



NEAR-FIELD POWER DENSITY EVALUATION REPORT

Applicant Name

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Date of Testing

06/06/2022 – 06/10/2022

Test Site/Location

Element, Columbia, MD, USA

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A3LSMF721U

APPLICANT:

SAMSUNG ELECTRONICS CO., LTD.

DUT Type:

Portable Handset

Application Type:

Certification

FCC Rule Part(s):

CFR §2.1093

Model:

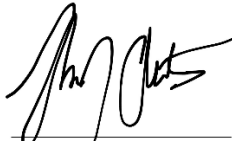
SM-F721U

Additional Model(s):

SM-F721U1

Band & Mode	Tx Frequency	Measured psPD	Reported psPD
	MHz	mW/cm ²	mW/cm ²
n258	24250 - 24450; 24750 - 25250	0.351	0.794
n261	27500 - 28350	0.301	0.794
n260	37000 - 40000	0.370	0.794
Total Exposure Ratio		0.994	
Verdict		PASS	

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.



RJ Ortanez
 Executive Vice President



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APPENDIX B: SYSTEM VERIFICATION PLOTS

APPENDIX C: TOTAL EXPOSURE RATIO

APPENDIX D: PROBE AND VERIFICATION SOURCE CALIBRATION CERTIFICATES

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1 DEVICE UNDER TEST

1.1 NR FR2 Checklist

NR FR2 Operations Information	
Form Factor	Portable Handset
Subcarrier Spacing (kHz)	120
Total Number of Supported Uplink CCs (SISO)	2
Total Number of Supported Uplink CCs (MIMO)	2
Total Number of Supported DL CCs	8
CP-OFDM Modulations Supported in UL	QPSK, 16QAM, 64QAM
DFT-s-OFDM Modulations Supported in UL	PI/2 BPSK, QPSK, 16QAM, 64QAM
LTE Anchor Bands	n258: 2/5/12/14/30/66, n261: 2/5/12/13/48/66, n260: 2/5/12/13/14/30/48/66
NR FR1 Anchor Bands	n258: 2/5/12/25/30/41/66, n261: 2/5/25/41/48/66/77, n260: 2/5/12/25/30/41/48/66/77
Duplex Type (mmWave)	TDD

NR FR2 Channels & Frequencies							
NR Band	Bandwidth (MHz)	Low		Mid		High	
		Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
n258	100	2018333	24350.04	2025833	24800.04	2032499	25200.00
n258	50	2018333	24350.04	2025833	24800.04	2032915	25224.96
n261	100	2071667	27550.08	2077915	27924.96	2084165	28299.96
n261	50	2071249	27525.00	2077915	27924.96	2084581	28324.92
n260	100	2229999	37050.00	2254165	38499.96	2278331	39949.92
n260	50	2229599	37026.00	2254165	38499.96	2278749	39975.00

1.2 Time-Averaging Algorithm for RF Exposure Compliance

The device is enabled with Qualcomm® Smart Transmit GEN1 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 Qualcomm® Smart Transmit. Note that WLAN operations are not enabled with Smart Transmit.

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 *input.power.limit* for 5G mmW NR), for each characterized technology and band (see RF Exposure Part 0 Test Report).

Smart Transmit allows the device to transmit at higher power instantaneously when needed, but manages power limiting to maintain time-averaged transmit power to *input.power.limit*.

The purpose of this report (Part 1 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 *input.power.limit*.

1.3 Power Density Design Target and Uncertainty

Power Density Design Specifications	
<i>PD_design_target</i> (mW/m ²)	0.631
Design Related Total Uncertainty (dB)	2

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1.4 Input Power Specifications

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

Table 1-1
5G mmWave NR n258 Antenna K Patch input.power.limit

Band	Beam ID 1	Beam ID 2	input.power.limit
n258	0	-	7.3
n258	1	-	10.0
n258	2	-	9.4
n258	3	-	7.9
n258	4	-	8.7
n258	5	-	5.9
n258	6	-	4.2
n258	7	-	5.0
n258	8	-	7.0
n258	9	-	5.0
n258	10	-	4.3
n258	11	-	6.7
n258	12	-	1.3
n258	13	-	0.8
n258	14	-	0.8
n258	15	-	0.8
n258	16	-	1.3
n258	17	-	1.0
n258	18	-	0.9
n258	19	-	0.5
n258	20	-	1.3
n258	-	128	11.3
n258	-	129	10.4
n258	-	130	10.4
n258	-	131	10.7
n258	-	132	10.6
n258	-	133	7.1
n258	-	134	6.8
n258	-	135	6.7
n258	-	136	7.7
n258	-	137	7.2
n258	-	138	7.2
n258	-	139	7.2
n258	-	140	4.7
n258	-	141	3.1
n258	-	142	3.0
n258	-	143	2.5
n258	-	144	3.7
n258	-	145	3.7
n258	-	146	3.1
n258	-	147	2.5
n258	-	148	2.7
n258	0	128	5.4
n258	1	129	6.4
n258	2	130	6.1
n258	3	131	5.3
n258	4	132	5.7
n258	5	133	3.5
n258	6	134	2.4
n258	7	135	3.1
n258	8	136	3.9
n258	9	137	2.7
n258	10	138	2.0
n258	11	139	3.2
n258	12	140	-0.5
n258	13	141	-1.6
n258	14	142	-1.8
n258	15	143	-2.2
n258	16	144	-1.4
n258	17	145	-1.3
n258	18	146	-1.6
n258	19	147	-2.2
n258	20	148	-1.8

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Table 1-2
5G mmWave NR n261 Antenna K Patch input.power.limit

Band	Beam ID 1	Beam ID 2	input.power.limit
n261	0	-	6.4
n261	1	-	7.2
n261	2	-	7.1
n261	3	-	6.9
n261	4	-	6.6
n261	5	-	5.1
n261	6	-	3.5
n261	7	-	4.5
n261	8	-	4.8
n261	9	-	4.4
n261	10	-	4.3
n261	11	-	4.7
n261	12	-	0.0
n261	13	-	-0.2
n261	14	-	0.0
n261	15	-	-0.2
n261	16	-	0.0
n261	17	-	-0.6
n261	18	-	0.0
n261	19	-	-0.1
n261	20	-	-0.1
n261	-	128	10.5
n261	-	129	9.0
n261	-	130	9.1
n261	-	131	9.6
n261	-	132	9.6
n261	-	133	7.6
n261	-	134	5.8
n261	-	135	6.8
n261	-	136	6.4
n261	-	137	7.0
n261	-	138	7.0
n261	-	139	6.4
n261	-	140	4.5
n261	-	141	1.9
n261	-	142	1.9
n261	-	143	2.9
n261	-	144	2.0
n261	-	145	2.8
n261	-	146	2.0
n261	-	147	2.5
n261	-	148	1.9
n261	0	128	4.6
n261	1	129	4.4
n261	2	130	4.5
n261	3	131	4.5
n261	4	132	4.4
n261	5	133	2.7
n261	6	134	1.2
n261	7	135	2.2
n261	8	136	1.7
n261	9	137	1.9
n261	10	138	2.3
n261	11	139	2.3
n261	12	140	-2.0
n261	13	141	-2.5
n261	14	142	-2.7
n261	15	143	-2.9
n261	16	144	-3.3
n261	17	145	-2.7
n261	18	146	-2.2
n261	19	147	-3.0
n261	20	148	-3.4

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Table 1-3
5G mmWave NR n260 Antenna K Patch input.power.limit

Band	Beam ID 1	Beam ID 2	input.power.limit
n260	0	-	10.5
n260	1	-	10.1
n260	2	-	10.2
n260	3	-	10.5
n260	4	-	9.5
n260	5	-	7.3
n260	6	-	7.8
n260	7	-	7.4
n260	8	-	7.0
n260	9	-	7.3
n260	10	-	7.6
n260	11	-	7.2
n260	12	-	3.9
n260	13	-	5.2
n260	14	-	3.6
n260	15	-	3.2
n260	16	-	3.7
n260	17	-	4.2
n260	18	-	4.2
n260	19	-	3.9
n260	20	-	3.3
n260	-	128	10.5
n260	-	129	11.0
n260	-	130	10.3
n260	-	131	11.4
n260	-	132	9.8
n260	-	133	7.6
n260	-	134	7.3
n260	-	135	7.9
n260	-	136	7.1
n260	-	137	7.9
n260	-	138	8.6
n260	-	139	7.6
n260	-	140	3.5
n260	-	141	5.1
n260	-	142	4.7
n260	-	143	4.8
n260	-	144	3.3
n260	-	145	4.2
n260	-	146	4.8
n260	-	147	4.9
n260	-	148	3.7
n260	0	128	7.0
n260	1	129	7.5
n260	2	130	7.0
n260	3	131	7.1
n260	4	132	6.2
n260	5	133	4.3
n260	6	134	4.1
n260	7	135	4.8
n260	8	136	3.9
n260	9	137	4.0
n260	10	138	4.7
n260	11	139	3.8
n260	12	140	0.3
n260	13	141	0.8
n260	14	142	0.6
n260	15	143	0.2
n260	16	144	0.1
n260	17	145	0.1
n260	18	146	0.9
n260	19	147	0.8
n260	20	148	0.1

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1.5 DUT Antenna Locations

The table below indicates the surfaces evaluated for near field power density (part 1) evaluation. Refer to RF Exposure Part 0 Test Report for justification of these worst-surfaces.

**Table 1-4
Device Surfaces**

Band	Antenna	Antenna Type	Condition	Back	Front	Top	Bottom	Right	Left
n258	K	Patch	Closed	No	Yes	No	No	No	Yes
n261	K	Patch	Closed	No	Yes	No	No	No	Yes
n260	K	Patch	Closed	No	Yes	No	No	No	Yes
n258	K	Patch	Open	Yes	No	No	No	No	Yes
n261	K	Patch	Open	Yes	Yes	No	No	No	Yes
n260	K	Patch	Open	No	No	No	No	No	Yes

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1.6 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, transmitters are considered to be operating simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v06 4.3.2 procedures.

**Table 1-5
Simultaneous Transmission**

No.	Capable Transmit Configuration	Head	Body-worn	Wireless Router	Phablet	Notes
1	LTE + 5G NR FR2	Yes	Yes	N/A	Yes	
2	LTE + 2.4 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
3	LTE + Bluetooth Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
4	LTE + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes	Yes	Yes	Yes	
5	LTE + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
6	LTE + Bluetooth Ant 1 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
7	LTE + Bluetooth Ant 2 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
8	LTE + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
9	LTE + Bluetooth Ant 1 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
10	LTE + Bluetooth Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
11	LTE + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
12	LTE + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
13	LTE + 2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
14	5G NR FR1 + 5G NR FR2	Yes	Yes	N/A	Yes	
15	5G NR FR1 + 2.4 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
16	5G NR FR1 + Bluetooth Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
17	5G NR FR1 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes	Yes	Yes	Yes	
18	5G NR FR1 + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
19	5G NR FR1 + Bluetooth Ant 1 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
20	5G NR FR1 + Bluetooth Ant 2 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
21	5G NR FR1 + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
22	5G NR FR1 + Bluetooth Ant 1 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
23	5G NR FR1 + Bluetooth Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
24	5G NR FR1 + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN Ant 1 + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
25	5G NR FR1 + Bluetooth Ant 1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes [^]	Yes	Yes [^]	Yes	[^] Bluetooth Tethering is considered
26	5G NR FR1 + 2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	

NOTE:

- NR antenna arrays cannot transmit simultaneously.
- LTE + 5G NR FR2 and 5G NR1 + 5G NR FR2 scenarios are limited to EN-DC combinations with anchor bands as shown in the NR FR2 checklist.
- This device supports time averaging smart transmit algorithm in WWAN. Smart transmit adds directly the time-averaged RF exposure from 4G/5G NR FR1 and time-averaged RF exposure from 5G mmW NR FR2 to ensure that the normalized RF exposure from both 4G/5G NR FR1 and 5G mmW NR FR2 does not exceed FCC limit.
- NFC can transmit simultaneously with all scenarios above.
- 2.4 GHz WLAN ant 1 and 2.4 GHz Bluetooth ant 1 share the same antenna path and cannot transmit simultaneously.

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1.7 Guidance Applied

- November 2017, October 2018, April 2019, November 2019 TCBC Workshop Notes
- SPEAG DASY6 System Handbook
- IEC/IEEE 63195-1:2022
- FCC KDB 865664 D02 v01r04
- FCC KDB 447498 D01 v02r01

1.8 Bibliography

**Table 1-6
Bibliography**

Report Type	Report Serial Number
FCC SAR Evaluation Report (Part 1)	1M2204080051-19.A3L
Power Density Part 0 Test Report	
RF Exposure Part 2 Test Report	1M2204080051-22.A3L
RF Exposure Compliance Summary Report	1M2204080051-24.A3L
Power Density Simulation Report	

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2 MEASUREMENT SYSTEM

2.1 Measurement Setup

Peak spatially averaged power density (psPD) measurements for mmWave frequencies were performed using the DASY6 with cDASY6 5G module. The DASY6 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of a high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the 5G phantom. The robot is a six-axis industrial robot, performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF).

2.2 SPEAG EUmWVx Probe / E-Field 5G Probe

The EUmWVx probe consists of two dipoles optimally arranged to obtain pseudo-vector information.

Frequency Range	750 MHz – 110 GHz
Dynamic Range	< 20 V/m – 10,000 V/m with PRE-10 (min < 50 V/m – 3,000 V/m)
Position Precision	< 0.2 mm (cDASY6)
Dimensions	Probe Overall Length: 320 mm Probe Body Diameter: 8 mm Probe Tip Length: 23 mm Probe Tip Diameter: Encapsulation 8 mm Distance from Probe Tip to Sensor X Calibration Point: 1.5 mm Distance from Probe Tip to Sensor Y Calibration Point: 1.5 mm
Applications	E-field measurements of 5G devices and other mm-wave transmitters operating above 10 GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction
Compatibility	cDASY6 + 5G-Module SW

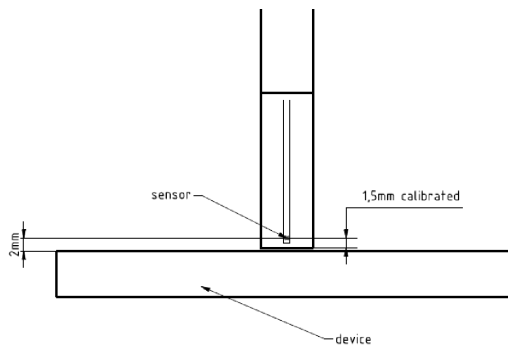
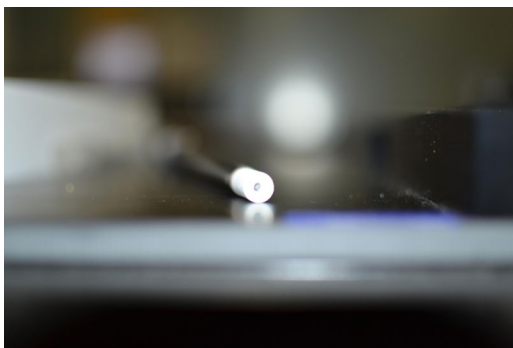


Figure 2-1
EUmWVx Probe

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2.3 Peak Spatially Averaged Power Density Assessment Based on E-field Measurements

Within a short distance from the transmitting source, power density was determined based on both electric and magnetic fields. Generally, the magnitude and phase of two components of either the E-field or H-field were needed on a sufficiently large surface to fully characterize the total E-field and H-field distributions. Nevertheless, solutions based on direct measurement of E-field and H-field can be used to compute power density. The general measurement approach used for this device was:

- a) The local E field on the measurement surface was measured at a reference location where the field is well above the noise level. This reference level was used at the end of this procedure to assess output power drift of the DUT during the measurement.
- b) The electric field on the measurement surface was scanned. Measurements are conducted according to the instructions provided by the measurement system manufacturer. Measurement spatial resolution can depend on the measured field characteristic and measurement methodology used by the system. The planar scan step size was configured at $\lambda/4$.
- c) For cDASY6, H-field was calculated from the measured E-field using a reconstruction algorithm. As the power density calculation requires knowledge of both amplitude and phase, reconstruction algorithms can also be used to obtain field information from the measured E-field data (e.g. the phase from the amplitude if only the amplitude is measured). H-field and phase data was reconstructed from repeated measurements (three per measurement point) on two measurement planes separated by $\lambda/4$.
- d) The total Peak spatially averaged power density (psPD) distribution on the evaluation surface is determined per the below equation. The spatial averaging area, A , is specified by the applicable exposure limits or regulatory requirements. A circular shape was used.

$$psPD = \frac{1}{2A_{av}} \iint_{A_{av}} || Re\{E \times H^*\} || dA$$

- e) The maximum spatial-average on the evaluation surface is the final quantity to determine compliance against applicable limits.
- f) The local E field reference value, at the same location as step 2, was re-measured after the scan was complete to calculate the power drift. If the drift deviated by more than 5%, the power density test and drift measurements were repeated.

2.4 Reconstruction Algorithm

Computation of the power density in general requires measurement information from the both E-field and H-field amplitudes and phases in the plane of incidence. Reconstruction of these quantities from pseudo-vector E-field measurements is feasible according to the manufacturer, as they are determined via Maxwell's equations. As such, the SPEAG reconstruction approach was based on the Gerchberg-Saxton algorithm, which benefits from the availability of the E-field polarization ellipse information obtained with the EUmmWVx probe.

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3 RF EXPOSURE LIMITS FOR POWER DENSITY

3.1 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.

3.2 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. This 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.

3.3 RF Exposure Limits for Frequencies Above 6 GHz

Per §1.1310 (d)(3), the MPE limits are applied for frequencies above 6 GHz. Power Density is expressed in units of W/m² or mW/cm².

Peak Spatially Averaged Power Density was evaluated over a circular area of 4 cm² per interim FCC Guidance for near-field power density evaluations per October 2018 TCB Workshop notes.

**Table 3-1
Human Exposure Limits Specified in FCC 47 CFR §1.1310**

Human Exposure to Radiofrequency (RF) Radiation Limits		
Frequency Range [MHz]	Power Density [mW/cm ²]	Average Time [Minutes]
(A) Limits For Occupational / Controlled Environments		
1,500 – 100,000	5.0	6
(B) Limits For General Population / Uncontrolled Environments		
1,500 – 100,000	1.0	30

Note: 1.0 mW/cm² is 10 W/m²

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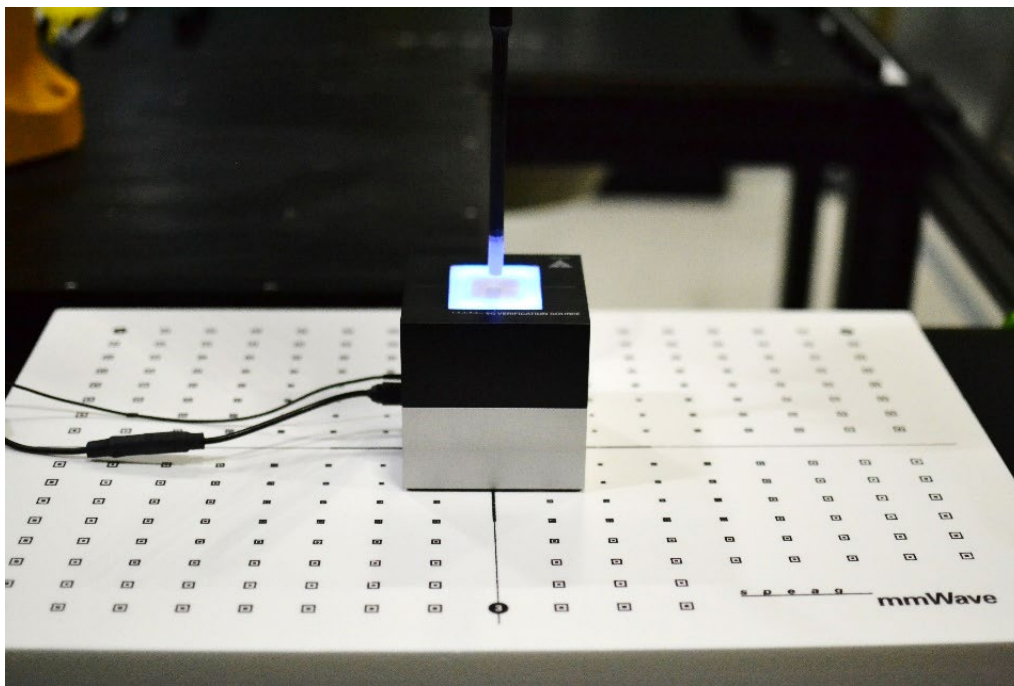
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4 SYSTEM VERIFICATION

4.1 Test System Verification

The system was verified to be within ± 0.66 dB of the power density targets on the calibration certificate according to the test system specification in the user's manual and calibration facility recommendation. The 0.66 dB deviation threshold represents the expanded uncertainty for system performance checks using SPEAG's mmWave verification sources. The same spatial resolution and measurement region used in the source calibration was applied during the system check.

The measured power density distribution of verification source was also confirmed through visual inspection to have no noticeable differences, both spatially (shape) and numerically (level) from the distribution provided by the manufacturer, per November 2017 TCBC Workshop Notes.



**Figure 4-1
System Verification Setup Photo**

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**Table 4-2
30 GHz Verifications**

System Verification											
System	Frequency	Date	Source S/N	Probe S/N	Normal psPD (W/m ² over 4 cm ²)		Deviation (dB)	Total psPD (W/m ² over 4 cm ²)		Deviation (dB)	Plot #
					Measured	Target		Measured	Target		
Q	30	06/06/2022	1045	9364	33.80	32.70	0.14	34.20	32.70	0.19	B1
R	30	06/08/2022	1035	9407	30.00	32.40	-0.33	30.40	32.40	-0.28	
Q	30	06/08/2022	1045	9364	33.40	32.70	0.09	33.80	32.70	0.14	
R	30	06/10/2022	1035	9407	29.80	32.40	-0.36	30.30	32.40	-0.29	B2

Note: A **10 mm distance spacing** was used from the reference horn antenna aperture to the probe element. This includes 4.45 mm from the reference antenna horn aperture to the surface of the verification source plus 5.55 mm from the surface to the probe. The SPEAG software requires a setting of "5.55 mm" for the correct set up.

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5 POWER DENSITY DATA @ INPUT.POWER.LIMIT

5.1 Power Density Results

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 on each worst-surface.

**Table 5-1
5G mmWave NR Band n258 - Closed**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency MHz	Channel	Beam ID 1	Beam ID 2	input.power.limit dBm	Signal Type	DUT S/N	Power Drift	Distance mm	DUT Surface	Normal psPD	Total psPD	Plot #
					V	H				dB			mW/cm ²	mW/cm ²	
n258	K	Patch	25200.00	High	13	-	0.8	CW	VDP0652M	-0.03	2	Front	0.058	0.101	
n258	K	Patch	24350.04	Low	-	146	3.1	CW	VDP0652M	-0.12	2	Front	0.306	0.322	
n258	K	Patch	25200.00	High	19	147	-2.2	CW	VDP0652M	0.11	2	Front	0.084	0.103	
n258	K	Patch	25200.00	High	19	-	0.5	CW	VDP0652M	0.20	2	Left	0.190	0.293	
n258	K	Patch	25200.00	High	-	147	2.5	CW	VDP0652M	-0.04	2	Left	0.262	0.329	A1
n258	K	Patch	25200.00	High	19	147	-2.2	CW	VDP0652M	0.18	2	Left	0.158	0.213	
n258	K	Patch	24350.04	Low	-	146	3.1	CW	VDP0653M	0.00	5	Front	0.291	0.301	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

**Table 5-2
5G mmWave NR Band n258 - Open**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency MHz	Channel	Beam ID 1	Beam ID 2	input.power.limit dBm	Signal Type	DUT S/N	Power Drift	Distance mm	DUT Surface	Normal psPD	Total psPD	Plot #
					V	H				dB			mW/cm ²	mW/cm ²	
n258	K	Patch	25200.00	High	14	-	0.8	CW	VDP0653M	-0.09	2	Back	0.083	0.140	
n258	K	Patch	24350.04	Low	-	146	3.1	CW	VDP0653M	-0.06	2	Back	0.115	0.126	
n258	K	Patch	25200.00	High	19	147	-2.2	CW	VDP0653M	-0.01	2	Back	0.067	0.093	
n258	K	Patch	25200.00	High	19	-	0.5	CW	VDP0653M	-0.20	2	Left	0.232	0.331	
n258	K	Patch	24350.04	Low	-	148	2.7	CW	VDP0653M	0.11	2	Left	0.231	0.351	A2
n258	K	Patch	25200.00	High	15	143	-2.2	CW	VDP0653M	0.17	2	Left	0.151	0.215	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

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**Table 5-3
5G mmWave NR Band n261 - Closed**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency	Channel	Beam ID 1	Beam ID 2	input.power.limit	Signal Type	DUT S/N	Power Drift	Distance	DUT Surface	Normal psPD	Total psPD	Plot #
			MHz		V	H				dBm			dB	mm	
n261	K	Patch	27550.08	Low	14	-	0.0	CW	VDP0652M	0.10	2	Front	0.061	0.074	
n261	K	Patch	27550.08	Low	-	147	2.5	CW	VDP0652M	-0.12	2	Front	0.244	0.301	A3
n261	K	Patch	27924.96	Mid	15	143	-2.9	CW	VDP0652M	-0.09	2	Front	0.043	0.055	
n261	K	Patch	27924.96	Mid	17	-	-0.6	CW	VDP0652M	0.20	2	Left	0.172	0.221	
n261	K	Patch	28299.96	High	-	148	1.9	CW	VDP0652M	0.02	2	Left	0.150	0.243	
n261	K	Patch	28299.96	High	20	148	-3.4	CW	VDP0652M	0.03	2	Left	0.062	0.085	
n261	K	Patch	27550.08	Low	-	143	2.9	CW	VDP0653M	-0.08	5	Front	0.132	0.152	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

**Table 5-4
5G mmWave NR Band n261 - Open**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency	Channel	Beam ID 1	Beam ID 2	input.power.limit	Signal Type	DUT S/N	Power Drift	Distance	DUT Surface	Normal psPD	Total psPD	Plot #
			MHz		V	H				dBm			dB	mm	
n261	K	Patch	27550.08	Low	14	-	0.0	CW	VDP0653M	-0.20	2	Back	0.088	0.117	
n261	K	Patch	27550.08	Low	-	147	2.5	CW	VDP0653M	-0.09	2	Back	0.197	0.262	
n261	K	Patch	27550.08	Low	15	143	-2.9	CW	VDP0653M	-0.10	2	Back	0.045	0.056	
n261	K	Patch	27550.08	Low	17	-	-0.6	CW	VDP0653M	0.11	2	Left	0.200	0.267	A4
n261	K	Patch	28299.96	High	-	148	1.9	CW	VDP0653M	0.20	2	Left	0.172	0.246	
n261	K	Patch	28299.96	High	20	148	-3.4	CW	VDP0653M	0.20	2	Left	0.071	0.095	
n261	K	Patch	27550.08	Low	13	141	-2.5	CW	VDP0653M	0.20	2	Front	0.113	0.145	
n261	K	Patch	27924.96	Mid	13	141	-2.5	CW	VDP0653M	0.13	2	Front	0.096	0.129	
n261	K	Patch	28299.96	High	13	141	-2.5	CW	VDP0653M	-0.05	2	Front	0.088	0.129	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

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**Table 5-5
5G mmWave NR Band n260 - Closed**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency	Channel	Beam ID 1	Beam ID 2	input.power.limit	Signal Type	DUT S/N	Power Drift	Distance	DUT Surface	Normal psPD	Total psPD	Plot #
			MHz		V	H	dBm			dB			mm	mW/cm ²	
n260	K	Patch	38499.96	Mid	15	-	3.2	CW	VDP0652M	-0.08	2	Left	0.201	0.265	
n260	K	Patch	37050.00	Low	-	144	3.3	CW	VDP0652M	-0.16	2	Left	0.222	0.370	A5
n260	K	Patch	38499.96	Mid	17	145	0.1	CW	VDP0652M	0.07	2	Left	0.185	0.217	
n260	K	Patch	37050.00	Low	-	142	4.7	CW	VDP0653M	0.00	5	Front	0.138	0.194	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

**Table 5-6
5G mmWave NR Band n260 - Open**

MEASUREMENT RESULTS															
Band	Module	Antenna Type	Frequency	Channel	Beam ID 1	Beam ID 2	input.power.limit	Signal Type	DUT S/N	Power Drift	Distance	DUT Surface	Normal psPD	Total psPD	Plot #
			MHz		V	H	dBm			dB			mm	mW/cm ²	
n260	K	Patch	38499.96	Mid	15	-	3.2	CW	VDP0653M	0.07	2	Left	0.234	0.300	
n260	K	Patch	37050.00	Low	-	144	3.3	CW	VDP0653M	0.03	2	Left	0.200	0.304	A6
n260	K	Patch	38499.96	Mid	20	148	0.1	CW	VDP0653M	0.15	2	Left	0.135	0.178	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population									Power Density 1 mW/cm ² averaged over 4 cm ²						

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5.2 Power Density Test Notes

General Notes:

1. The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
2. Batteries are fully charged at the beginning of the measurements. The DUT was connected to a wall charger for some measurements due to the test duration. It was confirmed that the charger plugged into this DUT did not impact the near-field PD test results.
3. Power density was calculated by repeated E-field measurements on two measurement planes separated by $\lambda/4$.
4. DUT was configured to transmit with a manufacturer provided test software to control specific antenna(s), Beam ID(s), and signal type to ensure the test configurations constant for the entire evaluation.
5. This device utilizes power reduction for some WLAN/BT wireless modes and technologies for simultaneous transmission compliance. These mechanisms are assessed in the SAR Test Report.
6. *Input.power.limit* parameter for 5G mmW NR radio was calculated in RF Exposure Part 0 test report.
7. 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. Per FCC guidance for devices enabled with Qualcomm® Smart Transmit feature, 4G LTE/5G NR FR1 and 5G mmW NR FR2 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.
8. Per FCC guidance for devices enabled with Qualcomm® 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 (TER) Appendix.
9. The Beam IDs with one of the highest initial simulated power density for that surface and distance was selected for Part 1 Power Density measurements.
10. The device was configured to transmit CW wave signal for testing. Per FCC guidance for devices enabled with Qualcomm® Smart Transmit feature, additional testing was not required for different modulations (CP-OFDM: QPSK, 16QAM, 64QAM, DFT-s-OFDM: PI/2 BPSK, QPSK, 16QAM, 64QAM), RB configurations, component carriers, channel configurations (low channel, mid channel, high channel) since the smart transmit algorithm monitors powers on a per symbol basis, which is independent of these signal characteristics.
11. The device was configured to MIMO configuration with H and V polarization beams transmitting together.
12. When additional sides are tested at a distance further than 2mm, the beam ID with the highest ratio of simulated power density of the tested distance to worst case 2mm was selected for power density measurements for that specific side and distance.
13. Additional power density measurements for open configuration front side at 2mm were evaluated to support TER considerations for head exposure condition. More information is provided in Appendix C.

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6 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
-	WL25-1	Conducted Cable Set (25GHz)	N/A	N/A	N/A	WL25-1
-	WL40-1	Conducted Cable Set (40GHz)	N/A	N/A	N/A	WL40-1
Agilent	N9038A	MXE EMI Receiver	N/A	N/A	N/A	MY51210133
EMCO	3160-09	Small Horn (18 - 26.5GHz)	N/A	N/A	N/A	00135427
Emco	3116	Horn Antenna (18 - 40GHz)	N/A	N/A	N/A	9203-2178
Rohde & Schwarz	SFUNIT-Rx	Shielded Filter Unit	N/A	N/A	N/A	102133
Rohde & Schwarz	FSW67	Signal / Spectrum Analyzer	N/A	N/A	N/A	103200
SPEAG	EUmmWV3	EUmmWV3 Probe	06/21/2021	Annual	06/21/2022	9364
SPEAG	EUmmWV3	EUmmWV3 Probe	12/13/2021	Annual	12/13/2022	9407
SPEAG	SM 003 100 AA	30GHz System Verification Ka- Band Source Antenna	12/07/2021	Annual	12/07/2022	1045
SPEAG	SM 003 100 AA	30GHz System Verification Ka- Band Source Antenna	02/22/2022	Annual	02/22/2023	1035
SPEAG	DAE4ip	Dasy Data Acquisition Electronics	11/11/2021	Annual	11/11/2022	1638
SPEAG	DAE4ip	Dasy Data Acquisition Electronics	01/21/2022	Annual	01/21/2023	1639
Agilent	N9030A	PXA Signal Analyzer (44GHz)	N/A	N/A	N/A	MY52350166
Emco	3115	Horn Antenna (1-18GHz)	N/A	N/A	N/A	9704-5182
Keysight Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	N/A	N/A	N/A	MY49430494
Rohde & Schwarz	180-442-KF	Horn (Small)	N/A	N/A	N/A	U157403-01
Rohde & Schwarz	ESU26	EMI Test Receiver (26.5GHz)	N/A	N/A	N/A	100342
Rohde & Schwarz	SFUNIT-Rx	Shielded Filter Unit	N/A	N/A	N/A	102134
Sunol	JB5	Bi-Log Antenna (30M - 5GHz)	N/A	N/A	N/A	A051107
Virginia Diodes Inc	SAX252	Spectrum Analyzer Extension Module	N/A	N/A	N/A	SAX252
Virginia Diodes Inc	SAX253	Spectrum Analyzer Extension Module	N/A	N/A	N/A	SAX253
Virginia Diodes Inc	SAX254	Spectrum Analyzer Extension Module	N/A	N/A	N/A	SAX254

Note:

1. Each equipment item was used solely within its respective calibration period.

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7 MEASUREMENT UNCERTAINTIES

a	b	c	d	e	f = c x f/e	g	
Uncertainty Component	Unc. (± dB)	Prob. Dist.	Div.	c _i	u _i (± dB)	v _i	
Measurement System							
Calibration	0.49	N	1	1	0.49	∞	
Probe Correction	0.00	R	1.73	1	0.00	∞	
Frequency Response	0.20	R	1.73	1	0.12	∞	
Sensor Cross Coupling	0.00	R	1.73	1	0.00	∞	
Isotropy	0.50	R	1.73	1	0.29	∞	
Linearity	0.20	R	1.73	1	0.12	∞	
Probe Scattering	0.00	R	1.73	1	0.00	∞	
Probe Positioning offset	0.30	R	1.73	1	0.17	∞	
Probe Positioning Repeatability	0.04	R	1.73	1	0.02	∞	
Sensor Mechanical Offset	0.00	R	1.73	1	0.00	∞	
Probe Spatial Resolution	0.00	R	1.73	1	0.00	∞	
Field Impedance Dependence	0.00	R	1.73	1	0.00	∞	
Amplitude and Phase Drift	0.00	R	1.73	1	0.00	∞	
Amplitude and Phase Noise	0.04	R	1.73	1	0.02	∞	
Measurement Area Truncation	0.00	R	1.73	1	0.00	∞	
Data Acquisition	0.03	N	1	1	0.03	∞	
Sampling	0.00	R	1.73	1	0.00	∞	
Field Reconstruction	0.60	R	1.73	1	0.35	∞	
Forward Transformation	0.00	R	1.73	1	0.00	∞	
Power Density Scaling	0.00	R	1.73	1	0.00	∞	
Spatial Averaging	0.10	R	1.73	1	0.06	∞	
System Detection Limit	0.04	R	1.73	1	0.02	∞	
Test Sample Related							
Probe Coupling with DUT	0.00	R	1.73	1	0.00	∞	
Modulation Response	0.40	R	1.73	1	0.23	∞	
Integration Time	0.00	R	1.73	1	0.00	∞	
Response Time	0.00	R	1.73	1	0.00	∞	
Device Holder Influence	0.10	R	1.73	1	0.06	∞	
DUT alignment	0.00	R	1.73	1	0.00	∞	
RF Ambient Conditions	0.04	R	1.73	1	0.02	∞	
Ambient Reflections	0.04	R	1.73	1	0.02	∞	
Immunity/Secondary Reception	0.00	R	1.73	1	0.00	∞	
Drift of DUT	0.21	R	1.73	1	0.12	∞	
Combined Standard Uncertainty (k=1)					RSS	0.76	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)					k=2	1.52	

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8 CONCLUSION

8.1 Measurement Conclusion

The power density measurements and total exposure ratio analysis indicate that the DUT complies with the RF radiation exposure limits of the FCC, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the RF Exposure and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

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- [10] October 2018 Telecommunications Certification Body Council (TCBC) Workshop Notes
- [11] April 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes
- [12] November 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes
- [13] SPEAG DASY6 System Handbook (September 2019)

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