



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

RF Evaluation Exclusion Exhibit For:

RM191-SM (LoRa)

Prepared by:

Shane Dock, EMC Engineer

4-7-2016



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Contents

Product Description: 3

Associated Antenna(s): 3

Statement of compliance:..... 3

Limits:..... 4



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Product Description:

The RM191-SM module is designed to enable OEMs to add a long range LoRa radio link as well as central role Bluetooth Low Energy (BLE) to small, portable, power-conscious devices. The RM191-SM module is enabled with Laird's smart BASIC, an event-driven programming language that enables OEMs to make their product development quicker and simpler, significantly reducing time to market. smartBASIC enables customers to develop a complete embedded application inside the compact RM191 hardware, connecting to a wide array of external sensors via its I2C, SPI, UART, ADC or GPIO interfaces. The module is based on the world-leading Nordic Semiconductor nRF51822 (BLE) and Semtech Sx1272 (LoRa) chipsets, the RM191-SM module provides ultra-low power consumption with outstanding wireless range using the LoRa radio link and local BLE connections. The unit can accept a voltage between 1.8 – 3.6V.

Associated Antenna(s):

The antennas associated with the EUT are all dipole antennas:

1. World Products: 2 dBi antenna
2. Walsin: 2 dBi antenna
3. Nearson 915 MHz: 2dBi antenna

Statement of compliance:

The RM191-SM module was evaluated against the requirements and limits of OET Bulletin 65, KDB 447498 as well as RSS-102 Issue 5 and was found to be compliant.



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Limits:

A. Mobile (MPE)

OET Bulletin 65 limits for General population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
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
1500-100,000	--	--	1.0	30

f = frequency in MHz

*Plane-wave equivalent power density



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

RSS 102 limits for General population/Uncontrolled Exposure

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/ <i>f</i>	-	6**
1.1-10	87/ <i>f</i> ^{0.5}	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ <i>f</i> ^{0.25}	0.1540/ <i>f</i> ^{0.25}	8.944/ <i>f</i> ^{0.5}	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 <i>f</i> ^{0.3417}	0.008335 <i>f</i> ^{0.3417}	0.02619 <i>f</i> ^{0.6834}	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ <i>f</i> ^{1.2}
150000-300000	0.158 <i>f</i> ^{0.5}	4.21 x 10 ⁻⁴ <i>f</i> ^{0.5}	6.67 x 10 ⁻⁵ <i>f</i>	616000/ <i>f</i> ^{1.2}
<p>Note: <i>f</i> is frequency in MHz. *Based on nerve stimulation (NS). ** Based on specific absorption rate (SAR).</p>				

Per RSS 102 issue 5 section 2.5.2, RF exposure evaluation is required is separation distance between the user and/or bystander and the device's radiating element is greater than 20cm, except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 22.48/*f*^{0.5}W (adjusted for tune-up tolerance), where *f* is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1.31 x 10⁻² *f*^{0.6834} W (adjusted for tune-up tolerance), where *f* is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

B. Portable (SAR Test Exclusion Threshold).

FCC:

SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 20 cm

1-g SAR test exclusion threshold equation:

$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] * [\sqrt{f(\text{GHz})}] \leq 3.0$$

10-g SAR test exclusion threshold equation:

$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] * [\sqrt{f(\text{GHz})}] \leq 7.5$$

RSS 102:

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Note:

1. Table above if for 1-gram tissue, head and body, evaluation (uncontrolled). Limb-worn devices where 10-gram tissue applies, multiply limit by a factor of 2.5



a Laird Business



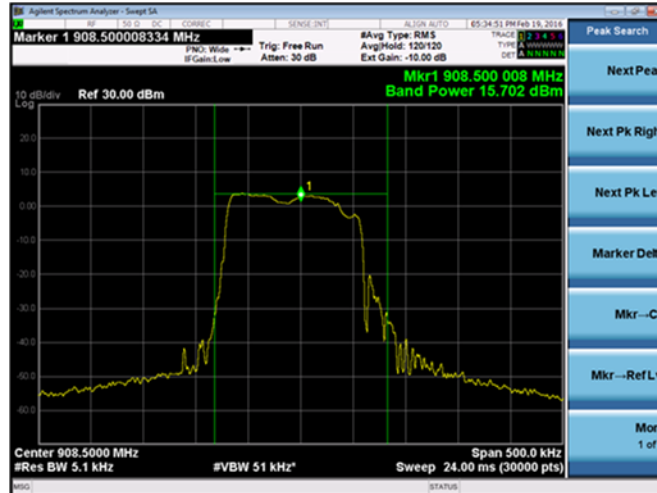
W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Data and calculations:

Screen Capture of maximum output power



Frequency 908.5 MHz;



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

A. MPE Calculation

The following MPE calculations are based on a measured conducted RF power of +15.7 dBm as presented to the antenna. The peak gain of this antenna, based on the data sheet is 2.0 dBi.

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density

P = power input to the antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	<u>15.70</u>	(dBm)
Maximum peak output power at antenna input terminal:	<u>37.154</u>	(mW)
Antenna gain(typical):	<u>2</u>	(dBi)
Maximum antenna gain:	<u>1.585</u>	(numeric)
Prediction distance:	<u>20</u>	(cm)
Prediction frequency:	<u>908.5</u>	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	<u>0.606</u>	(mW/cm ²)
Power density at prediction frequency:	0.011715	(mW/cm ²)
Maximum allowable antenna gain:	19.1	(dBi)
Margin of Compliance at 20 cm =	17.1	dB



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Power Density = 0.011715 mW/cm^2 = 0.11715 W/m^2

RF Exposure Evaluation:

Evaluated against exposure limits: General Public Use Controlled Use

Duty cycle used in evaluation: 100 %

Standard(s)/Procedure(s) used for evaluation (e.g. IEEE C95.3): OET Bulletin 65 and RSS 102

Measurement distance: 20 cm

RF field strength value: 0.117 V/m A/m W/m²

Measured Computed Calculated

Summary:

The calculated power density of the EUT was found to be below the OET Bulletin 65 MPE limit. Per RSS 102 issue 5 section 2.5.2, since the EUT operates at less than

$$1.31 \times 10^{-2} * (908.5)^{0.6834} \text{ W} = 1.377 \text{ W}$$

The EUT is excluded from Routine evaluation.



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

B. SAR Test Exclusion

FCC:

Frequency = 908.5MHz

Output Power = 16.2 dBm (15.7 + 0.5 dB for tune up tolerance)
= 41.7 mW

Minimum separation distance for SAR test exclusion (1g tissue) = $(P_{out} * [v_f(\text{GHz})])/3$
= $(41.7 * 0.95)/3$
= **13.2 mm**

Minimum separation distance for SAR test exclusion (10g tissue) = $(P_{out} * [v_f(\text{GHz})])/7.5$
= $(41.7 * 0.95)/7.5$
= **5.3 mm**

RSS 102:

Frequency = 908.5MHz

Output Power = 16.2 dBm (15.7 + 0.5 dB for tune up tolerance)

Antenna gain = 2 dBi

EIRP = 18.2 dBm = 66.61 mW

Minimum separation distance for SAR test Exclusion (1g tissue) = **30.0 mm** (based on table 1 of RSS 102)
Limit at 908.5 MHz = 81.3 mW

Minimum separation distance for SAR test Exclusion (10g tissue) = **10.0 mm** (based on table 1 of RSS 102)
Limit at 908.5 MHz = 71.5 mW

Summary:

Based on the calculation above, the EUT, when used in a portable application complies with SAR test exclusion requirement when used at a minimum separation distance of at least 25.0 mm.



a Laird Business



W66 N220 Commerce Court • Cedarburg, WI 53012

Phone: 262.375.4400 • Fax: 262.375.4248

www.lsr.com

Simultaneous Transmitting (LoRa + BLE):

Standalone SAR estimation KDB 447498 section 4.3.2 2): 10-G

1. LoRa (908.5MHz)
SAR estimation = $(66.61\text{mw}/10\text{mm}) * (\sqrt{.9085}/7.5)$
= 0.8465 W/kg
2. Bluetooth (2440 MHz)
SAR estimation = $(2.22\text{mw}/5\text{mm}) * (\sqrt{2.440}/7.5)$
= 0.0924 W/kg

Standalone SAR estimation KDB 447498 section 4.3.2 2): 1-G

1. LoRa (908.5MHz)
SAR estimation = $(66.61\text{mw}/30\text{mm}) * (\sqrt{.9085}/3)$
= 0.7054 W/kg
2. Bluetooth (2440 MHz)
SAR estimation = $(2.22\text{mw}/5\text{mm}) * (\sqrt{2.440}/3)$
= 0.2312 W/kg

Per section 4.3.2 of KDB 447498, if the sum of the SAR of all simultaneously transmitting antenna in operating mode and exposure condition is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration.

Sum of standalone SAR 10-G = $(0.8465 + 0.0924) = \underline{\underline{0.9389}}$ W/kg

Sum of standalone SAR 1-G = $(0.7054 + 0.2312) = \underline{\underline{0.9366}}$ W/kg

1 G Limit for general population/uncontrolled environment (CFR 47 part 2.1093(d)(2)) = 1.6 W/kg

10 G Limit = 4 W/kg

Since,

0.9366 W/kg < 1.6 W/kg and,

0.9389 W/kg < 4 W/kg,

SAR test exclusion applies at a minimum distance of 30 mm.