Maximum Permissible Exposure Report

1. Product Information

FCC ID:	2AVL4-QUARTZGOLD5G
Product name:	Industrial 5G/4G/3G Router
Test Model:	QUARTZ-GOLD-5G
Power supply:	Input: 12V⎓2A For Adapter Input: 100-240V~, 50/60Hz, 0.8A For Adapter Output: 12V⎓2000mA
Hardware Version:	/
Software Version:	/
2.4G WLAN	
Frequency Range:	2412MHz~2462MHz
Channel Spacing:	5MHz
Channel Number:	11 Channels for 20MHz bandwidth (2412~2462MHz) 7 Channels for 40MHz bandwidth (2422~2452MHz)
Modulation Type:	IEEE 802.11b: DSSS (CCK, DQPSK, DBPSK) IEEE 802.11g: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n: OFDM (64QAM, 16QAM, QPSK, BPSK)
Antenna Description:	External Antenna, 4.0dBi(Max.)
5.2G WLAN	
Frequency Range:	5180MHz~5240MHz
Channel Number:	4 Channels for 20MHz bandwidth(5180MHz~5240MHz) 2 channels for 40MHz bandwidth(5190MHz~5230MHz) 1 channels for 80MHz bandwidth(5210MHz)
Modulation Type	IEEE 802.11a/n: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)
Antenna Description	External Antenna, 4.0dBi(Max.)
5.8G WLAN	
Frequency Range:	5745MHz-5825MHz
Channel Number:	5 channels for 20MHz bandwidth(5745MHz~5825MHz) 2 channels for 40MHz bandwidth(5755MHz~5795MHz) 1 channels for 80MHz bandwidth(5775MHz)
Modulation Type:	IEEE 802.11a/n: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)
Antenna Description:	External Antenna, 4.0dBi(Max.)
UMTS Specification	
Single Band & Antenna Gain:	WCDMA Band Ⅱ: 0.91dBi WCDMA Band Ⅳ: 1.47dBi WCDMA Band Ⅴ: 2.68dBi
Modulation:	QPSK
E-UTRA Specification	

Single Band & Antenna Gain:	LTE Band 2: 0.91dB LTE Band 4: -1.47dBi LTE Band 5: 2.68dBi LTE Band 7: 0.55dBi LTE Band 12: -0.2dBi LTE Band 13: 1.54dBi LTE Band 14: 2.42dBi LTE Band 17: -0.2dBi LTE Band 25: 0.25dBi LTE Band 26: 2.87dBi LTE Band 30: -5.7dBi LTE Band 38: -0.23dBi LTE Band 41: 0.78dBi LTE Band 42: -6.1dBi LTE Band 43: -6.1dBi LTE Band 48: -6.1dBi LTE Band 66: -1.47dBi LTE Band 71: -1.22dBi LTE CA_2C: 0.91dBi LTE CA_5B: 2.86dBi LTE CA_7C: 0.55dBi LTE CA_38C: -0.23dBi LTE CA_41C: 0.78dBi LTE CA_43C: -6.1dBi LTE CA_48C: -6.1dBi LTE CA_66B: -1.47dBi LTE CA_66C: -1.47dBi LTE CA_42C: -6.1dBi
Modulation:	QPSK, 16QAM, 64QAM,256QAM
5G NR Specification	
Radio System Type	SA, NSA
Single Band & Antenna Gain：	NR Band n2: 0.25dBi NR Band n5: 2.68dBi NR Band n7: 0.55dBi NR Band n12: -0.2dBi NR Band n13: 1.54dBi NR Band n14: 2.42dBi NR Band n25: 0.25dBi NR Band n26: 2.87dBi NR Band n30: -5.7dBi NR Band n38: -0.23dBi NR Band n41: 0.78dBi NR Band n48: -6.1dBi NR Band n66: 1.47dBi

	NR Band n70: 1.3dBi NR Band n71: 1.22dBi NR Band n77: -6.1dBi NR Band n78: -6.1dBi
ENDC	ENDC DC_13A_n66A;DC_5A_n2A;DC_14A_n2A;DC_30A_n2A;DC_2A_n5A; DC_30A_n5A;DC_66A_n5A;DC_2A_n12A;DC_66A_n12A;DC_2A_n66A; DC_5A_n66A;DC_12A_n66A;DC_14A_n66A;DC_30A_n66A;DC_12A_n2A; DC_66A_n2A;DC_71A_n2A;DC_12A_n41A;DC_71A_n66A;DC_2A_n71A DC_66A_n71A;DC_66A_n25A;DC_25A_n41A;DC_12A_n78A;DC_13A_n78A DC_25A_n78A;DC_12A_n77A;DC_13A_n77A;DC_14A_n77A;DC_26A_n78A DC_2A_n78A;DC_26A_n41A;DC_2A_n41A;DC_7A_n5A;DC_38A_n78A DC_7A_n71A;DC_41A_n78A;DC_5A_n7A;DC_12A_n7A;DC_66A_n7A DC_13A_n2A;DC_48A_n5A;DC_48A_n66A;DC_7A_n66A;DC_2A_n48A DC_5A_n48A;DC_13A_n48A;DC_66A_n48A;DC_4A_n78A;DC_20A_n77A DC_5A_n78A;DC_4A_n41A;DC_66A_n38A;DC_2A_n38A;DC_12A_n38A DC_4A_n38A;DC_5A_n38A;DC_66A_n78A;DC_12A_n25A;DC_25A_n77A DC_2A_n77A;DC_71A_n78A;DC_71A_n38A;DC_13A_n7A;DC_5A_n41A DC_66A_n41A;DC_2A_n7A;DC_7A_n2A;DC_5A_n40A;DC_30A_n77A DC_41A_n77A;DC_7A_n78A;DC_48A_n25A;DC_66A_n28A;DC_71A_n41A DC_28A_n66A;DC_30A_n12A;DC_2A_n14A;DC_30A_n14A;DC_66A_n14A DC_2A_n30A;DC_5A_n30A;DC_12A_n30A;DC_14A_n30A;DC_66A_n30A DC_71A_n7A;DC_7A_n12A;DC_5A_n77A;DC_66A_n77A;DC_71A_n77A DC_4A_n2A;DC_7A_n25A;DC_71A_n25A;DC_5A_n25A;DC_26A_n25A DC_4A_n7A;DC_13A_n25A;DC_7A_n77A;DC_48A_n71A;DC_48A_n12A NR UL CA: n25A-n41A;n41A-n66A;n41A-n71A;n7A-n78A;n5A-n78A n66A-n78A;n7A-n77A;n2A-n77A;n5A-n77A;n66A-n77A n30A-n77A;n48A-n66A;n2A-n48A;n5A-n48A;n48A-n70A n48A-n71A;n71A-n77A;n71A-n78A;n25A-n78A;n38A-n66A n25A-n48A;n25A-n77A;n25A-n38A;n13A-n77A
SCS for NR cell:	FDD Band: 15kHz; TDD Band: 30kHz
Modulation:	UL & DL up to 256QAM
Exposure category:	General population/uncontrolled environment
EUT Type:	Production Unit
Device Type:	Mobile Devices

Note: all antenna information is provided by the manufacturer.

2. Evaluation Method

Systems operating under the provisions of FCC 47 CFR section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.
In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as mobile device whereby a distance of 0.2m normally can be maintained between the user and the device, and below RF Permissible Exposure limit shall comply with.

In accordance with KDB447498D01 for Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on the calculated/estimated, numerically modelled or measured field strengths or power density, is ≤ 1.0. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency. Either the maximum peak or spatially averaged results from measurements or numerical simulations may be used to determine the MPE ratios. Spatial averaging does not apply when MPE is estimated using simple calculations based on far-field plane-wave equivalent conditions. The antenna installation and operating requirements for the host device must meet the minimum test separation distances required by all antennas, in both standalone and simultaneous transmission operations, to satisfy compliance.

3. Limit

3. 1 Refer Evaluation Method

ANSI C95.1–1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
FCC KDB publication 447498 D01 General 1 RF Exposure Guidance v06: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.
FCC CFR 47 part1 1.1310: Radiofrequency radiation exposure limits.
FCC CFR 47 part2 2.1091: Radiofrequency radiation exposure evaluation: Mobile Devices

3. 2 Limit

Limits for Maximum Permissible Exposure (MPE)/Controlled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm^2)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	(100) *	6
3.0 – 30	1842/f	4.89/f	($900/f^2$)*	6
30 – 300	61.4	0.163	1.0	6
300 – 1500	/	/	f/300	6
1500 – 100,000	/	/	5	6

Limits for Maximum Permissible Exposure (MPE)/Uncontrolled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm^2)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	(100) *	30
3.0 – 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

4. MPE Calculation Method

Predication of MPE limit at a given distance
Equation from page 18 of OET Bulletin 65, Edition 97-01

$S=PG/4\pi R^2$

Where: S=power density
P=power input to 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

5. Conducted Power

[2.4GWIFI Max Conducted Power]

Mode	Channel	Frequency (MHz)	Ant 1 Max Conducted Power(dBm)
11B	1	2412	12.28
	6	2437	12.7
	11	2462	12.8
11G	1	2412	12.83
	6	2437	13.23
	11	2462	13.21
11N20 SISO	1	2412	11.82
	6	2437	12.15
	11	2462	13.84
11N40 SISO	3	2422	12.83
	6	2437	13.04
	9	2452	13.13

[5.2GWIFI Max Conducted Power]

Mode	Channel	Frequency (MHz)	Ant 1 Max Conducted Power(dBm)
11A	36	5180	10.84
	40	5200	10.96
	48	5240	11.30
11N20 SISO	36	5180	10.56
	40	5200	10.93
	48	5240	11.09
11N40 SISO	38	5190	10.84
	46	5230	11.26
11AC20 SISO	36	5180	10.72
	40	5200	10.83
	48	5240	11.22

11AC40 SISO	38	5190	10.89
	46	5230	11.28
11AC80 SISO	42	5210	11.22

[5.8WIFI Max Conducted Power]

Mode	Channel	Frequency (MHz)	Ant 1 Max Conducted Power(dBm)
11A	149	5745	10.87
	157	5785	11.02
	165	5825	11.10
11N20 SISO	149	5745	11.68
	157	5785	10.84
	165	5825	10.96
11N40 SISO	151	5755	11.22
	159	5795	10.87
11AC20 SISO	149	5745	10.90
	157	5785	10.79
	165	5825	10.81
11AC40 SISO	151	5755	11.21
	159	5795	11.05
11AC80 SISO	155	5775	11.01

6. Manufacturing Tolerance

[2.4G WIFI]

11B (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	12.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11G (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	12.0	13.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0

[2.4G WIFI]

11N20 (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	12.0	12.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40 (Peak)			
Channel	Channel 3	Channel 6	Channel 9
Target (dBm)	12.0	13.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0

[5.2G WIFI]

11A (Average)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	10.0	10.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0

[5.2G WIFI]

11N20 (Average)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	10.0	10.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40 (Average)			
Channel	Channel 38		Channel 46
Target (dBm)	10.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC20 (Average)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	10.0	10.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0
11AC40 (Average)			
Channel	Channe38		Channel 46
Target (dBm)	10.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC80 (Average)			
Channel	Channel 42		
Target (dBm)	11.0		
Tolerance ±(dB)	1.0		

[5.8G WIFI]

11A (Average)			
Channel	Channel 149	Channel 157	Channel 165
Target (dBm)	10.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0

[5.8G WIFI]

11N20 (Average)			
Channel	Channel 149	Channel 157	Channel 165
Target (dBm)	11.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40 (Average)			
Channel	Channel 151		Channel 159
Target (dBm)	11.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC20 (Average)			
Channel	Channel 149	Channel 157	Channel 165
Target (dBm)	11.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0
11AC40 (Average)			
Channel	Channe151		Channel 159
Target (dBm)	11.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC80 (Average)			
Channel	Channel 155		
Target (dBm)	11.0		
Tolerance ±(dB)	1.0		

7. Measurement Results

7.1 Standalone MPE Evaluation

As declared by the Applicant, the EUT is a wireless device used in a fix application, at least 20 cm from any body part of the user or nearby persons; from the maximum EUT RF output power, the minimum separation distance, r =20cm, as well as the gain of the used antenna refer to antenna information, the RF power density can be obtained.

[2.4G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
IEEE 802.11b	13.0	19.9526	4.0	2.5119	0.0100	1.0000	0.0100
IEEE 802.11g	14.0	25.1189	4.0	2.5119	0.0126	1.0000	0.0126

[2.4G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
IEEE 802.11n HT20	14.0	25.1189	4.0	2.5119	0.0126	1.0000	0.0250
IEEE 802.11n HT40	14.0	25.1189	4.0	2.5119	0.0126	1.0000	0.0250

[5.2G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
11A	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079

[5.2G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
11N20	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11N40	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC20	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC40	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC80	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079

[5.8G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
11A	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079

[5.8G WIFI]

Band/Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios
	dBm	mW					
11N20	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11N40	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC20	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC40	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079
11AC80	12.0	15.8489	4.0	2.5119	0.0079	1.0000	0.0079

WCDMA/LTE/5G NR

Test Mode	Frequency Band (MHz)	Maximum Conducted Power (dBm)	Antenna Gain (dBi)	Maximum Conducted Power (mW)	Power Density at 20cm (mW/cm^2)	Limit (mW/cm^2)	MPE ratios
WCDMA B2	1852.4	25.00	0.91	316.2278	0.0776	1.0000	0.0776
WCDMA B4	1712.4	25.00	1.47	316.2278	0.0883	1.0000	0.0883
WCDMA B5	826.4	25.00	2.68	316.2278	0.1166	0.5509	0.2117
LTE B2/CA_2C/n2	1880	25.00	0.91	316.2278	0.1166	1.0000	0.1166
LTE B4	1710.7	25.00	-1.47	316.2278	0.0448	1.0000	0.0448
LTE B5/CA_5B/n5	824.70	25.00	2.68	316.2278	0.1166	0.5498	0.2121
LTE B7/CA_7C/n	2502.50	25.00	0.55	316.2278	0.0714	1.0000	0.0714
LTE B12/n12	699.70	25.00	-0.2	316.2278	0.0601	0.4665	0.1288
LTE B13/n13	779.50	25.00	1.54	316.2278	0.0897	0.5197	0.1726
LTE B14/n14	790.5	25.00	2.42	316.2278	0.1098	0.5270	0.2083
LTE B17	706.5	25.00	-0.2	316.2278	0.0601	0.4710	0.1276
LTE B25/n25	1850.7	25.00	0.25	316.2278	0.0666	1.0000	0.0666
LTE B26/n26(814-824)	814.7	25.00	2.87	316.2278	0.1218	0.5431	0.2243
LTE B26/n26(824-849)	824.7	25.00	2.87	316.2278	0.1218	0.5498	0.2215
LTE B30/n30	2307.5	25.00	-5.7	316.2278	0.0169	1.0000	0.0169
LTE B38/n38/CA_38C	2572.5	28.00	-0.23	630.9573	0.1191	1.0000	0.1191
LTE B48/n48/CA_48C	3550	25.00	-6.1	316.2278	0.0154	1.0000	0.0154
LTE B41/CA_41C/n41	2498.5	28.00	0.78	630.9573	0.1502	1.0000	0.1502
LTE B42/42C(3450-3550)	3452.5	28.00	-6.1	630.9573	0.0308	1.0000	0.0308

LTE B43(3700-3800)	3702.5	28.00	-6.1	630.9573	0.0308	1.0000	0.0308
LTE B66/n66	1710.7	25.00	-1.47	316.2278	0.0448	1.0000	0.0448
NR Band n70	1997.5	25.00	1.3	316.2278	0.0849	1.0000	0.0849
LTE B71/n71	665.5	25.00	1.22	316.2278	0.0833	0.4437	0.1877
NR Band n77	3455.01	28.00	-6.1	630.9573	0.0308	1.0000	0.0308
NR Band n78	3455.01	28.00	-6.1	630.9573	0.0308	1.0000	0.0308

Remark:
1. Output power including turn-up tolerance;
2. Output power is burst average power;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer;
4. MPE values = PG/4πR²

7.2 Simultaneous Transmission MPE

The EUT equiped with two Wi-Fi antenna and WCDMA/LTE/5G NR module antenna. so need consider simultaneous transmission;
Simultaneous transmission MPE
According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;
∑∑of MPE ratios ≤ 1.0

Mode	2.4GHz Wi-Fi ratios	5GHz Wi-Fi ratios	WCDMA/LTE/5G NR ratios	∑ MPE ratios	Limit	Results
2.4GHz Wi-Fi + WCDMA/LTE/5G NR	0.0126	/	0.2243	0.2369	1.0	Pass
5GHz Wi-Fi + WCDMA/LTE/5G NR	/	0.0079	0.2243	0.2322	1.0	Pass
2.4GHz Wi-Fi + 5GHz Wi-Fi+WCDMA/LTE/5G NR	0.0126	0.0079	0.2243	0.2448	1.0	Pass

Note: Only the worst test mode is recorded in the report

8. Conclusion

The measurement results comply with the FCC Limit per 47 CFR 2.1091 for the uncontrolled RF Exposure of mobile device.

----------THE END OF REPORT----------