

Prüfbericht-Nr.: <i>Test report no.:</i>	CN23HQZY 002	Auftrags-Nr.: <i>Order no.:</i>	168417547 Seite 1 von 22 Page 1 of 22
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	N/A	Auftragsdatum: <i>Order date:</i>	2023-03-09
Auftraggeber: <i>Client:</i>	Promethean Ltd. Promethean House, Lower Philips Rd, Blackburn, United Kingdom, BB1 5TH		
Prüfgegenstand: <i>Test item:</i>	OPS-A		
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	OPS-A1-8R64S, OPS-A1-4R32S		
Auftrags-Inhalt: <i>Order content:</i>	Test Report		
Prüfgrundlage: <i>Test specification:</i>	CFR47 FCC Part 15: Subpart C Section 15.247 RSS-247 Issue 2 February 2017 RSS-Gen Issue 5 March 2019		
Wareneingangsdatum: <i>Date of sample receipt:</i>	2023-03-13	Please refer to Photo Document	
Prüfmuster-Nr.: <i>Test sample no.:</i>	A003427527-002~003 A003427527-006~010		
Prüfzeitraum: <i>Testing period:</i>	2023-03-24 - 2023-04-03		
Ort der Prüfung: <i>Place of testing:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.		
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.		
Prüfergebnis*: <i>Test result*:</i>	Pass		
geprüft von: <i>tested by:</i>		genehmigt von: <i>authorized by:</i>	
Datum: <i>Date:</i> 2023-04-24	Signed by: Bell Hu	Ausstellungsdatum: <i>Issue date:</i> 2023-04-24	Signed by: Lin Lin
Stellung / Position:	Sachverständige(r)/Expert	Stellung / Position:	Sachverständige(r)/Expert
Sonstiges / Other:	FCC ID: QAM024 IC: 5459A-024 HVIN: OPS-A1-8R64S, OPS-A1-4R32S This report is for 2.4GHz Wi-Fi.		
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>	Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>		
* Legende: P(ass) = entspricht o.g. Prüfgrundlage(n) F(ail) = entspricht nicht o.g. Prüfgrundlage(n) N/A = nicht anwendbar N/T = nicht getestet * Legend: P(ass) = passed a.m. test specification(s) F(ail) = failed a.m. test specification(s) N/A = not applicable N/T = not tested			
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the above mentioned test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</i>			

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Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:

Seite 2 von 22
Page 2 of 22

Test Summary

5.1.1 ANTENNA REQUIREMENT

RESULT: Pass

5.1.2 MAXIMUM PEAK CONDUCTED OUTPUT POWER

RESULT: Pass

5.1.3 CONDUCTED POWER SPECTRAL DENSITY

RESULT: Pass

5.1.4 99%dB BANDWIDTH

RESULT: Pass

5.1.5 6dB BANDWIDTH

RESULT: Pass

5.1.6 CONDUCTED SPURIOUS EMISSIONS MEASURED IN 100 KHz BANDWIDTH

RESULT: Pass

5.1.7 RADIATED SPURIOUS EMISSION

RESULT: Pass

5.1.8 CONDUCTED EMISSION ON AC MAINS

RESULT: Pass

Contents

1	GENERAL REMARKS	4
1.1	COMPLEMENTARY MATERIALS.....	4
2	TEST SITES.....	5
2.1	TEST FACILITIES	5
2.2	LIST OF TEST AND MEASUREMENT INSTRUMENTS	5
2.3	TRACEABILITY	6
2.4	CALIBRATION.....	6
2.5	MEASUREMENT UNCERTAINTY	6
2.6	LOCATION OF ORIGINAL DATA	6
2.7	STATUS OF FACILITY USED FOR TESTING	6
3	GENERAL PRODUCT INFORMATION	7
3.1	PRODUCT FUNCTION AND INTENDED USE	7
3.2	RATINGS AND SYSTEM DETAILS.....	7
3.3	INDEPENDENT OPERATION MODES.....	9
3.4	NOISE GENERATING AND NOISE SUPPRESSING PARTS	9
3.5	SUBMITTED DOCUMENTS.....	9
4	TEST SET-UP AND OPERATION MODES.....	10
4.1	PRINCIPLE OF CONFIGURATION SELECTION	10
4.2	TEST OPERATION AND TEST SOFTWARE	10
4.3	SPECIAL ACCESSORIES AND AUXILIARY EQUIPMENT	10
4.4	COUNTERMEASURES TO ACHIEVE EMC COMPLIANCE	10
4.5	TEST SETUP DIAGRAM	11
5	TEST RESULTS	13
5.1	TRANSMITTER REQUIREMENT & TEST SUITES.....	13
5.1.1	<i>Antenna Requirement.....</i>	<i>13</i>
5.1.2	<i>Maximum Peak Conducted Output Power</i>	<i>14</i>
5.1.3	<i>Conducted Power Spectral Density.....</i>	<i>16</i>
5.1.4	<i>99%dB Bandwidth</i>	<i>17</i>
5.1.5	<i>6dB Bandwidth</i>	<i>18</i>
5.1.6	<i>Conducted Spurious Emissions Measured in 100 kHz Bandwidth.....</i>	<i>19</i>
5.1.7	<i>Radiated Spurious Emission</i>	<i>20</i>
5.1.8	<i>Conducted Emission on AC Mains.....</i>	<i>21</i>
6	PHOTOGRAPHS OF THE TEST SET-UP	22
7	LIST OF TABLES.....	22

1 General Remarks

1.1 Complementary Materials

All attachments are integral parts of this test report. This applies especially to the following appendix:

Appendix A: Test Results of 2.4GHz Wi-Fi.

Appendix B: Photographs of the Test Set-up

2 Test Sites

2.1 Test Facilities

TÜV Rheinland (Shenzhen) Co., Ltd.

No.362, Huanguan Middle Road, Songyuansha Community, Guanhu Subdistrict, Longhua District, Shenzhen 518110, Guangdong, China

FCC Registration No.: 694916

ISED wireless device testing laboratory: 25069

2.2 List of Test and Measurement Instruments

Table 1: List of Test and Measurement Equipment

Radio Spectrum Testing (SRD-Tonscend)				
Equipment	Manufacturer	Model	Serial No.	Cal. until
EXA Signal Analyzer, Multi-touch	Keysight	N9010B	MY60241175	2023-10-10
MXG X-Series RF Vector Signal Generator	Keysight	N5182B	MY61250137	2023-10-10
EXG X-Series Microwave Analog Signal Generator	Keysight	N5173B	MY61250141	2023-10-10
DC power supply	Keysight	E3642A	MY61276100	2023-10-10
Power Control Unit	Tonscend	JS0806-4ADC	N/A	2023-10-10
Automation Control Unit	Tonscend	JS0806-2	21C8060396	2023-10-10
Test Software	Tonscend	JS1120-3	N/A	N/A
Control PC	Lenovo	TianYi510S-071MB	Y LX23JMF	N/A
Shielding Room 8#	Albatross	SR8	APC17151-SR8	2024-06-22
Unwanted Emission Testing (TS9975)				
Equipment	Manufacturer	Model	Serial No.	Cal. until
EMI Test Receiver	R&S	ESR 7	102021	2023-08-02
Signal Analyzer	R&S	FSV 40	101439	2023-08-01
System Controller Interface	R&S	SCI-100	S10010038	N/A
Filterbank	R&S	Wlan	100759	2023-08-01
OSP	R&S	OSP 120	102040	N/A
Pre-amplifier	R&S	SCU08F1	08320031	2023-08-02
Amplifier	R&S	SCU-18F	180070	2023-08-02
Amplifier	R&S	SCU40A	100475	2023-08-02
Trilog Broadband Antenna (30 MHz - 7 GHz)	Schwarzbeck	VULB 9162	193	2024-08-06
Double-Ridged Antenna (1 -18 GHz)	ETS-LINDGREN	3117	00218717	2024-08-06
Wideband Ridged Horn Antenna (18-40 GHz)	Steatite	QMS-00880	19067	2024-08-27
Active Loop Antenna	Schwarzbeck	FMZB 1513	302	2023-08-06
Test software	R&S	EMC32 (V10.60.10)	N/A	N/A

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 6 von 22
Page 6 of 22

Control PC	Dell	OptiPlex 7050	36NV9P2	N/A
3m Semi-Anechoic Chamber	Albatross	SAC-3m	APC17151-SAC	2024-06-22

Conducted Emissions

Equipment	Manufacturer	Model No.	Serial No.	Cal. Until
EMI Test Receiver	R&S	ESR3	102428	2023-07-31
Artificial Mains Network	R&S	ENV216	102333	2023-08-01
EMC32 test software	R&S	EMC32(Ver.10.50.00)	N/A	N/A

2.3 Traceability

All measurement equipment calibrations are traceable to NIM (National Institute of Metrology) or where calibration is performed in other countries, to equivalent nationally recognized standards organizations.

2.4 Calibration

Equipment requiring calibration is calibrated periodically by the manufacturer or according to manufacturer's specifications. Additionally all equipment is verified for proper performance on a regular basis using in house standards or comparisons.

2.5 Measurement Uncertainty

The estimated combined standard uncertainty for radiated emissions and conducted emissions measurements as below table.

Parameter	Uncertainty (k=2)
RF output power, conducted	± 0.99 dB
Occupied Channel Bandwidth	± 2.08 %
RF power density, conducted	± 0.99 dB
Unwanted Emissions, conducted	± 0.89 dB
All emissions, radiated	±4.17 dB
Conducted Emission, (9kHz to 150kHz)/(150kHz to 30MHz)	± 3.70 dB / ± 3.30 dB

2.6 Location of Original Data

The original copies of all test data taken during actual testing were attached at Appendix A & B of this report and delivered to the applicant. A copy has been retained in the TÜV Rheinland (Shenzhen) file for certification follow-up purposes.

2.7 Status of Facility Used for Testing

The TÜV Rheinland (Shenzhen) Co., Ltd. Test facility located at No.362, Huanguan Middle Road, Songyuansha Community, Guanhu Subdistrict, Longhua District, Shenzhen 518110, Guangdong, China is listed on the US Federal Communications Commission list of facilities approved to perform measurements.

3 General Product Information

3.1 Product Function and Intended Use

The EUT is an OPS-A, which supports Bluetooth(dual mode), 2.4GHz Wi-Fi 802.11 b/g/n/ax and 5GHz Wi-Fi 802.11a/n/ac/ax wireless technology.

For details refer to the User Manual, Technical Description and Circuit Diagram.

3.2 Ratings and System Details

Table 2: Technical Specification of EUT

General Information of EUT	Value
Kind of Equipment:	OPS-A
Type Designation:	OPS-A1-8R64S, OPS-A1-4R32S
FCC ID:	QAM024
IC ID:	5459A-024
PMN:	OPS-A
HVIN:	OPS-A1-8R64S, OPS-A1-4R32S
Operating Voltage:	12V~19V DC input via panel JAE port
Testing Voltage:	AC 120V, 60Hz
Technical Specification of Bluetooth (dual mode)	
Operating Frequency:	2402 MHz to 2480 MHz
Type of Modulation:	GFSK, $\pi/4$ -DQPSK, 8DPSK
Channel Number:	BDR & EDR mode:79 channels; Low Energy mode:40 channels
Channel Separation:	BDR & EDR mode: 1MHz, 2MHz; Low Energy mode: 2MHz
Data Rate:	BDR & EDR mode: 1Mbps, 2Mbps, 3Mbps Low Energy mode: 1Mbps, 2Mbps
Antenna Type:	External Antenna
Antenna Gain of Bluetooth:	5.0 dBi Max(As detailed in Antenna spec)
Technical Specification of Wi-Fi 802.11 b/g/n/ax	
Operating Frequency:	2412 - 2462 MHz for 802.11b/g/n(HT20)/ax(HE20) 2422 - 2452 MHz for 802.11n(HT40)/ax(HE40)
Type of Modulation:	802.11b: CCK, DQPSK, DBPSK 802.11g/n : BPSK, QPSK, 16QAM, 64QAM 802.11ax: BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM
Data Rate:	1/2/5.5/11 Mbps for 802.11b 6/9/12/18/24/36/48/54 Mbps for 802.11g MCS0~MCS 7 for 802.11n(HT20/40) MCS0~MCS11 for 802.11ax(HE20/40) (All data rates considered, only the Worst-cases reported)
Channel Number:	11 channels for 802.11b/g/n(HT20)/ax(HE20) 7 channels for 802.11n(HT40)/ax(HE40)
Channel Separation:	5 MHz
Antenna Type:	External Antenna

Number of Antenna:	2
Antenna Gain:	5.0 dBi Max(As detailed in Antenna spec)
Note: WLAN 2.4GHz 802.11n and 802.11ax For directional gain: Array Gain = $10 \log(NANT/NSS)$ dB. So the Directional gain = GANT + $10 \log(NANT)$ dBi (The worst case directional gain will occur when NSS = 1).	
Technical Specification of Wi-Fi 802.11 a/n/ac/ax	
Operating Frequency:	5180-5320MHz, 5500-5720MHz, 5745-5825MHz
Type of Modulation:	802.11n/a: BPSK, QPSK, 16QAM, 64QAM 802.11ac: BPSK, QPSK, 16QAM, 64QAM, 256QAM 802.11ax: BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM
Protocol:	802.11 a/n20/n40/ac20/ac40/ac80/ ax20/ax40/ax80
Data Rate:	6/9/12/18/24/36/48/54 Mbps for 802.11a MCS0~MCS7 for 802.11n MCS0~MCS9 for 802.11ac MCS0~MCS11 for 802.11ax (All data rates considered, only the Worst-cases reported)
Channel Separation	5 MHz
Antenna Type:	External Antenna
Number of Antenna:	2
Antenna Gain:	5.0 dBi Max(As detailed in Antenna spec)
TPC function:	Supported
Type of Device	Slave Device without Radar Detection
Note: WLAN 5GHz 802.11n/802.11ac/802.11ax. For directional gain: Array Gain = $10 \log(NANT/NSS)$ dB. So the Directional gain = GANT + $10 \log(NANT)$ dBi (The worst case directional gain will occur when NSS = 1).	

Table 3: RF Channel and Frequency of Wi-Fi 802.11 b/g/n/ax

RF Channel	802.11 b/g/n(HT20)/ax(HE20)	802.11 n(HT40)/ax(HE40)
	Frequency (MHz)	Frequency (MHz)
01	2412	/
02	2417	/
03	2422	2422
04	2427	2427
05	2432	2432
06	2437	2437
07	2442	2442
08	2447	2447
09	2452	2452
10	2457	/
11	2462	/

Test frequencies are lowest channel: 2412 MHz, middle channel: 2437 MHz and highest channel: 2462 MHz for 802.11b/g/n(HT20)/ax(HE20)

Test frequencies are lowest channel: 2422 MHz, middle channel: 2437 MHz and highest channel: 2452 MHz for 802.11n(HT40)/ax(HE40)

3.3 Independent Operation Modes

The basic operation modes are:

- A. On, Wi-Fi transmitting mode
 - 1) Low Channel
 - 2) Middle Channel
 - 3) High Channel
- B. On, Normal operation
- C. Off

3.4 Noise Generating and Noise Suppressing Parts

Refer to Circuit Diagram for further details.

3.5 Submitted Documents

- Application Form
- User Manual
- ID Label and Location Info
- Operation Description

4 Test Set-up and Operation Modes

4.1 Principle of Configuration Selection

Radio Spectrum: The equipment under test (EUT) was configured at its highest power output in order to measure its highest possible radiation and conducted level. The test modes were adapted accordingly in reference to the instructions for use.

Emission: The equipment under test (EUT) was configured to measure its highest possible radiation level. The test modes were adapted accordingly in reference to the instructions for use.

4.2 Test Operation and Test Software

Test operation refers to test setup in chapter 5. All testing were performed according to the procedures in ANSI C63.10: 2013.

According to clause 3.1, all tests were performed on model OPS-A1-8R64S in this report.

4.3 Special Accessories and Auxiliary Equipment

Table 4: List of Accessories and Auxiliary Equipment

Description	Manufacturer	Model	S/N
Laptop	Lenovo	T480	PF-16A6N8
Portable Laptop	Lenovo	ThinkPad T480	10Q67059
Test Board	Promethean Ltd.	/	SN: RESX-LG-2204070022
AC/DC Adapter	MOSO	XKD-Z3000IC 12.0-36W II	Input: 100-240V AC, 50/60Hz, 1.0A MAX Output: DC 12V 3A

4.4 Countermeasures to Achieve EMC Compliance

The test sample which has been tested contained the noise suppression parts as described in the Technical Construction File (TCF).

No additional measures were employed to achieve compliance.

4.5 Test Setup Diagram

Diagram of Measurement Configuration for Radiation Test (Below 1GHz)

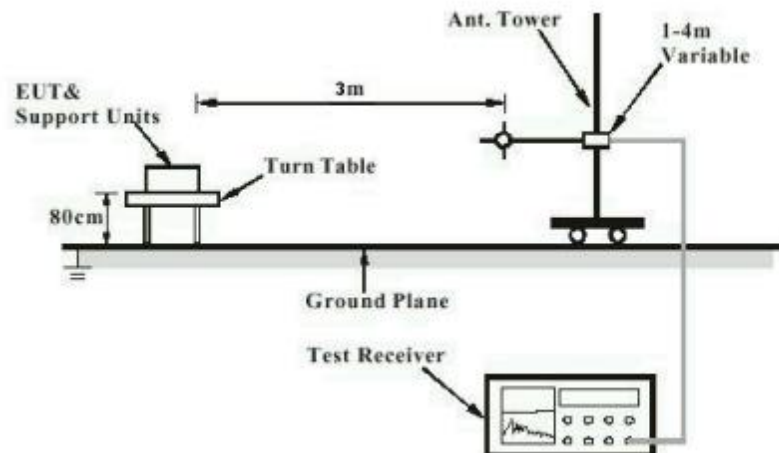


Diagram of Measurement Configuration for Radiation Test (Above 1GHz)

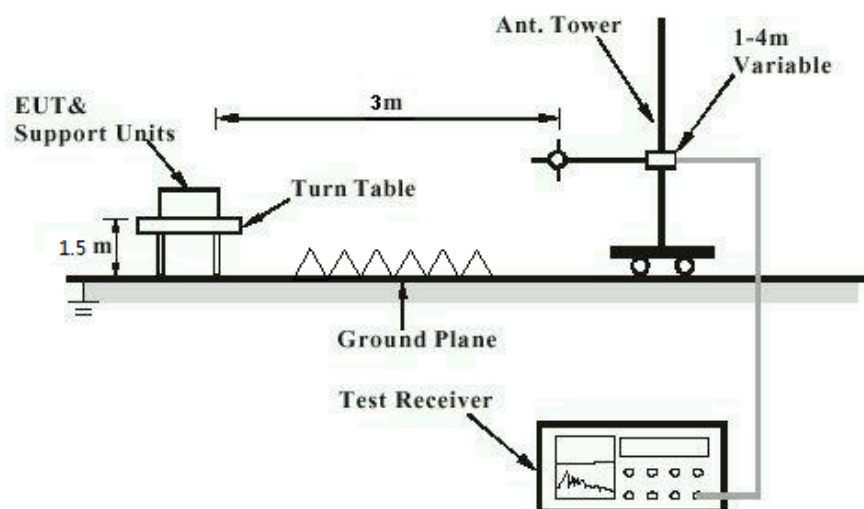


Diagram of Measurement Configuration for Mains Conduction Measurement

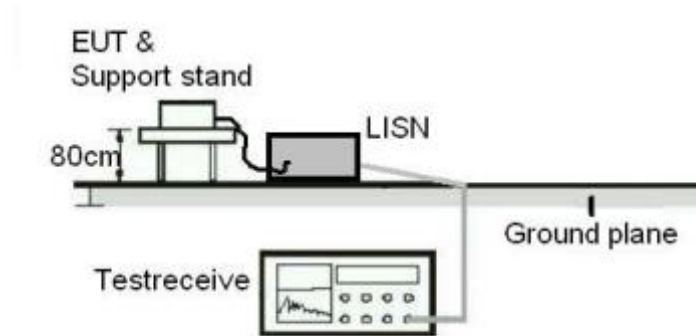
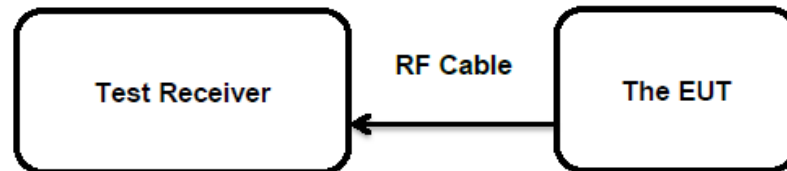


Diagram of Measurement Configuration for Conducted Transmitter Measurement



5 Test Results

5.1 Transmitter Requirement & Test Suites

5.1.1 Antenna Requirement

RESULT:

Pass

Test Specification

Test standard : FCC Part 15.247(b)(4) and Part 15.203
RSS-Gen Clause 6.8

The EUT have External Antennas, the Maximum antenna gain of antenna is 5.0 dBi, and Non-standard connector (RP-SMA) designed, no consideration of replacement.

Therefore the EUT is considered sufficient to comply with the provision.

Refer to EUT Photo for further details.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 14 von 22
Page 14 of 22

5.1.2 Maximum Peak Conducted Output Power

RESULT:**Pass****Test Specification**

Test standard : FCC Part 15.247(b)(3)
RSS-247 Clause 5.4(d)

Basic standard : ANSI C63.10: 2013

Limits : < 1 W (Maximum Conducted Peak Power)
e.i.r.p. <4W

Kind of test site : Shielded Room

Test Setup

Date of testing : 2023-03-24 to 2023-04-03

Input voltage : AC 120V, 60Hz

Operation mode : A

Test channel : Low / Middle / High

Ambient temperature : 24.1 °C

Relative humidity : 61 %

Atmospheric pressure : 101 kPa

For details refer to following test result.

Table 5: Test Result of Maximum Peak Conducted Output Power

Worst case for SISO mode (Ant 0)

Test Mode	Data Rate	Test Channel (MHz)	Measured Peak Power		Measured conducted average Power		Limit (dBm)
			(dBm)	(W)	(dBm)	(W)	
802.11b	1 Mbps	2412	23.96	0.2489	21.02	0.126	30
		2437	23.80	0.2399	21.23	0.133	
		2462	21.81	0.1517	19.09	0.081	
802.11g	6 Mbps	2412	26.35	0.4315	18.77	0.075	
		2437	26.41	0.4375	18.93	0.078	
		2462	25.42	0.3483	17.90	0.062	
802.11n (HT20)	MCS0	2412	24.75	0.2985	17.16	0.052	
		2437	24.74	0.2979	17.20	0.052	
		2462	24.80	0.3020	17.22	0.053	
802.11n (HT40)	MCS0	2422	25.77	0.3776	17.64	0.058	
		2437	25.16	0.3281	19.79	0.095	
		2452	25.01	0.3170	17.65	0.058	
802.11ax (HE20)	MCS0	2412	25.17	0.3289	17.16	0.052	
		2437	25.27	0.3365	17.20	0.052	
		2462	25.25	0.3350	17.21	0.053	
802.11ax (HE40)	MCS0	2422	25.46	0.3516	17.75	0.060	
		2437	25.45	0.3508	17.69	0.059	
		2452	25.36	0.3436	17.55	0.057	

Max. e.i.r.p.=26.41dBm+5.0dBi=31.41dBm, which is less than 36dBm=4W.

Worst case for MIMO mode (Ant0+1)

Test Mode	Data Rate	Test Channel (MHz)	Measured Peak Power		Measured conducted average Power		Limit (dBm)
			(dBm)	(W)	(dBm)	(W)	
802.11n (HT20)	MCS0	2412	26.51	0.448	19.29	0.085	28
		2437	26.48	0.445	19.35	0.086	
		2462	26.44	0.441	19.31	0.085	
802.11n (HT40)	MCS0	2422	26.75	0.473	19.79	0.095	
		2437	26.79	0.478	19.71	0.094	
		2452	26.68	0.466	19.69	0.093	
802.11ax (HE20)	MCS0	2412	26.89	0.489	19.22	0.084	
		2437	26.97	0.498	19.36	0.086	
		2462	26.91	0.491	19.31	0.085	
802.11ax (HE40)	MCS0	2422	27.18	0.522	19.87	0.097	
		2437	27.14	0.518	19.80	0.095	
		2452	26.95	0.495	20.52	0.113	

*: The directional gain for MIMO mode is 8dBi, which is 2dB higher than 6dBi, thus power limit should be reduced to 28dBm.

Max. e.i.r.p.=27.18dBm+8.0dBi=35.18dBm, which is less than 36dBm=4W.

Note:

- 1) The cable loss is taken into account in results.
- 2) Antenna gain(G): 5.0 dBi Max

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:

Seite 16 von 22
Page 16 of 22

5.1.3 Conducted Power Spectral Density

RESULT:

Pass

Test Specification

Test standard : FCC Part 15.247(e)
RSS-247 Clause 5.2(b)
Basic standard : ANSI C63.10: 2013
Limits : 8 dBm / 3kHz
Kind of test site : Shielded Room

Test Setup

Date of testing : 2023-03-24 to 2023-04-03
Input voltage : AC 120V, 60Hz
Operation mode : A
Test channel : Low / Middle / High
Ambient temperature : 24.1 °C
Relative humidity : 61 %
Atmospheric pressure : 101 kPa

For the measurement records, refer to the appendix A.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:

Seite 17 von 22
Page 17 of 22

5.1.4 99%dB Bandwidth

RESULT:

Pass

Test Specification

Test standard : RSS-Gen clause 6.7
Basic standard : ANSI C63.10: 2013
Kind of test site : Shielded Room

Test Setup

Date of testing : 2023-03-24 to 2023-04-03
Input voltage : AC 120V, 60Hz
Operation mode : A
Test channel : Low / Middle / High
Ambient temperature : 24.1 °C
Relative humidity : 61 %
Atmospheric pressure : 101 kPa

For the measurement records, refer to the appendix A.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 18 von 22
Page 18 of 22

5.1.5 6dB Bandwidth

RESULT:

Pass

Test Specification

Test standard : FCC Part 15.247(a)(2)
RSS-247 Clause 5.2(a)
Basic standard : ANSI C63.10: 2013
Limits : > 500 KHz
Kind of test site : Shielded Room

Test Setup

Date of testing : 2023-03-24 to 2023-04-03
Input voltage : AC 120V, 60Hz
Operation mode : A
Test channel : Low / Middle / High
Ambient temperature : 24.1 °C
Relative humidity : 61 %
Atmospheric pressure : 101 kPa

For the measurement records, refer to the appendix A.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 19 von 22
Page 19 of 22

5.1.6 Conducted Spurious Emissions Measured in 100 kHz Bandwidth

RESULT:**Pass****Test Specification**

Test standard	: FCC Part 15.247(d) RSS-247 Clause 5.5
Basic standard	: ANSI C63.10: 2013
Limits	: 20dB (below that in the 100kHz bandwidth within the band that contains the highest level of the desired power); In addition, radiated emissions which fall in the restricted bands, must also comply with the radiated emission limits specified in 15.209(a)
Kind of test site	: Shielded Room

Test Setup

Date of testing	: 2023-03-24 to 2023-04-03
Input voltage	: AC 120V, 60Hz
Operation mode	: A
Test channel	: Low / Middle / High
Ambient temperature	: 24.1 °C
Relative humidity	: 61 %
Atmospheric pressure	: 101 kPa

Test results of 100kHz Bandwidth of Frequency Band Edge by Conducted method refer to test plots, and compliance is achieved as well.

For the measurement records, refer to the appendix A.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 20 von 22
Page 20 of 22

5.1.7 Radiated Spurious Emission

RESULT:**Pass****Test Specification**

Test standard : FCC Part 15.247(d) & FCC Part 15.205
RSS-247 Clause 3.3 & 5.5

Basic standard : ANSI C63.10: 2013

Limits : Refer to 15.209(a) of FCC part 15.247(d)
RSS-Gen Table 5

Kind of test site : 3m Semi-anechoic Chamber

Test Setup

Date of testing : 2023-03-30 to 2023-04-01

Input voltage : AC 120V, 60Hz

Operation mode : A

Test channel : Low / Middle / High

Ambient temperature : Refer to test result

Relative humidity : Refer to test result

Atmospheric pressure : 101 kPa

Remark:

Testing was carried out within frequency range 9kHz to the tenth harmonics. Only the worst case spurious emissions configuration of the each mode were reported.

For the measurement records, refer to the appendix A.

Prüfbericht - Nr.: CN23HQZY 002
Test Report No.:Seite 21 von 22
Page 21 of 22

5.1.8 Conducted Emission on AC Mains

RESULT:**Pass****Test Specification**

Test standard	: FCC Part 15.207(a) RSS-Gen Clause 8.8
Basic standard	: ANSI C63.10: 2013
Frequency range	: 0.15 – 30MHz
Limits	: FCC Part 15.207(a) RSS-Gen Table 4
Kind of test site	: Shielded Room

Test Setup

Date of testing	: 2023-03-27
Input voltage	: AC 120V, 60Hz
Operation mode	: B
Earthing	: Not connected
Ambient temperature	: 23.2 °C
Relative humidity	: 50.6 %
Atmospheric pressure	: 101 kPa

For the measurement records, refer to the appendix A.

6 Photographs of the Test Set-Up

For photographs of the test set-up, refer to the appendix B.

7 List of Tables

Table 1: List of Test and Measurement Equipment.....	5
Table 2: Technical Specification of EUT.....	7
Table 3: RF Channel and Frequency of Wi-Fi 802.11 b/g/n/ax	9
Table 4: List of Accessories and Auxiliary Equipment.....	10
Table 5: Test Result of Maximum Peak Conducted Output Power	15