

FCC Maximum Permissible RF Exposure (MPE) Estimation Report

In accordance with the requirements of
FCC 47 CFR Part 2(2.1091), ANSI/IEEE C95.1-1992 and
KDB 447498 D01

Product Name: PIQS Virtual Touch Projector

Trademark: PIQS

Model Name: Q1

Serial Model: Q1S, Q+, Q1+, Q Plus, Q1 Plus, Q Pro, Q1 Pro

Report No.: SER180630307001E

FCC ID: 2ALH2-PFAQ100

Prepared for

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Product description

Product name : PIQS Virtual Touch Projector
Trademark : PIQS
Model and/or type reference : Q1
Serial Model..... : N/A

Standards : FCC 47 CFR Part 1(1.1310)
 FCC 47 CFR Part 2(2.1091)
 ANSI/IEEE C95.1-1992
 KDB 447498 D01

This device described above has been tested by Shenzhen NTEK. Testing has shown that this device is capable of compliance with MPE specified in FCC 47 CFR Part 2(2.1091) and ANSI/IEEE C95.1-1992. The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

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Date of Test

Date (s) of performance of tests..... : 02 Jul. 2018 ~ 13 Aug. 2018

Date of Issue : 13 Aug. 2018

Test Result : **Pass**

Prepared By :
 (Test Engineer) : _____
 (Allen Liu)

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※ ※ **Revision History** ※ ※

REV.	DESCRIPTION	ISSUED DATE	REMARK
Rev.1.0	Initial Test Report Release	13 Aug. 2018	Allen Liu

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1 General Information

1.1 RF Exposure Requirements

1.1.1 RF Exposure Limits

Table - 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)
(A) 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
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f ²	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30
f = frequency in MHz * = Plane-wave equivalent power density				

A rough estimation of the expected exposure in power flux density on a given point can be made with the following equation:

$$S = \frac{P_t * G_t}{4 * \pi * R^2}$$

Where:

S = Power density (mW/cm²)

P_t = Conducted output power (dBm)

G_t = numeric gain of the antenna in the direction of interest relative to an isotropic radiator (dBi)

R = distance to the centre of radiation of the antenna (cm)

EIRP = P_t * G_t

The antenna of the product, under normal use condition is at least 20 cm away from the body of the user. Warning statement to the user for keeping at least 20cm separation distance and the prohibition of operating to a person has been printed on the user's manual. Therefore, the S of the device is calculated with R=20cm, and if it is below the limit S, then we can conclude the device complies with the rules.

1.1.2 Additional Description

An estimation of MPE in this application for product is used to ensure if it complies to the rules of the standard in the regulation list above.

Maximum permissible exposure (MPE) refers to the RF energy that is acceptable for human exposure. It is broken down into two categories, Occupational/controlled and General population/uncontrolled.

Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

We analysis if it comply with the limits for General population/uncontrolled exposure. The FCC's MPE limits for field strength and power density are given in 47CFR 1.1310(Table below).These limits are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP), and also partly based on guidelines recommended by the American National Standards Institute (ANSI) in Section 4.1 of ANSI/IEEE C95.1.

1.2 EUT Description

Device Information	
Product Name	PIQS Virtual Touch Projector
Trade Name	PIQS
Model Name	Q1
Serial Model	Q1S, Q+, Q1+, Q Plus, Q1 Plus, Q Pro, Q1 Pro
FCC ID	2ALH2-PFAQ100
Device Phase	Identical Prototype
Exposure Category	General population / Uncontrolled environment
Antenna Type	See Note 1
Antenna Gain	See Note 1
Device Operating Configurations	
Operating Frequency	2412-2462MHz for 802.11b/g/11n(HT20); 2402MHz~2480MHz for BT V4.0(EDR+BR) 5180-5240MHz for 802.11a/n(HT20)/ac20; 5190-5230MHz for 802.11n(HT40)/ac40; 5210MHz for 802.11 ac80; 5745-5825 MHz for 802.11a/n(HT20)/ac20; 5755-5795 MHz for 802.11a/n(HT40)/ac40; 5775MHz for 802.11 ac80;
Smart system	<input checked="" type="checkbox"/> SISO for 802.11a/b/g <input checked="" type="checkbox"/> MIMO for 802.11n/ac <input checked="" type="checkbox"/> SISO for BT V4.0(EDR+BR)
Modulation	DSSS with DBPSK/DQPSK/CCK for 802.11b; OFDM with BPSK/QPSK/16QAM/64QAM for 802.11g/n; OFDM with BPSK/QPSK/16QAM/64QAM/256QAM for 802.11a/n/ac; GFSK, π/4-DQPSK, 8-DPSK for BT V4.0(EDR+BR)

Note 1:

The EUT has two types of antenna.

Antenna	Brand	Model Name (P/N)	Antenna Type	Connector	Antenna Gain(dBi)	
					2.4G/5.2G	2.4G/5.8G
1(main)	N/A	N/A	FPCB	I-PEX	2.0	2.0
2(aux)	N/A	N/A	FPCB	I-PEX	2.0	2.0

For MIMO mode , Directional gain= $[10\log(G_A + G_B)]$ dbi =5.01dbi in 5.2GHz

Directional gain= $[10\log(G_A + G_B)]$ dbi =5.01dbi in 5.8GHz

802.11n/ac 5GHz has MIMO mode.

Note: G_A means antenna gain for ANT 1 in Num.

G_B means antenna gain for ANT 2 in Num.

The BT v4.0 (EDR + BR) only supports Antenna 1 emission

1.3 Test specification(s)

FCC 47 CFR Part 1(1.1310)
FCC 47 CFR Part 2(2.1091)
ANSI/IEEE C95.1-1992
KDB 447498 D01 General RF Exposure Guidance

1.4 Ambient Condition

Ambient temperature	20°C – 24°C
Relative Humidity	30% – 70%

2 RF Output Power

2.1 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
Agilent	Power Meter	DARE/ RPR3006W	15I00041SNO84	2018.08.08	2019.08.07

2.2 RF Output Power

2.2.1 WIFI Output Power

BT(EDR+BR)

Test Channel	Frequency	Power Setting	Peak Output Power	LIMIT	Verdict
	(MHz)		(dBm)		
1Mbps					
0	2402	Default	5.83	20.97	PASS
39	2441	Default	6.35	20.97	PASS
78	2480	Default	5.85	20.97	PASS
2Mbps					
0	2402	Default	5.14	20.97	PASS
39	2441	Default	5.36	20.97	PASS
78	2480	Default	4.08	20.97	PASS
3Mbps					
0	2402	Default	5.67	20.97	PASS
39	2441	Default	5.87	20.97	PASS
78	2480	Default	4.64	20.97	PASS

BT(BLE)

Test Channel	Frequency (MHz)	Power Setting	Peak Output Power (dBm)	LIMIT (dBm)	Verdict
1Mbps					
00	2402	Default	2.35	30	PASS
19	2440	Default	3.25	30	PASS
39	2480	Default	2.80	30	PASS

2.4G WIFI:

Test Channel	Frequency (MHz)	Power Setting	Duty Cycle Factor (dB)	Peak Output Power(dBm)		Total		LIMIT (dBm)	Verdict
				ANT A	ANT B	(dBm)			
802.11b									
1	2412	Default	0	15.1	12.4	-	-	30	PASS
6	2437	Default	0	15.4	12.6	-	-	30	PASS
11	2462	Default	0	15.1	13.0	-	-	30	PASS
802.11g									
1	2412	Default	0	15.1	12.7	-	-	30	PASS
6	2437	Default	0	15.2	12.9	-	-	30	PASS
11	2462	Default	0	15.0	13.2	-	-	30	PASS
802.11n HT20									
1	2412	Default	0	15.0	12.5	16.94		30	PASS
6	2437	Default	0	15.2	12.7	17.14		30	PASS
11	2462	Default	0	14.9	13.0	17.06		30	PASS

5.2G WIFI:

Test Channel	Frequency (MHz)	Maximum output power. Antenna port (AV) (dBm)		Total Power (AV) (dBm)	LIMIT (dBm)	Result
		ANT A	ANT B	dBm		
TX 802.11a Mode						
CH36	5180	9.3	8.7	-	23.98	Pass
CH40	5200	9.1	8.6	-	23.98	Pass
CH48	5240	8.7	8.1	-	23.98	Pass
TX 802.11 n20M Mode						
CH36	5180	8.9	8.6	11.76	23.98	Pass
CH40	5200	9.0	8.5	11.77	23.98	Pass
CH48	5240	8.5	8.0	11.27	23.98	Pass
TX 802.11 n40M Mode						
CH38	5190	8.3	8.0	11.16	23.98	Pass
CH46	5230	8.1	7.6	10.87	23.98	Pass
TX 802.11 ac20M Mode						
CH36	5180	9.1	8.6	11.87	23.98	Pass
CH40	5200	9.0	8.5	11.77	23.98	Pass
CH48	5240	8.8	8.1	11.47	23.98	Pass
TX 802.11 ac40M Mode						
CH38	5190	8.3	8.0	11.16	23.98	Pass
CH46	5230	8.2	7.6	10.92	23.98	Pass
TX 802.11 ac80M Mode						
CH42	5210	7.3	7.1	10.21	23.98	Pass

5.8G WIFI:

Test Channel	Frequency	Maximum output power. Antenna port		Total Power	LIMIT	Result
		(AV) (dBm)		(AV)		
	(MHz)	ANT A	ANT B	dBm	dBm	
TX 802.11a Mode						
CH 149	5745	9.0	8.7	–	30	Pass
CH 157	5785	8.4	7.5	–	30	Pass
CH 165	5825	7.4	6.4	–	30	Pass
TX 802.11 n20M Mode						
CH 149	5745	8.8	8.8	11.81	30	Pass
CH 157	5785	8.4	7.5	10.98	30	Pass
CH 165	5825	7.5	6.3	9.95	30	Pass
TX 802.11 n40M Mode						
CH 151	5755	9.3	9.2	12.26	30	Pass
CH 159	5795	8.6	7.9	11.27	30	Pass
TX 802.11 ac20M Mode						
CH 149	5745	8.9	8.7	11.81	30	Pass
CH 157	5785	8.4	7.6	11.03	30	Pass
CH 165	5825	7.4	6.3	9.90	30	Pass
TX 802.11 ac40M Mode						
CH 151	5755	9.5	9.1	12.31	30	Pass
CH 159	5795	8.8	7.8	11.34	30	Pass
TX 802.11 ac80M Mode						
CH 155	5775	8.2	7.6	10.92	30	Pass

3 RF Exposure Evaluation

3.1 Operation in BT(EDR+BR) FOR SISO MODE

ANT 1:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
7	2	9	7.94	20	0.001580	1.000	Pass

3.2 Operation in BT(BLE) FOR SISO MODE

ANT 1:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
4	2	6	3.98	20	0.000792	1.000	Pass

3.3 Operation in WLAN 2.4G FOR SISO MODE

ANT 1:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
16	2	18	63.10	20	0.012552	1.000	Pass

ANT 2:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
16	2	18	63.10	20	0.012552	1.000	Pass

3.4 Operation in WLAN 5.2G FOR SISO MODE

ANT 1:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
10	2	12	15.85	20	0.003153	1.000	Pass

ANT 2:

Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
10	2	12	15.85	20	0.003153	1.000	Pass

3.5 Operation in WLAN 5.8G FOR SISO MODE

ANT 1:

Tune-up limit (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
10	2	12	15.85	20	0.003153	1.000	Pass

ANT 2:

Tune-up limit (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
10	2	12	15.85	20	0.003153	1.000	Pass

4 Exposure calculations for multiple sources

When a number of sources at different frequencies, and/or broadband sources, contribute to the total exposure, it becomes necessary to weigh each contribution relative to the MPE in accordance with the provisions of Table (A) and Table (B). To comply with the MPE, the fraction of the MPE in terms of E^2 , H^2 (or power density) incurred within each frequency interval should be determined and the sum of all such fractions should not exceed unity.

In order to ensure compliance with the MPE for a controlled environment, the sum of the ratios of the power density to the corresponding MPE should not exceed unity. That is

$$\sum_{i=1}^n \frac{S_i}{MPE_i}$$

The product also has multiple transmitters The Simultaneous Transmission Possibilities are as below:

Simultaneous Tx Combination	Configuration
1	WLAN 2.4G MIMO
2	WLAN 5.2G MIMO
3	WLAN 5.8G MIMO
4	WLAN 5.2G+BT(EDR+BR)
5	WLAN 5.8G+BT(EDR+BR)
6	WLAN 5.2G+BT(BLE)
7	WLAN 5.8G+BT(BLE)

4.1 Estimation for WLAN MIMO 2.4G

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
1	16.00	2	18.00	63.10	20	0.012552	0.025103	1.000	Pass
2	16.00	2	18.00	63.10		0.012552			

4.2 Estimation for WLAN MIMO 5.2G

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
1	10.00	2	12.00	15.85	20	0.003153	0.006306	1.000	Pass
2	10.00	2	12.00	15.85		0.003153			

4.3 Estimation for WLAN MIMO 5.8G

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
1	10.00	2	12.00	15.85	20	0.003153	0.006306	1.000	Pass
2	10.00	2	12.00	15.85		0.003153			

4.4 Estimation for WLAN 5.2G+BT(EDR+BR)

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
2	10.00	2	12.00	15.85	20	0.003153	0.004728	1.000	Pass
1	7.00	2	9.00	7.94		0.001580			

4.5 Estimation for WLAN 5.8G+BT(EDR+BR)

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
2	10.00	2	12.00	15.85	20	0.003153	0.004728	1.000	Pass
1	7.00	2	9.00	7.94		0.001580			

4.6 Estimation for WLAN 5.2G+BT(BLE)

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
2	10.00	2	12	15.85	20	0.002504	0.003942	1.000	Pass
1	4.00	2	6	6.31		0.000997			

4.7 Estimation for WLAN 5.8G+BT(BLE)

ANT	Max Tune-up (dBm)	Gain (dBi)	EIRP (dBm)	EIRP (mW)	R(cm)	S (mW/cm ²)	Total S (mW/cm ²)	MPE Limit (mW/cm ²)	Conclusion
2	10.00	2	12	15.85	20	0.002504	0.003942	1.000	Pass
1	4.00	2	6	6.31		0.000997			

According to the Table above, we can conclude that the calculation results of all simultaneous transmission possibilities are less than 1, so it is into compliance.

Therefore the product also meets the requirements under multiple sources condition.

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