



**FCC 47 CFR § 2.1093
IEC TR 63170-2018**

POWER DENSITY EVALUATION REPORT

FOR

GSM/WCDMA/LTE/5G NR Phone + BT/BLE, DTS/UNII a/b/g/n/ac/ax, and NFC

MODEL NUMBER: SM-A546V

FCC ID: A3LSMA546V

REPORT NUMBER: 4790632299-S2V2

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Testing Laboratory

TL-637

Revision History

Rev.	Date	Revisions	Revised By
V1	1/17/2023	Initial Issue	--
V2	1/25/2023	Revised description of algorithm in Sec.12	Jeongyeon Won

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1. Attestation of Test Results

Applicant Name	SAMSUNG ELECTRONICS CO.,LTD.	
FCC ID	A3LSMA546V	
Model Name	SM-A546V	
Applicable Standards	FCC 47 CFR § 2.1093 IEC TR 63170-2018	
Exposure Category	RADIOFREQUENCY RADIATION EXPOSURE (above 6GHz)	
	Power density Uncontrol (mW/cm ² over 4cm ²) for 30min average	
General population / Uncontrolled exposure	1.0	
Applicable limit	<input checked="" type="checkbox"/> Uncontrol	
	Measured psPD	Reported psPD
n261 Result (mW/cm ² over 4cm ²)	0.57	0.74
n260 Result (mW/cm ² over 4cm ²)	0.41	0.74
Simultaneous TX	0.98	
Date Tested	12/6/2022 to 1/12/2023	
Test Results	Pass	
<p>UL Korea, Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Korea, Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.</p> <p>Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Korea, Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Korea, Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by IAS, any agency of the Federal Government, or any agency of any government. This report is written to support regulatory compliance of the applicable standards stated above.</p>		
Approved & Released By:	Prepared By:	
		
Justin Park Operations Leader UL Korea, Ltd. Suwon Laboratory	Jeongyeon Won Laboratory Engineer UL Korea, Ltd. Suwon Laboratory	

2. Introduction

The equipment under test (EUT) is a Phone, model SM-A546V (FCC ID: A3LSMA546V), it contains Samsung S.LSI modems supporting 2G/3G/4G technologies and 5G NR bands. These WWAN modems enable Samsung S.LSI Smart Transmit features with algorithms to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure from WWAN is in compliance with FCC requirements.

The purpose of this PD RF Exposure Test report is to demonstrate that this EUT complies with FCC RF exposure limits at maximum time-averaged transmit power limits for WWAN technologies, and at maximum transmit power limits for WLAN technologies.

- Power density (PD) compliance for all WWAN radios (4G + 5G mmW NR) is assessed based on maximum time-averaged transmit power (static transmission condition). Relevant FCC KDBs and exclusion criteria are applied on a time-average power basis for WWAN technologies. The maximum time-averaged transmit power limits for supported WWAN technologies, bands, and antennas in this report are derived in PD Char report. The validation of the Samsung S.LSI Smart Transmit time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in TAS Validation (SAR and PD) report.
- PD compliance for WLAN radios is assessed based on maximum transmit power as per relevant FCC KDBs.
- Demonstrate compliance in simultaneous transmission scenarios involving both WWAN and WLAN transmissions, where WWAN exposure is assessed based on time-averaged transmit power limits, and WLAN exposure is assessed separately.

By following the above steps, this report demonstrates that this EUT complies with FCC RF exposure limits for FCC equipment authorization of FCC ID: A3LSMA546V.

The Plimit used in this report are determined and listed in PD Char report.

Refer to compliance Summary report for product description and terminology used in this report.

3. Measurement setup and General Information

The SAR measurement are recorded in UL FCC Report SAR (Report No. 4790632299-S1). This section provides the detail of the test setup used for PD measurement.

3.1. Power density measurement system

The power density measurement system is constructed based on the DASY6 platform by SPEAG. The DASY6 with EummWV2 and 5G software module can measure the RF exposure (power density) up to 110GHz as close as 2mm from any transmitter.

3.1.1. Power density probe

The EummWV2 probe is used in the power density measurement. It is designed for precise near-field measurements in the mm-wave range by Schmid & Partner Engineering AG of Zurich, Switzerland. The specifications are:

- Frequency range: 0.75 ~ 110 GHz
- Dynamic range: <50 – 3000 V/m (up to 10000 V/m with additional PRE-10 voltage divider)
- Linearity: < ±0.2 dB
- Supports sensor model calibration (SMC)
- ISO 17025 accredited calibration

3.1.2. Power density measurement system verification

The power density system verification is performed using the SPEAG verification device. It consists of a ka-band horn antenna with a corresponding gun oscillator packaged within a cube-shaped housing.

The specification of the verification device is:

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

Table 2-1 shows the verification test results. The measured power density (PD) value is within 10% of target level. Note that the uncertainty of 5G verification source is 1.4dB (k=2).

3.2. Test Specification, Methods and Procedures

Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, the following FCC Published RF exposure KDB procedures:

- 447498 D01 General RF Exposure Guidance v06
- 447498 D03 Supplement C Cross-Reference v01
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02
- SPEAG, 5G Module V1.2 Application Note: 5G Compliance Testing, August 2018
- IEC TR 63170 Edition 1.0 2018-08

In addition to the above, [TCB workshop](#) information was used.

- [TCB workshop](#) November, 2017; Page 19 - 25, RF Exposure Procedures (Power Density Evaluation)
- [TCB workshop](#) October, 2018; Page 3, RF Exposure Procedures (Millimeter Wave Assessment)
- [TCB workshop](#) October, 2018; Page 5, RF Exposure Procedures (Millimeter Wave Measurement)
- [TCB workshop](#) April, 2019; Page 3, RF Exposure Procedures (Millimeter Wave RF Exposure Evaluation)
- [TCB workshop](#) November, 2019; Page 14, RF Exposure Procedures (Millimeter Wave Scan Requirements)

3.3. Test Specification, Methods and Procedures

The test sites and measurement facilities used to collect data are located at

Suwon
SAR 8
SAR 9

UL Korea, Ltd. is accredited by IAS, Laboratory Code TL-637.

The full scope of accreditation can be viewed at :

<https://www.iasonline.org/wp-content/uploads/2017/05/TL-637-cert-New.pdf>.

4. Test Condition, Configuration, and Assessment

4.1. Samsung S.LSI Smart Transmit parameters

The input parameters described are required for functionality of Samsung S.LSI Smart Transmit algorithm.

These parameters are entered through the NV settings and cannot be accessed by the end-user.

PD Char report documents determination of P_{limit} for sub-6 WWAN bands, and P_{limit} for 5G mmW NR bands using the below design targets and device related uncertainty:

- SAR_{design_target} of 1.0 W/kg for 1g SAR and sub-6 WWAN device design related uncertainty of 1.0 dB.
- PD_{design_target} of 0.442 mW/cm² 4cm²PD and mmW device design related uncertainty of 2.3 dB.

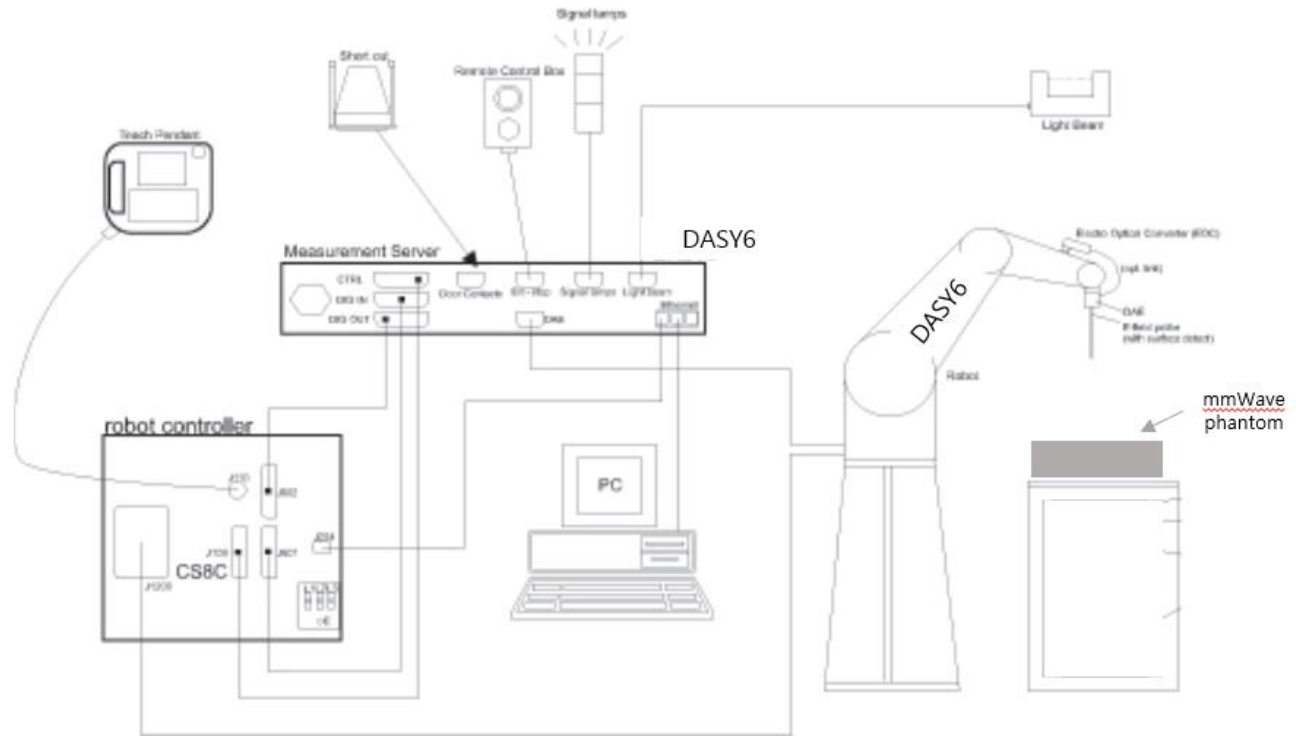
4.2. Samsung S.LSI Smart Transmit parameters for the 5G mmW NR

The Plimit parameter for 5G mmW NR radio determined in Section 8.5 of this report are populated via NV settings into the EUT.

5. Measurement System & Test Equipment

5.1. Measurement System

The DASY6 & 8 system used for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- The EUmmWVx probe is based on the pseudo-vector probe design, which not only measures the field magnitude but also derives its polarization ellipse.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win10 and the DASY6 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom which is specialized for 5G other accessories according to the targeted measurement.

5.2. EUmmWVx / 5G Probe

E-Field mm-Wave Probe for General Near-Field Measurements



Frequency Range
Dynamic Range
Position Precision

Dimensions

Applications

Compatibility

Two dipoles optimally arranged to obtain pseudo-vector information
Minimum 3 measurements/point, 120° rotated around probe axis
Sensors (0.8mm length) printed on glass substrate protected by high density foam
Low perturbation of the measured field
Requires positioner which can do accurate probe rotation

750 MHz – 110 GHz

< 20 V/m - 10'000 V/m with PRE-10 (min < 50 V/m - 3000 V/m)

< 0.2 mm (DASY6)

Overall length: 337 mm (tip: 20 mm)

Tip diameter: encapsulation 8 mm (internal sensor < 1mm)

Distance from probe tip to dipole centers: < 2 mm

Sensor displacement to probe's calibration point: < 0.3 mm

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 (cDASY6 5G or ICEy-mmW module required)

cDASY6 + 5G-Module SW1.0 and higher

5.3. Data Acquisition Electronics(DAE)



Measurement Range
Input Offset Voltage
Input Resistance
Input Bias Current
Battery Power
Dimensions (L x W x H)

Serial optical link for communication with DASY4/5 embedded system (fully remote controlled) Two-step probe touch detector for mechanical surface detection and emergency robot stop

-100 – +300 mV (16 bit resolution and two range settings: 4 mV, 400 mV)

<5 μV (with auto zero)

200 Mohm

<50 fA

>10 hours of operation (with two 9.6 V NiMH batteries)

60 x 60 x 68 mm

6. Measurement Procedures

6.1. System Verification Scan Procedures

cDASY6 5G Module V1.2 supports “5G Scan”, a fine resolution scan performed on two different planes which is used to reconstruct the E- and H-fields as well as the power density; the average power density is derived from this measurement.

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to device under test.

Step 2: 5G Scan

The steps in the X, Y, and Z directions are specified in terms of fractions of the signal wavelength, λ . Area Scan Parameters extracted from SPEAG, 5G Module V1.2 Application Note.

Recommended settings for measurement of verification sources

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 ($\frac{\lambda}{4}$)	31/31	26 × 26
90	0.25 ($\frac{\lambda}{4}$)	29/29	35 × 35

The minimum distance of probe sensors to verification source surface, horn antenna, is 10 mm. In other case, distance is determined as $\lambda / 5$, details are shown in section 6.3.

Step 3: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

When the drift is larger than $\pm 5\%$, test is repeated from step1.

6.2. Scan Procedures

Step 1: Power Reference Measurement

Same as System Verification Scan Procedures step 1.

Step 2: 5G Scan

Same as System Verification Scan Procedures step 2. But measurement area is defined based on TCB workshop “A sufficiently large measurement region and proper measurement spatial resolution are required to maintain field reconstruction accuracy”.

Step 3: Power drift measurement

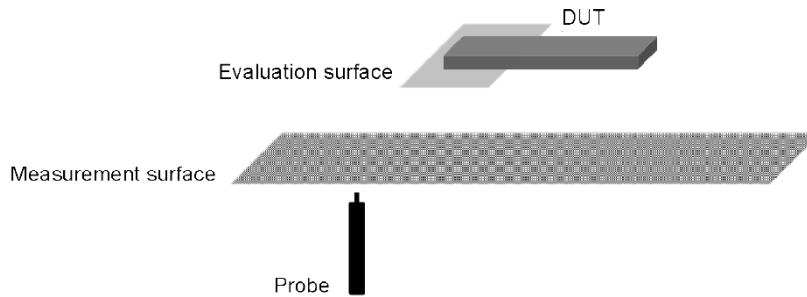
Same as System Verification Scan Procedures step 3.

When the drift is smaller than $\pm 5\%$, it is considered in the uncertainty budget if drifts larger than 5%, uncertainty is re-calculate.

6.3. Total Field and Power Flux Density Reconstruction(measurement distance)

Reconstruction algorithms are used to project or transform the measured fields from the measurement surface to the evaluation surface (below fig) in order to determine power density or to compute spatial-average and/or local power density with known uncertainty.

Manufacture has 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 EummWVx probe. This reconstruction algorithm, together with the ability of the probe to measure extremely close to the source without perturbing the field, permits reconstruction of the E- and H-fields, as well as of the power density, on measurement planes located as near as $\lambda / 5$ away.



6.4. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
5G probe	SPEAG	EummWV4	9559	2-28-2023
5G probe	SPEAG	EummWV4	9536	2-28-2023
Data Acquisition Electronics	SPEAG	DAE4	1591	3-24-2023
Data Acquisition Electronics	SPEAG	DAE4	1668	4-27-2023
5G Verification Source (30GHz)	SPEAG	5G verification source_30GHz	1082	3-1-2023
Thermometer	Lutron	MHB-382SD	AK.12102	8-9-2023

7. Measurement Uncertainty

Measurement Uncertainty for cDASY6 Module mmWave						
Error Description	Uncertainty value (\pm dB)	Probe Dist.	Divisor	(Ci)	Std. Unc. (\pm dB)	(Vi)
Uncertainty terms dependent on the measurement system						
1.Probe Calibration	0.49	Normal	1	1	0.49	Infinity
2.Probe correction	0.00	Rectangular	1.73	1	0.00	Infinity
3.Frequency response (BW =< 1 GHz)	0.20	Rectangular	1.73	1	0.12	Infinity
4.Sensor cross coupling	0.00	Rectangular	1.73	1	0.00	Infinity
5.Isotropy	0.50	Rectangular	1.73	1	0.29	Infinity
6.Linearity	0.20	Rectangular	1.73	1	0.12	Infinity
7.Probe scattering	0.00	Rectangular	1.73	1	0.00	Infinity
8.Probe positioning offset	0.30	Rectangular	1.73	1	0.17	Infinity
9.Probe positioning repeatability	0.04	Rectangular	1.73	1	0.02	Infinity
10.Sensor mechanical offset	0.00	Rectangular	1.73	1	0.00	Infinity
11.Probe spatial resolution	0.00	Rectangular	1.73	1	0.00	Infinity
12.Field impedance dependance	0.00	Rectangular	1.73	1	0.00	Infinity
13.Amplitude and phase drift	0.00	Rectangular	1.73	1	0.00	Infinity
14.Amplitude and phase noise	0.04	Rectangular	1.73	1	0.02	Infinity
15.Measurement area truncation	0.10	Rectangular	1.73	1	0.06	Infinity
16.Data acquisition	0.03	Normal	1.00	1	0.03	Infinity
17.Sampling	0.00	Rectangular	1.73	1	0.00	Infinity
18.Field reconstruction	0.60	Rectangular	1.73	1	0.35	Infinity
19.Forward transformation	0.00	Rectangular	1.73	1	0.00	Infinity
20.Power density scaling	-	Rectangular	1.73	1	-	Infinity
21.Spatial averaging	0.10	Rectangular	1.73	1	0.06	Infinity
22.System detection limit	0.04	Rectangular	1.73	1	0.02	Infinity
Uncertainty terms dependent on the DUT and environmental factors						
23.Probe coupling with DUT	0.00	Rectangular	1.73	1	0.00	Infinity
24.Modulation response	0.40	Rectangular	1.73	1	0.23	Infinity
25.Integration time	0.00	Rectangular	1.73	1	0.00	Infinity
26.Response time	0.00	Rectangular	1.73	1	0.00	Infinity
27.Device holder influence	0.10	Rectangular	1.73	1	0.06	Infinity
28.DUT alignment	0.00	Rectangular	1.73	1	0.00	Infinity
29.RF ambient conditions	0.04	Rectangular	1.73	1	0.02	Infinity
30.Ambient reflections	0.04	Rectangular	1.73	1	0.02	Infinity
31.Immunity / secondary reception	0.00	Rectangular	1.73	1	0.00	Infinity
32.Drift of the DUT	0.22	Rectangular	1.73	1	0.13	Infinity
Combined Std. Uncertainty					0.76	Infinity
Expanded Standard Uncertainty (95%)					1.53	

7.1. DECISION RULE

Decision rule for statement(s) of conformity is based on Procedure 1, Clause 4.4.2 in IEC Guide 115:2007.

8. DUT Information

8.1. DUT Description

Device Dimension	Refer to Appendix A.		
Back Cover	The Back Cover is not removable		
Battery Options	The rechargeable battery is not user accessible.		
Test sample information	No.	S/N	Notes
	1	R3CTB0J1P6F	mmWave Radiated
	2	R3CTB0J12ZJ	mmWave Radiated
	3	R3CTB0J15TK	mmWave Radiated

8.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
5G NR mmW	NR Band 261 (50MHz & 100MHz) NR Band 260 (50MHz & 100MHz)	DFT-s-OFDM : QPSK, 16QAM, 64QAM CP-OFDM : QPSK, 16QAM, 64QAM	100%

8.3. 5G NR mmWave Test and Reporting Considerations

Item	Description		
Frequency range, Channel Bandwidth, Numbers and Frequencies	Band 261	Frequency range: 27500 – 28350 MHz	
		Channel Bandwidth	
		100MHz	
		50MHz	
		MHz / Channel	MHz / Channel
	Low	27559.32 / 2071821	27559.32 / 2071821
	Mid	27923.52 / 2077891	27923.52 / 2077891
	High	28292.16 / 2084035	28292.16 / 2084035
	Band 260	Frequency range: 37000 – 40000 MHz	
		Channel Bandwidth	
		100MHz	
		50MHz	
		MHz / Channel	MHz / Channel
Low	37051.80 / 2230029	37051.80 / 2230029	
Mid	38498.88 / 2254147	38498.88 / 2254147	
High	39949.92 / 2278331	39949.92 / 2278331	
Sub carrier Spacing	120 kHz		
Total Number of Supported Uplink CCs (SISO)	1		
Total Number of Supported Uplink CCs (MIMO)	1		
Total Number of Supported DL CCs	4		
LTE Anchor Bands (n261)	LTE B2 / 5 / 13 / 48 / 66		
LTE Anchor Bands (n260)	LTE B2 / 5 / 13 / 48 / 66		
Duplex Type (mmWave)	TDD		

8.4. Time-Averaging Algorithm for RF Exposure Compliance

The equipment under test(EUT) are supporting 2G/3G/4G/5G NR technologies through Samsung S.LSI modem. Samsung S.LSI modem is enabled with Samsung S.LSI Smart Transmit feature. This feature performs time averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements all the time. Refer to Compliance Summary document for detailed description of Samsung S.LSI Smart Transmit feature.

The Smart Transmit algorithm maintains the time-averaged transmit power, in turn, time-averaged RF exposure of *SAR_design_target* or *PD_design_target*, below the predefined time-averaged power limit (i.e., P_{limit} for sub-6 radio, and P_{limit} for 5G mmW NR), for each characterized technology and band. Smart Transmit allows the device to transmit at higher power instantaneously when needed. but manages power limiting to maintain time-averaged transmit power to *P_{limit}* listed in Section 8.5.

The purpose of this report (PD RF Exposure Test) is to demonstrate that the EUT meets FCC PD limits when transmitting in static transmission scenario at maximum allowable time-averaged power level given by P_{limit} .

8.5. Plimit

All power density measurements for this device were performed at the *Plimit* given in below tables. Input power is per antenna element and polarization for each antenna module. When Plimit is calculated to be above the maximum input power, the device is limited to the maximum input power.

5G NR n261 L Patch Plimit

Antenna	Beam ID_1	Beam ID_2	input.power.limit (dBm)	
L patch	0		14.4	
	1		14.9	
	2		14.3	
	3		15.3	
	4		15.8	
	5		15.6	
	6		14.1	
		7	12.3	
		8	13.9	
		9	13.8	
		10	12.6	
		11	14.1	
		12	13.9	
		13	13.1	
		0	7	10.9
		1	8	11.9
		2	9	11.2
		3	10	10.8
		4	11	11.7
		5	12	12.7
		6	13	11.0

5G NR n260 L Patch Plimit

Antenna	Beam ID_1	Beam ID_2	input.power.limit (dBm)	
L patch	0		13.9	
	1		14.2	
	2		13.7	
	3		14.0	
	4		14.9	
	5		14.1	
	6		14.2	
		7	13.5	
		8	13.4	
		9	13.0	
		10	13.7	
		11	13.2	
		12	13.7	
		13	13.8	
		0	7	11.0
		1	8	11.1
		2	9	10.6
		3	10	11.1
		4	11	11.1
		5	12	11.1
		6	13	10.8

9. RF Exposure Conditions (Test Configurations)

9.1. Operating mode(s)

DUTs can transmit in operating modes and frequency bands using different signal characteristics (e.g. modulation, source coding, channel bandwidth, etc.) that require power density tests. The appropriate operating modes should be selected for testing taking into consideration differences in maximum output power and production variations, to ensure maximum power density is assessed.

Supported mode:

- | | |
|--|---------------------------------------|
| <input checked="" type="checkbox"/> CW | <input type="checkbox"/> D-QPSK |
| <input type="checkbox"/> AM | <input type="checkbox"/> QPSK |
| <input type="checkbox"/> FMCW | <input type="checkbox"/> Up to 16QAM |
| <input type="checkbox"/> FM | <input type="checkbox"/> Up to 64QAM |
| <input type="checkbox"/> pi/2-BPSK | <input type="checkbox"/> Up to 256QAM |
| <input type="checkbox"/> pi/2-QPSK | <input type="checkbox"/> pi/2-16QAM |

9.2. Measurement position(s)

Power density evaluated at worst-surfaces according to test results of Power density Char report.

Band	Antenna	Back Rear	Front	Top Edge 1	Bottom Edge 3	Left Edge 4	Right Edge 2
5G NR Band n260	L Patch	Yes	Yes	Yes	No	No	Yes
5G NR Band n261	L Patch	Yes	Yes	Yes	No	No	Yes

Please refer to Appendix A for Antenna's location.

10. Dielectric Property & System Check

10.1. Dielectric Property

Media is air so Relative Permittivity (ϵ_r) and Conductivity (σ) is 1.

10.2. System Check

Per Nov 2017,TCB Workshop

System validation is required before a system is deployed for measurement

System check is also required before each series of continuous measurement and, as applicable, repeated at least weekly

Peak and spatially averaged power density at the peak location(s) must be compared to calibrated results according to the defined test conditions

- the same spatial resolution and measurement region used in the waveguide calibration should be applied to system validation and system check
- 4 cm² spatial averaging have been used according to FCC requirement.
- power density distribution should also be verified, both spatially (shape) and numerically (level) through visual inspection for noticeable differences
- the measured results should be within 10% of the calibrated targets

SAR 8 Room

SAR Lab	Date	Sorce SN	Sorce Cal. Due Data	Measured Total psPD for 4cm ² (W/m ²)	Target (Ref. Value) (W/m ²)	Delta $\pm 10\%$	visual inspection	Plot No.
SAR 8	1-4-2023	1082	3-1-2023	46.4	44.1	5.22	confirmed	
SAR 8	1-5-2023	1082	3-1-2023	45.9	44.1	4.08	confirmed	
SAR 8	1-6-2023	1082	3-1-2023	47.1	44.1	6.80	confirmed	1
SAR 8	1-10-2023	1082	3-1-2023	46.7	44.1	5.90	confirmed	
SAR 8	1-12-2023	1082	3-1-2023	46.9	44.1	6.35	confirmed	

SAR 9 Room

SAR Lab	Date	Sorce SN	Sorce Cal. Due Data	Measured Total psPD for 4cm ² (W/m ²)	Target (Ref. Value) (W/m ²)	Delta $\pm 10\%$	visual inspection	Plot No.
SAR 9	1-2-2022	1082	3-1-2023	49.2	45.5	8.13	confirmed	2
SAR 9	1-3-2022	1082	3-1-2023	46.6	45.5	2.42	confirmed	

Note(s):

psPD value used the pS_{tot} avg value of test result plot.

11. Measured and Reported (Scaled) Results

Both Normal psPD and Total psPD are record in test results according to TCB workshop October 2018 note . But Only Total psPD level are considered according to FCC requirement.

The PD test for each beam ID configuration were selected by simulation report on SISO Beam's Right side, MIMO Beam's Back, Front, Top and Right side.

- 1) Horizontal polarization, CW tone signal at the highest channel in the simulation report
- 2) Vertical polarization, CW tone signal at the highest channel in the simulation report
- 3) MIMO polarization, CW tone signal at the highest channel in the simulation report
- 4) From the PD measurement result of 1)~3), the Worst case measurement surface of the DUT is determined.
- 5) Under the DUT side of the highest measurement result in 1)~4), Power density measurement of remaining channels are performed with the Beam ID selected from the results of Simulation Report.

11.1. NR Band n261 Test Results

Antenna	Dist. (mm)	Test Position	Freq. (MHz)	Ch.	Beam ID1	Beam ID2	Plimit (dBm)	Tested Power (dBm)	Tested Signal	Duty Cycle	Power Drift	Normal psPD (mW/cm ²)	Total psPD (mW/cm ²)	Plot No.
					V	H						Meas.	Meas.	
L patch	2 mm	Rear	27923.52	Mid	3	10	10.8	11.0	CW	100.0%	0.05	0.117	0.153	
	2 mm	Front	28292.16	High	2	9	11.2	12.0	CW	100.0%	-0.19	0.144	0.201	
	2 mm	Right	28292.16	High	6		14.1	15.0	CW	100.0%	0.01	0.248	0.310	
	2 mm	Right	27923.52	Mid		7	12.3	13.0	CW	100.0%	-0.09	0.098	0.138	
	2 mm	Right	28292.16	High	3	10	10.8	11.0	CW	100.0%	-0.07	0.520	0.570	1
	2 mm	Top	28292.16	High	1	8	11.9	12.0	CW	100.0%	-0.06	0.037	0.045	
	2 mm	Right	27559.32	Low	0	7	10.9	11.0	CW	100.0%	0.17	0.164	0.209	
	2 mm	Right	27923.52	Mid	0	7	10.9	11.0	CW	100.0%	0.14	0.096	0.128	

(10 W/m² = 1.0 mW/cm²)

Note(s):

1. This device utilizes power reduction for some WLAN wireless modes and technologies for simultaneous transmission compliance. These mechanisms are assessed In the SAR Test Report.
2. *PD_design_target* of 0.442 mW/cm² was used with mmW device design related uncertainty of 2.3 dB.
3. *Plimit* parameter for 5G mmW NR radio was calculated in RF Exposure PD Char report.
4. The measurement was tested by setting it to a higher Tested Power than *Plimit*.
5. Devices enabled with Samsung S.LSI Smart Transmit feature, simultaneous transmission analysis is evaluated by combining the exposure from each WWAN and WLAN antenna. 5G mmW NR and WLAN simultaneous transmission scenario is evaluated under the Total Exposure Ratio.
6. The device was configured to transmit CW wave signal for testing. Additional testing was not evaluated for different modulations, RB configurations, component carriers, channel configurations since the smart transmit algorithm monitors powers on a per symbol basis, which is independent of these signal characteristics.

11.2. NR Band n260 Test Results

Antenna	Dist. (mm)	Test Position	Freq. (MHz)	Ch.	Beam ID1	Beam ID2	Plimit (dBm)	Tested Power (dBm)	Tested Signal	Duty Cycle	Power Drift	Normal psPD (mW/cm ²)	Total psPD (mW/cm ²)	Plot No.
					V	H						Meas.	Meas.	
L patch	2 mm	Rear	37051.80	Low	2	9	10.6	11.0	CW	100.0%	0.02	0.223	0.233	
	2 mm	Front	37051.80	Low	2	9	10.6	11.0	CW	100.0%	-0.13	0.094	0.114	
	2 mm	Right	37051.80	Low	2		13.7	14.0	CW	100.0%	0.01	0.160	0.192	
	2 mm	Right	37051.80	Low		9	13.0	13.0	CW	100.0%	0.01	0.233	0.242	
	2 mm	Right	37051.80	Low	2	9	10.6	11.0	CW	100.0%	-0.08	0.336	0.411	2
	2 mm	Top	38498.88	Mid	4	11	11.1	12.0	CW	100.0%	0.15	0.041	0.046	
	2 mm	Right	38498.88	Mid	3	10	11.1	12.0	CW	100.0%	0.09	0.255	0.302	
	2 mm	Right	39949.92	High	3	10	11.1	12.0	CW	100.0%	-0.04	0.212	0.253	

(10 W/m² = 1.0 mW/cm²)

Note(s):

1. This device utilizes power reduction for some WLAN wireless modes and technologies for simultaneous transmission compliance. These mechanisms are assessed in the SAR Test Report.
2. *PD_design_target* of 0.442 mW/cm² was used with mmW device design related uncertainty of 2.3 dB.
3. *Plimit* parameter for 5G mmW NR radio was calculated in RF Exposure PD Char report.
4. The measurement was tested by setting it to a higher Tested Power than *Plimit*.
5. Devices enabled with Samsung S.LSI Smart Transmit feature, simultaneous transmission analysis is evaluated by combining the exposure from each WWAN and WLAN antenna. 5G mmW NR and WLAN simultaneous transmission scenario is evaluated under the Total Exposure Ratio.
6. The device was configured to transmit CW wave signal for testing. Additional testing was not evaluated for different modulations, RB configurations, component carriers, channel configurations since the smart transmit algorithm monitors powers on a per symbol basis, which is independent of these signal characteristics.

12. Simultaneous Transmission Conditions

Total exposure ratio calculated by taking ratio of reported SAR divided by SAR limit and adding it to measured power density divided by power density limit. Numerical sum of the two ratios should be less than 1

$$TER = \sum_{a=1}^A \frac{SAR_a}{SAR_{a, limit}} + \sum_{b=1}^B \frac{psPD_b}{psPD_{b, limit}} < 1$$

The Total exposure ratio shall be less than unity to ensure compliance with the limits.

$$\sum_{n=1}^N \frac{4G SAR_n}{4G SAR_{n, limit}} + \sum_{m=1}^M \frac{5G mmW NR psPD_m}{5G mmW NR psPD_{m, limit}} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_{p, limit}} < 1$$

Samsung S.LSI Smart Transmit algorithm for WWAN adds directly the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G mmW NR. Smart transmit algorithm controls the total RF exposure from both 4G and 5G NR to not exceed the RF exposure from each 4G or 5G individually. Therefore, per FCC guidance, Total Exposure Ratio does not need to be evaluated directly for the 4G and 5G simultaneous compliance via summation. The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in TAS Validation (SAR and PD) report.

$$\sum_{n=1}^N \frac{4G SAR_n}{4G SAR_{n, limit}} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_{p, limit}} < 1$$

$$\sum_{m=1}^M \frac{5G mmW NR psPD_m}{5G mmW NR psPD_{m, limit}} + \sum_{p=1}^P \frac{WLAN SAR_p}{WLAN SAR_{p, limit}} < 1$$

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 2.3 dB. For this device, the manufacturer has added an additional permanent back-off for every beam in the calculations for Plimit used in the NV Settings. The back-off levels can be found in the PD Char report. Therefore, 5G mmW NR RF exposure for this DUT is evaluated by reported psPD calculated as;

$$Reported_psPD = PD_design_target + 2.3 \text{ dB} = 0.741 \text{ mW} / \text{cm}^2$$

Note that since not all the beams supported by this EUT are measured, reported_psPD cannot be computed based on limited measured_psPD data. Alternatively, since measured psPD for all the beams will be PD_design_target + 2.3 dB, reported_psPD is computed based on this worst-case psPD as shown above.

The compliance analysis for simultaneous transmission scenarios of WWAN with Smart Transmit and 4G & WLAN can be found in two reports indicated in the table below.

	Simultaneous Scenario	Evaluation Report
1	4G LTE WWAN + WLAN	FCC Report SAR
2	4G LTE WWAN + 5G mmW NR WWAN	FCC Report TAS Validation (SAR and PD)

Simultaneous Transmission Condition

RF Exposure Condition	Item	Capable Transmit Configurations				
Standalone	1	EN-DC (LTE + 5G mmW NR)	+	DTS_Ant. 1	or	DTS_Ant. 2
	2	EN-DC (LTE + 5G mmW NR)	+	DTS_MIMO		
	3	EN-DC (LTE + 5G mmW NR)	+	U-NI1_Ant. 1	or	U-NI1_Ant. 2
	4	EN-DC (LTE + 5G mmW NR)	+	U-NI1_MIMO		
	5	EN-DC (LTE + 5G mmW NR)	+	BT		
	6	EN-DC (LTE + 5G mmW NR)	+	BT	+	U-NI1_Ant. 1 or U-NI1_Ant. 2
	7	EN-DC (LTE + 5G mmW NR)	+	BT	+	U-NI1_MIMO
	8	Scenation item (1-7)	+	NFC		

Note(s):

- 5G mmW NR Operations are limited to Non-Standalone (EN-DC) operations only.
- 5G NR antenna arrays cannot transmit at the same time.
- 5G NR bands cannot transmit at the same time.
- For EN-DC mode, Samsung S.LSI Smart Transmit algorithm in WWAN adds directly the time-averaged RF exposure from 4G(LTE) and time-averaged RF exposure from 5G NR. Smart Transmit algorithm controls the total RF exposure from both 4G and 5G NR to not exceed FCC limit. Therefore, simultaneous transmission compliance between 4G+5G NR operation is demonstrated in the TAS Validation (SAR and PD) Report during algorithm validation. In PD RF Exposure Test Report, simultaneous transmission compliance was evaluated individually with other Radios (WLAN and (or) BT) using 5G mmW NR.

12.1. 5G mmW NR psPD for TER Ratio analysis

Antenna	NR Band	Surface	Evaluation Distance (mm)	Adjustment Factor due to Simulation	Adjusted Reported psPD (mW/cm2)	Measured psPD (mW/cm2)	Final Reported psPD (mW/cm2)
L-patch	n261	Back	2	1.000	0.741	0.153	0.741
	n261	Front	2	0.979	0.725	0.201	0.725
	n261	Edge 1	2	0.294	0.218	0.045	0.218
	n261	Edge 2	2	1.000	0.741	0.570	0.741
	n261	Edge 3	2	0.054	0.040	-	0.040
	n261	Edge 4	2	0.047	0.035	-	0.035
	n260	Back	2	0.806	0.597	0.233	0.597
	n260	Front	2	0.743	0.551	0.114	0.551
	n260	Edge 1	2	0.333	0.247	0.046	0.247
	n260	Edge 2	2	1.000	0.741	0.411	0.741
	n260	Edge 3	2	0.031	0.023	-	0.023
	n260	Edge 4	2	0.031	0.023	-	0.023
	n261	Rear	10	0.466	0.345	-	0.345
	n260	Rear	10	0.418	0.310	-	0.310
	n261	Front	10	0.400	0.239	-	0.239
	n260	Front	10	0.371	0.222	-	0.222

12.2. 5G mmW NR Head Total Exposure Ratio

		psPD	2.4GHz Ant 1 Reported SAR	2.4GHz Ant 2 Reported SAR	5GHz Ant 1 Reported SAR	5GHz Ant 2 Reported SAR	Bluetooth Reported SAR	psPD+2.4GHz Ant 1+2.4GHz Ant 2 Reported SAR	psPD+5GHz Ant 1+5GHz Ant 2 Reported SAR	psPD+Bluetooth Reported SAR	psPD+5GHz Ant 1+5GHz Ant 2+Bluetooth Reported SAR
		mW/cm ²	W/kg	W/kg	W/kg	W/kg	W/kg				
		1	2	3	4	5	6	1+2+3	1+4+5	1+6	1+4+5+6
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0
Front (Head)	Reported Value	0.725	0.249	0.162	0.101	0.057	0.154				
	Ratio to Limit	0.725	0.156	0.101	0.063	0.036	0.096	0.982	0.824	0.821	0.920

Note(s):

- Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.
- Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for Total Exposure Ratio analysis.
- For power density measurements, a test separation distance of 2 mm was used for phablet configuration due to probe restraints.
- Total Exposure Ratio (TER) is less than 1 in RF exposure conditions.

12.3. 5G mmW NR Body-worn Total Exposure Ratio

	psPD mW/cm ²	2.4GHz Ant 1 Reported SAR	2.4GHz Ant 2 Reported SAR	2.4GHz Ant MIMO Reported SAR	5GHz Ant 1 Reported SAR	5GHz Ant 2 Reported SAR	Bluetooth Reported SAR	psPD+2.4GHz Ant 1 Reported SAR	psPD+2.4GHz Ant 2 Reported SAR	psPD+2.4GHz Ant MIMO Reported SAR	psPD+5GHz Ant 1+5GHz Ant 2 Reported SAR	psPD+Bluetooth Reported SAR	psPD+5GHz Ant 1+5GHz Ant 2+Bluetooth Reported SAR
		W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg
		1	2	3	4	5	6	7	1+2	1+3	1+4	1+5+6	1+7
Applicable Limit	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0	1.0
Rear	Reproted Value	0.345	0.270	0.073	0.188	0.368	0.190	0.094					
	Ratio to Limit	0.345	0.169	0.046	0.118	0.230	0.119	0.059	0.514	0.391	0.463	0.694	0.464
Front	Reproted Value	0.239	0.270	0.073	0.188	0.368	0.190	0.094					
	Ratio to Limit	0.239	0.169	0.046	0.118	0.230	0.119	0.059	0.408	0.285	0.357	0.588	0.358

Note(s):

- Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.
- Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for Total Exposure Ratio analysis.
- For power density measurements, a test separation distance of 2/10 mm was used for phablet configuration due to probe restraints.
- Total Exposure Ratio (TER) is less than 1 in RF exposure conditions.
- Green value is estimated SAR value.

12.4. 5G mmW NR Hotspot Total Exposure Ratio

	psPD mW/cm ²	2.4GHz Ant 1 Reported SAR	2.4GHz Ant 2 Reported SAR	2.4GHz Ant MIMO Reported SAR	5GHz Ant 1 Reported SAR	5GHz Ant 2 Reported SAR	Bluetooth Reported SAR	psPD+2.4GHz Ant 1 Reported SAR	psPD+2.4GHz Ant 2 Reported SAR	psPD+2.4GHz Ant MIMO Reported SAR	psPD+5GHz Ant 1 + 5GHz Ant 2 Reported SAR	psPD+Bluetooth Reported SAR	psPD+5GHz Ant 1 + 5GHz Ant 2 + Bluetooth Reported SAR
		W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg	W/kg
		1	2	3	4	5	6	7	1+2	1+3	1+4	1+5+6	1+7
Applicable Limit	1.0	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0	1.0
Rear	Reproted Value	0.345	0.576	0.175	0.383	0.084	0.224	0.206					
	Ratio to Limit	0.345	0.360	0.109	0.239	0.053	0.140	0.129	0.705	0.454	0.584	0.538	0.474
Front	Reproted Value	0.239	0.576	0.175	0.383	0.125	0.224	0.082					
	Ratio to Limit	0.239	0.360	0.109	0.239	0.078	0.140	0.051	0.599	0.348	0.478	0.457	0.290
Edge 1	Reproted Value	0.247	0.576	0.175	0.263	0.125	0.224	0.030					
	Ratio to Limit	0.247	0.360	0.109	0.164	0.078	0.140	0.019	0.607	0.356	0.411	0.465	0.266
Edge 2	Reproted Value	0.741	0.000	0.000	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.741	0.000	0.000	0.000	0.000	0.000	0.000	0.741	0.741	0.741	0.741	0.741
Edge 3	Reproted Value	0.040	0.000	0.000	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.040	0.040	0.040	0.040
Edge 4	Reproted Value	0.035	0.436	0.175	0.136	0.125	0.224	0.166					
	Ratio to Limit	0.035	0.273	0.109	0.085	0.078	0.140	0.104	0.308	0.144	0.120	0.253	0.139

Note(s):

- Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.
- Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for Total Exposure Ratio analysis.
- For power density measurements, a test separation distance of 2/10 mm was used for phablet configuration due to probe restraints.
- Total Exposure Ratio (TER) is less than 1 in RF exposure conditions.
- Green value is estimated SAR value.

12.5. 5G mmW NR Phablet Total Exposure Ratio

		psPD	5Hz Ant 1 Reported SAR	5Hz Ant 2 Reported SAR	5Hz Ant MIMO Reported SAR	NFC Ant Reported SAR	psPD+5GHz Ant 1 Reported SAR	psPD+5GHz Ant 2 Reported SAR	psPD+5GHz Ant MIMO Reported SAR	psPD+NFC Ant Reported SAR	psPD+5GHz Ant MIMO +NFC Reported SAR
		mW/cm ²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1+2	1+3	1+4	1+5	1+4+5
Applicable Limit		1.0	4.0	4.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0
Rear	Reported Value	0.741	0.564	0.872	0.695	0.028					
	Ratio to Limit	0.741	0.141	0.218	0.174	0.007	0.882	0.959	0.915	0.748	0.922
Front	Reported Value	0.725	0.576	0.872	0.879	0.000					
	Ratio to Limit	0.725	0.144	0.218	0.220	0.000	0.869	0.943	0.945	0.725	0.945
Edge 1	Reported Value	0.247	1.265	0.872	0.879	0.000					
	Ratio to Limit	0.247	0.316	0.218	0.220	0.000	0.563	0.465	0.467	0.247	0.467
Edge 2	Reported Value	0.741	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.741	0.000	0.000	0.000	0.000	0.741	0.741	0.741	0.741	0.741
Edge 3	Reported Value	0.040	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.040	0.000	0.000	0.000	0.000	0.040	0.040	0.040	0.040	0.040
Edge 4	Reported Value	0.035	1.265	0.872	0.879	0.000					
	Ratio to Limit	0.035	0.316	0.218	0.220	0.000	0.351	0.253	0.255	0.035	0.255

Note(s):

- Adjusted factor is (simulated PD on desired exposure plane)/(PD on worst-surface at 2mm evaluation distance) out of all beams and out of all channels. See Power Density Simulation Report.
- Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for Total Exposure Ratio analysis.
- For power density measurements, a test separation distance of 2 mm was used for phablet configuration due to probe restraints.
- Green value is estimated SAR value.

Appendixes

Refer to separated files for the following appendixes.

4790632299-S2 FCC Report PD_App A_Setup Photos

4790632299-S2 FCC Report PD_App B_System Check Plots

4790632299-S2 FCC Report PD_App C_Highest Test Plots

4790632299-S2 FCC Report PD_App D_Probe Calibration Certificates

4790632299-S2 FCC Report PD_App E_Verification source Calibration Certificates

END OF REPORT