ELEMENT MATERIALS TECHNOLOGY
(Formerly PCTEST)
7185 Oakland Mills Road, Columbia, MD 21046 USA
Tel. +1.410.290.6652 / Fax +1.410.290.6654
http://www.element.com

TOTAL EXPOSURE RATIO EVALUATION REPORT

Applicant Name
Samsung Electronics Co., Ltd.
129, Samsung-ro, Maetan dong,
Yeongtong-gu, Suwon-si
Gyeonggi-do, 16677, Korea

Date of Testing
08/29/2022
Test Site/Location
Element, Columbia, MD, USA
Document Serial No:
1M2208100088-04.A3L

FCC ID:	**A3LSMF721U**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD.**

DUT Type:	Portable Handset
Application Type:	Class II Permissive Change
FCC Rule Part(s):	CFR §2.1093
Model:	SM-F721U
Additional Model(s):	SM-F721U1
Permissive Change(s):	See change document
Date of Original Certification:	07/12/2022

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

ACCREDITED
CERTIFICATE # 2041.01

TABLE OF CONTENTS

1 DEVICE UNDER TEST

1.1 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*.

Table 1-1
Simultaneous Transmission Scenarios

No.	Capable Transmit Configuration	Head	Body-Worn Accessory	Wireless Router	Phablet	Notes
1	LTE + 2.4 GHz WLAN Ant 1 + 5G NR FR2	Yes	Yes	Yes	Yes	
2	LTE + 2.4 GHz WLAN Ant 2 + 5G NR FR2	Yes	Yes	Yes	Yes	
3	LTE + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
4	LTE + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
5	LTE + 2.4 GHz Bluetooth Ant 2 + 5G NR FR2	Yes^	Yes	Yes^	Yes	^ Bluetooth Tethering is considered
6	5G NR FR1 + 2.4 GHz WLAN Ant 1 + 5G NR FR2	Yes	Yes	Yes	Yes	
7	5G NR FR1 + 2.4 GHz WLAN Ant 2 + 5G NR FR2	Yes	Yes	Yes	Yes	
8	5G NR FR1 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
9	5G NR FR1 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO + 5G NR FR2	Yes	Yes	Yes	Yes	
10	5G NR FR1 + 2.4 GHz Bluetooth Ant 2 + 5G NR FR2	Yes^	Yes	Yes^	Yes	^ Bluetooth Tethering is considered

There was no change to FR2 operations in this device. Only simultaneous transmission scenarios added during this C2PC are evaluated in this report. See original certification filing for full simultaneous transmission analysis and PD measurement data.

2 TOTAL EXPOSURE RATIO

2.1 Total Exposure Ratio

The Total Exposure Ratio (TER) is calculated by combining all SAR measurements and power density measurements after normalizing to their respective limits. The general expression is below.

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

The TER shall be less than unity to ensure compliance with the limits.

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

Qualcomm® Smart Transmit algorithm for WWAN adds directly the time-averaged RF exposure from 4G and time-averaged RFexposure from 5G mmW NR. Smart Transmit algorithm controls the total RF exposure from both 4G and 5G mmW NR to not exceed FCC limit. Therefore, per FCC guidance, TER does not need to be evaluated directly for the 4G and 5G simultaneous compliance via summation. The following equations are derived later in Appendix C. The validation of the time-averaging algorithm and compliance under the Tx varying transmission scenario for WWAN technologies are reported in Part 2 report. The report SN could be found in Bibliography section.

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

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

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 device uncertainty. For this device, the manufacturer has added an additional permanent back-off (indicated below as WWAN backoff) for every beam in the calculations for input.power.limits used in the EFS file. The back-off levels can be found in the Part 0 Test report. Therefore, 5G mmW NR RF exposure for this DUT is evaluated by reported psPD calculated as:

$$reported\_psPD = (PD\_design\_target + PD\_uncertainty) \times 10^{(-WWAN\ backoff\ in\ dB)/10}$$

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* + *PD_uncertainty* uncertainty, *reported_psPD* is computed based on this worst-case psPD as shown above.

The compliance analysis for simultaneous transmission scenarios of WWAN (4G LTE & 5G mmW NR) with Smart Transmit and 4G & WLAN can be found in two reports indicated in the table below. This appendix demonstrates compliance for the 5G + WLAN scenarios. The report SNs can be found in Bibliography section.

	Simultaneous Scenario	**Evaluation Report**
1.	4G LTE WWAN + WLAN	FCC SAR Evaluation Report (Part 1)
2.	4G LTE WWAN + 5G mmW NR WWAN	RF Exposure Part 2 Test Report

RF exposure compliance with 5G mmW NR WWAN+WLAN simultaneous transmission scenarios is demonstrated for various radio configurations below.

Note that the above *reported psPD* applies to the worst-case surfaces of the DUT at 2mm evaluation distance.

Worst-case PD on other surfaces of the DUT are calculated from simulated PD data (see Power Density Simulation Report), by multiplying reported psPD with the highest proportion out of all beams and out of all three channels in each band, where the adjustment for each beam/channel is computed as the proportion of “simulated PD on desired surface” to “simulated PD on worst-surface”. For example, to determine worst-case PD on front surface (needed for Head RF Exposure evaluation during simultaneous transmission), highest proportion of (simulated PD on front surface)/(simulated PD on worst surface) was determined out of all supported beams and out of all three channels by the DUT in each band.

In some cases, the simulation vs measurement for some surfaces can exceed the device's total uncertainty. In those cases, if the measured psPD > simulated adjusted psPD (assuming a linear congruency of the psPD across surfaces), then measured psPD should be used towards the simultaneous TX analysis. Table C-1 lists the relevant worst-case reported psPD values based on the additional surfaces and evaluation distances needed to perform the TER analysis. The highest of the adjusted Reported_psPD and Measured Total psPD was chosen for TER analysis and the chosen values are indicated by bolded psPD values.

Table 2-1
5G mmW NR FR2 psPD - Closed

NR Band	Antenna	Surface	Evaluation Distance (mm)	Adjustment Factor due to Simulation	Adjusted Reported psPD (mW/cm²)	Measured Total psPD (mW/cm²)	Final Reported psPD (mW/cm²)
n258	K	Back	2	0.294	0.233	0.022	**0.233**
n258	K	Front	2	1.000	0.794	0.322	**0.794**
n258	K	Top	2	0.147	0.117	0.081	**0.117**
n258	K	Bottom	2	0.059	0.047	-	**0.047**
n258	K	Right	2	0.085	0.067	-	**0.067**
n258	K	Left	2	1.000	0.794	0.329	**0.794**
n261	K	Back	2	0.344	0.273	0.005	**0.273**
n261	K	Front	2	0.960	0.763	0.349	**0.763**
n261	K	Top	2	0.151	0.120	0.054	**0.120**
n261	K	Bottom	2	0.081	0.065	-	**0.065**
n261	K	Right	2	0.085	0.068	-	**0.068**
n261	K	Left	2	1.000	0.794	0.243	**0.794**
n260	K	Back	2	0.266	0.211	0.003	**0.211**
n260	K	Front	2	0.712	0.565	-	**0.565**
n260	K	Top	2	0.195	0.155	0.087	**0.155**
n260	K	Bottom	2	0.083	0.066	-	**0.066**
n260	K	Right	2	0.077	0.061	-	**0.061**
n260	K	Left	2	1.000	0.794	0.370	**0.794**
n258	K	Front	5	0.803	0.638	0.301	**0.638**
n261	K	Front	5	0.696	0.553	0.152	**0.553**
n260	K	Front	5	0.536	0.426	0.194	**0.426**

Note: 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.

Table 2-2
5G mmW NR FR2 psPD - Open

NR Band	Antenna	Surface	Evaluation Distance (mm)	Adjustment Factor due to Simulation	Adjusted Reported psPD (mW/cm²)	Measured Total psPD (mW/cm²)	Final Reported psPD (mW/cm²)
n258	K	Back	2	1.000	0.794	0.140	**0.794**
n258	K	Front	2	0.597	0.475	0.136	**0.475**
n258	K	Top	2	0.057	0.045	-	**0.045**
n258	K	Bottom	2	0.011	0.008	-	**0.008**
n258	K	Right	2	0.065	0.052	-	**0.052**
n258	K	Left	2	1.000	0.794	0.351	**0.794**
n261	K	Back	2	1.000	0.794	0.590	**0.794**
n261	K	Front	2	0.674	0.535	0.145	**0.535**
n261	K	Top	2	0.074	0.059	-	**0.059**
n261	K	Bottom	2	0.022	0.017	-	**0.017**
n261	K	Right	2	0.042	0.033	-	**0.033**
n261	K	Left	2	1.000	0.794	0.267	**0.794**
n260	K	Back	2	0.727	0.578	0.212	**0.578**
n260	K	Front	2	0.643	0.511	0.233	**0.511**
n260	K	Top	2	0.072	0.058	-	**0.058**
n260	K	Bottom	2	0.025	0.020	-	**0.020**
n260	K	Right	2	0.107	0.085	-	**0.085**
n260	K	Left	2	1.000	0.794	0.304	**0.794**

Note: 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.

Note: Additional beams with highest adjustment factors for n261 Antenna K were evaluated at 2mm front side to show that measured psPD is lower than adjusted reported psPD for those specific beams. The worst-case adjustment factor due to simulation of the non-selected beams was used in the above table for n261 Antenna K (Front).

Table 2-3
5G mmW NR FR2 Head Total Exposure Ratio - Open

		NR FR2	2.4 GHz WLAN Ant 1 Reported SAR	2.4 GHz WLAN Ant 2 Reported SAR	Bluetooth Ant 2 Reported SAR	5 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Ant 1	NR FR2 + 2.4 GHz WLAN Ant 2	NR FR2 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO	NR FR2 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO	NR FR2 + Bluetooth Ant 2
			12.0 dBm	12.0 dBm	10.5 dBm	13.0 dBm					
		mW/cm²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1 + 2	1 + 3	1 + 2 +5	1 + 3 + 5	1 + 4
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0
Front Side	Reported Value	0.535	0.191	0.258	0.253	0.276					
	Ratio to Limit	0.535	0.119	0.161	0.158	0.173	0.654	0.696	0.827	0.869	0.693

Table 2-4
5G mmW NR FR2 Body-Worn Total Exposure Ratio – Closed

		NR FR2	2.4 GHz WLAN Ant 1 Reported SAR	2.4 GHz WLAN Ant 2 Reported SAR	Bluetooth Ant 2 Reported SAR	5 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Ant 1	NR FR2 + 2.4 GHz WLAN Ant 2	NR FR2 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO	NR FR2 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO	NR FR2 + Bluetooth Ant 2
			18.0 dBm	18.0 dBm	16.5 dBm	20.0 dBm					
		mW/cm²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1 + 2	1 + 3	1 + 2 +5	1 + 3 + 5	1 + 4
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.273	0.040	0.039	0.017	0.032					
	Ratio to Limit	0.273	0.025	0.024	0.011	0.020	0.298	0.297	0.318	0.317	0.284

Table 2-5
5G mmW NR FR2 Body-Worn Total Exposure Ratio - Open

		NR FR2	2.4 GHz WLAN Ant 1 Reported SAR	2.4 GHz WLAN Ant 2 Reported SAR	Bluetooth Ant 2 Reported SAR	5 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Ant 1	NR FR2 + 2.4 GHz WLAN Ant 2	NR FR2 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO	NR FR2 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO	NR FR2 + Bluetooth Ant 2
			18.0 dBm	18.0 dBm	16.5 dBm	20.0 dBm					
		mW/cm²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1 + 2	1 + 3	1 + 2 +5	1 + 3 + 5	1 + 4
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.794	0.074	0.084	0.041	0.115					
	Ratio to Limit	0.794	0.046	0.053	0.026	0.072	0.840	0.847	0.912	0.918	0.820

Table 2-6
5G mmW NR FR2 Hotspot Total Exposure Ratio – Closed

		NR FR2	2.4 GHz WLAN Ant 1 Reported SAR	2.4 GHz WLAN Ant 2 Reported SAR	Bluetooth Ant 2 Reported SAR	5 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Ant 1	NR FR2 + 2.4 GHz WLAN Ant 2	NR FR2 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO	NR FR2 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO	NR FR2 + Bluetooth Ant 2
			12.0 dBm	12.0 dBm	16.5 dBm	13.0 dBm					
		mW/cm²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1 + 2	1 + 3	1 + 2 +5	1 + 3 + 5	1 + 4
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.273	0.034	0.125	0.065	0.084					
	Ratio to Limit	0.273	0.021	0.078	0.041	0.053	0.294	0.351	0.347	0.404	0.314
Front Side	Reported Value	0.638	0.063	0.125	0.312	0.084					
	Ratio to Limit	0.638	0.039	0.078	0.195	0.053	0.677	0.716	0.730	0.769	0.833
Top Edge	Reported Value	0.155	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.155	0.000	0.000	0.000	0.000	0.155	0.155	0.155	0.155	0.155
Bottom Edge	Reported Value	0.066	0.092	0.125	0.179	0.084					
	Ratio to Limit	0.066	0.058	0.078	0.112	0.053	0.124	0.144	0.176	0.197	0.178
Right Edge	Reported Value	0.068	0.126	0.125	0.056	0.084					
	Ratio to Limit	0.068	0.079	0.078	0.035	0.053	0.147	0.146	0.199	0.199	0.103
Left Edge	Reported Value	0.794	0.126	0.000	0.000	0.084					
	Ratio to Limit	0.794	0.079	0.000	0.000	0.053	0.873	0.794	0.925	0.847	0.794

Table 2-7
5G mmW NR FR2 Hotspot Total Exposure Ratio - Open

		NR FR2	2.4 GHz WLAN Ant 1 Reported SAR	2.4 GHz WLAN Ant 2 Reported SAR	Bluetooth Ant 2 Reported SAR	5 GHz WLAN MIMO Reported SAR	NR FR2 + 2.4 GHz WLAN Ant 1	NR FR2 + 2.4 GHz WLAN Ant 2	NR FR2 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO	NR FR2 + 2.4 GHz WLAN Ant 2 + 5 GHz WLAN MIMO	NR FR2 + Bluetooth Ant 2
			18.0 dBm	18.0 dBm	16.5 dBm	13.0 dBm					
		mW/cm²	W/kg	W/kg	W/kg	W/kg					
		1	2	3	4	5	1 + 2	1 + 3	1 + 2 +5	1 + 3 + 5	1 + 4
Applicable Limit		1.0	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0	1.0
Back Side	Reported Value	0.794	0.128	0.189	0.092	0.013					
	Ratio to Limit	0.794	0.080	0.118	0.058	0.008	0.874	0.912	0.882	0.920	0.852
Front Side	Reported Value	0.535	0.169	0.189	0.077	0.013					
	Ratio to Limit	0.535	0.106	0.118	0.048	0.008	0.641	0.653	0.649	0.661	0.583
Top Edge	Reported Value	0.059	0.068	0.189	0.093	0.013					
	Ratio to Limit	0.059	0.043	0.118	0.058	0.008	0.102	0.177	0.110	0.185	0.117
Bottom Edge	Reported Value	0.020	0.000	0.000	0.000	0.000					
	Ratio to Limit	0.020	0.000	0.000	0.000	0.000	0.020	0.020	0.020	0.020	0.020
Right Edge	Reported Value	0.085	0.295	0.052	0.032	0.013					
	Ratio to Limit	0.085	0.184	0.033	0.020	0.008	0.269	0.118	0.278	0.126	0.105
Left Edge	Reported Value	0.794	0.295	0.000	0.000	0.013					
	Ratio to Limit	0.794	0.184	0.000	0.000	0.008	0.978	0.794	0.987	0.802	0.794

Notes:

1. Worst-case power density results for each test configuration among all antenna arrays and among all supported bands were considered for TER analysis.
2. If test positions were not required to be evaluated for WLAN SAR per FCC KDB publication 248227, the worst-case WLAN SAR result for the applicable exposure conditions was used for simultaneous transmission analysis. Any such values are indicated in the above tables in blue.
3. If Part 1 SAR report does not include standalone WLAN MIMO results, then per KDB Publication 248227 D01v02r02, SAR for MIMO was evaluated by following the simultaneous SAR provisions from KDB Publication 447498 D01v06 by evaluating the sum of the 1g SAR values of each antenna transmitting independently. Any such values are indicated in the above tables in green.
4. When additional sides were tested at a distance greater than 2mm for hotspot and body-worn configurations, those power density results were used for TER. Otherwise, power density results at 2mm were considered as a more conservative evaluation.
5. Per FCC guidance, the bands/modes that are not required to be evaluated for Phablet SAR are not considered for TER analysis.
6. Worst-case front side reported psPD was considered for Head TER analysis.
7. The worst-case between Adjusted Reported_psPD and Measured Total psPD was chosen for TER analysis. The bolded psPD values in Table C-1 and Table C-2 indicate the worst-case Reported psPD used in TER analysis.
8. In WLAN MIMO operations, each antenna transmits at target powers to achieve the MIMO target powers as indicated above.
9. 4G LTE terms in the introduction and equation derivation equally apply to NR FR1.

The above numerical summed PD and SAR for all the worst-case simultaneous transmission conditions were below the Total Exposure Ratio. Therefore, the above analysis is sufficient to determine no further test cases are required and that simultaneous transmission is compliant to the FCC RF Exposure Limit.

2.1 Mathematical Derivation of TER Compliance

$$Total\ Normalized\ RFx\ =\ Normalized\ RFx_{\ Time\ Averaged\ WWAN} + Normalized\ RFx_{\ WLAN}\ \leq\ 1.0 \quad (1)$$

Since WWAN Smart Transmit algorithm adds directly the time-averaged RF exposure from 4G and time-averaged RF exposure from 5G mmW NR, per chipset manufacturer's guidance, Normalized RF exposure from 4G and from 5G mmW NR could be assumed as

$$Normalized\ RFx_{\ Time\ Averaged\ WWAN} = \frac{4G\ SAR}{4G\ SAR\ Limit} + \frac{5G\ mmW\ NR\ psPD}{5G\ mmW\ NR\ psPD\ Limit} \leq 1.0 \quad (2)$$

Smart Transmit algorithm assumes that 4G and 5G mmW NR hotspots are co-located and therefore:

$$Time\ Averaged\ WWAN = [\ x(t) \times A] + [(1\text{-}x(t)) \times B] \leq 1.0\ Normalized\ Limit \quad (3)$$

A = Max normalized time-averaged SAR exposure from 4G
B = Max normalized time-averaged PD exposure from 5G mmW NR

x(t) = Ranges between [0,1]
x(t)× A = Percentage of normalized time-averaged RF exposure from 4G
(1-x(t))× B = Remaining percentage of RF exposure contribution from 5G mmW NR

Smart Transmit controls "*x*" in real time such that the sum of these exposures never exceeds 1.0 Normalized Limit. If the equations below (4a, 4b) are proven, then, mathematically equation (5) would be proven.

$$A\ +\ norm.\ SAR\ from\ WLAN \leq 1.0\ normalized\ limit \quad (4a)$$

$$B\ +\ norm.\ SAR\ from\ WLAN \leq 1.0\ normalized\ limit \quad (4b)$$

$$[x(t)\times A] + [(1-x(t))\times B] +\ norm.\ SAR\ from\ WLAN \leq 1.0\ normalized\ limit \quad (5)$$

Without 5G mmW NR, Smart Transmit limits the maximum RF exposure contributed from 4G to 100% normalized exposure. For this device, the manufacturer has added an additional permanent back-off (indicated below as WWAN backoff) for every beam in the calculations for input.power.limits used in the EFS file. Therefore,

$$Smart\ Tx\ WWAN:\ A = max\ (normalized\ SAR\ exposure\ from\ 4G) \leq 1.0\ normalized\ limit \quad (6a)$$

$$Smart\ Tx\ WWAN:\ B = max\ (normalized\ PD\ exposure\ from\ 5G\ mmW\ NR) x 10^{(-WWAN\ backoff\ in\ dB)/10} \leq 1.0\ normalized\ limit \quad (6b)$$

To demonstrate simultaneous transmission compliance in equation (1), below equations (7a & 7b) obtained by combining equations (4a & 4b) and (6a & 6b), should be proven for simultaneous transmission compliance:

$$Total\ Normalized\ RFx\ =\ Normalized\ SAR_{\ 4G\ WWAN} + Normalized\ SAR_{\ WLAN} < 1.0 \quad (7a)$$

$$Total\ Normalized\ RFx\ =\ 10^{(-WWAN\ backoff\ in\ dB)/10} x\ Normalized\ psPD_{\ 5G\ mmW\ NR\ WWAN} + Normalized\ SAR_{\ WLAN} < 1.0 \quad (7b)$$

which are re-written as:

$$Total\ Normalized\ RFx\ =\ \frac{4G\ SAR}{4G\ SAR\ Limit} + \frac{WLAN\ SAR}{WLAN\ SAR\ Limit} < 1 \quad (8a)$$

$$Total\ Normalized\ RFx\ =\ 10^{(-WWAN\ backoff\ in\ dB)/10} * \frac{5G\ mmW\ NR\ psPD}{5G\ mmW\ NR\ psPD\ Limit} + \frac{WLAN\ SAR}{WLAN\ SAR\ Limit} < 1 \quad (8b)$$

Analysis for equation (8a) is performed in Appendix D of FCC SAR Evaluation Report (Part 1). Analysis for equation (8b) is performed in this appendix.

3 CONCLUSION

3.1 Measurement Conclusion

The 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.

4 REFERENCES

[1] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.

[2] IEC/IEEE 63195-1:2022, Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz)

[3] IEC TR 62630 : 2010, Guidance for Evaluating Exposure from Multiple Electromagnetic Sources

[4] K. Pokovic, T. Schmid, J. Frohlich, and N. Kuster. Novel Probes and Evaluation Procedures to Assess Field Magnitude and Polarization. IEEE Transactions on Electromagnetic Compatibility 42(2): 240 -244, 2000

[5] R. W. Gerchberg and W. O. Saxton. A Practical Algorithm for the Determination of Phase from Image and Diffraction Plane Pictures. Optik 35(2): 237 – 246, 1972

[6] A. P. Anderson and S. Sali. New Possibilities for Phaseless Microwave Diagnostics. Part 1: Error Reduction Techniques. IEE Proceedings H – Microwaves, Antennas and Propagation 132(5): 290 – 298, 1985

[7] FCC KDB 865664 D02 v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[8] FCC KDB 447498 D01 v02r01: RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[9] November 2017 Telecommunications Certification Body Council (TCBC) Workshop Notes

[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)