Power Density Evaluation Report

Applicant	**: Motorola Mobility LLC**
Equipment	**: Mobile Cellular Phone**
Brand Name	**: Motorola**
Model Name	**: XT2201-4**
FCC ID	**: IHDT56AB3**
Standard	**: FCC 47 CFR Part 2 (2.1093)**

We, Sporton International (Kunshan) Inc., would like to declare that the tested sample provide by manufacturer and the test data has been evaluated in accordance with the test procedures given in 47 CFR part2.1093 and has been pass the FCC requirement.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.

Tony Zhang

Reviewed by: Tony Zhang / Supervisor

Kat Yin

Approved by: Kat Yin / Manager

ilac-MRA

ACCREDITED
Cert #5145.02

Sporton International (Kunshan) Inc.
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China

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History of this test report

Report No.	Version	Description	Issued Date
FA192317-02C	01	Initial issue of report	Jan. 17, 2022

1. Summary

The maximum measured average power density found during testing for **Motorola Mobility LLC, Mobile Cellular Phone**, are as follows.

<table>
<tr><th colspan="4">Standalone transmission</th><th>Simultaneous transmission with other transmitters</th></tr>
<tr><th colspan="2">RF Transmitter</th><th>Measured PD (mW/cm^2)</th><th>Reported PD (mW/cm^2)</th><th>Summation of Exposure Ratio</th></tr>
<tr><td rowspan="2">5G FR2</td><td>n260</td><td>0.518</td><td>0.800</td><td rowspan="2">0.957</td></tr>
<tr><td>n261</td><td>0.468</td><td>0.800</td></tr>
<tr><td colspan="2">Result</td><td colspan="3">PASS</td></tr>
</table>

2. Administration Data

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

<table>
<tr><th colspan="4">Testing Laboratory</th></tr>
<tr><td>Test Firm</td><td colspan="3">Sporton International (Kunshan) Inc.</td></tr>
<tr><td>Test Site Location</td><td colspan="3">No. 1098, Pengxi North Road, Kunshan Economic Development Zone
Jiangsu Province 215300 People's Republic of China
TEL : +86-512-57900158
FAX : +86-512-57900958</td></tr>
<tr><td rowspan="2">Test Site No.</td><td>Sporton Site No.</td><td>FCC Designation No.</td><td>FCC Test Firm Registration No.</td></tr>
<tr><td>SAR04-KS</td><td>CN1257</td><td>314309</td></tr>
</table>

Applicant	
Company Name	Motorola Mobility LLC
Address	222 W,Merchandise Mart Plaza, Chicago IL 60654 USA

Manufacturer	
Company Name	Motorola Mobility LLC
Address	222 W,Merchandise Mart Plaza, Chicago IL 60654 USA

3. 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
- FCC KDB 648474 D04 SAR Evaluation Considerations for Wireless Handsets v01r03
- TCBC workshop notes
- IEC TR 63170

4. Equipment Under Test (EUT) Information

4.1 General Information

Product Feature & Specification	
Equipment Name	Mobile Cellular Phone
Brand Name	Motorola
Model Name	XT2201-4
FCC ID	IHDT56AB3
Wireless Technology and Frequency Range	GSM850: 824 MHz ~ 849 MHz GSM1900: 1850 MHz ~ 1910 MHz WCDMA Band II: 1850 MHz ~ 1910 MHz WCDMA Band V: 824 MHz ~ 849 MHz LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 4: 1710 MHz ~ 1755 MHz LTE Band 5: 824 MHz ~ 849 MHz LTE Band 7: 2500 MHz ~ 2570 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 48: 3550 MHz ~ 3700 MHz LTE Band 66: 1710 MHz ~ 1780 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n66 : 1710 MHz ~ 1780 MHz 5G NR n77 : 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3980 MHz 5G NR n78 : 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3800 MHz 5G NR n260 : 37 GHz~40 GHz 5G NR n261 : 27.5 GHz~28.35 GHz WLAN 2.4GHz Band: 2400 MHz ~ 2483.5 MHz WLAN 5.2GHz Band: 5150 MHz ~ 5250 MHz WLAN 5.3GHz Band: 5250 MHz ~ 5350 MHz WLAN 5.5GHz Band: 5470 MHz ~ 5725 MHz WLAN 5.8GHz Band: 5725 MHz ~ 5825 MHz WLAN6E UNII 5: 5925 MHz ~ 6425 MHz WLAN6E UNII 6: 6425 MHz ~ 6525 MHz WLAN6E UNII 7: 6525 MHz ~ 6875 MHz WLAN6E UNII 8: 6875 MHz ~ 7125 MHz Bluetooth: 2402 MHz ~ 2480 MHz WPC: 110 kHz ~ 148 kHz NFC : 13.56 MHz
Mode	GSM/GPRS/EGPRS RMC/AMR 12.2Kbps HSDPA HSUPA DC-HSDPA HSPA+(16QAM uplink is not supported) LTE: QPSK, 16QAM, 64QAM, 256QAM 5G NR : CP-OFDM / DFT-s-OFDM, PI/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 2.4GHz 802.11ax HE20/HE40 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac/ax VHT20/VHT40/VHT80/VHT160/HE20/HE40/HE80/HE160 WLAN 6GHz 802.11a WLAN 6GHz 802.11ax HE20/HE40/HE80/HE160 Bluetooth BR/EDR/LE WPC: ASK NFC: ASK

5. RF Exposure Limits

5.1 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.

5.2 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

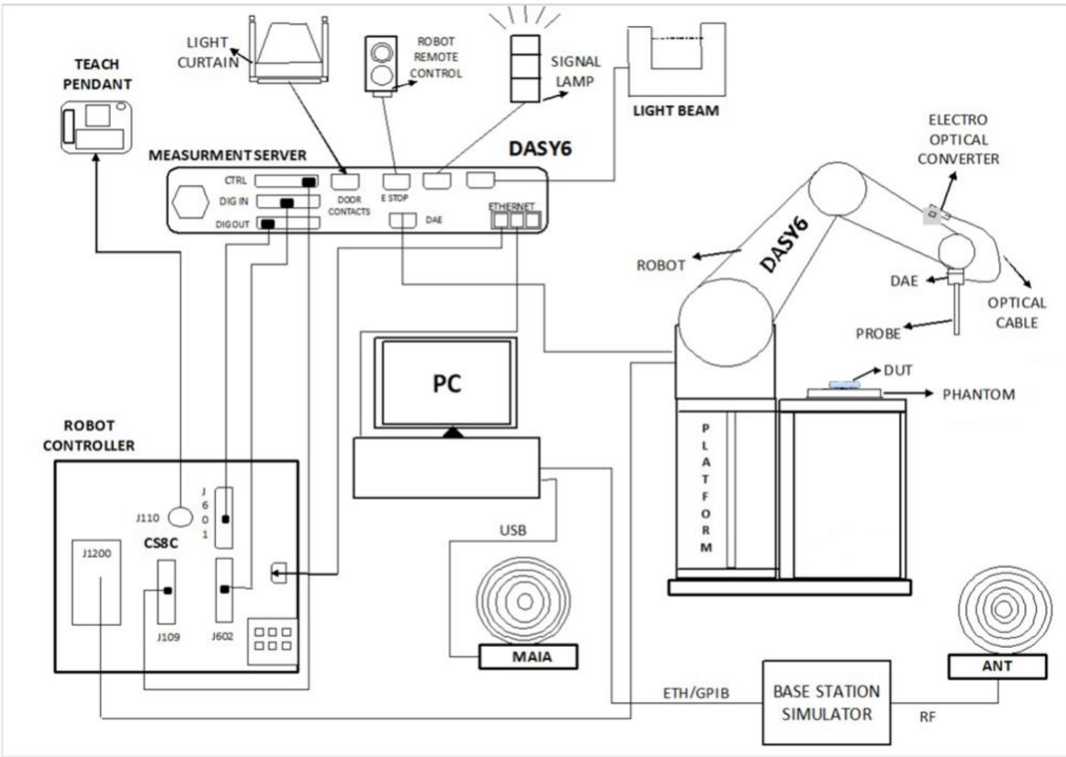
Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f2)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000		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

6. System Description and Setup

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

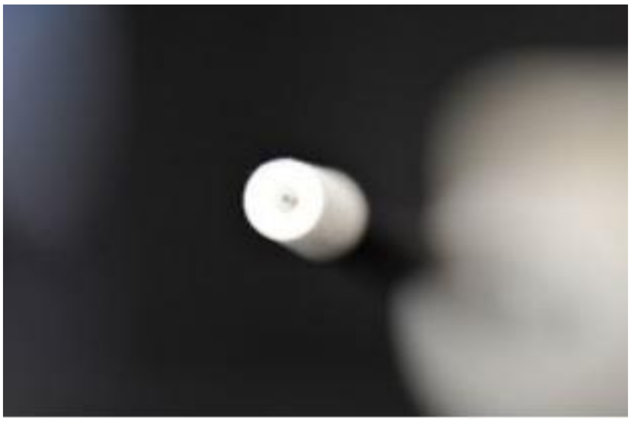
- SPEAG DASY6 system
- SPEAG cDASY6 5G module software
- EUmmWVx probe
- 5G Phantom cover

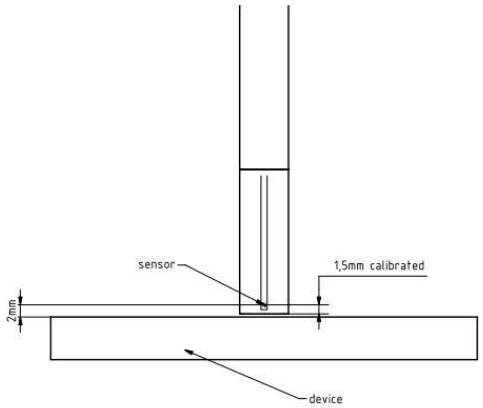


6.1 EUmmWave Probe / E-Field 5G Probe

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

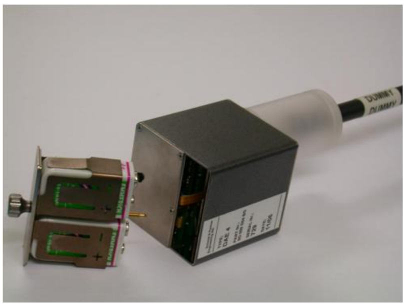




6.2 Data Acquisition Electronics (DAE)

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.



6.3 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.

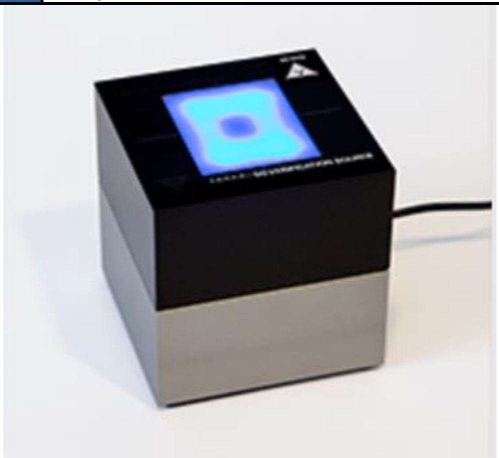
7. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	5G Verification Source	30GHz	1080	2021/4/6	2022/4/5
SPEAG	EUmmWV Probe Tip Protection	EUmmWV3	9553	2021/4/1	2022/3/31
SPEAG	Data Acquisition Electronics	DAE4	1650	2021/6/9	2022/6/8
R&S	Spectrum Analyzer	FSV40	101078	2021/4/8	2022/4/7
Anymetre	Thermo-Hygrometer	JR593	2015030904	2021/7/21	2022/7/20

8. 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 5.55mm 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	100 x 100 x 100 mm
Weight	1 kg



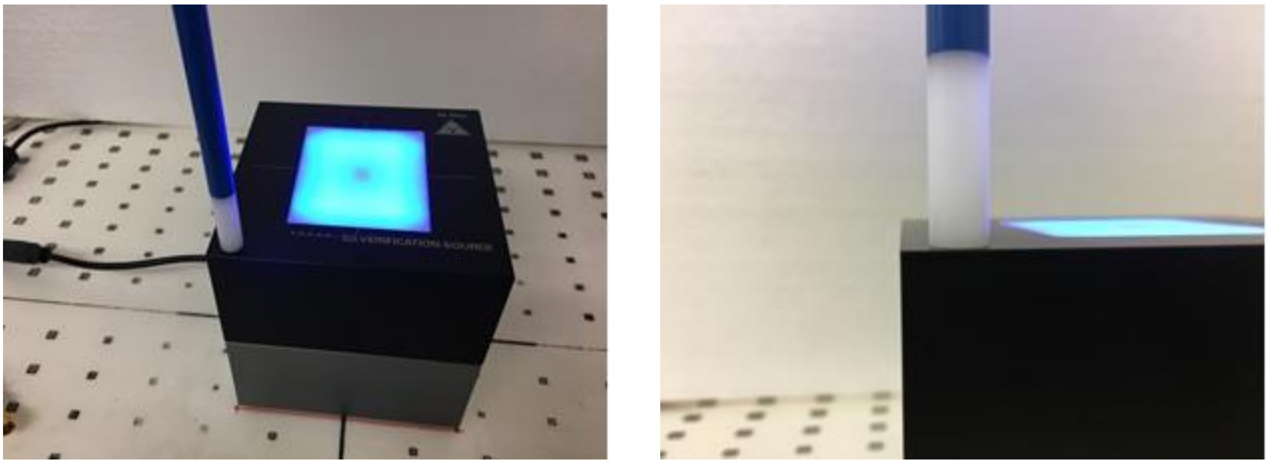
9. Power Density System Verification

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 0.66 dB 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

10. System Verification Results

Frequency (GHz)	5G Verification Source	Probe S/N	DAE S/N	Distance (mm)	Measured 4 cm^2 (W/m^2)	Targeted 4 cm^2 (W/m^2)	Deviation (dB)	Date
30GHz	SN:1080	9553	1650	5.55	41.8	42.7	-0.09	2021.12.25
30GHz	SN:1080	9553	1650	5.55	40.2	42.7	-0.26	2021.12.27

10.1 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 (∅, 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, ∅ and θ) are sufficient for the description of the incident field.

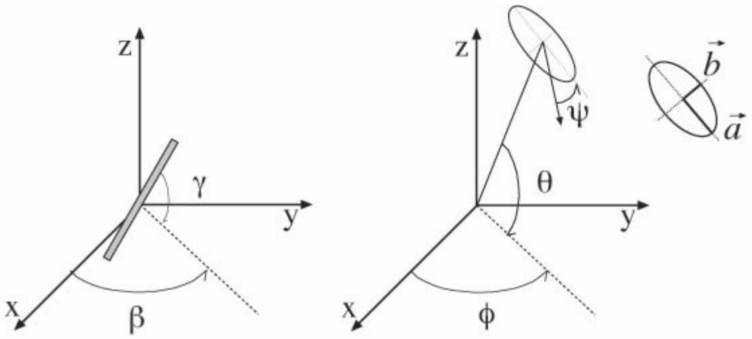


Illustration of the angles used for the numerical description of the sensor and the orientation of an ellipse in 3-D space.

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 (∅, 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.

10.2 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.

10.3 Test Positions

Band	Antenna Module	Measurement Plane					
		Front 2mm	Back 2mm	Left Side 2mm	Right Side 2mm	Top Side 2mm	Bottom Side 2mm
5G NR Band 260	0	No	Yes	No	No	No	No
	1	No	No	No	Yes	No	No
5G NR Band 261	0	No	Yes	No	No	No	No
	1	No	Yes	No	Yes	No	No

From the Part 0 and simulation report, beam IDs with highest PD and corresponding input power limit were selected to be tested for each antenna module and for each frequency band.

11. RF Exposure Evaluation Results

1. The PD test was performed of a 2mm separation between sensor and EUT surface (the probe tip is 0.5mm to the EUT surface), 2 mm separation distance PD testing is for hotspot and body worn exposure conditions.
2. According to TCBC Workshop in October 2018, 4 cm^2 averaging area are used.
3. This device is enabled with Qualcomm® Smart Transmit feature, smart transmit will manage and ensure LTE and 5G simultaneous transmission is compliant. The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in Part 2 report.
4. Input power limit parameter for 5G mmW NR radio was calculated in RF Exposure Part 0 test report.
5. The device was configured to transmit CW wave signal for testing, due to Qualcomm® Smart Transmit feature, additional testing was not required for different modulations (CP-OFDM QPSK, CP-OFDM 16QAM, CP-OFDM 64QAM), RB configurations, component carriers, channel configurations (low channel, mid channel, high channel).
6. Power density measurements were performed with DUT transmitting at input.power.limit for one single beam for each polarization (H & V) and one beam-pair, for each antenna type and for each antenna module (0,1) on the worst-surfaces.
7. The Beam ID with one of the highest initial simulated power density for that surface and distance was selected for Part 1 Power Density measurements.
8. Some Power Density Evaluations were performed at a more conservative power level.
9. It's illustrated in Part 0 report that , for 5G mmW NR since there is total design-related uncertainty arising from TxAGC and device-to-device variation, the worst-case RF exposure should be determined by accounting for this device uncertainty of 2.1 dB, as well as PD design target of 4.93 W/m^2. Therefore, 5G mmW NR RF exposure for this DUT is evaluated by reported PD calculated as:

   Reported PD=PD design target + 2.1 dB = 8.00 W/m^2 = 0.800 mW/cm^2
10. The 2nd generation of SmartTransmit(GEN2), Backoff(dB) corresponds to the backoff entered in v16 (or higher) EFS for the tested mmW NR band, tested QTM module.
11. The 2nd generation of Smart Transmit (GEN2) operates based on pre-defined sub6 antenna groups (AG) and mmW module groups (MG) and was implemented on this device
    - Per QC's guidance, for simultaneous TER analysis, the device needs to demonstrate that combined PD for these identified PD beams at each QTM's dominant surface are less than PD_design_target+total uncertainty. However In this device, the 2 QTM modules are in physically separated devices, and each QTM module has its own PD evaluation planes, unlike conventional devices where the QTM modules are collocated in the same physical device and share the same PD evaluation plane.

- Since the 2 QTM modules have different RF exposure conditions, the combined PD doesn't apply here. Hence, there's no need for additional verifications for Smart Transmit Gen 2 mmWave favor mode.

Test Number	Band	Antenna Module	Beam ID 1	Beam ID 2	Frequency (GHz)	Exposure Surface	Input power level(dBm)	Test Separation	Modulation	Measured results Savg inc 4cm^2 (W/m^2)	Measured results Savg tot 4cm^2 (W/m^2)
	n260	Module 0	41	-	40	Back (S2)	6.44	2mm	CW	3.17	4.21
	n260	Module 0	-	157	40	Back (S2)	5.30	2mm	CW	2.57	3.29
	n260	Module 0	41	169	40	Back (S2)	-2.41	2mm	CW	0.877	1.08
01	n260	Module 0	31	-	40	Back (S2)	6.56	2mm	CW	4.18	**5.18**
	n260	Module 0	7	-	40	Back (S2)	12.58	2mm	CW	3.44	4.43
	n260	Module 1	27	-	37	Right (S4)	3.55	2mm	CW	4.19	4.93
	n260	Module 1	-	163	37	Right (S4)	4.63	2mm	CW	4.21	4.7
	n260	Module 1	35	163	37	Right (S4)	-3.03	2mm	CW	0.741	0.884
	n261	Module 0	41	-	27.5	Back (S2)	2.00	2mm	CW	3.51	4.25
	n261	Module 0	-	160	27.925	Back (S2)	2.40	2mm	CW	3.85	4.16
	n261	Module 0	33	161	27.5	Back (S2)	-5.04	2mm	CW	0.209	0.281
02	n261	Module 0	31	-	27.5	Back (S2)	2.68	2mm	CW	4.4	**4.68**
	n261	Module 0	1	-	27.5	Back (S2)	9.27	2mm	CW	2.78	3.34
	n261	Module 1	37	-	28.35	Right (S4)	3.25	2mm	CW	3.06	3.5
	n261	Module 1	-	165	28.35	Right (S4)	2.54	2mm	CW	2.96	3.48
	n261	Module 1	27	155	28.35	Back (S2)	-3.16	2mm	CW	1.22	1.26

12. 5G NR + LTE + WLAN + BT Sim-Tx analysis

In 5G NR + LTE + WLAN + BT simultaneous transmission, 5G NR and LTE transmission are managed and controlled by Qualcomm® Smart Transmit, while the RF exposure from WLAN and BT radios is managed using legacy approach, i.e., through a fixed power back-off if needed.

Since WLAN and BT do not employ time-averaging, 1gSAR and 10gSAR measurement for WLAN and BT need to be conducted at their corresponding rated power following current FCC test procedures to determine reported SAR values.

Smart Transmit current implementation assumes hotspots from 5G NR and LTE are collocated. Therefore, for a total of 100% exposure margin, if LTE uses x%, then the exposure margin left for 5G NR is capped to (100-x)%. Thus, the compliance equation for LTE + 5G NR is

$$x\% * A + (100-x)\% * B \leq 1.0,$$

Where, A is normalized reported time-averaged SAR exposure ratio from LTE, and $A \leq 1.0$; B is normalized reported time-averaged exposure ratio from 5G NR (i.e., PD exposure for mmW NR or SAR exposure for sub6 NR), and $B \leq 1.0$.

Let C = normalized reported SAR exposure ratio from WLAN+BT, then for compliance,

$$x\% * A + (100-x)\% * B + C \leq 1.0 \qquad (1)$$

$$x\% * A + (100-x)\% * B \leq x\% * \max(A, B) + (100-x)\% * \max(A, B) \leq \max(A, B)$$

$$x\% * A + (100-x)\% * B + C \leq \max(A, B) + C \leq 1.0 \qquad (2)$$

if $A + C \leq 1.0$ and $B + C \leq 1.0$ can be proven, then "$x\% * A + (100-x)\% * B + C \leq 1.0$". Therefore simultaneous transmission analysis for 5G NR + LTE + WLAN + BT can be performed in two steps

Step 1: Prove total exposure ratio (TER) of LTE + WLAN + BT < 1
Step 2: Prove total exposure ratio (TER) of 5G NR + WLAN + BT < 1

Else, if $A + C > 1.0$ and/or $B + C > 1.0$, then the followings need to hold true for compliance:

i. A and C are decoupled based on the SPLSR criteria , and
ii. $(100-x)\% * B + C \leq 1.0$, and
iii. $x\% * A + (100-x)\% * B \leq 1.0$

Note iii. is covered in Part 2 report; i. and ii. should be addressed in Part 2 report.

Step 1: it's justified in Part 1 SAR report (Sporton report number FA192317-02)
Step 2: it's justified in section 12.1

During TER analysis, the ***reported*** **time-averaged PD** (assuming *input.power.limit* for at least one beam < NV setting *Pmax*) applies only to the worst-surface of the device. For other surfaces, worst-case PD needs to be calculated to assess TER for the corresponding surface. To determine worst-case PD for other surfaces, using simulation results

1. Calculate ratio of simulated PD for desired surface to simulated PD of worstsurface for a given beam

2. Repeat 1 to obtain ratios for all supported beams, and determine maximum ratio

3. Repeat 1~2 to obtain the corresponding worst-case PD for rest of surfaces (non worst-case surfaces) needed for TER analysis.

For example, if the back surface of device has highest PD and is determined as worst-surface, then,

- *Back_surface_worst-case_PD* = ***reported*** **time-averaged PD**
  where, ***reported*** **time-averaged PD** = *PD_design_target* + mmW device design related uncertainty

- *For other surfaces*
  - *front_surface_worst-case_PD = PD_ratio_front_to_back* * ***reported*** **time-averaged PD**
    where, PD_ratio_front_to_back =*max* $\left\{\frac{simulated\ PD_{front(i)}}{simulated\ PD\_back(i)}, beam\ i = 1,2 \dots N\right\}$,N= total N beams (all beams) supported by the mmW module being evaluated being evaluated.
  - *Follow similar approach to determine worst-case PD for bottom/top/left/right (if applicable).*

- *For body-worn and hotspot scenario, if SAR was measured at 5mm, respectively, then the worst-case PD at 5mm separation distance should be determined per surface as*
  - *5mm_worst-case_PD = PD_ratio_5mm_to_2mm* * ***reported*** **time-averaged PD**
    Here, PD_ratio_5 mm _to_2mm =*max* $\left\{\frac{simulated\ Pd\ at\ 5\ mm\ (i)}{simulated\ PD\ at\ 2\ mm\ (i)}, beam\ i = 1,2 \dots N\right\}$, , N = total number of beams (**all** beams) supported by the mmW module being evaluated.
  - Note the validated model/simulation should be used in worst-case PD determination.

Smart Transmit EFS version 16 (or higher) with backoff in WWAN/FR2 when WLAN/BT is ON:
Smart Transmit EFS version 16 (or higher) provides the option to backoff WWAN radio when WLAN/BT ON. This WWAN/FR2 backoff can be configured per tech/band/antenna (or mmW module)/DSI of WWAN radios. The analysis performed above in this section is still applicable after applying the backoff to WWAN radio exposures, i.e., **A**, **and B** should be replaced as shown below:
normalized exposure of WWAN primary radio: A → replaced with "A * 10^$^{(\text{-WWAN backoff in dB for A when WLAN/BT ON})/10}$".
normalized exposure of 5GNR secondary radio: B → replaced with "B * 10^$^{(\text{-WWAN backoff in dB for B when WLAN/BT ON})/10}$".

13. Simultaneous-Tx analysis

No.	Simultaneous Transmission Configurations	Portable Handset			
		Head	Body-worn	Hotspot	Product specific 10g SAR
1.	WLAN2.4GHz + n260/n261	Yes	Yes	Yes	Yes
2.	WLAN5GHz + n260/n261	Yes	Yes	Yes	Yes
3.	WLAN6E + n260/n261	Yes	Yes		Yes
4.	Bluetooth + n260/n261	Yes	Yes	Yes	Yes
5.	Bluetooth + WLAN5GHz+ n260/n261	Yes	Yes	Yes	Yes
6.	Bluetooth + WLAN6E+ n260/n261	Yes	Yes		Yes
7.	WLAN2.4GHz + WLAN5GHz + n260/n261	Yes	Yes	Yes	Yes
8.	WLAN2.4GHz + WLAN6E+ n260/n261	Yes	Yes		Yes

General Note:

1. The WLAN and Bluetooth SAR test results were referring the report of FCC ID: IHDT56AB3 (Sporton SAR Report No. FA192317-02).
2. Considering n260/n261 transmitter with 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.
   i) Use the standalone SAR according original report to collocate with n260/n261 transmitter power density at each exposure positions, if the result < 1, additional analysis is not necessary.
   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.
3. This device is enabled with Qualcomm® Smart Transmit feature to control and manage transmitting power in real time and to ensure that the time-averaged RF exposure from WWAN is in compliance with FCC requirements. Since the device enabled with Qualcomm® Smart Transmit feature, 4G LTE/5G NR FR1 and 5G mmW NR simultaneous transmission scenario does not need to be evaluated under Total Exposure Ratio (TER). The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in Part 2 report.
4. For 5G mmW NR, compute reported time-averaged PD = PD_design_target * 10(mmW device design uncertainty in dB)/10 and use this computed reported time-averaged PD in total exposure ratio (TER) analysis.
5. For 5G mmW NR, compute reported time-averaged PD when WiFi is ON= PD_design_target * $10^{\wedge(\text{mmW device design uncertainty in dB/10})} * 10^{\wedge(\text{-WWAN backoff in dB /10})}$, and use this computed reported time-averaged PD in total exposure ratio (TER) analysis.

Frequency band	Antenna module	Backoff Level (dB)	Reported PD W/m^2 (WIFI/BT off)	Reported PD W/m^2 (WIFI/BT on)
n260/n261	Module 0	1.25	8.00	6.00
n260/n261	Module 1	1.25	8.00	6.00

13.1 Simultaneous transmission analysis for WiFi/BT + 5G NR

<Head Exposure Condition>

WWAN Band		Exposure Position	2	3	4	5	6	7	8	9	10	1	Reported SAR/1.6 + PD/10 Summation							
			WLAN2.4GHz Ant 4+6 DBS Only	WLAN2.4GHz Ant 4+6 WWAN+WLAN	WLAN2.4GHz Ant 4+6 WWAN+DBS	WLAN5GHz Ant 5+6 DBS Only	WLAN5GHz Ant 5+6 WWAN+WLAN	WLAN5GHz Ant 5+6 WWAN+DBS	Bluetooth Ant 4	Bluetooth Ant 6	WIFI 6E	PD	1+3 Summed	1+4+7 Summed	1+4+10 Summed	1+6+8 Summed	1+6+9 Summed	1+8+10 Summed	1+9+10 Summed	1+6+10 Summed
			1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	4cm^2 (W/m^2)								
n260	Antenna Module 0	Right Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.207	6.000	**0.957**	**0.950**	**0.909**	**0.948**	**0.772**	**0.908**	**0.731**	**0.899**
		Right Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.244	6.000	**0.957**	**0.950**	**0.933**	**0.948**	**0.772**	**0.931**	**0.754**	**0.923**
		Left Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.185	6.000	**0.957**	**0.950**	**0.896**	**0.948**	**0.772**	**0.894**	**0.718**	**0.886**
		Left Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.255	6.000	**0.957**	**0.950**	**0.939**	**0.948**	**0.772**	**0.938**	**0.761**	**0.929**
n260	Antenna Module 1	Right Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.207	6.000	**0.957**	**0.950**	**0.909**	**0.948**	**0.772**	**0.908**	**0.731**	**0.899**
		Right Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.244	6.000	**0.957**	**0.950**	**0.933**	**0.948**	**0.772**	**0.931**	**0.754**	**0.923**
		Left Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.185	6.000	**0.957**	**0.950**	**0.896**	**0.948**	**0.772**	**0.894**	**0.718**	**0.886**
		Left Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.255	6.000	**0.957**	**0.950**	**0.939**	**0.948**	**0.772**	**0.938**	**0.761**	**0.929**
n261	Antenna Module 0	Right Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.207	6.000	**0.957**	**0.950**	**0.909**	**0.948**	**0.772**	**0.908**	**0.731**	**0.899**
		Right Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.244	6.000	**0.957**	**0.950**	**0.933**	**0.948**	**0.772**	**0.931**	**0.754**	**0.923**
		Left Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.185	6.000	**0.957**	**0.950**	**0.896**	**0.948**	**0.772**	**0.894**	**0.718**	**0.886**
		Left Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.255	6.000	**0.957**	**0.950**	**0.939**	**0.948**	**0.772**	**0.938**	**0.761**	**0.929**
n261	Antenna Module 1	Right Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.207	6.000	**0.957**	**0.950**	**0.909**	**0.948**	**0.772**	**0.908**	**0.731**	**0.899**
		Right Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.244	6.000	**0.957**	**0.950**	**0.933**	**0.948**	**0.772**	**0.931**	**0.754**	**0.923**
		Left Cheek	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.185	6.000	**0.957**	**0.950**	**0.896**	**0.948**	**0.772**	**0.894**	**0.718**	**0.886**
		Left Tilted	0.734	0.571	0.288	0.732	0.272	0.272	0.285	0.003	0.255	6.000	**0.957**	**0.950**	**0.939**	**0.948**	**0.772**	**0.938**	**0.761**	**0.929**

<Hotspot Exposure Condition>

WWAN Band		Exposure Position	3 WLAN2.4GHz Ant 4+6 WWAN+WLAN 1g SAR (W/kg)	4 WLAN2.4GHz Ant 4+6 WWAN+DBS 1g SAR (W/kg)	6 WLAN5GHz Ant 5+6 WWAN+WLAN 1g SAR (W/kg)	7 WLAN5GHz Ant 5+6 WWAN+DBS 1g SAR (W/kg)	8 Bluetooth Ant 4 1g SAR (W/kg)	9 Bluetooth Ant 6 1g SAR (W/kg)	1 PD 4cm^2 (W/m^2)	Reported SAR/1.6 + PD/10 Summation 1+3 Summed	1+4+7 Summed	1+6+8 Summed	1+6+9 Summed
n260	Antenna Module 0	Front	0.231	0.197	0.160	0.160	0.197	0.029	6.000	0.744	0.823	0.823	0.718
		Back	0.278	0.241	0.245	0.245	0.241	0.087	6.000	0.774	0.904	0.904	0.808
		Left side	0.073	0.074	0.115	0.115	0.074	0.036	6.000	0.646	0.718	0.718	0.694
		Right side	0.068	0.064	0.083	0.083	0.064	0.032	6.000	0.643	0.692	0.692	0.672
		Top side	0.439	0.287	0.276	0.276	0.287	0.009	6.000	0.874	0.952	0.952	0.778
		Bottom side							6.000	0.600	0.600	0.600	0.600
n260	Antenna Module 0	Front	0.231	0.197	0.160	0.160	0.197	0.029	6.000	0.744	0.823	0.823	0.718
		Back	0.278	0.241	0.245	0.245	0.241	0.087	6.000	0.774	0.904	0.904	0.808
		Left side	0.073	0.074	0.115	0.115	0.074	0.036	6.000	0.646	0.718	0.718	0.694
		Right side	0.068	0.064	0.083	0.083	0.064	0.032	6.000	0.643	0.692	0.692	0.672
		Top side	0.439	0.287	0.276	0.276	0.287	0.009	6.000	0.874	0.952	0.952	0.778
		Bottom side							6.000	0.600	0.600	0.600	0.600
n261	Antenna Module 0	Front	0.231	0.197	0.160	0.160	0.197	0.029	6.000	0.744	0.823	0.823	0.718
		Back	0.278	0.241	0.245	0.245	0.241	0.087	6.000	0.774	0.904	0.904	0.808
		Left side	0.073	0.074	0.115	0.115	0.074	0.036	6.000	0.646	0.718	0.718	0.694
		Right side	0.068	0.064	0.083	0.083	0.064	0.032	6.000	0.643	0.692	0.692	0.672
		Top side	0.439	0.287	0.276	0.276	0.287	0.009	6.000	0.874	0.952	0.952	0.778
		Bottom side							6.000	0.600	0.600	0.600	0.600
n261	Antenna Module 0	Front	0.231	0.197	0.160	0.160	0.197	0.029	6.000	0.744	0.823	0.823	0.718
		Back	0.278	0.241	0.245	0.245	0.241	0.087	6.000	0.774	0.904	0.904	0.808
		Left side	0.073	0.074	0.115	0.115	0.074	0.036	6.000	0.646	0.718	0.718	0.694
		Right side	0.068	0.064	0.083	0.083	0.064	0.032	6.000	0.643	0.692	0.692	0.672
		Top side	0.439	0.287	0.276	0.276	0.287	0.009	6.000	0.874	0.952	0.952	0.778
		Bottom side							6.000	0.600	0.600	0.600	0.600

<Body-Worn Exposure Condition>

WWAN Band		Exposure Position	2	3	4	5	6	7	8	9	10	1	Reported SAR/1.6 + PD/10 Summation							
			WLAN2.4GHz Ant 4+6 DBS Only	WLAN2.4GHz Ant 4+6 WWAN+WLAN	WLAN2.4GHz Ant 4+6 WWAN+DBS	WLAN5GHz Ant 5+6 DBS Only	WLAN5GHz Ant 5+6 WWAN+WLAN	WLAN5GHz Ant 5+6 WWAN+DBS	Bluetooth Ant 4	Bluetooth Ant 6	WIFI 6E	PD	1+3 Summed	1+4+7 Summed	1+4+10 Summed	1+6+8 Summed	1+6+9 Summed	1+8+10 Summed	1+9+10 Summed	1+6+10 Summed
			1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	4cm^2 (W/m^2)								
n260	Antenna Module 0	Front	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.118	6.000	0.918	0.931	0.826	0.929	0.833	0.824	0.728	0.852
		Back	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.239	6.000	0.918	0.931	0.902	0.929	0.833	0.900	0.804	0.928
n260	Antenna Module 1	Front	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.118	6.000	0.918	0.931	0.826	0.929	0.833	0.824	0.728	0.852
		Back	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.239	6.000	0.918	0.931	0.902	0.929	0.833	0.900	0.804	0.928
n261	Antenna Module 0	Front	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.118	6.000	0.918	0.931	0.826	0.929	0.833	0.824	0.728	0.852
		Back	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.239	6.000	0.918	0.931	0.902	0.929	0.833	0.900	0.804	0.928
n261	Antenna Module 1	Front	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.118	6.000	0.918	0.931	0.826	0.929	0.833	0.824	0.728	0.852
		Back	0.663	0.509	0.244	0.728	0.285	0.285	0.241	0.087	0.239	6.000	0.918	0.931	0.902	0.929	0.833	0.900	0.804	0.928

<Product Specific Exposure Condition>

WWAN Band		Exposure Position	2	3	1	Reported SAR/4.0 + PD/10 Summation	
			WLAN5GHz Ant 5+6 WWAN+DBS&WWAN+No DBS	WIFI 6E	PD	1+2 Summed	1+3 Summed
			1g SAR (W/kg)	1g SAR (W/kg)	4cm^2(W/m^2)		
n260	Antenna Module 0	Front	0.640	0.177	6.000	0.760	0.644
		Back	0.640	0.350	6.000	0.760	0.688
		Left side	0.640	0.098	6.000	0.760	0.625
		Right side	0.640	0.080	6.000	0.760	0.620
		Top side	0.640	0.349	6.000	0.760	0.687
		Bottom side	0.640		6.000	0.760	0.600
n260	Antenna Module 0	Front	0.640	0.177	6.000	0.760	0.644
		Back	0.640	0.350	6.000	0.760	0.688
		Left side	0.640	0.098	6.000	0.760	0.625
		Right side	0.640	0.080	6.000	0.760	0.620
		Top side	0.640	0.349	6.000	0.760	0.687
		Bottom side	0.640		6.000	0.760	0.600
n261	Antenna Module 0	Front	0.640	0.177	6.000	0.760	0.644
		Back	0.640	0.350	6.000	0.760	0.688
		Left side	0.640	0.098	6.000	0.760	0.625
		Right side	0.640	0.080	6.000	0.760	0.620
		Top side	0.640	0.349	6.000	0.760	0.687
		Bottom side	0.640		6.000	0.760	0.600
n261	Antenna Module 0	Front	0.640	0.177	6.000	0.760	0.644
		Back	0.640	0.350	6.000	0.760	0.688
		Left side	0.640	0.098	6.000	0.760	0.625
		Right side	0.640	0.080	6.000	0.760	0.620
		Top side	0.640	0.349	6.000	0.760	0.687
		Bottom side	0.640		6.000	0.760	0.600

Test Engineer : Bruce Li, Martin Li, Varus Wang, Damon Zhu

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	∞
Probe Correction	0.00	R	1.732	1	0.00	∞
Frequency Response (BW ≤ 1GHz)	0.20	R	1.732	1	0.12	∞
Sensor Cross coupling	0.00	R	1.732	0	0.00	∞
Isotropy	0.50	R	1.732	1	0.29	∞
Linearity	0.20	R	1.732	1	0.12	∞
Probe Scattering	0.00	R	1.732	1	0.00	∞
Probe Positioning Offset	0.30	R	1.732	1	0.17	∞
Probe Positioning Repeatability	0.04	R	1.732	1	0.02	∞
Sensor Mechanical Offset	0.00	R	1.732	1	0.00	∞
Probe Spatial Resolution	0.00	R	1.732	1	0.00	∞
Field Impedance Dependence	0.00	R	1.732	1	0.00	∞
Amplitude and phase drift	0.00	R	1.732	1	0.00	∞
Amplitude and phase noise	0.04	R	1.732	1	0.02	∞
Measurement area truncation	0.00	R	1.732	1	0.00	∞
Data acquisition	0.03	N	1	1	0.03	∞
Sampling	0.00	R	1.732	1	0.00	∞
Field Reconstruction	0.60	R	1.732	0	0.35	∞
Forward Transformation	0.00	R	1.732	1	0.00	∞
Power Density Scaling	-	R	1.732	1	-	∞
Spatial Averaging	0.10	R	1.732	1	0.06	∞
System Detection Limit	0.04	R	1.732	1	0.02	∞
Test Sample and Environmental Factors						
Probe Coupling with DUT	0.00	R	1.732	1	0.00	∞
Modulation Response	0.40	R	1.732	1	0.23	∞
Integration Time	0.00	R	1.732	1	0.00	∞
Response Time	0.00	R	1.732	1	0.00	∞
Device Holder Influence	0.10	R	1.732	1	0.06	∞
DUT Alignment	0.00	R	1.732	1	0.00	∞
RF Ambient Conditions	0.04	R	1.732	1	0.02	∞
Ambient Reflections	0.04	R	1.732	1	0.02	∞
Immunity / Secondary Reception	0.00	R	1.732	1	0.00	∞
Drift of the DUT	0.22	R	1.732	1	0.13	∞
Combined Std. Uncertainty					0.76 dB	∞
Coverage Factor for 95 %					K=2	
Expanded STD Uncertainty					1.53 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.

[5] IEC TR 63170: 2018 Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz

Appendix A. Plots of System Performance Check

The plots are shown as follows.

Measurement Report for Source 30GHz, FRONT, Validation band, CW, Channel 30000 (30000.0 MHz)

Device Under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Source 30GHz,	100.0 x 100.0 x 100.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G	FRONT, 5.55	Validation band	CW, 0--	30000.0, 30000	1.0

Hardware Setup

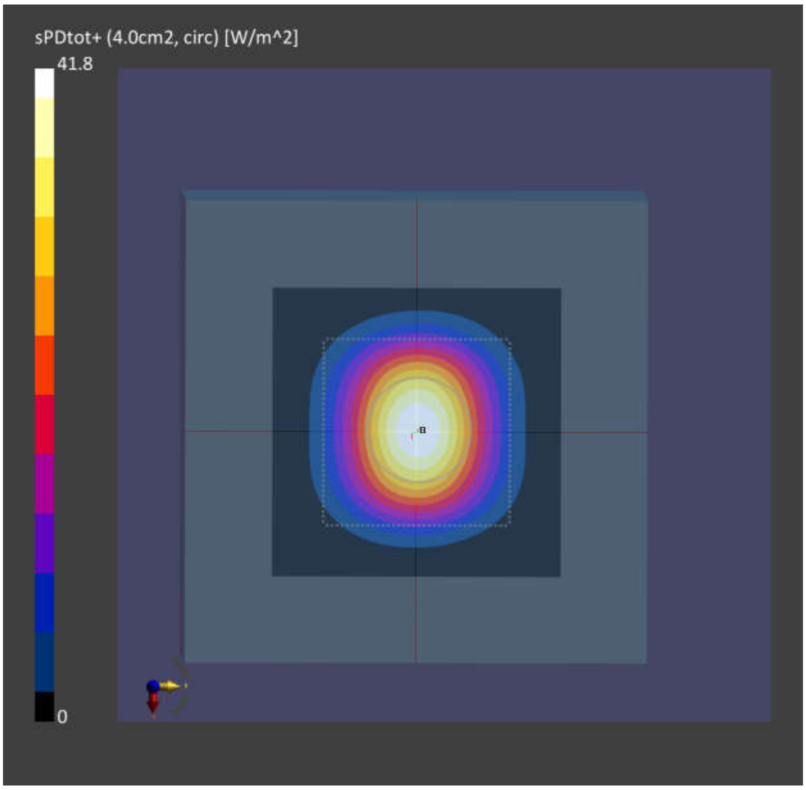
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave - 1065	Air -	EUmmWV4 - SN9553_F1-55GHz, 2021-04-01	DAE4 Sn1650, 2021-06-09

Scans Setup

Scan Type	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	N/A

Measurement Results

Scan Type	5G Scan
Date	2021-12-25
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	41.5
psPDtot+ [W/m^2]	41.8
psPDmod+ [W/m^2]	42.2
E_{max} [V/m]	149
Power Drift [dB]	-0.02



Measurement Report for Device, FRONT, Validation band, CW, Channel 30000 (30000.0 MHz)

Device Under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	100.0 x 100.0 x 100.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G	FRONT, 5.55	Validation band	CW, 0--	30000.0, 30000	1.0

Hardware Setup

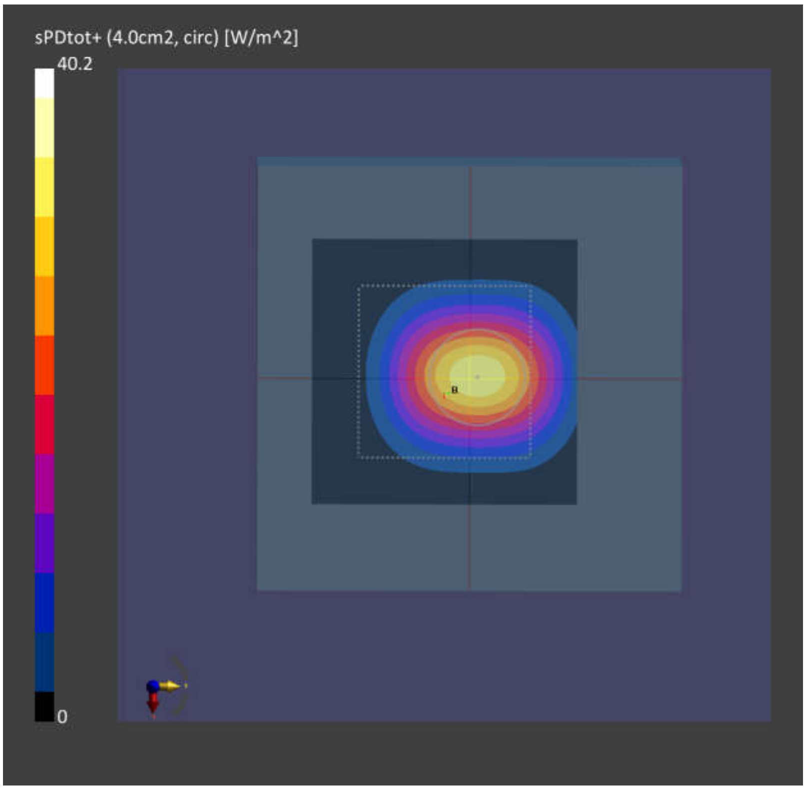
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave - 1065	Air -	EUmmWV4 - SN9553_F1-55GHz, 2021-04-01	DAE4 Sn1650, 2021-06-09

Scans Setup

Scan Type	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	N/A

Measurement Results

Scan Type	5G Scan
Date	2021-12-27
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	39.9
psPDtot+ [W/m^2]	40.2
psPDmod+ [W/m^2]	40.6
E_{max} [V/m]	140
Power Drift [dB]	-0.12



Appendix B. Plots of Power Density Measurement

The plots are shown as follows.

01_n260_Module 0_Beam ID 31_Frequency 40GHz_Back (S2)_2mm

Device Under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	164.0 x 76.4 x 11.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G	BACK, 2.00	Custom Band	CW, 0--	40000.0, 40000000	1.0

Hardware Setup

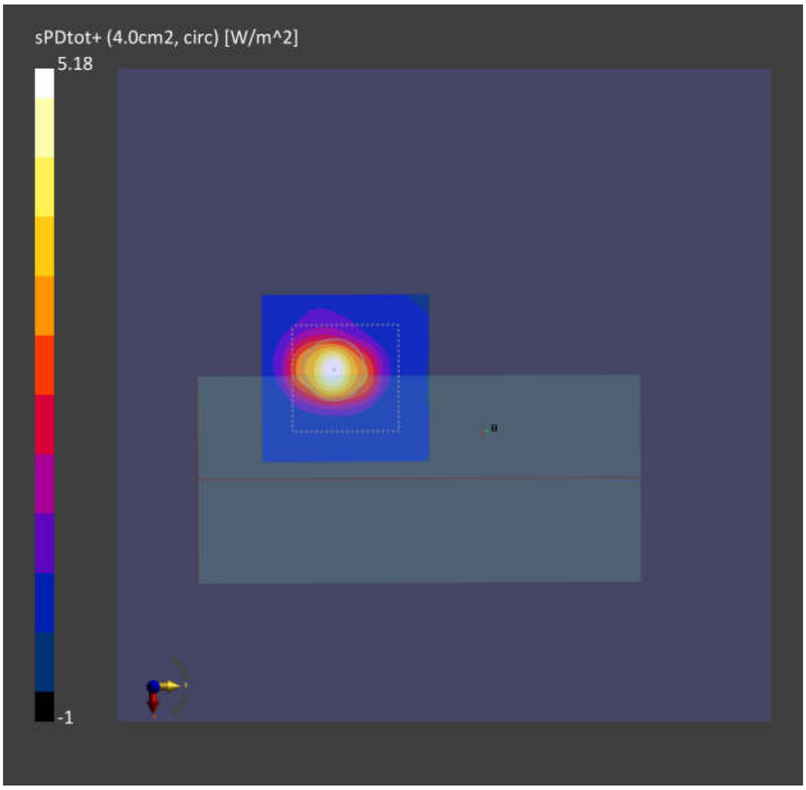
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave - 1065	Air -	EUmmWV4 - SN9553_F1-55GHz, 2021-04-01	DAE4 Sn1650, 2021-06-09

Scans Setup

Scan Type	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	2.0
MAIA	N/A

Measurement Results

Scan Type	5G Scan
Date	2021-12-25
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	4.18
psPDtot+ [W/m^2]	5.18
psPDmod+ [W/m^2]	5.49
E_{max} [V/m]	93.5
Power Drift [dB]	0.03



02_n261_Module 0_Beam ID 31_Frequency 27.5GHz_Back (S2)_2mm

Device Under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	164.0 x 76.4 x 11.0		Phone

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor
5G	BACK, 2.00	Custom Band	CW, 0--	27500.0, 27500000	1.0

Hardware Setup

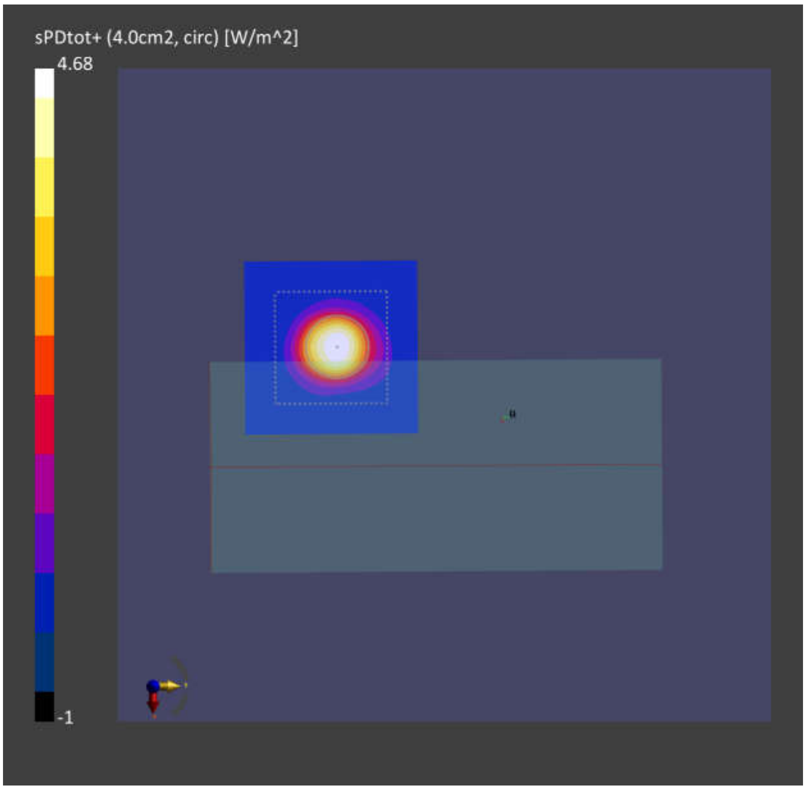
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave - 1065	Air -	EUmmWV4 - SN9553_F1-55GHz, 2021-04-01	DAE4 Sn1650, 2021-06-09

Scans Setup

Scan Type	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	2.0
MAIA	N/A

Measurement Results

Scan Type	5G Scan
Date	2021-12-27
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	4.40
psPDtot+ [W/m^2]	4.68
psPDmod+ [W/m^2]	5.21
E_{max} [V/m]	83.8
Power Drift [dB]	0.02



Appendix C. DASY Calibration Certificate

The DASY calibration certificates are shown as follows.

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: SCS 0108

Client **Sporton**

Certificate No: 5G-Veri30-1080_Apr21

CALIBRATION CERTIFICATE

Object	5G Verification Source 30 GHz - SN: 1080
Calibration procedure(s)	QA CAL-45.v3 Calibration procedure for sources in air above 6 GHz
Calibration date:	April 6, 2021

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Reference Probe EUmmWV3	SN: 9374	30-Dec-20 (No. EUmmWV3-9374_Dec20)	Dec-21
DAE4ip	SN: 1602	11-Aug-20 (No. DAE4ip-1602_Aug20)	Aug-21

Secondary Standards	ID #	Check Date (in house)	Scheduled Check

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 8, 2021

Glossary

CW Continuous wave

Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45-5Gsources
- IEC TR 63170 ED1, "Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz", January 2018

Methods Applied and Interpretation of Parameters

- *Coordinate System:* z-axis in the waveguide horn boresight, x-axis is in the direction of the E-field, y-axis normal to the others in the field scanning plane parallel to the horn flare and horn flange.
- *Measurement Conditions: (1) 10 GHz:* The forward power to the horn antenna is measured prior and after the measurement with a power sensor. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by far-field measurements. *(2) 30, 45, 60 and 90 GHz*: The verification sources are switched on for at least 30 minutes. Absorbers are used around the probe cub and at the ceiling to minimize reflections.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- *E- field distribution:* E field is measured in two x-y-plane (10mm, 10mm + $\lambda/4$) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm^2 and 4cm^2) power density values at 10mm in front of the horn.
- *Field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

Calibrated Quantity

- Local peak E-field (V/m) and average of peak spatial components of the poynting vector (W/m^2) averaged over the surface area of 1 cm^2 and 4cm^2 at the nominal operational frequency of the verification source. Both square and circular averaging results are listed.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	cDASY6 Module mmWave	V2.2
Phantom	5G Phantom	
Distance Horn Aperture - plane	10 mm	
XY Scan Resolution	dx, dy = 2.5 mm	
Number of measured planes	2 (10mm, 10mm + λ/4)	
Frequency	30 GHz ± 10 MHz	

Calibration Parameters, 30 GHz

Circular Averaging

Distance Horn Aperture to Measured Plane	***Prad***[1] ***(mW)***	**Max E-field (V/m)**	Uncertainty (k = 2)	Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m²)		Uncertainty (k = 2)
				1 cm²	**4** cm²	
10 mm	40.0	**145**	1.27 dB	**48.4**	**42.7**	1.28 dB

Square Averaging

Distance Horn Aperture to Measured Plane	***Prad***[1] ***(mW)***	**Max E-field (V/m)**	Uncertainty (k = 2)	Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m²)		Uncertainty (k = 2)
				1 cm²	**4** cm²	
10 mm	40.0	**145**	1.27 dB	**48.4**	**42.5**	1.28 dB

[1] derived from far-field data

DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 30 GHz	100.0 x 100.0 x 100.0	SN: 1080	-

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0

Hardware Setup

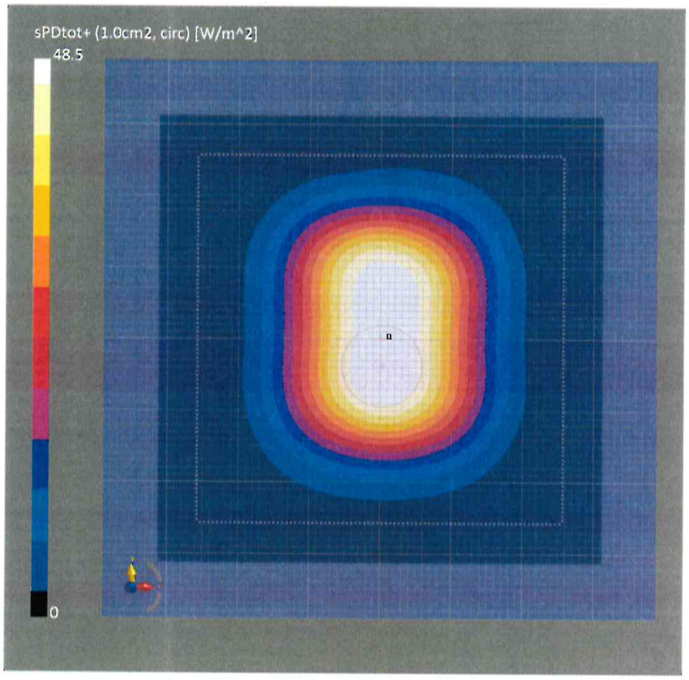
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-04-06, 08:30
Avg. Area [cm²]	1.00
psPDn+ [W/m²]	48.1
psPDtot+ [W/m²]	48.5
psPDmod+ [W/m²]	48.7
E_{max} [V/m]	145
Power Drift [dB]	-0.09



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 30 GHz	100.0 x 100.0 x 100.0	SN: 1080	-

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0

Hardware Setup

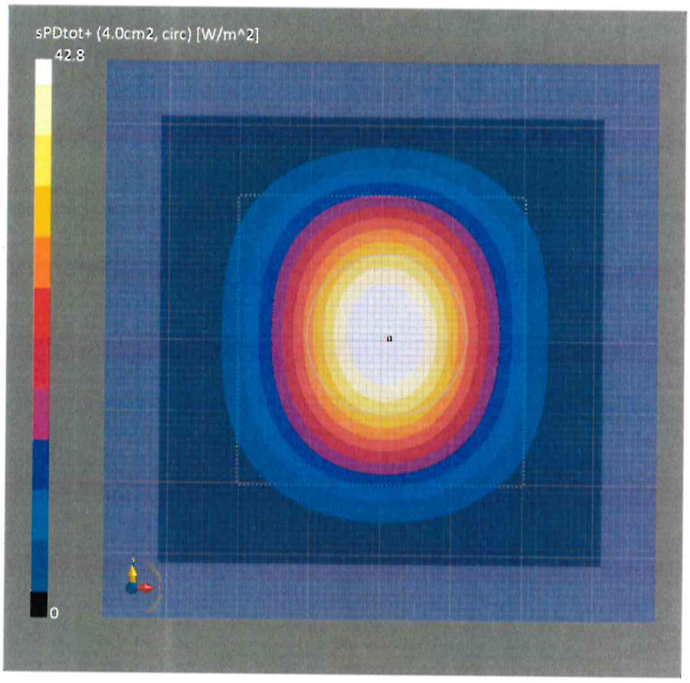
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-04-06, 08:30
Avg. Area [cm²]	4.00
psPDn+ [W/m²]	42.3
psPDtot+ [W/m²]	42.8
psPDmod+ [W/m²]	42.9
E_{max} [V/m]	145
Power Drift [dB]	-0.09



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 30 GHz	100.0 x 100.0 x 100.0	SN: 1080	-

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0

Hardware Setup

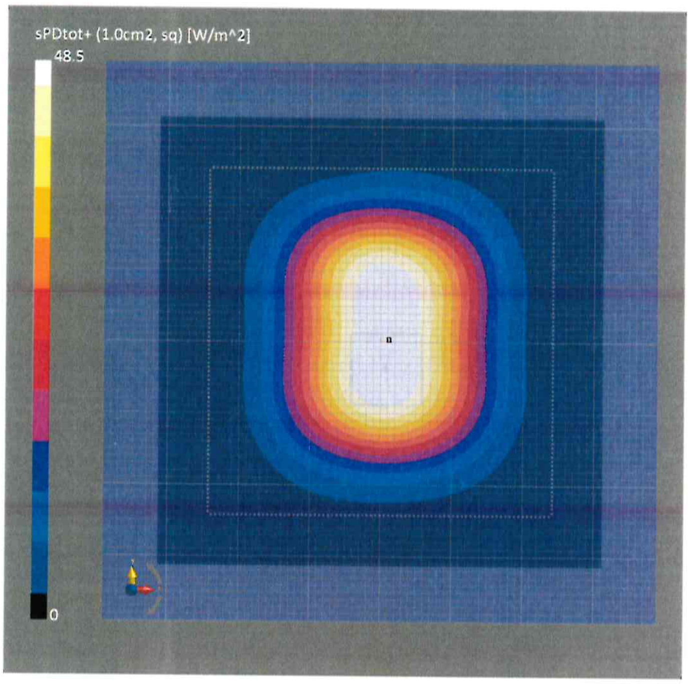
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-04-06, 08:30
Avg. Area [cm²]	1.00
psPDn+ [W/m²]	48.1
psPDtot+ [W/m²]	48.5
psPDmod+ [W/m²]	48.7
E_{max} [V/m]	145
Power Drift [dB]	-0.09



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 30 GHz	100.0 x 100.0 x 100.0	SN: 1080	-

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0

Hardware Setup

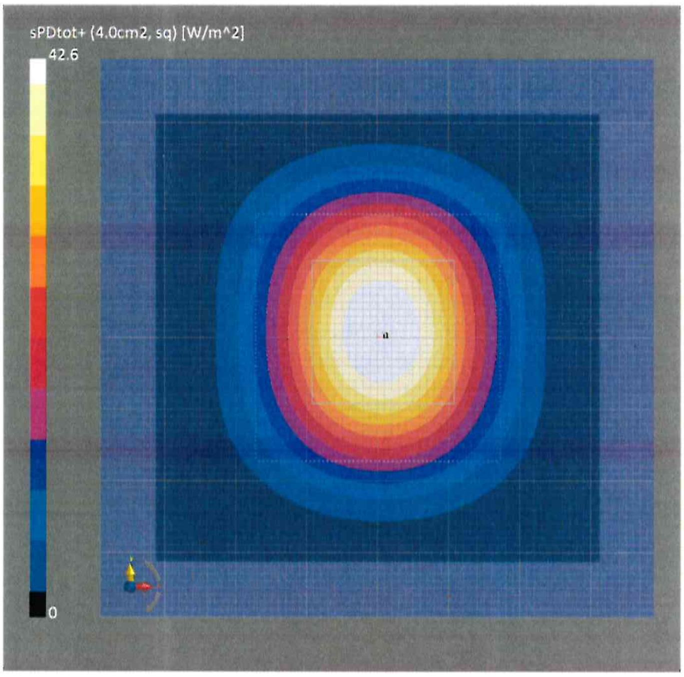
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	60.0 x 60.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-04-06, 08:30
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	42.2
psPDtot+ [W/m^2]	42.6
psPDmod+ [W/m^2]	42.8
E_{max} [V/m]	145
Power Drift [dB]	-0.09



Calibration Laboratory of
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Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: SCS 0108

Client **Sporton**

Certificate No: EUmmWV4-9553_Apr21

CALIBRATION CERTIFICATE

Object	EUmmWV4 - SN:9553
Calibration procedure(s)	QA CAL-02.v9, QA CAL-25.v7, QA CAL-42.v2 Calibration procedure for E-field probes optimized for close near field evaluations in air
Calibration date:	April 1, 2021

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Reference 20 dB Attenuator	SN: CC2552 (20x)	31-Mar-20 (No. 217-03106)	Apr-21
Reference Probe ER3DV6	SN: 2328	05-Oct-20 (No. ER3-2328_Oct20)	Oct-21
DAE4	SN: 789	23-Dec-20 (No. DAE4-789_Dec20)	Dec-21
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-20)	In house check: Jun-22
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 8, 2021

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: SCS 0108

Glossary:

NORMx,y,z	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system
Sensor Angles	sensor deviation from the probe axis, used to calculate the field orientation and polarization
k	is the wave propagation direction

Calibration is Performed According to the Following Standards:

a) IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). For frequencies > 6 GHz, the far field in front of waveguide horn antennas is measured for a set of frequencies in various waveguide bands up to 110 GHz.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- The frequency sensor model parameters are determined prior to calibration based on a frequency sweep (sensor model involving resistors R, R_p, inductance L and capacitors C, C_p).
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z*: *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *Sensor Offset*: The sensor offset corresponds to the mechanical from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).
- *Equivalent Sensor Angle*: The two probe sensors are mounted in the same plane at different angles. The angles are assessed using the information gained by determining the *NORMx* (no uncertainty required).
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide / horn setup.

DASY - Parameters of Probe: EUmmWV4 - SN:9553

Basic Calibration Parameters

	Sensor X	Sensor Y	Unc (k=2)
Norm (μV/(V/m)^2)	0.01702	0.01798	± 10.1 %
DCP (mV)[B]	105.0	105.0	
Equivalent Sensor Angle	-61.9	37.5	

Calibration results for Frequency Response (750 MHz – 110 GHz)

Frequency GHz	Target E-Field V/m	Deviation Sensor X dB	Deviation Sensor Y dB	Unc (k=2) dB
0.75	77.2	-0.20	-0.33	± 0.43 dB
1.8	140.4	0.05	0.04	± 0.43 dB
2	133.0	0.05	0.06	± 0.43 dB
2.2	124.8	0.06	0.07	± 0.43 dB
2.5	123.0	0.01	0.03	± 0.43 dB
3.5	256.2	0.29	0.22	± 0.43 dB
3.7	249.8	0.32	0.22	± 0.43 dB
6.6	41.8	0.78	0.77	± 0.98 dB
8	48.4	0.57	0.22	± 0.98 dB
10	54.4	0.28	0.15	± 0.98 dB
15	71.5	-0.06	-0.42	± 0.98 dB
18	85.3	-0.31	0.01	± 0.98 dB
26.6	96.9	-0.32	-0.24	± 0.98 dB
30	92.6	-0.06	0.00	± 0.98 dB
35	93.7	-0.15	-0.03	± 0.98 dB
40	91.5	-0.15	-0.17	± 0.98 dB
50	19.6	0.68	0.23	± 0.98 dB
55	22.4	0.41	0.51	± 0.98 dB
60	23.0	0.16	0.04	± 0.98 dB
65	27.4	-0.44	-0.20	± 0.98 dB
70	23.9	-0.34	-0.38	± 0.98 dB
75	20.0	-0.17	-0.02	± 0.98 dB
75	14.8	-0.10	0.03	± 0.98 dB
80	22.5	-0.18	0.06	± 0.98 dB
85	22.8	-0.06	-0.11	± 0.98 dB
90	23.8	-0.01	0.00	± 0.98 dB
92	23.9	-0.26	-0.26	± 0.98 dB
95	20.5	-0.36	-0.21	± 0.98 dB
97	24.4	-0.25	-0.19	± 0.98 dB
100	22.6	-0.04	-0.09	± 0.98 dB
105	22.7	-0.04	0.06	± 0.98 dB
110	19.7	0.27	0.18	± 0.98 dB

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[B] Numerical linearization parameter: uncertainty not required.

[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY - Parameters of Probe: EUmmWV4 - SN:9553

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Max Unc[E] (k=2)
0	CW	X	0.00	0.00	1.00	0.00	110.7	± 3.3 %	± 4.7 %
		Y	0.00	0.00	1.00		92.8		
10352-AAA	Pulse Waveform (200Hz, 10%)	X	3.01	60.00	15.17	10.00	6.0	± 1.2 %	± 9.6 %
		Y	2.45	60.00	15.54		6.0		
10353-AAA	Pulse Waveform (200Hz, 20%)	X	2.10	60.00	14.02	6.99	12.0	± 1.1 %	± 9.6 %
		Y	1.69	60.00	14.48		12.0		
10354-AAA	Pulse Waveform (200Hz, 40%)	X	1.26	60.00	12.73	3.98	23.0	± 1.6 %	± 9.6 %
		Y	1.02	60.00	13.29		23.0		
10355-AAA	Pulse Waveform (200Hz, 60%)	X	0.75	60.00	12.01	2.22	27.0	± 1.0 %	± 9.6 %
		Y	0.62	60.00	12.58		27.0		
10387-AAA	QPSK Waveform, 1 MHz	X	1.27	60.00	12.34	1.00	22.0	± 1.3 %	± 9.6 %
		Y	1.19	60.00	12.46		22.0		
10388-AAA	QPSK Waveform, 10 MHz	X	1.29	60.00	11.98	0.00	22.0	± 0.7 %	± 9.6 %
		Y	1.26	60.00	12.24		22.0		
10396-AAA	64-QAM Waveform, 100 kHz	X	3.67	66.28	16.33	3.01	17.0	± 0.7 %	± 9.6 %
		Y	2.93	63.57	15.21		17.0		
10399-AAA	64-QAM Waveform, 40 MHz	X	2.09	60.00	12.47	0.00	19.0	± 0.8 %	± 9.6 %
		Y	2.03	60.00	12.68		19.0		
10414-AAA	WLAN CCDF, 64-QAM, 40MHz	X	3.24	60.00	12.89	0.00	12.0	± 1.0 %	± 9.6 %
		Y	3.11	60.00	13.09		12.0		

Note: For details on all calibrated UID parameters see Appendix

Calibration Results for Linearity Response

Frequency GHz	Target E-Field V/m	Deviation Sensor X dB	Deviation Sensor Y dB	Unc (k=2) dB
0.9	50.0	-0.13	0.14	± 0.2 dB
0.9	100.0	-0.13	0.13	± 0.2 dB
0.9	500.0	-0.01	-0.02	± 0.2 dB
0.9	1000.0	0.01	0.01	± 0.2 dB
0.9	1500.0	0.01	-0.01	± 0.2 dB
0.9	2000.0	-0.02	-0.02	± 0.2 dB

Sensor Frequency Model Parameters (750 MHz – 55 GHz)

	Sensor X	Sensor Y
R (Ω)	88.64	79.92
R_p (Ω)	82.87	90.61
L (nH)	0.10075	0.10010
C (pF)	0.3606	0.3340
C_p (pF)	0.1012	0.0850

Sensor Frequency Model Parameters (55 GHz – 110 GHz)

	Sensor X	Sensor Y
R (Ω)	27.86	32.26
R_p (Ω)	97.91	96.00
L (nH)	0.04157	0.03609
C (pF)	0.1309	0.1842
C_p (pF)	0.1179	0.1242