

EMI – TEST REPORT

- Human Exposure -

Type / Model Name : Morin

Product Description : WLAN-Modul 2.4 GHz

Applicant : Embedded Wireless GmbH

Address : Soeflinger Str. 200
89077 ULM, GERMANY

Manufacturer : Embedded Wireless GmbH

Address : Soeflinger Str. 200
89077 ULM, GERMANY

Licence holder : Embedded Wireless GmbH

Address : Soeflinger Str. 200
89077 ULM, GERMANY

Test Result according to the standards
listed in clause 1 test standards:

POSITIVE

Test Report No. : **T41447-02-02HS**

23. March 2017
Date of issue



Deutsche
Akkreditierungsstelle
D-PL-12030-01-01
D-PL-12030-01-02

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test results
without the written permission of the test laboratory.

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ATTACHMENT A as separate supplement

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 1, Subpart I - Procedures Implementing the National Environmental Policy Act of 1969

Part 1, Subpart I, Section 1.1310 Radiofrequency radiation exposure limits

Part 1, Subpart 2, Section 2.1091 Radiofrequency radiation exposure evaluation: **mobile devices**.

Part 1, Subpart 2, Section 2.1093 Radiofrequency radiation exposure evaluation: **portable devices**.

OET Bulletin 65, 65A, 65B Edition 97-01, August 1997 – Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

KDB 447498 D01 v06 Mobile and portable devices RF Exposure procedures and equipment authorisation policies, October 23, 2015.

KDB 865664 D01 v01r04 SAR Measurement Requirements for 100 MHz to 6 GHz, August 7, 2015.

ANSI C95.1: 2005 IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

ETSI TR 100 028 V1.3.1: 2001-03, Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – See ATTACHMENT A

2.2 Equipment type

WLAN - AP

2.1 Short description of the equipment under test (EUT)

The EUT is a WLAN-module and may be configured as access point or client. The firmware does not support ad-hoc modes and gives the user no possibility to choose the channel for data transmission or power setting. The AP is compatible with 802.11b, g, n Standard. It supports the 2.4 GHz frequency band and supports no beam forming.

Number of tested samples: 1
Serial number: 133
Firmware version: 1.0

EUT configuration:

(The CDF filled by the applicant can be viewed at the test laboratory.)

2.2 Variants of the EUT

There are no variants.

2.3 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan WLAN Standard 802.11b/g/n, HT20:

Channel	Frequency (MHz)
1	2412
2	2417
3	2422
4	2427
5	2432
6	2437
7	2442
8	2447
9	2452
10	2457
11	2462

Note: the marked frequencies are determined for final testing.

Channel plan WLAN Standard 802.11n, HT40:

Channel, HT40 up	Channel, HT40 down	Frequency (MHz)
1 up	5 down	2422
2 up	6 down	2427
3 up	7 down	2432
4 up	8 down	2437
5 up	9 down	2442
6 up	10 down	2447
7 up	11 down	2452

Note: The marked frequencies are determined for final testing.

2.4 Transmit operating modes

The EUT use DSSS or OFDM modulation and may operate under operating mode 2 and provide following data rates with auto-fall-back:

- | | | |
|-----------------|-----------------------------------|------------------------------|
| - 802.11b mode | 11, 5.5, 2, 1 Mbps | (Mbps = megabits per second) |
| - 802.11g mode | 54, 48, 36, 24, 18, 12, 9, 6 Mbps | (Mbps = megabits per second) |
| - 802.11n HT20, | MCS 0 - 15 | |
| - 802.11n HT40, | MCS 0 - 15 | |

2.5 Antenna

The following antenna shall be used with the EUT:

Number	Characteristic	Certification name	Plug	f -range (GHz)	Gain (dBi)	Cable loss (dB)	Effective gain (dBi)
1	Omni	PCB-inverted F	-	2.4	2.1	0	2.1

2.6 Power supply system utilised

Power supply voltage, V_{nom} : 5 VDC (USB-power supply of the test jig)

2.7 Extreme test conditions

The extreme temperature range for the EUT is defined by the manufacturer:

-5 °C to +65 °C, $T_{nom} = 20\text{ °C}$;

2.8 Peripheral devices and interface cables

The following peripheral devices and interface cables are connected during the measurements:

- | | |
|------------------|---------------------|
| - USB-cable, 1 m | Model : Common type |
| - - | Model : - |
| - | Model : |

2.9 Determination of worst case conditions for final measurement

Measurements are made in all three orthogonal axes and the settings of the EUT are changed to locate at which position and at what setting of the EUT produce the maximum of the emissions. For the further measurement the EUT is set in X position.

The tests are carried out in the following frequency band:

2400 MHz – 2483.5 MHz

Preliminary tests are performed to find the worst case mode from all possible combinations between available modulations and data rates. The maximum output power depends on used data rate. The output power can be set by application software from 1 dBm to 20 dBm (P1 to P20) in 1 dB steps.

For the final test the following channels and test modes are selected:

WLAN	Available channel	Tested channels	Modulation	Modulation type	Data rate
802.11b	1 to 11	1, 6, 11	DSSS	DBPSK	1 Mbps
802.11n HT20	1 to 11	1, 6, 11	OFDM	BPSK	MCS0
802.11n HT40	1up to 7up	1up, 4up, 7up	OFDM	BPSK	MCS0

- TX continuous mode, 802.11 b
- TX continuous mode, 802.11n

Table of power setting			
WLAN	Lower channel	Middle channel	Upper channel
802.11b	P11	P14	P14
802.11g	P5	P14	P8
802.11n HT20	P4	P14	P8
802.11n HT40	P3	P9	P8

Due to the modulation 802.11g is nearly the same as 802.11n HT20 except the header, the 802.11n HT20 is listed as worst case only.

2.9.1 Test jig

The measurements are performed under the support of a test jig. The test jig provides a USB-Jack for control signals and power supply. The host is already at the WLAN module on-board.

2.9.2 Test software

The test software (OpenWRT) for the EUT provides free power setting, the special test mode RX and the TX continuous mode (TX99), modulated. The tests are performed using the country setting DE, packet sending. The EUT is set with test modulation to transmit data during the tests with a duty cycle (X) of assumed X = 99.

3 TEST RESULT SUMMARY

WLAN device using digital modulation:

Operating in the 2400 MHz – 2483.5 MHz:

FCC Rule Part	RSS Rule Part	Description	Result
15.247(i)	RSS 102, 2.5.2	MPE	passed
KDB 447498	RSS 102, 2.5.1	SAR exclusion consideration	not applicable
OET Bulletin 65	RSS102, 3.2	Co-location, Co-transmission	not applicable

The mentioned RSS Rule Parts in the above table are related to:
RSS 102, Issue 5, March 2015

3.1 Final assessment

The equipment under test fulfills the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 07 March 2017

Testing concluded on : 07 March 2017

Checked by:

Tested by:

Klaus Gegenfurtner
Teamleader Radio

Hermann Smetana
Radio Team

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

**CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY**

4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature: 15-35 °C

Humidity: 30-60 %

Atmospheric pressure: 86-106 kPa

4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor $k = 2$. The true value is located in the corresponding interval with a probability of 95 %. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 11.2003 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Measurement Type	Range	Confidence Level	Calculated Uncertainty
AC power line conducted emissions	0.15 MHz to 30 MHz	95%	± 3.29 dB
EBW and OBW	2400 MHz to 3000 MHz	95%	$\pm 2.5 \times 10^{-7}$
Maximum peak conducted output power	2400 MHz to 3000 MHz	95%	± 0.62 dB
Power spectral density	2400 MHz to 3000 MHz	95%	± 0.62 dB
Conducted Spurious Emissions	9 kHz to 10000 MHz	95%	± 2.15 dB
Conducted Spurious Emissions	10000 MHz to 40000 MHz	95%	± 3.47 dB
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	± 3.53 dB
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	± 3.71 dB
Radiated Spurious Emissions	1000 MHz to 10000 MHz	95%	± 2.34 dB
Field strength of the fundamental	100 kHz to 100 MHz	95%	± 3.53 dB

4.4 Measurement protocol for FCC and ISED

4.4.1 General information

The Open Area test site is a listed Open Site under the Canadian Test-Sites File-No:

IC 3009A-1

The Anechoic chamber is a listed test site under the Canadian Test-Sites File-No:

IC 3009A-2

In compliance with RSS 247 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.10 and applying the CISPR 22 limits.

5 TEST CONDITIONS AND RESULTS

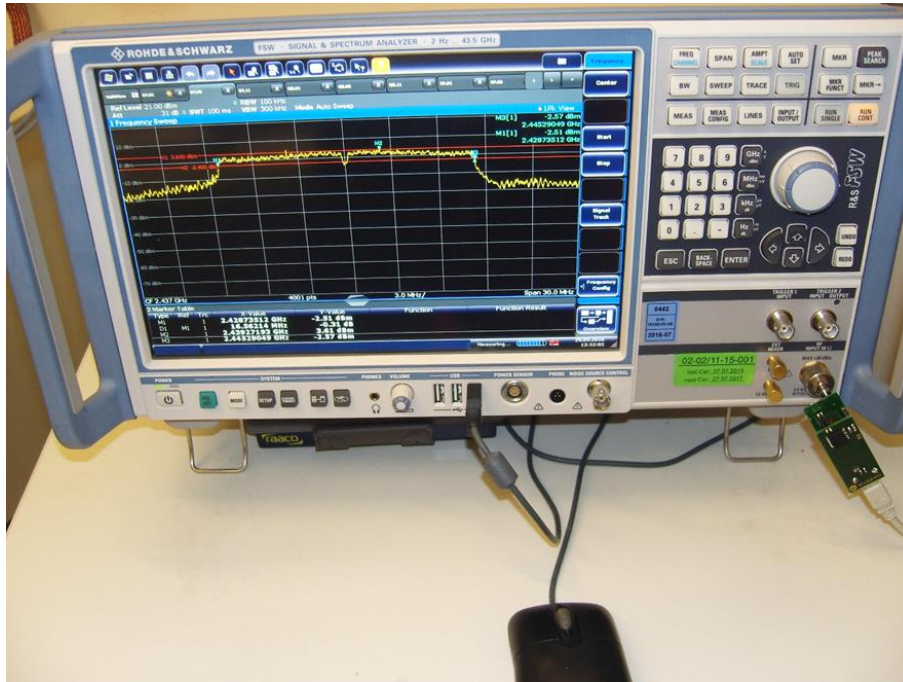
5.1 Maximum peak conducted output power

For test instruments and accessories used see section 6 Part CPC 3.

5.1.1 Description of the test location

Test location: NONE

5.1.2 Photo documentation of the test set-up



5.1.3 Applicable standard

According to FCC Part 15, Section 15.247(b)(3):

For systems using digital modulation in the 2400 – 2483.5 MHz and 5725 – 5850 MHz bands, the maximum peak output power of the transmitter shall not exceed 1 Watt. The limit is based on transmitting antennas of directional gain that do not exceed 6 dBi.

5.1.4 Description of Measurement

The maximum peak conducted output power is measured using a gated average power meter following the procedure set out in KDB 558074, item 9.2.3.2. The EUT is set in TX continuous mode while measuring. For the power settings see item 2.11.

5.1.5 Test result

WLAN Standard 802.11b

802.11b, 1 Mbps, 1 TX		Test results		
Duty cycle: 98%				
Chain 1		A [Pmax] (dBm)	Limit (dBm)	Margin (dB)
Lowest frequency: CH1				
T_{nom}	V_{nom}	15.7	30.0	-14.3
Middle frequency: CH6				
T_{nom}	V_{nom}	17.6	30.0	-12.4
Highest frequency: CH11				
T_{nom}	V_{nom}	17.9	30.0	-12.1

WLAN Standard 802.11n HT20

802.11n HT20, MCS0, 1 TX		Test results		
Duty cycle: 98%				
Chain 1		A [Pmax] (dBm)	Limit (dBm)	Margin (dB)
Lowest frequency: CH1				
T_{nom}	V_{nom}	15.1	30.0	-14.9
Middle frequency: CH6				
T_{nom}	V_{nom}	20.2	30.0	-9.8
Highest frequency:CH11				
T_{nom}	V_{nom}	18.0	30.0	-12.0

WLAN Standard 802.11n HT40

802.11n HT40, MCS0, 1 TX		Test results		
Duty cycle: 98%				
Chain 1		A [Pmax] (dBm)	Limit (dBm)	Margin (dB)
Lowest frequency: CH1up				
T_{nom}	V_{nom}	14.6	30.0	-15.4
Middle frequency: CH4up				
T_{nom}	V_{nom}	17.7	30.0	-12.3
Highest frequency: CH7up				
T_{nom}	V_{nom}	17.3	30.0	-12.7

Peak Power Limit according to FCC Part 15, Section 15.247(b)(3):

Frequency (MHz)	Peak Power Limit	
	(dBm)	(Watt)
902-928	30	1.0
2400-2483.5	30	1.0
5725-5850	30	1.0

The requirements are **FULFILLED**.

Remarks: The measurement is taken from Test Report T41447-02-00HS by CSA Group Bayern GmbH.

6 HUMAN EXPOSURE

6.1 Maximum permissible exposure (MPE)

For test instruments and accessories used see section 6 Part **CPC 3**.

6.1.1 Description of the test location

Test location: NONE

6.1.2 Applicable standard

According to FCC Part 15, Section 15.247(i):

Systems operating under the provisions of this section shall be operated in a manner that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

The test methods used comply with ANSI/IEEE C95.1, "IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz".

This test report shows the compliance with the limits for Maximum Permissible Exposure (MPE) specified in FCC Part 1, Section 1.1310 and the criteria to evaluate the environmental impact of human exposure to radio frequency (RF) radiation as specified in FCC Part 1, Section 1.1307(b).

6.1.3 Description of Measurement

The maximum total power input to the antenna has been measured conducted as described in clause 5.3 of this document. Through the Friis transmission formula, the known maximum gain of the antenna and the maximum power, can be calculated the MPE in a defined distance away from the product.

Friis transmission formula:

$$P_d = \frac{P_{out} * G}{4 * \pi * r^2}$$

Where:

P_d = power density (mW/cm²)

P_{out} = output power to antenna (mW)

G = gain of antenna (linear scale)

r = distance between antenna and observation point (cm)

According to FCC Rules 47CFR 2.1093(b) the EUT is not a portable device. The EUT is designed to be used that radiating structures are 20 cm outside of the body of the user. ($r = 20$ cm)

6.1.4 Test result

Note: for MPE-calculation the maximum rated output power is used.
WLAN Standard 802.11b

Channel frequency	P _{EIRP}	P	P	P _d	Limit P _d	Exposure ratio
(MHz)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2412	18.0	63.096	0.063096	0.012552	0.54	2.3
2437	20.0	100.000	0.100000	0.019894	0.54	3.7
2462	20.0	100.000	0.100000	0.019894	0.54	3.7

WLAN Standard 802.11n, HT20

Channel frequency	P _{EIRP}	P	P	P _d	Limit P _d	Exposure ratio
(MHz)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2412	17.0	50.119	0.050119	0.009971	0.54	1.9
2437	23.0	199.526	0.199526	0.039694	0.54	7.3
2462	20.0	100.000	0.100000	0.019894	0.54	3.7

WLAN Standard 802.11n, HT40

Channel frequency	P _{EIRP}	P	P	P _d	Limit P _d	Exposure ratio
(MHz)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2422	16.0	39.811	0.039811	0.007920	0.54	1.5
2437	20.0	100.000	0.100000	0.019894	0.54	3.7
2452	19.0	79.433	0.079433	0.015803	0.54	2.9

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)
(B) Limits for General Population / Uncontrolled Exposure				
0.3 – 3.0	614	1.63	100	30
3.0 – 30	824/ <i>f</i>	2.19/ <i>f</i>	180/ <i>f</i> ²	30
30 - 300	27.5	0.073	0.2	30
300-1500	---	---	<i>f</i> /1500	30
1500-100000	---	---	1.0	30

f = Frequency in MHz

Limits for maximum permissible exposure (MPE) according RSS102, table 4:

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (minutes)
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

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

f = Frequency in MHz

Determination of the limit per frequency:

Applied frequency (MHz)	RSS102 Power density limit (W/m ²)	RSS102 Power density limit (mW/cm ²)	FCC-limit (mW/cm ²)
2412	5.4	0.54	1
2437	5.4	0.54	1
2462	5.4	0.54	1

The requirements are **FULFILLED**.

Remarks:

6.2 Co-location and Co-transmission

Applicable standard:

OET Bulletin 65, Edition 97-01, Section 2: Multiple-transmitter sites and Complex Environments

The FCC's MPE limits vary with frequency. Therefore, in mixed or broadband RF fields where several sources and frequencies are involved, the fraction of the recommended limit (in terms of power density or square of the electric or magnetic field strength) incurred within each frequency interval should be determined, and the sum of all fractional contributions should not exceed 1.0, or 100 % in terms of percentage.

Remarks: There is no co-location issue because there is only one transmitter.

6.3 SAR test exclusion considerations

6.3.1 Applicable standard

According to RF exposure guidance:

Systems operating under the provisions of this section shall be operated in a manner that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Remarks: Not applicable, the EUT will used in fixed stations.

6.1 Exemption limits for routine evaluation - SAR evaluation

6.1.1 Applicable standard

According to RSS-102, item 2.5.1:

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Remarks: Not applicable, the EUT will used in fixed stations.

7 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
-	-	-	-	-	-	-