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PART 0 SAR CHAR REPORT

Applicant Name:
Apple, Inc.
One Apple Park Way
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Date of Testing:
02/15/2021 – 03/15/2021
Test Site/Location:
PCTEST Lab, Morgan Hill, CA, USA
Document Serial No.:
1C2101020003-34.BCG

FCC ID:	**BCGA2459**
APPLICANT:	**APPLE, INC.**

Report Type:	Part 0 SAR Characterization
DUT Type:	Tablet Device
Model(s):	A2459, A2460
Reference FCC ID:	BCGA2301

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.

Randy Ortanez
President

ACCREDITED
CERT #2041.02

REV 1.0
06/01/2019

TABLE OF CONTENTS

1 DEVICE UNDER TEST 3
1.1 Device Overview 3
1.2 Data Referencing 4
1.3 Time-Averaging for SAR 5
1.4 Nomenclature for Part 0 Report 5
1.5 Bibliography 5
2 SAR AND POWER DENSITY MEASUREMENTS 6
2.1 SAR Definition 6
2.2 SAR Measurement Procedure 6
3 SAR CHARACTERIZATION 8
3.1 DSI and SAR Determination 8
3.2 SAR Design Target 8
3.3 SAR Char 9
4 EQUIPMENT LIST 11
5 MEASUREMENT UNCERTAINTIES 12

APPENDIX A: SAR TEST RESULTS FOR P_{Limit} CALCULATIONS

1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
GPRS/EDGE 850	Data	824.20 - 848.80 MHz
GPRS/EDGE 1900	Data	1850.20 - 1909.80 MHz
UMTS 850	Data	826.40 - 846.60 MHz
UMTS 1750	Data	1712.4 - 1752.6 MHz
UMTS 1900	Data	1852.4 - 1907.6 MHz
LTE Band 71	Data	665.5 - 695.5 MHz
LTE Band 12	Data	699.7 - 715.3 MHz
LTE Band 17	Data	706.5 - 713.5 MHz
LTE Band 13	Data	779.5 - 784.5 MHz
LTE Band 14	Data	790.5 - 795.5 MHz
LTE Band 26 (Cell)	Data	814.7 - 848.3 MHz
LTE Band 5 (Cell)	Data	824.7 - 848.3 MHz
LTE Band 4 (AWS)	Data	1710.7 - 1754.3 MHz
LTE Band 66 (AWS)	Data	1710.7 - 1779.3 MHz
LTE Band 2 (PCS)	Data	1850.7 - 1909.3 MHz
LTE Band 25 (PCS)	Data	1850.7 - 1914.3 MHz
LTE Band 30	Data	2307.5 - 2312.5 MHz
LTE Band 7	Data	2502.5 - 2567.5 MHz
LTE Band 41	Data	2498.5 - 2687.5 MHz
LTE Band 48	Data	3552.5 - 3697.5 MHz
NR Band n71	Data	665.5 - 695.5 MHz
NR Band n12	Data	701.5 - 713.5 MHz
NR Band n5 (Cell)	Data	826.5 - 846.5 MHz
NR Band n66 (AWS)	Data	1712.5 - 1777.5 MHz
NR Band n25 (PCS)	Data	1852.5 - 1912.5 MHz
NR Band n2 (PCS)	Data	1852.5 - 1907.5 MHz
NR Band n41	Data	2506.02 - 2679.99 MHz
NR Band n77	Data	3710.01 - 3969.99 MHz
2.4 GHz WLAN	Voice/Data	2412 - 2472 MHz
U-NII-1	Voice/Data	5180 - 5240 MHz
U-NII-2A	Voice/Data	5260 - 5320 MHz
U-NII-2C	Voice/Data	5500 - 5720 MHz
U-NII-3	Voice/Data	5745 - 5825 MHz
Bluetooth	Data	2402 - 2480 MHz

This device uses the Qualcomm® Smart Transmit feature to control and manage transmitting power in real time and to ensure the time-averaged RF exposure is in compliance with the FCC requirement at all times for 2G/3G/4G/5G WWAN operations. Additionally, this device supports WLAN/BT technologies, but the output power of these modems is not controlled by the Smart Transmit algorithm.

1.2 Data Referencing

Mode:	Reference FCC ID: BCGA2301	Variant FCC ID: BCGA2459
GPRS/EDGE 850 Ant 1	Fully Evaluated	Referenced
GPRS/EDGE 1900 Ant 1	Fully Evaluated	Referenced
UMTS 850 Ant 1	Fully Evaluated	Referenced
UMTS 1750 Ant 1	Fully Evaluated	Referenced
UMTS 1900 Ant 1	Fully Evaluated	Referenced
LTE Band 71 Ant 1	Fully Evaluated	Referenced
LTE Band 12 Ant 1	Fully Evaluated	Referenced
LTE Band 13 Ant 1	Fully Evaluated	Referenced
LTE Band 14 Ant 1	Fully Evaluated	Referenced
LTE Band 26 (Cell) Ant 1	Fully Evaluated	Referenced
LTE Band 5 (Cell) Ant 1	Fully Evaluated	Referenced
LTE Band 66 (AWS) Ant 1	Fully Evaluated	Referenced
LTE Band 25 (PCS) Ant 1	Fully Evaluated	Referenced
LTE Band 30 Ant 1	Fully Evaluated	Referenced
LTE Band 7 Ant 1	Fully Evaluated	Referenced
LTE Band 41 Ant 1	Fully Evaluated	Referenced
LTE Band 48 Ant 1	Fully Evaluated	Referenced
NR Band n71 Ant 1	Fully Evaluated	Referenced
NR Band n12 Ant 1	Fully Evaluated	Referenced
NR Band n5 Ant 1	Fully Evaluated	Referenced
NR Band n66 Ant 1	Fully Evaluated	Referenced
NR Band n25 Ant 1	Fully Evaluated	Referenced
NR Band n41 Ant 1	Fully Evaluated	Referenced
NR Band n77 Ant 1	Fully Evaluated	Referenced
GPRS/EDGE 850 Ant 3	Fully Evaluated	Referenced
GPRS/EDGE1900 Ant 3	Fully Evaluated	Referenced
UMTS 850 Ant 3	Fully Evaluated	Referenced
UMTS 1750 Ant 3	Fully Evaluated	Referenced
UMTS 1900 Ant 3	Fully Evaluated	Referenced
LTE Band 71 Ant 3	Fully Evaluated	Referenced
LTE Band 12 Ant 3	Fully Evaluated	Referenced
LTE Band 13 Ant 3	Fully Evaluated	Referenced
LTE Band 14 Ant 3	Fully Evaluated	Referenced
LTE Band 26 (Cell) Ant 3	Fully Evaluated	Referenced
LTE Band 5 (Cell) Ant 3	Fully Evaluated	Referenced
LTE Band 66 (AWS) Ant 3	Fully Evaluated	Referenced
LTE Band 25 (PCS) Ant 3	Fully Evaluated	Referenced
LTE Band 30 Ant 3	Fully Evaluated	Referenced
LTE Band 7 Ant 3	Fully Evaluated	Referenced
LTE Band 41 Ant 3	Fully Evaluated	Referenced
LTE Band 48 Ant 3	Fully Evaluated	Referenced
NR Band n71 Ant 3	Fully Evaluated	Referenced
NR Band n12 Ant 3	Fully Evaluated	Referenced
NR Band n5 Ant 3	Fully Evaluated	Referenced
NR Band n66 Ant 3	Fully Evaluated	Referenced
NR Band n25 Ant 3	Fully Evaluated	Referenced
NR Band n41 Ant 3	Fully Evaluated	Referenced
NR Band n77 Ant 3	Fully Evaluated	Referenced
GPRS/EDGE 1900 Ant 2b	Fully Evaluated	Referenced
UMTS 1750 Ant 2b	Fully Evaluated	Referenced
UMTS 1900 Ant 2b	Fully Evaluated	Referenced
LTE Band 66 (AWS) Ant 2b	Fully Evaluated	Referenced
LTE Band 25 (PCS) Ant 2b	Fully Evaluated	Referenced
LTE Band 30 Ant 2b	Fully Evaluated	Referenced
LTE Band 7 Ant 2b	Fully Evaluated	Referenced
LTE Band 41 Ant 2b	Fully Evaluated	Referenced
NR Band n66 Ant 2b	Fully Evaluated	Referenced
NR Band n25 Ant 2b	Fully Evaluated	Referenced
NR Band n41 Ant 2b	Fully Evaluated	Referenced
LTE Band 48 Ant 2a	Fully Evaluated	Referenced
NR Band n77 Ant 2a	Fully Evaluated	Referenced
GPRS/EDGE 1900 Ant 4b	Fully Evaluated	Referenced
UMTS 1750 Ant 4b	Fully Evaluated	Referenced
UMTS 1900 Ant 4b	Fully Evaluated	Referenced
LTE Band 66 (AWS) Ant 4b	Fully Evaluated	Referenced
LTE Band 25 (PCS) Ant 4b	Fully Evaluated	Referenced
LTE Band 30 Ant 4b	Fully Evaluated	Referenced
LTE Band 7 Ant 4b	Fully Evaluated	Referenced
LTE Band 41 Ant 4b	Fully Evaluated	Referenced
NR Band n66 Ant 4b	Fully Evaluated	Referenced
NR Band n25 Ant 4b	Fully Evaluated	Referenced
NR Band n41 Ant 4b	Fully Evaluated	Referenced
LTE Band 48 Ant 4a	Fully Evaluated	Fully Evaluated
NR Band n77 Ant 4a	Fully Evaluated	Fully Evaluated
2.4 GHz WLAN Ant 2a	Fully Evaluated	Referenced
2.4 GHz WLAN Ant 4a	Fully Evaluated	Fully Evaluated
5 GHz WLAN Ant 4b	Fully Evaluated	Referenced
5 GHz WLAN Ant 5b	Fully Evaluated	Referenced
Bluetooth Ant 2a	Fully Evaluated	Referenced
Bluetooth Ant 4a	Fully Evaluated	Fully Evaluated

Per manufacturer declaration, there are two tablet devices FCC ID: BCGA2301 and FCC ID: BCGA2459, with high degree of similarity, reference model FCC ID: BCGA2301 and variant model FCC ID: BCGA2459. The reference model supports mmWave operations, while the variant model has the mmWave components/antennas removed. Both models share the same material, form factor, circuit design, and components, including antennas and their locations. The reference and variant models use the same material, form factor, circuit design, and components, including antennas and their locations. The reference and variant models use the same power tables and have same tune-up tolerances.

Per FCC Approved Data Referencing Test Plan, testing was done fully on the reference model FCC ID: BCGA2301, while spot-check verification has been performed on variant model FCC ID: BCGA2459. Additionally, due to Antenna 4a location being close to the depopulated mmWave component, full testing has been done for all supported technologies on Antenna 4a. Please see RF exposure Technical report S/N: 1C2101020002-34.BCG (Rev 1) for complete compliance characterization for the reference model.

1.3 Time-Averaging for SAR

This device is enabled with Qualcomm® Smart Transmit algorithm to control and manage transmitting power in real time and to ensure that the time-averaged RF exposure from 2G/3G/4G/5G Sub-6 NR WWAN is in compliance with FCC requirements. This Part 0 report shows SAR characterization of WWAN radios for 2G/3G/4G/5G Sub-6 NR. Characterization is achieved by determining P_{Limit} for 2G/3G/4G/5G Sub-6 NR that corresponds to the exposure design targets after accounting for all device design related uncertainties, i.e., SAR_design_target (< FCC SAR limit) for sub-6 radio. The SAR characterization is denoted as SAR Char in this report. Section 1.3 includes a nomenclature of the specific terms used in this report.

The compliance test under the static transmission scenario and simultaneous transmission analysis are reported in Part 1 report. The validation of the time-averaging algorithm and compliance under the dynamic (time- varying) transmission scenario for WWAN technologies are reported in Part 2 report (report SN could be found in Section 1.4 – Bibliography).

1.4 Nomenclature for Part 0 Report

Technology	Term	Description
2G/3G/4G/5G Sub-6 NR	P_{limit}	Power level that corresponds to the exposure design target (*SAR_design_target)* after accounting for all device design related uncertainties
	P_{max}	Maximum tune up output power
	SAR_design_target	Target SAR level < FCC SAR limit after accounting for all device design related uncertainties
	SAR Char	Table containing *Plimit* for all technologies and bands

1.5 Bibliography

Report Type	Report Serial Number
FCC SAR Evaluation Report (Part 1)	1C2101020003-01.BCG
RF Exposure Part 2 Test Report	1C2101020003-19.BCG
RF Exposure Compliance Summary	1C2101020003-20.BCG

2 SAR AND POWER DENSITY MEASUREMENTS

2.1 SAR Definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Equation 2-1).

Equation 2-1
SAR Mathematical Equation

$$SAR = \frac{d}{dt}\left(\frac{dU}{dm}\right) = \frac{d}{dt}\left(\frac{dU}{\rho dv}\right)$$

SAR is expressed in units of Watts per Kilogram (W/kg).

$$SAR = \frac{\sigma \cdot E^2}{\rho}$$

where:

σ	=	conductivity of the tissue-simulating material (S/m)
ρ	=	mass density of the tissue-simulating material (kg/m^3)
E	=	Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relation to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.[6]

2.2 SAR Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See
2. Table 2-1) and IEEE 1528-2013.
3. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.

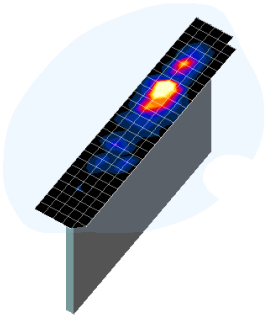

Figure 2-1
Sample SAR Area Scan

4. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 2 1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):
   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in
   b. Table 2-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).

   c. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.

   d. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
5. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

Table 2-1
Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04*

Frequency	Maximum Area Scan Resolution (mm) (Δx_{area}, Δy_{area})	Maximum Zoom Scan Resolution (mm) (Δx_{zoom}, Δy_{zoom})	Maximum Zoom Scan Spatial Resolution (mm)			Minimum Zoom Scan Volume (mm) (x,y,z)
			Uniform Grid	Graded Grid		
			$\Delta z_{zoom}(n)$	$\Delta z_{zoom}(1)$*	$\Delta z_{zoom}(n>1)$*	
≤ 2 GHz	≤ 15	≤ 8	≤ 5	≤ 4	≤ 1.5*Δz_{zoom}(n-1)	≥ 30
2-3 GHz	≤ 12	≤ 5	≤ 5	≤ 4	≤ 1.5*Δz_{zoom}(n-1)	≥ 30
3-4 GHz	≤ 12	≤ 5	≤ 4	≤ 3	≤ 1.5*Δz_{zoom}(n-1)	≥ 28
4-5 GHz	≤ 10	≤ 4	≤ 3	≤ 2.5	≤ 1.5*Δz_{zoom}(n-1)	≥ 25
5-6 GHz	≤ 10	≤ 4	≤ 2	≤ 2	≤ 1.5*Δz_{zoom}(n-1)	≥ 22

*Also compliant to IEEE 1528-2013 Table 6

3 SAR CHARACTERIZATION

3.1 DSI and SAR Determination

This device uses different Device State Index (DSI) to configure different time averaged power levels based on certain exposure scenarios. Depending on the detection scheme implemented in the tablet, the worst-case SAR was determined by measurements for the relevant exposure conditions for that DSI. Detailed descriptions of the detection mechanisms are included in the operational description.

The device state index (DSI) conditions used in Table 3-1 represent different exposure scenarios.

Table 3-1
DSI and Corresponding Exposure Scenarios

Scenario	Description	SAR Test Cases
(DSI = 1)	▪ Detect Mode Activated	*Tablet SAR per KDB Publication 616217 D04*

3.2 SAR Design Target

SAR_design_target is determined by ensuring that it is less than FCC SAR limit after accounting for total device designed related uncertainties specified by the manufacturer (see Table 3-2).

Table 3-2
***SAR_design_target* Calculations**

SAR_design_target	
$SAR\_design\_target < SAR\_regulatory\_limit \times 10^{\frac{-Total\ Uncertainty}{10}}$	
1g SAR (W/kg)	
Total Uncertainty	1.0 dB
SAR_regulatory_limit	1.6 W/kg
SAR_design_target	0.8 W/kg

3.3 SAR Char

SAR test results corresponding to *Pmax* for each antenna/technology/band/DSI can be found in Appendix A.

Plimit is calculated by linearly scaling with the measured SAR at the Ppart0 to correspond to the *SAR_design_target*. When *Plimit* < *Pmax*, *Ppart0* was used as Plimit in the Smart Transmit EFS. When *Plimit* > *Pmax* and *Ppart0*=Pmax, calculated *Plimit* was used in the Smart Transmit EFS. All reported SAR obtained from the Ppart0 SAR tests was less than *SAR_Design_targe*t+ 1 dB Uncertainty. The final *Plimit* determination for each exposure scenario corresponding to *SAR_design_target* are shown in Table 3-3.

Table 3-3
***PLimit* Determination**

Device State Index (DSI)	*PLimit* Determination Scenarios
1	The worst-case SAR exposure is determined as maximum SAR normalized to the limit among: 1. Tablet SAR measured at 0 mm for Back, Top, Bottom, Right, Left surfaces

Note:

For DSI = 1, P_{limit} is calculated by:

P_{limit} corresponding to 1g Tablet SAR evaluation at 0 mm for back, top, bottom, left and right surfaces

Table 3-4
SAR Characterizations

Exposure Scenario:	Ant 3 Body	Ant 3 Maximum Tune-up Output Power*	Ant 1 Body	Ant 1 Maximum Tune-up Output Power*	Ant 4a/4b Body	Ant 4a/4b Maximum Tune-up Output Power*	Ant 2a/2b Body	Ant 2a/2b Maximum Tune-up Output Power*
Averaging Volume:	1g		1g		1g		1g	
Spacing:	0 mm		0 mm		0 mm		0 mm	
DSI:	1		1		1		1	
Technology/Band	**Plimit corresponding to 0.8mW/g (SAR_design_target)**	Pmax	**Plimit corresponding to 0.8mW/g (SAR_design_target)**	Pmax	**Plimit corresponding to 0.8mW/g (SAR_design_target)**	Pmax	**Plimit corresponding to 0.8mW/g (SAR_design_target)**	Pmax
GPRS/EDGE 850 MHz	17.51	24.81	18.31	23.31	N/A	N/A	N/A	N/A
GPRS/EDGE 1900 MHz	14.91	22.81	13.71	19.81	11.81	22.81	13.71	19.81
UMTS B5	18.00	24.70	17.90	22.90	N/A	N/A	N/A	N/A
UMTS B4	15.00	24.70	14.50	21.20	13.10	24.20	14.00	21.20
UMTS B2	15.20	24.70	14.20	21.20	11.50	24.20	14.00	21.20
LTE FDD B71	19.70	24.70	19.10	22.90	N/A	N/A	N/A	N/A
LTE FDD B12	18.80	24.70	19.50	22.90	N/A	N/A	N/A	N/A
LTE FDD B17	18.80	24.70	19.50	22.90	N/A	N/A	N/A	N/A
LTE FDD B13	18.90	24.70	19.50	22.90	N/A	N/A	N/A	N/A
LTE FDD B14	18.90	24.70	19.50	22.90	N/A	N/A	N/A	N/A
LTE FDD B26	18.00	24.70	17.90	22.90	N/A	N/A	N/A	N/A
LTE FDD B5	18.00	24.70	17.90	22.90	N/A	N/A	N/A	N/A
LTE FDD B66/4	15.00	24.70	14.50	21.20	13.10	24.20	14.00	21.20
LTE FDD B25/2	15.20	24.70	14.20	21.20	11.50	24.20	14.00	21.20
LTE FDD B30	17.20	22.70	14.50	17.90	11.40	22.00	11.60	18.90
LTE FDD B7	14.70	24.70	13.40	19.90	11.50	24.20	11.80	20.90
LTE TDD B48	10.01	20.01	11.01	16.71	9.61	16.31	10.41	16.61
LTE TDD B48 ULCA	10.01	20.01	11.01	18.71	9.61	16.31	10.41	16.61
LTE TDD B41 PC3	14.11	22.71	15.51	17.91	11.81	22.21	10.61	18.91
LTE TDD B41 ULCA PC3	14.11	22.71	15.51	17.91	11.81	22.21	10.61	18.91
LTE TDD B41 PC2	14.11	23.06	15.51	18.26	11.81	22.56	10.61	19.26
LTE TDD B41 ULCA PC2	14.11	23.36	15.51	18.56	11.81	22.86	10.61	19.56
NR FDD n71	19.70	24.70	19.10	22.90	N/A	N/A	N/A	N/A
NR FDD n12	18.80	24.70	19.50	22.90	N/A	N/A	N/A	N/A
NR FDD n5	18.00	24.70	17.90	22.90	N/A	N/A	N/A	N/A
NR FDD n66	15.00	24.70	14.50	21.20	13.10	24.20	14.00	21.20
NR FDD n25/n2	15.20	24.70	14.20	21.20	11.50	24.20	14.00	21.20
NR TDD n41 PC3	14.10	21.20	13.00	24.70	11.80	21.20	10.60	24.20
NR TDD n41 PC2	14.10	19.49	13.00	22.99	11.80	19.49	10.60	22.49
NR TDD n77 PC3	10.00	24.70	9.10	20.70	8.50	24.70	8.80	21.70
NR TDD n77 PC2	10.00	22.99	9.10	18.99	8.50	22.99	8.80	19.99

Notes:

1. When $P_{max} < P_{limit}$, the DUT will operate at a power level up to P_{max}.

4 EQUIPMENT LIST

For SAR measurements

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/16/2020	Annual	9/16/2021	MY40000670
Agilent	E4438C	ESG Vector Signal Generator	12/2/2020	Annual	12/2/2021	MY42081752
Agilent	E5515C	Wireless Communications Test Set	12/15/2020	Annual	12/15/2021	GB42361078
Agilent	N5182A	MXG Vector Signal Generator	9/25/2020	Annual	9/25/2021	US46240505
Agilent	N5182A	MXG Vector Signal Generator	12/1/2020	Annual	12/1/2021	MY47420837
Agilent	N9020A	MXA Signal Analyzer	12/21/2020	Annual	12/21/2021	MY50200571
Amplifier Research	150A100C	Amplifier	CBT	N/A	CBT	350132
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA24106A	USB Power Sensor	9/15/2020	Annual	9/15/2021	1244515
Anritsu	MA24106A	USB Power Sensor	9/15/2020	Annual	9/15/2021	1248508
Anritsu	MA24106A	USB Power Sensor	6/8/2020	Annual	6/8/2021	2018534
Anritsu	MA24106A	USB Power Sensor	6/3/2020	Annual	6/3/2021	2018527
Anritsu	MA2411B	Pulse Power Sensor	12/18/2020	Annual	12/18/2021	1126066
Anritsu	ML2495A	Power Meter	11/3/2020	Annual	11/3/2021	1039008
Anritsu	MT8820C	Radio Communication Analyzer	9/30/2020	Annual	9/30/2021	6201240328
Anritsu	MT8821C	Radio Communication Analyzer	5/21/2020	Annual	5/21/2021	6201144419
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291455
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291460
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670646
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
Insize	1108-150	Digital Caliper	1/17/2020	Biennial	1/17/2022	409193536
KEYSIGHT	E4438C	VECTOR SIGNAL GENERATOR	6/22/2020	Annual	6/22/2021	MY45092078
MCL	BW-N10W5+	10dB Attenuator	CBT	N/A	CBT	1611
MCL	BW-N3W5+	3dB Attenuator	CBT	N/A	CBT	1812
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1311
Mini-Circuits	NLP-1000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	ZHDC-16-63-S+	50-6000MHz Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	5/13/2020	Annual	5/13/2021	167284
Rohde & Schwarz	CMW500	Radio Communication Tester	4/28/2020	Annual	4/28/2021	167285
Rohde & Schwarz	CMW500	Radio Communication Tester	10/16/2020	Annual	10/16/2021	101699
Rohde & Schwarz	CMW500	Radio Communication Tester	10/16/2020	Annual	10/16/2021	106578
Rohde & Schwarz	CMW500	Radio Communication Tester	10/27/2020	Annual	10/27/2021	108843
Rohde & Schwarz	FSP-7	Spectrum Analyzer	1/9/2020	Biennial	1/9/2022	100990
Rohde& Schwarz	CMW500	Wideband Radio Communication Tester	9/17/2020	Annual	9/17/2021	145663
Rosenberger	32W1006-016	Torque Wrench	12/1/2020	Annual	12/1/2021	N/A
SPEAG	DAKS-3.5	Portable DAK	9/9/2020	Annual	9/9/2021	1045
SPEAG	D2450V2	2450 MHz SAR Dipole	11/12/2018	Triennial	11/12/2021	921
SPEAG	D3500V2	3500 MHz SAR Dipole	8/16/2019	Biennial	8/16/2021	1055
SPEAG	D3700V2	3700 MHz SAR Dipole	10/17/2019	Biennial	10/17/2021	1002
SPEAG	D3900V2	3900 MHz SAR Dipole	11/13/2020	Annual	11/13/2021	1062
SPEAG	EX3DV4	SAR Probe	7/16/2020	Annual	7/16/2021	7546
SPEAG	EX3DV4	SAR Probe	3/20/2020	Annual	3/20/2021	7421
SPEAG	EX3DV4	SAR Probe	1/18/2021	Annual	1/18/2022	3837
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/14/2020	Annual	4/14/2021	1532
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/19/2020	Annual	3/19/2021	604
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/13/2021	Annual	1/13/2021	793

Note:

1. CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.
2. Each equipment item was used solely within its respective calibration period.

5 MEASUREMENT UNCERTAINTIES

For SAR Measurements

a	b	c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Uncertainty Component	IEEE 1528 Sec.	Tol. (± %)	Prob. Dist.	Div.	c_i 1gm	c_i 10 gms	1gm u_i (± %)	10gms u_i (± %)	v_i
Measurement System									
Probe Calibration	E.2.1	6.55	N	1	1	1	6.6	6.6	∞
Axial Isotropy	E.2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E.2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E.2.3	2	R	1.732	1	1	1.2	1.2	∞
Linearity	E.2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E.2.4	0.25	R	1.732	1	1	0.1	0.1	∞
Readout Electronics	E.2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E.2.7	0.8	R	1.732	1	1	0.5	0.5	∞
Integration Time	E.2.8	2.6	R	1.732	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E.6.1	3	R	1.732	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	3	R	1.732	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.8	R	1.732	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E.6.3	6.7	R	1.732	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E.5	4	R	1.732	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E.4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E.4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E.2.9	5	R	1.732	1	1	2.9	2.9	∞
SAR Scaling	E.6.5	0	R	1.732	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E.3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E.3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E.3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E.3.4	3.4	R	1.732	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E.3.4	0.6	R	1.732	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E.3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E.3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				11.6	11.4	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				23.2	22.8	

The above measurement uncertainties are according to IEEE Std. 1528-2013

APPENDIX A: SAR TEST RESULTS FOR P_{LIMIT} CALCULATIONS

Note: This device is depopulated version of the fully populated reference model FCC ID: BCGA2379. SAR characterization of antenna 1/2a/2b/3/4b/5b was referenced based on the reference model test results.

Table A-1
DSI = 1 P_{Limit} Calculations – Ant 4a LTE Band 48

MEASUREMENT RESULTS																
FREQUENCY			Mode	Bandwidth [MHz]	Conducted Power [dBm]	MPR [dB]	Antenna Config.	Modulation	RB Size	RB Offset	Spacing	Side	Duty Cycle	SAR (1g)	Plimit	Minimum Plimit
MHz	Ch.													(W/kg)	[dBm]	[dBm]
3560.00	55340	Low	LTE Band 48	20	11.54	0	Ant 4a	QPSK	1	99	0 mm	back	1:1.58	0.624	10.63	10.32
3603.30	55773	Low-Mid	LTE Band 48	20	11.58	0	Ant 4a	QPSK	1	99	0 mm	back	1:1.58	0.600	10.84	
3646.70	56207	Mid-High	LTE Band 48	20	11.74	0	Ant 4a	QPSK	1	99	0 mm	back	1:1.58	0.561	11.30	
3690.00	56640	High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	1	0	0 mm	back	1:1.58	0.660	10.68	
3560.00	55340	Low	LTE Band 48	20	11.70	0	Ant 4a	QPSK	50	50	0 mm	back	1:1.58	0.635	10.72	
3603.30	55773	Low-Mid	LTE Band 48	20	11.72	0	Ant 4a	QPSK	50	50	0 mm	back	1:1.58	0.615	10.88	
3646.70	56207	Mid-High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	50	50	0 mm	back	1:1.58	0.593	11.14	
3690.00	56640	High	LTE Band 48	20	11.85	0	Ant 4a	QPSK	50	0	0 mm	back	1:1.58	0.646	10.79	
3690.00	56640	High	LTE Band 48	20	11.82	0	Ant 4a	QPSK	100	0	0 mm	back	1:1.58	0.651	10.73	
3690.00	56640	High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	1	0	0 mm	top	1:1.58	0.201	15.84	
3690.00	56640	High	LTE Band 48	20	11.85	0	Ant 4a	QPSK	50	0	0 mm	top	1:1.58	0.192	16.06	
3690.00	56640	High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	1	0	0 mm	bottom	1:1.58	0.000	38.87	
3690.00	56640	High	LTE Band 48	20	11.85	0	Ant 4a	QPSK	50	0	0 mm	bottom	1:1.58	0.000	38.90	
3690.00	56640	High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	1	0	0 mm	right	1:1.58	0.000	38.87	
3690.00	56640	High	LTE Band 48	20	11.85	0	Ant 4a	QPSK	50	0	0 mm	right	1:1.58	0.000	38.90	
3560.00	55340	Low	LTE Band 48	20	11.54	0	Ant 4a	QPSK	1	99	0 mm	left	1:1.58	0.671	10.32	
3603.30	55773	Low-Mid	LTE Band 48	20	11.58	0	Ant 4a	QPSK	1	99	0 mm	left	1:1.58	0.593	10.89	
3646.70	56207	Mid-High	LTE Band 48	20	11.74	0	Ant 4a	QPSK	1	99	0 mm	left	1:1.58	0.587	11.10	
3690.00	56640	High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	1	0	0 mm	left	1:1.58	0.567	11.34	
3560.00	55340	Low	LTE Band 48	20	11.70	0	Ant 4a	QPSK	50	50	0 mm	left	1:1.58	0.659	10.56	
3603.30	55773	Low-Mid	LTE Band 48	20	11.72	0	Ant 4a	QPSK	50	50	0 mm	left	1:1.58	0.611	10.90	
3646.70	56207	Mid-High	LTE Band 48	20	11.83	0	Ant 4a	QPSK	50	50	0 mm	left	1:1.58	0.579	11.25	
3690.00	56640	High	LTE Band 48	20	11.85	0	Ant 4a	QPSK	50	0	0 mm	left	1:1.58	0.566	11.37	
3690.00	56640	High	LTE Band 48	20	11.82	0	Ant 4a	QPSK	100	0	0 mm	left	1:1.58	0.565	11.34	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population						Body 1.6 W/kg (mW/g) averaged over 1 gram										

Table A-2
DSI = 1 P_{Limit} Calculations – Ant 4a NR Band n77

MEASUREMENT RESULTS																	
FREQUENCY			Mode	Bandwidth [MHz]	Conducted Power [dBm]	Antenna Config	MPR [dB]	Waveform	Modulation	RB Size	RB Offset	Spacing	Side	Duty Cycle	SAR (1g)	Plimit	Minimum Plimit
MHz	Ch.														(W/kg)	[dBm]	[dBm]
3750.00	650000	Low	NR Band n77	100	8.37	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	137	0 mm	back	1:1	0.498	10.43	
3930.00	662000	High	NR Band n77	100	8.32	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	1	0 mm	back	1:1	0.530	10.11	
3750.00	650000	Low	NR Band n77	100	8.36	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	0	0 mm	back	1:1	0.408	11.28	
3930.00	662000	High	NR Band n77	100	8.12	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	69	0 mm	back	1:1	0.661	8.95	
3750.00	650000	Low	NR Band n77	100	8.19	Ant 4a	0.0	DFT-S-OFDM	QPSK	270	0	0 mm	back	1:1	0.346	11.83	
3750.00	650000	Low	NR Band n77	100	8.37	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	137	0 mm	top	1:1	0.117	16.72	
3750.00	650000	Low	NR Band n77	100	8.36	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	0	0 mm	top	1:1	0.161	15.32	
3750.00	650000	Low	NR Band n77	100	8.37	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	137	0 mm	bottom	1:1	0.000	37.40	
3750.00	650000	Low	NR Band n77	100	8.36	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	0	0 mm	bottom	1:1	0.000	37.39	8.83
3750.00	650000	Low	NR Band n77	100	8.37	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	137	0 mm	right	1:1	0.000	37.40	
3750.00	650000	Low	NR Band n77	100	8.36	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	0	0 mm	right	1:1	0.000	37.39	
3750.00	650000	Low	NR Band n77	100	8.37	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	137	0 mm	left	1:1	0.470	10.68	
3930.00	662000	High	NR Band n77	100	8.32	Ant 4a	0.0	DFT-S-OFDM	QPSK	1	1	0 mm	left	1:1	0.544	9.99	
3750.00	650000	Low	NR Band n77	100	8.36	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	0	0 mm	left	1:1	0.444	10.92	
3930.00	662000	High	NR Band n77	100	8.12	Ant 4a	0.0	DFT-S-OFDM	QPSK	135	69	0 mm	left	1:1	0.680	8.83	
3750.00	650000	Low	NR Band n77	100	8.19	Ant 4a	0.0	DFT-S-OFDM	QPSK	270	0	0 mm	left	1:1	0.442	10.77	
3930.00	662000	High	NR Band n77	100	8.39	Ant 4a	0.0	CP-OFDM	QPSK	1	1	0 mm	left	1:1	0.574	9.83	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population							Body 1.6 W/kg (mW/g) averaged over 1 gram										