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Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Test report No:
NIE: 61183RAN.001

Assessment report
RF EXPOSURE REPORT ACCORDING TO
FCC 47 CFR Part 2.1091
ISED RSS-102 Issue 5:2015

(*) Identification of item under evaluation	Cellular communication module
(*) Trademark	Sequans Communication
(*) Model and /or type reference	SKY66430
Other identification of the product	FCC ID: 2AAGM66430 IC: 12732A-66430
(*) Features	LTE-M, 3GPP E-UTRA Release 13 compliant
Manufacturer	Skyworks Solutions Inc 20 Sylvan Rd, Woburn, MA 01801, USA
Test method requested, standard	FCC 47 CFR Part 2.1091 Radiofrequency radiation exposure evaluation: mobile devices. ISED RSS-102 Issue 5 (2015-03) – Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) IEEE Std C95.3™ -2002 (R2008). IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Miguel Lacave Antennas Lab Manager  MIGUEL LACAVE GARCÍA 2019.10.01 15:31:58 +02'00'
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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 tested", "Trademark", "Model and/or type reference tested").

2. Maximum output power and maximum antenna gain information.

3. The device under evaluation consists of a multi-band module supporting cellular LTE-M (half-duplex FDD) platforms.

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

SEQUANS COMMUNICATIONS

55 Boulevard Charles de Gaulle, 92700 Colombes

Document history

Report number	Date	Description
61183RAN.001	2019-10-01	First release

General description of the device under evaluation

The device under evaluation consists of a multi-band module supporting cellular LTE-M (half-duplex FDD) platforms.

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	Band	Frequency (MHz)	Maximum Conducted Output Power RMS Burst (Incl. Tune-Up) (dBm)
LTE Cat-M1	2	1850 - 1910	26.00
LTE Cat-M1	4	1710 - 1755	26.00
LTE Cat-M1	5	824 - 849	26.00
LTE Cat-M1	12	699 - 716	26.00
LTE Cat-M1	13	777 - 787	26.00
LTE Cat-M1	25	1850 - 1915	26.00

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 A and B) shall not exceed the following values:

Technology / Mode	Band	Frequency (MHz)	Maximum Gain to comply with:			Maximum Gain (dBi)
			FCC MPE Limits (dBi)	ISED MPE Limits (dBi)	FCC/ISED EIRP Limits (dBi)	
LTE Cat-M1	2	1850 - 1910	11.0	7.5	7.0	**7.0**
LTE Cat-M1	4	1710 - 1755	11.0	7.2	4.0	**4.0**
LTE Cat-M1	5	824 - 849	8.4	5.1	14.6	**5.1**
LTE Cat-M1	12	699 - 716	7.6	4.6	10.9	**4.6**
LTE Cat-M1	13	777 - 787	8.1	4.9	10.9	**4.9**
LTE Cat-M1	25	1850 - 1915	11.0	7.5	7.0	**7.0**

Table 2: Maximum Antenna Gain values

Maximum Gain to meet FCC Radiofrequency radiation exposure limits:

Technology / Mode	Band	Frequency (MHz)	Distance (cm)	Power density (mW/cm^2)	FCC General Population Limit (mW/cm^2)	Verdict	Maximum Gain to meet FCC MPE Limits (dBi)
LTE Cat-M1	2	1850 - 1910	20.0	0.08	1.0	**Pass**	**11.0**
LTE Cat-M1	4	1710 - 1755	20.0	0.08	1.0	**Pass**	**11.0**
LTE Cat-M1	5	824 - 849	20.0	0.08	0.5	**Pass**	**8.4**
LTE Cat-M1	12	699 - 716	20.0	0.08	0.5	**Pass**	**7.6**
LTE Cat-M1	13	777 - 787	20.0	0.08	0.5	**Pass**	**8.1**
LTE Cat-M1	25	1850 - 1915	20.0	0.08	1.0	**Pass**	**11.0**

Table 3: Maximum Antenna Gain values based on MPE limits

Maximum Gain to meet ISED Radiofrequency radiation exposure limits:

Technology / Mode	Band	Frequency (MHz)	Distance (cm)	Power density (W/m^2)	ISED General Public Limit (W/m^2)	Verdict	Maximum Gain to meet ISED MPE Limits (dBi)
LTE Cat-M1	2	1850 - 1910	20.0	0.79	4.5	**Pass**	**7.5**
LTE Cat-M1	4	1710 - 1755	20.0	0.79	4.2	**Pass**	**7.2**
LTE Cat-M1	5	824 - 849	20.0	0.79	2.6	**Pass**	**5.1**
LTE Cat-M1	12	699 - 716	20.0	0.79	2.3	**Pass**	**4.6**
LTE Cat-M1	13	777 - 787	20.0	0.79	2.5	**Pass**	**4.9**
LTE Cat-M1	25	1850 - 1915	20.0	0.79	4.5	**Pass**	**7.5**

Table 4: Maximum Antenna Gain values based on RF Exposure limits

Maximum Gain to meet FCC & ISED EIRP limits:

Technology / Mode	Band	Frequency (MHz)	Maximum Conducted Output Power RMS Burst (Incl. Tune-Up) (dBm)	EIRP Limits (dBm)	Maximum Gain to meet EIRP Limits (dBi)
LTE Cat-M1	2	1850 - 1910	26.0	33.0	**7.0**
LTE Cat-M1	4	1710 - 1755	26.0	30.0	**4.0**
LTE Cat-M1	5	824 - 849	26.0	40.6	**14.6**
LTE Cat-M1	12	699 - 716	26.0	36.9	**10.9**
LTE Cat-M1	13	777 - 787	26.0	36.9	**10.9**
LTE Cat-M1	25	1850 - 1915	26.0	33.0	**7.0**

Table 5: Maximum Antenna Gain values based on EIRP limits

Appendix A: 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:

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

Minimum compliance distance: $R_{min}[cm] = \sqrt{\frac{P_{max}[mW]}{4\Pi S[mW/cm^2]}}$

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

Where:

S = power density

P_{max} = power input to the antenna

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

R_{min} = distance to the center of radiation of the antenna

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

FCC EIRP Limits

Maximum FCC EIRP limits are stated into FCC 47 CFR §22.913, FCC 47 CFR §24.232 and FCC 47 CFR §22.50 standards, these limits are frequency-dependent and are shown in the following table:

Standard	Frequency Band	Technology & Band	EIRP limit (W)	EIRP limit (dBm)
FCC 47 CFR §27.50 (c)	700	LTE 12	4.92	36.92
FCC 47 CFR §27.50 (d)	700	LTE 13	4.92	36.92
FCC Clause 90.542 (a) (7)	700	LTE 14	4.92	36.92
FCC 47 CFR §22.913	850	GSM 850, UMTS V, LTE 5/26	11.48	40.6
FCC 47 CFR §27.50 (d)	1700	WCDMA IV, LTE 4	1.0	30.0
FCC 47 CFR §24.232	1900	GSM 1900, UMTS 2, LTE 2/25	2.0	33.0
FCC 47 CFR §27.50 (a)	2300	LTE 30/40	0.25 (average EIRP)	23.9
FCC 47 CFR §27.50 (h) (2)	2600	LTE 7/41	2.0	33.0

Appendix B: ISED RF Exposure information

ISED RF Exposure evaluation for mobile devices

According to RSS-102 Issue 5, Paragraph "4. Exposure Limits", Industry of Canada has adopted the RF field strength limits established in Health Canada's RF exposure guideline, Safety code 6:

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142f^{0.3417}$	$0.008335f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

Table 6: RF Field Strength Limits for Controlled Use Devices (Controlled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10[23]	170	180	-	Instantaneous*
0.1-10	-	$1.6/f$	-	6**
1.29-10	$193/f^{0.5}$	-	-	6**
10-20	61.4	0.163	10	6
20-48	$129.8/f^{0.25}$	$0.3444/f^{0.25}$	$44.72/f^{0.5}$	6
48-100	49.33	0.1309	6.455	6
100-6000	$15.60f^{0.25}$	$0.04138f^{0.25}$	$0.6455f^{0.5}$	6
6000-15000	137	0.364	50	6
15000-150000	137	0.364	50	$616000/f^{1.2}$
150000-300000	$0.354f^{0.5}$	$9.40 \times 10^{-4} f^{0.5}$	$3.33 \times 10^{-4} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

ISED MPE Evaluation

Each supported transmission technology will be evaluated to determine if it is in compliance with RSS-102 Issue 5, RF Field Strength Limits for devices used by the General Public.

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: $S[W/m^2] = \frac{P_{max}[W]}{4\Pi R[m]^2}$

Minimum compliance distance: $R_{min}[m] = \sqrt{\frac{P_{max}[W]}{4\Pi S[W/m^2]}}$

Maximum gain to meet the RSS -102 limit: $G_{max}[dBi] = (10 * \log[S[W/m^2] * 4\Pi R[m]^2) + 30 - P_{max}[dBm]$

Where:

S = power density

P_{max} = power input to the antenna

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

R_{min} = distance to the center of radiation of the antenna

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

ISED EIRP Limits

Maximum ISED EIRP limits are stated into RSS-130 Issue 2, RSS-132 Issue 3, RSS-133 Issue 6, RSS-139 Issue 3 and RSS-199 Issue 3. These limits are frequency-dependent and are shown in the following table:

Standard	Frequency Band	Technology & Band	EIRP limit (W)	EIRP limit (dBm)
RSS-130 Issue 2	700	LTE 12/13	4.92	36.92
RSS-132 Issue 3	850	GSM 850, UMTS V, LTE 5/26	11.5	40.6
RSS-139. Issue 3	1700	WCDMA IV, LTE 4	1.0	30.0
RSS-133 Issue 6	1900	GSM 1900, UMTS 2, LTE 2/25	2.0	33.0
RSS-199 Issue 3	2600	LTE 7 / 41	2.0	33.0