RF EXPOSURE EVALUATION REPORT

FCC ID : **NM82Q6U100**
Equipment : **Smart Hub**
Model Name : **2Q6U100**
Applicant : **HTC Corporation**
No.88, Sec. 3, Zhongxing Rd., Xindian Dist., New Taipei City 231, Taiwan (R.O.C.)
Manufacturer : **HTC Corporation**
No.88, Sec. 3, Zhongxing Rd., Xindian Dist., New Taipei City 231, Taiwan (R.O.C.)
Standard : **FCC 47 CFR Part 2 (2.1093)**

We, SPORTON INTERNATIONAL INC have been evaluated in accordance with 47 CFR Part 2.1093 for the device and pass the limit.

The test results in this variant report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.

Cona Huang

Approved by: Cona Huang / Deputy Manager

SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
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History of this test report

Report No.	Version	Description	Issued Date
FA8D2018B	01	Initial issue of report	Mar. 13, 2019

1. Summary

The maximum measured average power density found during testing for HTC Corporation, Smart Hub, are as follows.

Standalone transmission			Simultaneous transmission with other transmitters
	Highest Total Power Density, averaging over $4cm^2$ (mW/cm^2)	Limit (FCC part 1.310) (mW/cm^2)	Summation of Exposure Ratio
802.11ad	0.867	1	0.998

2. Guidance Applied

The Power Density testing specification, method, and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2.1091
- FCC 47 CFR Part 2.1093
- FCC KDB 865664 D02 SAR Reporting v01r02
- FCC KDB 447498 D01 General RF Exposure Guidance v06
- TCBC workshop notes
- IEC Draft TR 63170

3. Equipment Under Test (EUT) Information

3.1 General Information

Product Feature & Specification	
Equipment Name	Smart Hub
Model Name	2Q6U100
FCC ID	NM82Q6U100
Wireless Technology and Frequency Range	LTE Band 2: 1850.7 MHz ~ 1909.3 MHz LTE Band 4: 1710.7 MHz ~ 1754.3 MHz LTE Band 5: 824.7 MHz ~ 848.3 MHz LTE Band 7: 2502.5 MHz ~ 2567.5 MHz LTE Band 12: 699.7 MHz ~ 715.3 MHz LTE Band 13: 779.5 MHz ~ 784.5 MHz LTE Band 25: 1850.7 MHz ~ 1914.3 MHz LTE Band 26: 814.7 MHz ~ 848.3 MHz LTE Band 41: 2498.5 MHz ~ 2687.5 MHz LTE Band 66: 1710.7 MHz ~ 1779.3 MHz LTE Band 71: 665.5 MHz ~ 695.5 MHz Sub 6G n41: 2506.02 MHz ~ 2679.99 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz 802.11ad: 60GHz
Mode	LTE / Sub 6G n41: QPSK, 16QAM, 64QAM 802.11a/b/g/n/ac HT20/HT40/VHT20/VHT40/VHT80 802.11ad Bluetooth BR/EDR/LE/HS
EUT Stage	Identical Prototype

Reviewed by: Eric Huang
Report Producer: Wan Liu

4. RF Exposure Limits

4.1 Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

4.2 Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. The exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure above 6GHz to radio frequency (RF) radiation as specified in §1.1310.

General Population Basic restriction for power density for frequencies between 1.5GHz and 100 GHz is 1.0 mW/cm^2 = 10 W/m^2

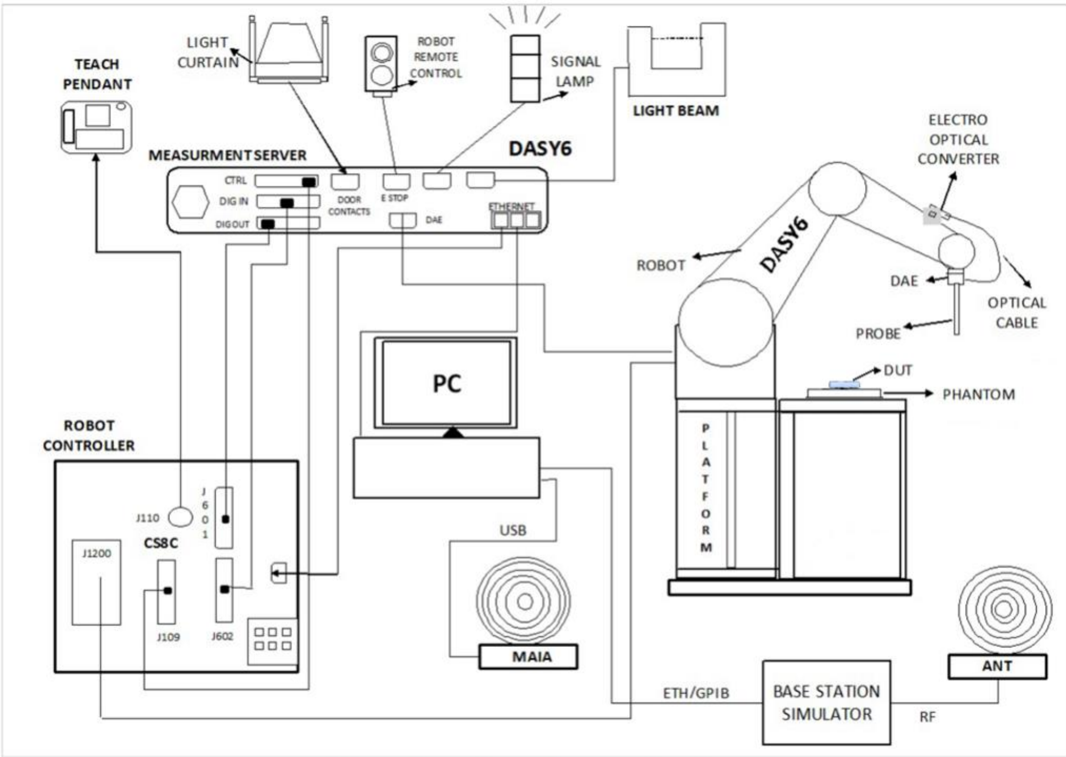
Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f2)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			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/f2)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

Table 1

5. System Description and Setup

The system to be used for the near field power density measurement

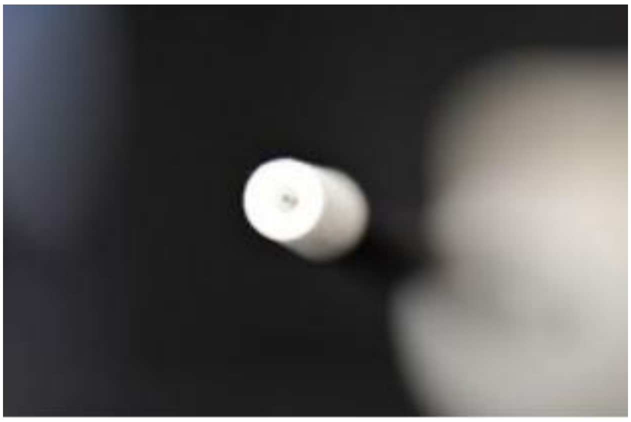
- SPEAG DASY6 system
- SPEAG cDASY6 5G module software
- EUmmWVx probe
- 5G Phantom cover

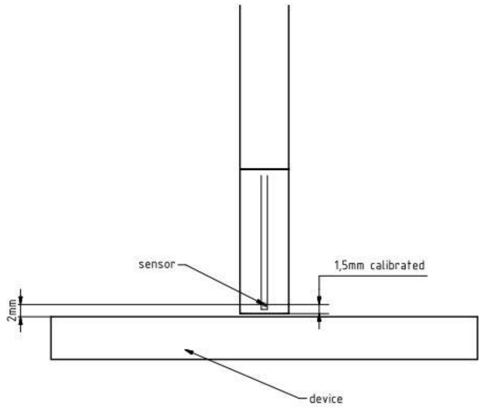


5.1 EUmmWave Probe / E-Field 5G Probe

The probe design allows measurements at distances as small as 2 mm from the sensors to the surface of the device under test (DUT). The typical sensor to probe tip distance is 1.5 mm.

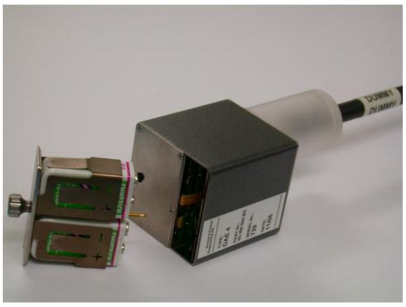
Frequency	750 MHz – 110 GHz
Probe Overall Length	320 mm
Probe Body Diameter	8.0 mm
Tip Length	23.0 mm
Tip Diameter	8.0 mm
Probe's two dipoles length	0.9 mm – Diode loaded
Dynamic Range	< 20 V/m - 10000 V/m with PRE-10 (min < 50 V/m - 3000 V/m)
Position Precision	< 0.2 mm
Distance between diode sensors and probe's tip	1.5 mm
Minimum Mechanical separation between probe tip and a Surface	0.5 mm
Applications	E-field measurements of 5G devices and other mm-wave transmitters operating above 10GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction.
Compatibility	cDASY6 + 5G-Module SW1.0 and higher





5.2 Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.
The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



5.3 Scan configuration

Fine-resolution scans on 2 different planes are performed to reconstruct the E- and H-fields as well as the power density; the z-distance between the 2 planes is set to $\lambda/4$.
The (x, y) grid step is also set $\lambda/4$, the grid extent is set to sufficiently large to identify the field pattern and the peak.

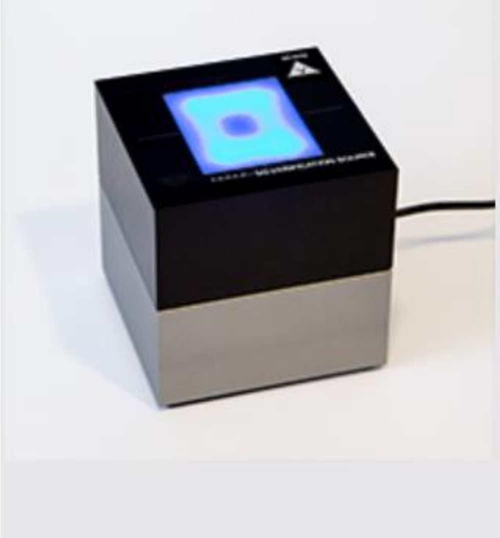
6. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	5G Verification Source	60 GHz	1009	Apr. 05, 2018	Apr. 04, 2019
SPEAG	EUmmWV Probe Tip Protection	EUmmWV3	9390	Jun. 28, 2018	Jun. 27, 2019
SPEAG	Data Acquisition Electronics	DAE4	778	May. 25, 2018	May. 24, 2019
Gencom	Thermometer	TE1	TM225-1	Mar. 16, 2018	Mar. 15, 2019
Gencom	Thermometer	TE1	TM225-1	Mar. 16, 2018	Mar. 15, 2019
OML	Mixer	M15HW/A	V91113-1	Oct. 10, 2018	Oct. 09, 2019
Rohde & Schwarz	Spectrum Analyzer	FSV40	101408	Jul. 30, 2018	Jul. 29, 2019
Custom Microwave	Standard Horn antenna	M15RH	V91113-A	NCR	NCR

7. System Verification Source

The System Verification sources at 30 GHz and above comprise horn-antennas and very stable signal generators.

Model	Ka-band horn antenna
Calibrated frequency:	30 GHz at 10mm from the case surface
Frequency accuracy	± 100 MHz
E-field polarization	linear
Harmonics	-20 dBc
Total radiated power	14 dBm
Power stability	0.05 dB
Power consumption	5 W
Size	00 x 100 x 100 mm
Weight	1 kg



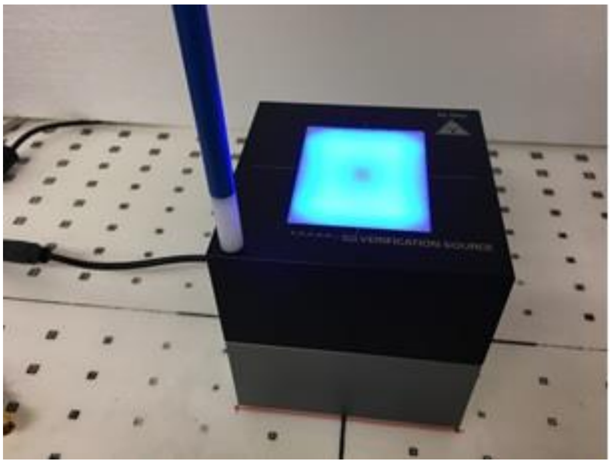
8. Power Density System Verification

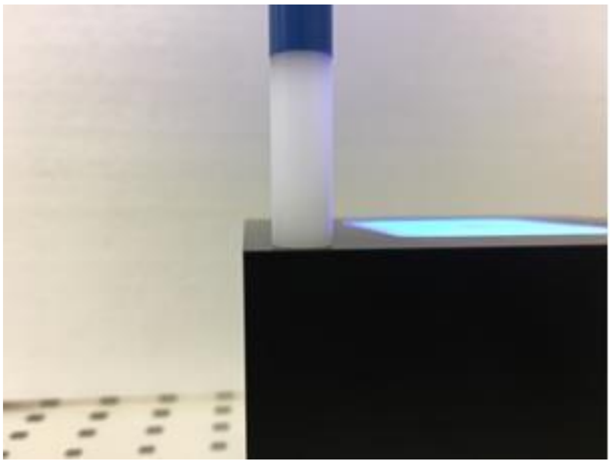
The system performance check verifies that the system operates within its specifications.

The EUT is replaced by a calibrated source, the same spatial resolution, measurement region and the test separation used in the calibration was applied to system check. Through visual inspection into the measured power density distribution, both spatially (shape) and numerically (level) have no noticeable difference. The measured results should be within 10% of the calibrated targets.

Frequency [GHz]	Grid step	Grid extent X/Y [mm]	Measurement points
10	0.25 ($\frac{\lambda}{4}$)	120/120	16 × 16
30	0.25 ($\frac{\lambda}{4}$)	60/60	24 × 24
60	0.25 ($\frac{\lambda}{4}$)	32.5/32.5	26 × 26
90	0.25 ($\frac{\lambda}{4}$)	30/30	36 × 36

Settings for measurement of verification sources





Verification Setup photo

9. System Verification Results

Date	Frequency (GHz)	5G Verification Source	Probe S/N	DAE S/N	Distance (mm)	Measured 4 cm² (W/m²)	Targeted 4 cm² (W/m²)	Deviation (%)
2019/2/12	60	60GHz-1009	9390	778	10	227	231.223	-1.83%
2019/2/19	60	60GHz-1009	9390	778	10	231	231.223	-0.10%
2019/2/26	60	60GHz-1009	9390	778	10	234	231.223	1.20%
2019/3/5	60	60GHz-1009	9390	778	10	223	231.223	-3.56%

9.1 Computation of the Electric Field Polarization Ellipse

For the numerical description of an arbitrarily oriented ellipse in three-dimensional space, five parameters are needed: the semi-major axis (a), the semi-minor axis (b), two angles describing the orientation of the normal vector of the ellipse (ø, θ), and one angle describing the tilt of the semi-major axis (ψ). For the two extreme cases, i.e., circular and linear polarizations, three parameters only (a, ø and θ) are sufficient for the description of the incident field.

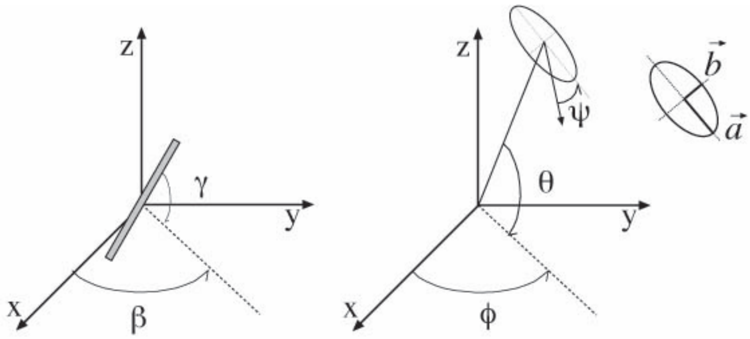


Illustration of the angles used for the numerical description of the sensor and the orientation of an ellipse in 3-D space.

For the reconstruction of the ellipse parameters from measured data, the problem can be reformulated as a nonlinear search problem. The semi-major and semi-minor axes of an elliptical field can be expressed as functions of the three angles (ø, θ and ψ). The parameters can be uniquely determined towards minimizing the error based on least-squares for the given set of angles and the measured data. In this way, the number of free parameters is reduced from five to three, which means that at least three sensor readings are necessary to gain sufficient information for the reconstruction of the ellipse parameters. However, to suppress the noise and increase the reconstruction accuracy, it is desirable that the system of equations be over determined. The solution to use a probe consisting of two sensors angled by r_1 and r_2 toward the probe axis and to perform measurements at three angular positions of the probe, i.e., at β_1, β_2 and β_3, results in over-determinations by a factor of two. If there is a need for more information or increased accuracy, more rotation angles can be added. The reconstruction of the ellipse parameters can be separated into linear and non-linear parts that are best solved by the Givens algorithm combined with a downhill simplex algorithm. To minimize the mutual coupling, sensor angles are set with a shift of 90 degree ($r_2 = r_1 + 90$ degree), and to simplify, the first rotation angle of the probe (β_1) can be set to 0 degree

9.2 Total Field and Power Flux Density Reconstruction

Computation of the power density in general requires knowledge of the electric and magnetic field amplitudes and phases in the plane of incidence. Reconstruction of these quantities from pseudo-vector E-field measurements is feasible, as they are constrained by Maxwell's equations. SPEAG have developed a reconstruction approach based on the Gerchberg-Saxton algorithm, which benefits from the availability of the E-field polarization ellipse information obtained with the EUmmWV2 probe.
The average of the reconstructed power density is evaluated over a circular area in each measurement plane. Two average power density values can be computed, the average total power density and the average incident power density, and the average total power density is used to determine compliance.

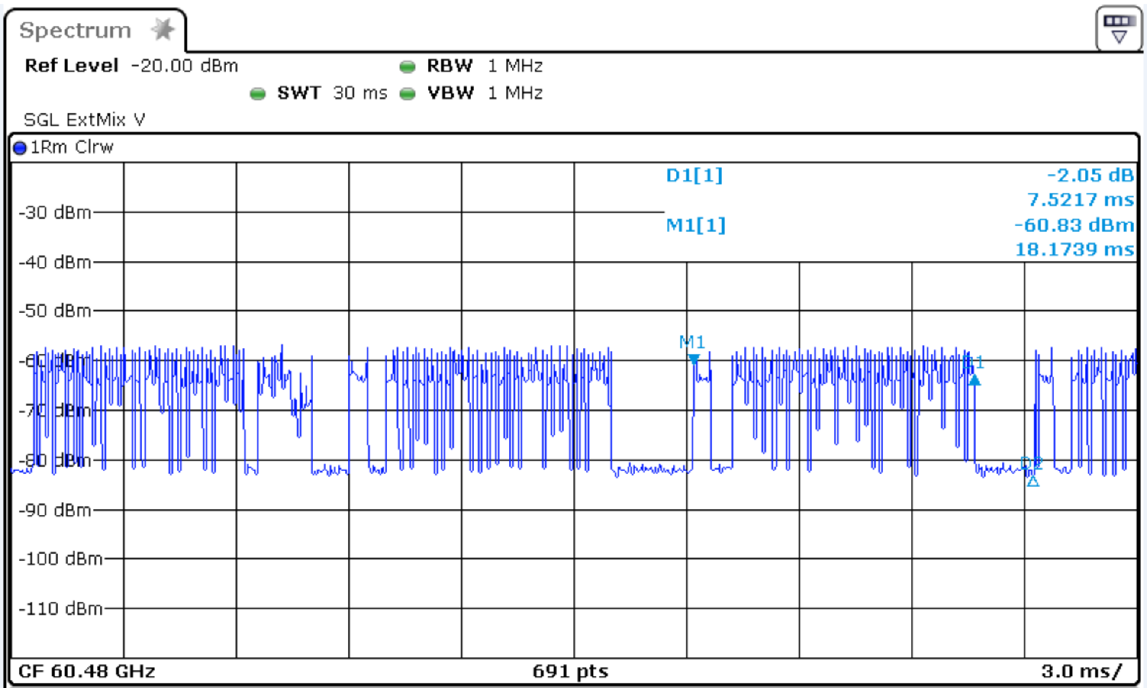
- $|Re\{S\}|$ is the total Poynting vector
- $\mathrm{n} \cdot Re\{S\}$ is the normal Poything vector

The software post-processing reports to values, “S avg tot” and “S avg inc”. “S avg tot” represents average total power density (all three xyz components included), and “S avg inc” represents average normal power density. The average total power density “S avg tot” is reported to determine the device compliance.

10. 802.11ad Duty cycle

<Duty Cycle>
The actual 11ad RF signal is a wideband signal and is limited to transmit at 85% duty cycle.

Mode	On Time(ms)	On+Off Time(ms)	Duty Cycle (%)
802.11ad	7.5217	9.0435	83.17%



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	18.1739 ms	-60.83 dBm		
D1	M1	1	7.5217 ms	-2.05 dB		
D2	M1	1	9.0435 ms	-22.50 dB		

11. Test Positions

802.11ad antenna module	Measurement Plane					
	Front @ 10 mm	Back @ 10 mm	Left @ 10 mm	Right @ 10 mm	Top @ 10 mm	Bottom @ 10 mm
Left	**Yes**	**Yes**	**Yes**	No	**Yes**	No
Right	**Yes**	**Yes**	No	**Yes**	**Yes**	No

General Note:

1. According to appendix E antenna location, when the antenna to the edge is higher than 25mm, for that edge is not tested.

12. RF Exposure Evaluation Results

General Note:

1. The 802.11ad PD test was performed of a 10mm separation between sensor and EUT surface (the probe tip is 0.5mm to the EUT surface).
2. The test position/separation and the area to scan for each test is selected and identified in the simulation report, details in illustrated in the simulation report exhibit and the operational description.
3. Using test software, the device under test was configured to transmit maximum power and at 100% duty cycle, at the center frequency of each desired channel. The actual 11ad RF signal is a wideband signal and is limited to transmit at 85% duty cycle. Therefore the measured maximum 4cm^2 average power density was scaled to account for the 85% duty factor.
4. According to TCBC Workshop in October 2018, 4 cm^2 averaging area may now be considered.
5. Above 6 GHz, Maximum Permissible Exposure (MPE) limits apply to portable exposure conditions according to 47 CFR §2.1093.

Plot No.	802.11ad antenna module	Test Distance (mm)	Channel	Sector	Exposure plane	Test Position	EIRP Average Power (dBm)	E-peak [V/m]	H-peak [A/m]	Measured 4cm^2 Average Normal PD (W/m^2)	Measured 4cm^2 Average Total PD (W/m^2)	4cm^2 Average Total PD (W/m^2)*85%
	Left	10	1	34	1	Front	14.66	103.00	0.277	7.620	8.34	7.09
	Left	10	1	36	1	Front	8.83	91.60	0.24	4.89	6.45	5.48
	Left	10	3	34	1	Front	15.54	106.00	0.26	7.74	8.56	7.28
01	Left	10	3	40	1	Front	23.01	125	0.315	9.39	10.2	8.67
	Left	10	4	37	1	Front	13.24	93.8	0.256	6.38	7.7	6.55
	Left	10	4	36	1	Front	19.38	126.00	0.32	7.92	8.21	6.98
	Left	10	1	33	2	Back	2.94	19.6	0.053	0.789	0.8	0.68
	Left	10	1	58	3	Top Side	14.10	26.6	0.065	0.677	0.711	0.60
	Left	10	4	50	4	Left Side	10.30	35.8	0.091	0.866	0.89	0.76
	Right	10	1	10	1	Front	10.29	105.0	0.281	6.560	7.81	6.64
	Right	10	1	20	1	Front	13.61	86.5	0.211	4.580	4.90	4.17
	Right	10	2	3	1	Front	11.56	106.0	0.277	8.110	9.20	7.82
	Right	10	2	12	1	Front	12.05	91.3	0.218	5.390	6.40	5.44
	Right	10	4	12	1	Front	15.55	129.0	0.329	9.01	9.97	8.47
	Right	10	4	3	1	Front	12.41	109	0.279	7.74	8.06	6.85
	Right	10	2	13	2	Back	10.18	32.1	0.092	1.44	1.47	1.25
	Right	10	2	18	3	Right Side	9.56	20.3	0.055	0.511	0.531	0.45
	Right	10	4	8	4	Top Side	6.70	26.6	0.068	1.01	1.07	0.91

13. Simultaneous Transmission Analysis

Simultaneous transmission combination scenarios	LTE Ant 0	LTE Ant 1	LTE Ant 2	Sub-6G n41 Ant 5	2.4GHz WLAN/BT Ant 0	2.4GHz WLAN Ant 1	5GHz WLAN Ant 0	4GHz WLAN Ant 1	802.11ad (Left Antenna module)	802.11ad (Right Antenna module)
1	☑				☑	☑			☑	
2		☑			☑	☑			☑	
3			☑	☑	☑	☑			☑	
4	☑						☑	☑	☑	
5		☑					☑	☑	☑	
6			☑	☑			☑	☑	☑	
7	☑				☑			☑	☑	
8		☑			☑			☑	☑	
9			☑	☑	☑			☑	☑	
10	☑				☑	☑				☑
11		☑			☑	☑				☑
12			☑	☑	☑	☑				☑
13	☑						☑	☑		☑
14		☑					☑	☑		☑
15			☑	☑			☑	☑		☑
16	☑				☑			☑		☑
17		☑			☑			☑		☑
18			☑	☑	☑			☑		☑

General Note:

1. The WWAN / WLAN and BT SAR test results were referring the report of FCC ID: NM82Q6U100 (Sporton SAR Report No. FA8D2018A)
2. For 802.11ad, the left and right antennas can't transmit simultaneously.
3. The 802.11ad PD test was performed of a 10mm separation between sensor and EUT surface, the test results are conservatively used in simultaneous transmission analysis in body exposure conditions.
4. for Sub-6G n41 only can transmit simultaneous with TDD LTE B41 at antenna 2
5. Considering 802.11ad with WWAN / WLAN and Bluetooth can transmit simultaneously, the basic restrictions are on SAR and power density, and summation of these quantities should follow below formula and the simultaneous transmission analysis was following below step and the detail analysis please refer to appendix D:
   i) Use the standalone SAR according original report to collocate with 802.11ad power density at each exposure positions, if the result < 1, additional analysis is not necessary.
   ii) If this ratio is larger than 1, use surface single point SAR measurements and treat as 1-gram measurements with 1.6 W/kg as the limit. Use these measurement for the point by point summation and confirm the ratio summation does not exceed 1

The [∑ of (the highest measured or estimated SAR for each standalone antenna configuration, adjusted for maximum tune-up tolerance) / 1.6 W/kg] + [∑ of MPE ratios] is ≤ 1.0.

Test Engineer： Aaron Chen, Steven Chang, Thomas Wang, and Nick Yu

14. Uncertainty Assessment

The budget is valid for evaluation distances > λ/2π. For specific tests and configurations, the Uncertainty could be considerably smaller.

Preliminary Module mmWave Uncertainty Budget Evaluation Distances to the Antennas > λ / 2π						
Error Description	**Uncertainty Value (± dB)**	**Probability**	**Divisor**	**(Ci)**	**Standard Uncertainty (±dB)**	**(Vi) Veff**
Measurement System						
Probe Calibration	0.49	N	1	1	0.49	∞
Hemispherical Isotropy	0.50	R	1.732	1	0.29	∞
Linearity	0.20	R	1.732	0	0.12	∞
System Detection Limits	0.04	R	1.732	1	0.02	∞
Modulation Response	0.40	R	1.732	1	0.23	∞
Readout Electronics	0.03	N	1	1	0.03	∞
Response Time	0.00	R	1.732	1	0.00	∞
Integration Time	0.00	R	1.732	1	0.00	∞
RF Ambient Noise	0.2	R	1.732	1	0.12	∞
RF Ambient Reflections	0.21	R	1.732	1	0.12	∞
Probe Positioner	0.04	R	1.732	1	0.02	∞
Probe Positioning	0.30	R	1.732	1	0.17	∞
S_{avg} Reconstruction	0.60	R	1.732	1	0.35	∞
Test Sample Related						
Power Drift	0.2	R	1.732	1	0.12	∞
Input Power	0	N	1	0	0.00	∞
Combined Std. Uncertainty					0.76 dB	∞
Coverage Factor for 95 %					K=2	
Expanded STD Uncertainty					1.52 dB	

15. References

[1] FCC 47 CFR Part 2 “Frequency Allocations and Radio Treaty Matters; General Rules and Regulations”

[2] FCC KDB 447498 D01 v06, “Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies”, Oct 2015

[3] FCC KDB 865664 D02 v01r02, “RF Exposure Compliance Reporting and Documentation Considerations” Oct 2015.

[4] FCC KDB 648474 D04 v01r03, “SAR Evaluation Considerations for Wireless Handsets”, Oct 2015.