

EMI – TEST REPORT

- Human Exposure -

Type / Model Name : Mach-Wireless-SRC

Product Description : Single channel wireless control module

Applicant : Dr. Mach GmbH Co. KG

Address : Flossmannstraße 28

85560 EBERSBERG, GERMANY

Manufacturer : Dr. Mach GmbH Co. KG

Address : Flossmannstraße 28

85560 EBERSBERG, GERMANY

Licence holder : Dr. Mach GmbH Co. KG

Address : Flossmannstraße 28

85560 EBERSBERG, GERMANY

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

POSITIVE

Test Report No. : **T39444-00-03TK**

25. June 2015

Date of issue



DAkkS

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.

Contents

1	<u>TEST STANDARDS</u>	3
2	<u>EQUIPMENT UNDER TEST</u>	4
2.1	Photo documentation of the EUT – see ATTACHMENT A	4
2.2	Equipment type, category	4
2.3	Short description of the equipment under test (EUT)	4
2.4	Variants of the EUT	4
2.5	Operation frequency and channel plan	4
2.6	Transmit operating modes	5
2.7	Antennas	5
2.8	Power supply system utilised	5
2.9	Peripheral devices and interface cables	5
2.10	Final measurement conditions	6
3	<u>TEST RESULT SUMMERY</u>	7
3.1	Final assessment	7
4	<u>TEST ENVIRONMENT</u>	8
4.1	Address of the test laboratory	8
4.2	Environmental conditions	8
4.3	Statement of the measurement uncertainty	8
4.4	Measurement protocol for FCC and IC	9
5	<u>TEST CONDITIONS AND RESULTS</u>	10
5.1	Maximum peak output power	10
6	<u>HUMAN EXPOSURE</u>	12
6.1	Maximum permissible exposure (MPE)	12
6.2	Co-location and Co-transmission	14
6.3	SAR test exclusion considerations	15
6.4	Correction for pulsed operation (duty cycle)	17

ATTACHMENT A as separte 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 2.1093 Radiofrequency radiation exposure evaluation: portable device

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 v05r02 Mobile and portable devices RF Exposure procedures and equipment authorisation policies, February 7, 2014.

KDB 865664 D01 SAR Measurement Requirements for 100 MHz to 6 GHz, February 7, 2014.

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, category

Proprietary wireless transceiver, fixed equipment.

2.3 Short description of the equipment under test (EUT)

The EUT is a 2.4 GHz wireless module on a micro controller module to send I²C-Bus commands within a modulated wireless transmission. A special test hardware is used to simulate a keystroke. The EUT has no external antenna and no temporary connector. All measurement are performed radiated.

Number of tested samples: 1
 Serial number: 67150216
 Firmware version: V1.06 Mach-Wireless-SRC

EUT configuration:

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

2.4 Variants of the EUT

None

2.5 Operation frequency and channel plan

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2400	22	2421	43	2442	64	2463
2	2401	23	2422	44	2443	65	2464
3	2402	24	2423	45	2444	66	2465
4	2403	25	2424	46	2445	67	2466
5	2404	26	2425	47	2446	68	2467
6	2405	27	2426	48	2447	69	2468
7	2406	28	2427	49	2448	70	2469
8	2407	29	2428	50	2449	71	2470
9	2408	30	2429	51	2450	72	2471
10	2409	31	2430	52	2451	73	2472
11	2410	32	2431	53	2452	74	2473
12	2411	33	2432	54	2453	75	2474
13	2412	34	2433	55	2454	76	2475
14	2413	35	2434	56	2455	77	2476
15	2414	36	2435	57	2456	78	2477
16	2415	37	2436	58	2457	79	2478
17	2416	38	2437	59	2458	80	2479
18	2417	39	2438	60	2459	81	2480
19	2418	40	2439	61	2460	82	2481
20	2419	41	2440	62	2461	83	2482
21	2420	42	2441	63	2462	84	2483

Note: the marked frequencies are determined for final testing.

2.6 Transmit operating modes

The EUT uses GMSK modulation with a data rate of 250 kbps (kbps = *kilobits per second*)

2.7 Antennas

The following antennas shall be used with the EUT:

Number	Type	Chracteristic	Plug	Frequency range (GHz)	Gain (dBi)
1	PCB-antenna	omni	none	2.4	-3.0

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 5 VDC (USB powered)
 Power supply voltage (alternative) : Input: 100-240 V, 47-63 Hz, 1 ϕ Power supply,
 Output: +5 VDC.

2.9 Peripheral devices and interface cables

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

- Arduino controller system with LCD Model : Seeeduino v3.0 (Keyboard simulation)
- Arduino controller system with LCD Model : Seeeduino v3.0 (Companion device)
- _____ Model : _____

2.10 Final measurement conditions

The tests are carried out in the following frequency band:

2400 MHz – 2483.5 MHz

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

Standard	Available channel	Tested channel	Power setting	Frequency range (MHz)	Modulation	Data rate
proprietary	82	82	0 dBm	2400 - 2483.5	GMSK	250 kbps

2.10.1 Test jig

The device is controlled by an Arduino controller board simulating a continuous keystroke. This effects a continuous stimulation to transmit a signal for test.

2.10.2 Test software

No special test software is used for testing.

3 TEST RESULT SUMMERY

Wireless 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	passed
OET Bulletin 65	RSS102, 3.2	Co-location, Co-transmission	passed

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 : 06 March 2015

Testing concluded on : 24 April 2015

Checked by:

Tested by:

Klaus Gegenfurtner
Teamleader Radio

Tobias Kammerer
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:	<u>15-35 °C</u>
Humidity:	<u>30-60 %</u>
Atmospheric pressure:	<u>86-106 kPa</u>

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.

4.4 Measurement protocol for FCC and IC

4.4.1 General information

4.4.1.1 Test methodology

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

IC 3009A

In compliance with RSS 210 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.4.1.3 Details of test procedures

In compliance with 47 CFR Part 15 Subpart A, Section 15.38 testing for FCC compliance may be achieved by following the procedures set out in ANSI C63.4 and applying the CISPR 22 limits.

5 TEST CONDITIONS AND RESULTS

5.1 Maximum peak output power

5.1.1 Description of the test location

Test location: NONE

Note:

No separate measurements were performed. The measurement value for fieldstrength is taken out of the test report T39444-00-01TK, section 5.2 (performed at CSA Group Bayern).

5.1.3 Applicable standard

According to FCC Part 15, Section 15.249(a):

For systems using digital modulation in the 2400-2483.5 MHz band, the average fieldstrength limit of the transmitter shall not exceed 94 $\mu\text{V/m}$ (50 mV/m).

5.1.4 Description of Measurement

The EUT gives no possibility to perform a conducted measurement. Therefore the maximum peak conducted output power is measured using a spectrum analyser following the procedure set out in KDB 558074, item 9.1.2. The EUT is set into permanent transmission mode. The measured value shows the radiated peak output power. A recalculation of the conducted output power was made taking into consideration the antenna gain of -3 dBi.

5.1.5 Test result

2481 MHz, 250 kbps, TX		Test results radiated			
		Fieldstrength Reading (dB $\mu\text{V/m}$)	Fieldstrength Limit AV (dB $\mu\text{V/m}$)	Margin (dB)	Detector
T_{nom}	V_{nom}	89.8	94.0	-4.2	Pk

802.15.1, 250 kbps, TX, 2481 MHz		Test results radiated	
		Fieldstrength E (dB $\mu\text{V/m}$)	EIRP (dBm)
T_{nom}	V_{nom}	89.8	-5.5

Calculated maximum peak output power

2481 MHz		Test results conducted		
		EIRP (dBm)	Antenna gain (dBi)	P (dBm)
T_{nom}	V_{nom}	-5.5	-3.0	-2.5

Peak Power Limit according to FCC Part 15, Section 15.249(a):

Frequency (MHz)	Field strength of fundamental	
	(mV/m)	dB(μ V/m)
902 - 928	50	94
2400 - 2483.5	50	94
5725-5875	50	94
24000 - 24250	250	108

The requirements are **FULFILLED**.

Remarks:

6 HUMAN EXPOSURE

6.1 Maximum permissible exposure (MPE)

6.1.1 Description of the test location

Test location: NONE

6.1.2 Applicable standard

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)

Test results for a single module

According to FCC rules

Channel frequency	P_{EIRP}	Duty cycle correction factor	P_{AV}	P	P	P_d	Limit P_d	Exposure ratio
(MHz)	(dBm)	(dB)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2481	-5.5	-15.6	-21.1	0.008	0.000008	0.0000015	1.00	0.0002

According to RSS-102 issue 5

Channel frequency	P_{EIRP}	Duty cycle correction factor	P_{AV}	P	P	P_d	Limit P_d	Exposure ratio
(MHz)	(dBm)	(dB)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2481	-5.5	-15.6	-21.1	0.008	0.000008	0.0000015	0.55	0.0003

Limits for maximum permissible exposure (MPE):

Applied frequency (MHz)	IC-limit (mW/cm ²)	FCC-limit (mW/cm ²)
2481	0.55	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.

Note:

The end application has an option to use four wireless modules within a distance of 20 cm. For this worst case condition the maximum density value is calculated by adding up the output of four modules. This method gives a correction factor of 6 dB to be added to the output power of a single module. The resulting EIRP value is 0.5 dBm.

According to FCC rules

Channel frequency	Four modules P_{EIRP}	Duty cycle correction factor	P_{AV}	P	P	P_d	Limit P_d	Exposure ratio
(MHz)	(dBm)	(dB)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2481	0.5	-15.6	-15.1	0.031	0.000031	0.0000061	1.00	0.0006

According to RSS-102 issue 5

Channel frequency	Four modules P_{EIRP}	Duty cycle correction factor	P_{AV}	P	P	P_d	Limit P_d	Exposure ratio
(MHz)	(dBm)	(dB)	(dBm)	(mW)	(W)	(mW/cm ²)	(mW/cm ²)	(%)
2481	0.5	-15.6	-15.1	0.031	0.000031	0.0000061	0.55	0.0011

The requirements are **FULFILLED**.

Remarks:

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.

NOTE:

The EUT fulfills the limits for SAR exclusion consideration given by KDB 447498 D01 General RF Exposure Guidance v05r02, Appendix A even for a distance of 5 mm to the emission antenna. Additional to that the EUT fulfills the limits for SAR evaluation exemption given by RSS-102, section 2.5.1 table 1. The end application gives the possibility to make a combination of up to four modules in number within a distance of 20 cm. For this case the worst case consideration is calculated for co-location and co-transmission in section 6.2 of this test report.

6.3.2 Determination of the standalone SAR test exclusion threshold

For DTS device:

The minimum separation distance results from the end application of the EUT which is a wall mounted control panel. This distance is assumed to ≤ 5 mm from the antenna to the hand of the user.

The maximum power according to the equipment for a simultaneous use of four modules, is:

Result:

Channel frequency (MHz)	EIRP (dBm)	EIRP (mW)	FCC SAR test exclusion limit (mW)
2481	0.5	1.12	9.9

Channel frequency (MHz)	EIRP (dBm)	EIRP (mW)	IC SAR test exemption limit (mW)
2481	0.5	1.12	3.9

Conclusion:

The Threshold level is smaller than the limit, no SAR measurement is necessary. Four devices can be co-located without exceeding SAR limits.

The requirements are **FULFILLED**.

Remarks: The limits can be viewed in the following tables. The limit is interpolated to the lower limit value and shows the worst case.

FCC limit table acc. to KDB 447498, Appendix A:
SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

Frequency (MHz)	5	10	15	20	25	mm
150	39	77	116	155	194	SAR Test Exclusion Threshold (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	
3600	8	16	24	32	40	
5200	7	13	20	26	33	
5400	6	13	19	26	32	
5800	6	12	19	25	31	

Frequency (MHz)	30	35	40	45	50	mm
150	39	77	116	155	194	SAR Test Exclusion Threshold (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	
3600	8	16	24	32	40	
5200	7	13	20	26	33	
5400	6	13	19	26	32	
5800	6	12	19	25	31	

IC limit table acc. to RSS-102 issue 5:
SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance

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

6.4 Correction for pulsed operation (duty cycle)

6.4.1 Description of the test location

Test location: NONE

Note:

The measurement values for "Correction for pulsed operation (duty cycle)" are taken out of the test report T39444-00-01TK, section 5.5 (performed at CSA Group Bayern).

6.4.1 Applicable standard

According to FCC Part 15A, Section 15.35(c):

When the radiated emission limits are expressed in terms of average value and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete puls train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the puls train exceeds 0.1s, the measured field strength shall be determined from the average absolute voltage during a 0.1s interval during which the field strength is at its maximum. The exact method of calculating the average field strength shall be submitted.

6.4.2 Description of Measurement

The duty cycle factor (dB) is calculated applying the following formula (the use formula is highlighted):

$$KE = 20 \log ((t_{iw}/T_w) * (t_{iB}/T_B)) \text{ for fieldstrength}$$

or

$$KE = 10 \log ((t_{iw}/T_w) * (t_{iB}/T_B)) \text{ for power}$$

KE : pulse operation correction factor

t_{iw} : pulse duration for one complete pulse track

t_{iB} : pulse duration for one pulse

T_w : a period of the pulse track

T_B : a period of one pulse

6.4.3 Test result

Duty cycle correction factor K_E (Duty cycle)

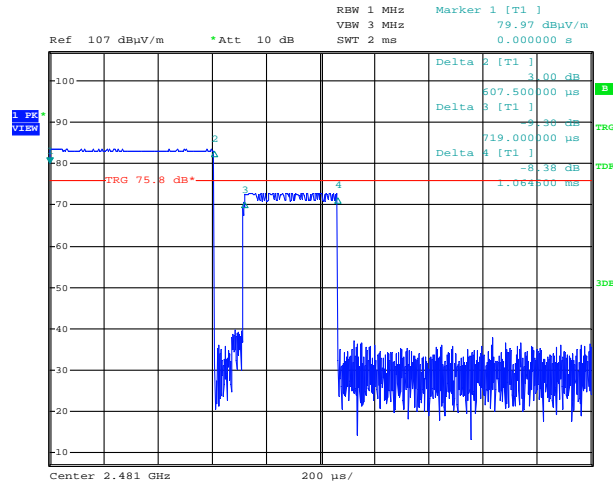
CH	t_{iw} (ms)	T_w (ms)	t_{iB} (ms)	T_B (ms)	K_E (dB)
38	22	22	0.607	22	-15.6

Remarks:

6.4.4 Test protocol

Correction for Pulse Operation (Duty Cycle) FCC Part 15A, Section 15.35(c)

Pulse length of a single pulse



Note: Deltamarkers 3 and 4 show the response of the companion device

Pulsetrain of 100 ms

