



EMI - TEST REPORT

- Human Exposure -

Type / Model Name : Radio Board H

Product Description : BLE Board

Applicant : Hilti Corporation

Address : Feldkircherstrasse 100

9494 SCHAAN, LIECHTENSTEIN

Manufacturer : Hilti Corporation

Address : Feldkircherstrasse 100

9494 SCHAAN, LIECHTENSTEIN

<p>Test Result according to the standards listed in clause 1 test standards:</p>	<p>POSITIVE</p>
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<p>Test Report No. : T45678-00-03WP</p>	<p style="text-align: center;">04. December 2019 Date of issue</p>
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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.

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

Contents

1	<u>TEST STANDARDS</u>	3
2	<u>EQUIPMENT UNDER TEST</u>	4
2.1	Photo documentation of the EUT – Detailed photos 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	5
2.6	Transmit operating modes	5
2.7	Antennas	5
2.8	Power supply system utilised	5
3	<u>TEST RESULT SUMMARY</u>	6
3.1	Final assessment	6
4	<u>TEST ENVIRONMENT</u>	7
4.1	Address of the test laboratory	7
4.2	Environmental conditions	7
4.3	Statement of the measurement uncertainty	7
5	<u>HUMAN EXPOSURE</u>	8
5.1	Maximum permissible exposure (MPE)	8
5.2	SAR test exclusion considerations	11
5.3	Exemption limits for routine evaluation - SAR evaluation	12

ATTACHMENTS A, B as separate supplements

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

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 .
KDB 447498 D01 v06	RF Exposure procedures and equipment authorisation policies for mobile and portable devices, 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

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – Detailed photos see ATTACHMENT A

2.2 Equipment type, category

Bluetooth Low Energy device

2.3 Short description of the equipment under test (EUT)

Board for communication between different Hilti tools.

Number of tested samples : 1
 Serial number : 1
 Firmware version : 2.11.5.432

Items	Description
BT type	5.0 Low Energy
Modulation	GFSK
Frequency range	2400 MHz to 2483.5 MHz
Channel numbers	40
Data rate (kbps)	125, 500, 1000, 2000
Antenna type	Ceramic Monopole Antenna

2.4 Variants of the EUT

The tested variant has the article number 2234663. A variant (PCBA) without connecting cables exists with the article number 2214513.

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

2.5 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan BT-Standard 802.15.1:

Channel	Frequency	Channel	Frequency
37	2402	18	2442
0	2404	19	2444
1	2406	20	2446
2	2408	21	2448
3	2410	22	2450
4	2412	23	2452
5	2414	24	2454
6	2416	25	2456
7	2418	26	2458
8	2420	27	2460
9	2422	28	2462
10	2424	29	2464
38	2426	30	2466
11	2428	31	2468
12	2430	32	2470
13	2432	33	2472
14	2434	34	2474
15	2436	35	2476
16	2438	36	2478
17	2440	39	2480

Note: the marked frequencies are determined for final testing.

2.6 Transmit operating modes

The EUT allows the user to select the following modes:

- TX continuous modulated

2.7 Antennas

The following antennas shall be used with the EUT:

The EUT has only an integrated PCB antenna, no external antenna shall be connected. The following antenna is soldered on the PCB:

Manufacturer	Model number	Type	Frequency range (GHz)	Peak gain (dBi)
Pulse Finland Oy	W3000 2.4 GHz WiFi Case #1	Ceramic Monopole Antenna	2.4 – 2.4835	1.4 @ 2.40 GHz 1.6 @ 2.44 GHz 1.9 @ 2.48 GHz

2.8 Power supply system utilised

Power supply voltage, V_{nom} : 3.0 – 3.3 V DC

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

3 TEST RESULT SUMMARY

BLE device using digital modulation:

Operating in the 2400 MHz – 2483.5 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
KDB 447498, 7.1	RSS 102, 2.5.2	MPE	passed
KDB 447498, 4.3.1	RSS 102, 2.5.1	SAR exclusion consideration	passed
KDB 447498, 7.2	RSS102, 3.2	Co-location, Co-transmission	not applicable ¹

¹ N/A, EUT incorporates only one transmitter

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 : 27 November 2019

Testing concluded on : 03 December 2019

Checked by:

Tested by:

Klaus Gegenfurtner
Teamleader Radio

Willibald Probst
Radio Team

FCC ID: SDL-PR5XM
IC: 5228A-PR5XM

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

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

5 HUMAN EXPOSURE

5.1 Maximum permissible exposure (MPE)

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 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).

5.1.3 Description of Determination

The maximum rated output power conducted included the tune up tolerance is used to calculate the EIRP. 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)

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

5.1.4 Determination of MPE according FCC

Rated output power:	8.0 dBm	6.3 mW
Tune-up tolerance:	+ 1.0 / - 1.3 dB	
Maximum output power:	9.0 dBm	7.9 mW
Antenna gain max (2402 MHz):	1.4 dBi	
Antenna gain max (2440 MHz):	1.6 dBi	
Antenna gain max (2480 MHz):	1.9 dBi	
Maximum EIRP (2402 MHz):	10.4 dBm	11.0 mW
Maximum EIRP (2440 MHz):	10.6 dBm	11.5 mW
Maximum EIRP (2480 MHz):	10.9 dBm	12.3 mW
Minimum distance r:	20.0 cm	

Channel frequency (MHz)	EIRP (dBm)	Antgain (dBi)	EIRP (mW)	G linear	EIRP (W)	S (mW/cm ²)	Limit S _{eq} (mW/cm ²)	Margin (mW/cm ²)	Exposure ratio (%)
2402	10.4	1.4	10.96	1.38	0.0110	0.0022	1.0	-0.998	0.22
2440	10.6	1.6	11.48	1.45	0.0115	0.0023	1.0	-0.998	0.23
2480	10.9	1.9	12.30	1.55	0.0123	0.0024	1.0	-0.998	0.24

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 – 1.34	614	1.63	100	30
1.34 – 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

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

5.1.5 Determination of MPE according ISED:

Rated output power:	8.0 dBm	6.3 mW
Tune-up tolerance:	+ 1.0 / - 1.3 dB	
Maximum output power:	9.0 dBm	7.9 mW
Antenna gain max (2402 MHz):	1.4 dBi	
Antenna gain max (2440 MHz):	1.6 dBi	
Antenna gain max (2480 MHz):	1.9 dBi	
Maximum EIRP (2402 MHz):	10.4 dBm	11.0 mW
Maximum EIRP (2440 MHz):	10.6 dBm	11.5 mW
Maximum EIRP (2480 MHz):	10.9 dBm	12.3 mW
Minimum distance r:	20.0 cm	

Frequency MHz	Antgain (dBi)	EIRP (W)	Factor	$f^{0.6834}$ (W)	Limit (W)	Margin (W)
2402	1.4	0.011	0.0131	204.3072	2.676	-2.6655
2440	1.6	0.011	0.0131	206.5105	2.705	-2.6938
2480	1.9	0.012	0.0131	208.8182	2.736	-2.7232

Exemption limits for routine Evaluation – RF exposure evaluation according RSS102, 2.5.2:

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 $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;

The requirements are **FULFILLED**.

Remarks:

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

5.2 SAR test exclusion considerations

5.2.1 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.

5.2.2 Determination of the standalone SAR test exclusion threshold

The formula under 4.3.1 1) for 100 MHz to 6 GHz for standalone equipment is used:

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

The max conducted average power is according the equipment (WLAN module):

Rated output power:	8.0 dBm	6.3 mW
Tune-up tolerance:	+ 1.0 / - 1.3 dB	
Maximum output power:	9.0 dBm	7.9 mW
Minimum distance r:	5.0 mm	

Channel frequency (MHz)	A (mW)	Threshold level	Limit 1g	Limit 10g	Margin 1g	Margin 10g
2402	7.9	2.46	3.0	7.5	-0.5	-5.0
2440	7.9	2.48	3.0	7.5	-0.5	-5.0
2480	7.9	2.50	3.0	7.5	-0.5	-5.0

Conclusion: The Threshold level at 5 mm is lower than the limit, SAR measurement is not necessary for separation distances ≤ 5 mm.

The requirements are **FULFILLED**.

Remarks: None.
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FCC ID: SDL-PR5XM
IC: 5228A-PR5XM

5.3 Exemption limits for routine evaluation - SAR evaluation

5.3.1 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.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance 4, 5

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	88 mW	195 mW	213 mW
835	80 mW	92 mW	177 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

4 The exemption limits in Table 1 are based on measurements and simulations of half-wave dipole antennas at separation distances of 5 mm to 25 mm from a flat phantom, providing a SAR value of approximately 0.4 W/kg for 1 g of tissue. For low frequencies (300 MHz to 835 MHz), the exemption limits are derived from a linear fit. For high frequencies (1900 MHz and above), the exemption limits are derived from a third order polynomial fit.

5 Transmitters operating between 0.003-10 MHz, meeting the exemption from routine SAR evaluation, shall demonstrate compliance to the instantaneous limits in Section 4.

FCC ID: SDL-PR5XM

IC: 5228A-PR5XM

5.3.2 Conclusion according RSS-102.

Rated output power:	8.0 dBm	6.3 mW
Tune-up tolerance:	+ 1.0 / - 1.3 dB	
Maximum output power:	9.0 dBm	7.9 mW
Antenna gain max (2402 MHz):	1.4 dBi	
Antenna gain max (2440 MHz):	1.6 dBi	
Antenna gain max (2480 MHz):	1.9 dBi	
Maximum EIRP (2402 MHz):	10.4 dBm	11.0 mW
Maximum EIRP (2440 MHz):	10.6 dBm	11.5 mW
Maximum EIRP (2480 MHz):	10.9 dBm	12.3 mW
Minimum distance r:	15.0 mm	

Maximum output power (EIRP) at 2480 MHz: **10.9 dBm \cong 12.3 mW** is < **15 mW**;

Conclusion: For the EUT SAR measurement is **NOT** necessary for separation distances > 15 mm to the user.

The requirements are **FULFILLED**.

Remarks: None.
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