of LTE Cat-M1, Cat-NB1 and GPS. The Development kit has LTE, GPS and BTLE Antennas included.

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Identification of the client

NORDIC SEMICONDUCTOR ASA
Otto Niensens Vel 12; 7052 Trondheim, Norway

Document history

Report number	Date	Description
72148RAN.001	2023-02-20	First release
72148RAN.001A1	2023-03-29	Second release. Added FCC US band 8 as part of the evaluation.
72148RAN.001A2	2023-06-12	Third release: LTE Cat-M1 and NBloT band 14 have been included on the assessment. This modification test report cancels and replaces the test report 72148RAN.001A1
72148RAN.001A3	2023-06-23	Fourth release: NBloT band 14 have been deleted from the assessment. This modification test report cancels and replaces the test report 72148RAN.001A2

Appendix A: FCC RF Exposure assessment result

General description of the equipment under evaluation

The equipment under evaluation consists of a Development Kit that has nRF9160 IOT Module and nRF52840 BTLE SoC. The nRF9160 is capable of LTE Cat-M1, Cat-NB1 and GPS. The Development kit has LTE, GPS and BTLE Antennas included.

As the equipment under evaluation is a module, a conservative evaluation distance of 20 cm has been used to perform the assessment.

The equipment specifications declared by the manufacturer for each supported technology and band are:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Maximum Conducted Output Power (Incl. Tune-Up) (dBm)
LTE Cat-M1	2	1850 - 1910	24.00
LTE Cat-M1	4	1710 - 1755	24.00
LTE Cat-M1	5	824 - 849	24.00
LTE Cat-M1	8	897.5 - 900.5	24.00
LTE Cat-M1	12	699 - 716	24.00
LTE Cat-M1	13	777 - 787	24.00
LTE Cat-M1	14	788 - 798	24.00
LTE Cat-M1	17	704 - 716	24.00
LTE Cat-M1	25	1850 - 1915	24.00
LTE Cat-M1	26	814 - 849	24.00
LTE Cat-M1	66	1710 - 1780	24.00
LTE NB-IoT	2	1850 - 1910	24.00
LTE NB-IoT	4	1710 - 1755	24.00
LTE NB-IoT	5	824 - 849	24.00
LTE NB-IoT	8	897.5 - 900.5	24.00
LTE NB-IoT	12	699 - 716	24.00
LTE NB-IoT	13	777 - 787	24.00
LTE NB-IoT	17	704 - 716	24.00
LTE NB-IoT	25	1850 - 1915	24.00
LTE NB-IoT	26	814 - 849	24.00
LTE NB-IoT	66	1710 - 1780	24.00

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	14	788 - 798	10.22	12.92	10.22
LTE Cat-M1	17	704 - 716	9.73	12.92	9.73
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 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	66	1710 - 1780	13.01	6.00	6.00

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/cm ²)	FCC General Population Limit (mW/cm ²)	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	14	788 - 798	20.00	0.05	0.53	10.22
LTE Cat-M1	17	704 - 716	20.00	0.05	0.47	9.73
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 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	66	1710 - 1780	20.00	0.05	1.00	13.01

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	14	788 - 798	24.00	36.92	12.92
LTE Cat-M1	17	704 - 716	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 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	66	1710 - 1780	24.00	30.00	6.00

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

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

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:

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

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

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 §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