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PART 0 SAR CHAR REPORT

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FCC ID:	**A3LSMG998U**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD**

Report Type:	Part 0 SAR Characterization
DUT Type:	Portable Handset
Model(s):	SM-G998U
Additional Model:	SM-G998U1

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

ilac-MRA
ACCREDITED
CERT #2041.01

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1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
CDMA/EVDO BC10 (§90S)	Voice/Data	817.90 - 823.10 MHz
CDMA/EVDO BC0 (§22H)	Voice/Data	824.70 - 848.31 MHz
PCS CDMA/EVDO	Voice/Data	1851.25 - 1908.75 MHz
GSM/GPRS/EDGE 850	Voice/Data	824.20 - 848.80 MHz
GSM/GPRS/EDGE 1900	Voice/Data	1850.20 - 1909.80 MHz
UMTS 850	Voice/Data	826.40 - 846.60 MHz
UMTS 1750	Voice/Data	1712.4 - 1752.6 MHz
UMTS 1900	Voice/Data	1852.4 - 1907.6 MHz
LTE Band 71	Voice/Data	665.5 - 695.5 MHz
LTE Band 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 14	Voice/Data	790.5 - 795.5 MHz
LTE Band 26 (Cell)	Voice/Data	814.7 - 848.3 MHz
LTE Band 5 (Cell)	Voice/Data	824.7 - 848.3 MHz
LTE Band 66 (AWS)	Voice/Data	1710.7 - 1779.3 MHz
LTE Band 4 (AWS)	Voice/Data	1710.7 - 1754.3 MHz
LTE Band 25 (PCS)	Voice/Data	1850.7 - 1914.3 MHz
LTE Band 2 (PCS)	Voice/Data	1850.7 - 1909.3 MHz
LTE Band 30	Voice/Data	2307.5 - 2312.5 MHz
LTE Band 7	Voice/Data	2502.5 - 2567.5 MHz
LTE Band 48	Voice/Data	3552.5 - 3697.5 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
LTE Band 38	Voice/Data	2572.5 - 2617.5 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 n30	Data	2307.5 - 2312.5 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 - 2462 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
U-NII-5	Voice/Data	5925 - 6425 MHz
U-NII-6	Voice/Data	6425 - 6525 MHz
U-NII-7	Voice/Data	6525 - 6875 MHz
U-NII-8	Voice/Data	6875 - 7125 MHz
Bluetooth	Data	2402 - 2480 MHz
NFC	Data	13.56 MHz
NR Band n260	Data	37000 - 40000 MHz
NR Band n261	Data	27500 - 28350 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/NFC technologies, but the output power of these modems is not controlled by the Smart Transmit algorithm.

2.1 Time-Averaging for SAR and Power Density

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).

2.2 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

2.3 Bibliography

Report Type	Report Serial Number
FCC SAR Evaluation Report (Part 1)	1M2012210203-01.A3L

3 SAR AND POWER DENSITY MEASUREMENTS

3.1 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 3-1).

Equation 3-1
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]

3.2 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 3-1) 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.

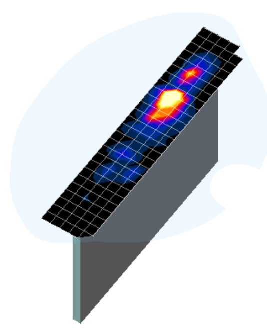

Figure 3-1
Sample SAR Area Scan

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
5. Table 3-1) 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 3-1. 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.
6. 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 3-1
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	$\leq 1.5^*\Delta z_{zoom}(n-1)$	≥ 30
2-3 GHz	≤ 12	≤ 5	≤ 5	≤ 4	$\leq 1.5^*\Delta z_{zoom}(n-1)$	≥ 30
3-4 GHz	≤ 12	≤ 5	≤ 4	≤ 3	$\leq 1.5^*\Delta z_{zoom}(n-1)$	≥ 28
4-5 GHz	≤ 10	≤ 4	≤ 3	≤ 2.5	$\leq 1.5^*\Delta z_{zoom}(n-1)$	≥ 25
5-6 GHz	≤ 10	≤ 4	≤ 2	≤ 2	$\leq 1.5^*\Delta z_{zoom}(n-1)$	≥ 22

*Also compliant to IEEE 1528-2013 Table 6

4 SAR CHARACTERIZATION

4.1 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 smartphone, 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.

When 1g SAR and 10g SAR exposure comparison is needed, the worst-case was determined from SAR normalized to 1g or 10g SAR limit.

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

Table 4-1
DSI and Corresponding Exposure Scenarios

Scenario	Description	SAR Test Cases
Head (DSI = 2)	▪ Device positioned next to head ▪ Receiver Active	*Head SAR per KDB Publication 648474 D04*
Hotspot mode (DSI = 3)	▪ Device transmits in hotspot mode near body ▪ Hotspot Mode Active	*Hotspot SAR per KDB Publication 941225 D06*
Phablet Grip (DSI=1 or 4)	▪ Device is held with hand and grip sensor is triggered ▪ Grip sensor triggered or earjack is active	*Phablet SAR per KDB Publication 648474 D04 & KDB Publication 616217 D04*
Phablet (DSI = 0)	▪ Device is held with hand and grip sensor is not triggered ▪ Distance grip sensor not triggered	*Phablet SAR per KDB Publication 648474 D04 & KDB Publication 616217 D04*
Body-worn (DSI = 0)	▪ Device being used with a body-worn accessory	*Body-worn SAR per KDB Publication 648474 D04*

4.2 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 4-2
***SAR_design_target* Calculations**

SAR_design_target			
$SAR\_design\_target < SAR\_regulatory\_limit \times 10^{\frac{-Total\ Uncertainty}{10}}$			
1g SAR (W/kg)		**10g SAR (W/kg)**	
Total Uncertainty	1.0 dB	*Total Uncertainty*	1.0 dB
SAR_regulatory_limit	1.6 W/kg	*SAR_regulatory_limit*	4.0 W/kg
SAR_design_target	1.0 W/kg	*SAR_design_target*	2.5 W/kg

4.3 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_target*+ 1 dB Uncertainty. The final *Plimit* determination for each exposure scenario corresponding to *SAR_design_target* are shown in Table 3-3.

Table 4-3
***PLimit* Determination**

Device State Index (DSI)	*PLimit* Determination Scenarios
0	The worst-case SAR exposure is determined as maximum SAR normalized to the limit among: 1. Body Worn SAR 2. Extremity SAR measured at 8, 6 and 11 mm spacing for back, front, bottom respectively 3. Extremity SAR measured at 0 mm for left and right surfaces
1 or 4	P_{limit} is calculated based on 10g Extremity SAR at 0 mm for back, front, and bottom surfaces
2	P_{limit} is calculated based on 1g Head SAR
3	P_{limit} is calculated based on 1g Hotspot SAR at 10 mm

Note:

For DSI = 0, P_{limit} is calculated by:

$$P_{limit} = \min\{P_{limit} \text{ corresponding to 1g Body Worn SAR evaluation at 15 mm spacing,} \\ P_{limit} \text{ corresponding to 10g Extremity SAR evaluation at } 6\sim11 \text{ mm spacing,} \\ P_{limit} \text{ corresponding to 10g Extremity SAR evaluation at 0 mm for left and right surfaces}\}$$

Table 4-4
SAR Characterizations

Exposure Scenario:		Body-Worn / Phablet	Phablet	Head	Hotspot	Earjack	Maximum Tune-up Output Power*
Averaging Volume:		1g / 10g	10g	1g	1g	10g	
Spacing:		15 mm / 8, 6, 11 mm	0 mm	0 mm	10 mm	0 mm	
DSI:		0	1	2	3	4	
Technology/Band	Antenna	Plimit corresponding to 1mW/g (SAR_design_target)					Pmax
CDMA/EVDO BC10	A	30.7	26.9	32.1	26.9	26.9	24.8
CDMA/EVDO BC0	A	30.5	27.0	31.9	27.0	27.0	24.8
CDMA/EVDO BC1	A	27.2	18.5	34.3	18.5	18.5	23.0
GSM/GPRS/EDGE 850 MHz	A	31.8	26.9	33.6	26.9	26.9	24.8
GSM/GPRS/EDGE 1900 MHz	A	26.3	18.8	35.4	18.8	18.8	21.3
UMTS B5	A	30.9	26.7	32.3	26.7	26.7	24.5
UMTS B4	A	25.4	18.5	32.5	18.5	18.5	23.0
UMTS B2	A	27.0	18.5	34.2	18.5	18.5	23.0
LTE FDD B71	A	31.8	27.4	34.0	27.4	27.4	24.8
LTE FDD B12	A	32.0	27.2	33.3	27.2	27.2	24.8
LTE FDD B13	A	31.5	27.0	32.6	27.0	27.0	24.8
LTE FDD B14	A	31.3	26.8	32.8	26.8	26.8	24.8
LTE FDD B26	A	31.4	26.9	32.9	26.9	26.9	24.8
LTE FDD B5	A	30.6	26.9	32.2	26.9	26.9	24.8
LTE FDD B66/4	A	24.8	18.5	31.9	18.5	18.5	23.0
LTE FDD B66	E	23.5	23.5	19.0	19.0	23.5	23.0
LTE FDD B25/2	A	25.7	18.5	32.0	18.5	18.5	23.5
LTE FDD B25/2	E	23.5	23.5	17.5	19.0	23.5	23.5
LTE FDD B30	A	27.2	20.0	37.6	19.0	20.0	23.0
LTE FDD B7	B	28.7	20.0	33.4	20.0	20.0	23.0
LTE TDD B48	I	20.0	20.0	17.0	20.0	20.0	21.5
LTE TDD B41/38	B	26.6	20.0	35.6	19.0	20.0	22.0
LTE TDD B41 (PC2)	B	26.6	20.0	35.6	19.0	20.0	22.9
NR FDD n71	A	31.3	29.2	33.6	29.2	29.2	24.5
NR FDD n12	A	31.1	28.8	33.3	28.8	28.8	24.5
NR FDD n5	A	30.3	27.1	31.8	26.6	27.1	24.5
NR FDD n66	A	24.6	18.5	32.1	18.5	18.5	23.8
NR FDD n66	E	23.5	23.5	19.0	19.0	23.5	23.5
NR FDD n25/2	A	26.5	18.5	33.8	18.5	18.5	23.8
NR FDD n25/2	E	23.5	23.5	19.0	19.0	23.5	23.5
NR FDD n30	A	25.4	20.0	35.9	19.0	20.0	23.0
NR TDD n41 (PC3)	B	18.0	14.0	18.0	13.0	14.0	24.5
NR TDD n41 (PC2)	B	18.0	14.0	18.0	13.0	14.0	25.0
NR TDD n41 (PC3)	E	17.0	17.0	14.0	15.0	17.0	24.0
NR TDD n41 (PC2)	E	17.0	17.0	14.0	15.0	17.0	26.0
NR TDD n77 (PC3)	I	19.5	19.5	15.0	17.5	19.5	23.5
NR TDD n77 (PC2)	I	19.5	19.5	15.0	17.5	19.5	25.5
NR TDD n77 (PC3)	B	18.0	18.0	13.5	16.0	18.0	22.0
NR TDD n77 (PC2)	B	18.0	18.0	13.5	16.0	18.0	24.0
NR TDD n77 (PC3)	G	15.5	15.5	11.0	13.5	15.5	19.5
NR TDD n77 (PC2)	G	15.5	15.5	11.0	13.5	15.5	21.5
NR TDD n77 (PC3)	D	16.5	16.5	12.0	14.5	16.5	20.5
NR TDD n77 (PC2)	D	16.5	16.5	12.0	14.5	16.5	22.5

Notes:

1. For all modes/bands, when Hotspot Mode (DSI=3) and Extremity sensor (DSI=1) are triggered at the same time, DSI=3 takes priority, thus the P_{limit} for DSI=3 is set to be less or equal to P_{limit} for DSI=1.
2. When $P_{max} < P_{limit}$, the DUT will operate at a power level up to P_{max}.
3. P_{limit} for DSI=1 and DSI =4 are the same.
4. For LTE Band 48, NR Band n77, LTE Band B66 Ant E, B25 Ant E, B2 Ant E, and NR Band n66 Ant E, n25 Ant E, and n41 Ant E, when RCV is active, DSI=2 takes priority over all levels.
5. Extremity SAR for NR TDD n77 Ant B/G/D was not included for SAR Characterization at DSI = 0/1/4 because its 1-g SAR was extremely low. It was determined NR TDD n77 Ant B/G/D 10-g SAR will not exceed SAR_design_target + 1dB Uncertainty.

5 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
Agilent	E4438C	ESG Vector Signal Generator	9/8/2020	Biennial	9/8/2022	MY45090700
Agilent	E4438C	ESG Vector Signal Generator	9/18/2020	Annual	9/18/2021	MY45091346
Agilent	N5182A	MXG Vector Signal Generator	5/13/2020	Annual	5/13/2021	MY47420603
Agilent	8753ES	S-Parameter Network Analyzer	9/16/2020	Annual	9/16/2021	MY40000670
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	353469
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433972
Anritsu	ML2496A	Power Meter	2/13/2020	Annual	2/13/2021	1306009
Anritsu	ML2496A	Power Meter	3/23/2020	Annual	3/23/2021	1351001
Anritsu	MA2411B	Pulse Power Sensor	8/12/2020	Annual	8/12/2021	1207364
Anritsu	MA2411B	Pulse Power Sensor	9/22/2020	Annual	9/22/2021	1339008
Anritsu	MA24106A	USB Power Sensor	6/8/2020	Annual	6/8/2021	1349501
Anritsu	MA24106A	USB Power Sensor	1/15/2021	Annual	1/15/2022	1349503
COMTech	AR85729-5	Solid State Amplifier	CBT	N/A	CBT	M1S5A00-009
COMTECH	AR85729-5/5759B	Solid State Amplifier	CBT	N/A	CBT	M3W1A00-1002
Control Company	4352	Long Stem Thermometer	1/24/2020	Biennial	1/24/2022	200043644
Control Company	4352	Long Stem Thermometer	1/24/2020	Biennial	1/24/2022	200043647
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/6/2020	Biennial	3/6/2022	200170313
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291455
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	N6705B	DC Power Analyzer	4/27/2019	Biennial	4/27/2021	MY53004059
Keysight Technologies	N9020A	MXA Signal Analyzer	8/14/2020	Annual	8/14/2021	US46470561
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/1/2020	Annual	9/1/2021	MY53401181
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
MiniCircuits	SLP-2400+	Low Pass Filter	CBT	N/A	CBT	R8979500903
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Narda	4014C-6	4 - 8 GHz SMA 6 dB Directional Coupler	CBT	N/A	CBT	N/A
Narda	BW-S3W2	Attenuator (3dB)	CBT	N/A	CBT	120
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	12/1/2020	Annual	12/1/2021	N/A
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	9/29/2020	Annual	9/29/2021	101307
SPEAG	DAK-12	Dielectric Assessment Kit (10MHz - 3GHz)	3/17/2020	Annual	3/17/2021	1102
SPEAG	DAK-3.5	Dielectric Assessment Kit	10/14/2020	Annual	10/14/2021	1091
SPEAG	D3700V2	3700 MHz SAR Dipole	1/21/2020	Biennial	1/21/2022	1067
SPEAG	D3900V2	3900 MHz SAR Dipole	10/9/2020	Annual	10/9/2021	1056
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/20/2020	Annual	5/20/2021	728
SPEAG	DAE4	Data Acquisition Electronics	12/7/2020	Annual	12/7/2021	1533
SPEAG	EX3DV4	SAR Probe	1/20/2021	Annual	1/20/2022	3589
SPEAG	EX3DV4	SAR Probe	10/20/2020	Annual	10/20/2021	7539

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.

6 MEASUREMENT UNCERTAINTIES

a	c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Uncertainty Component	Tol. (± %)	Prob. Dist.	Div.	c_i 1gm	c_i 10 gms	1gm u_i (± %)	10gms u_i (± %)	v_i
Measurement System								
Probe Calibration	6.55	N	1	1.0	1.0	6.6	6.6	∞
Axial Isotropy	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	2.0	R	1.73	1.0	1.0	1.2	1.2	∞
Linearity	0.3	N	1	1.0	1.0	0.3	0.3	∞
System Detection Limits	0.25	R	1.73	1.0	1.0	0.1	0.1	∞
Readout Electronics	0.3	N	1	1.0	1.0	0.3	0.3	∞
Response Time	0.8	R	1.73	1.0	1.0	0.5	0.5	∞
Integration Time	2.6	R	1.73	1.0	1.0	1.5	1.5	∞
RF Ambient Conditions - Noise	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
RF Ambient Conditions - Reflections	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	0.4	R	1.73	1.0	1.0	0.2	0.2	∞
Probe Positioning w/ respect to Phantom	6.7	R	1.73	1.0	1.0	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	4.0	R	1.73	1.0	1.0	2.3	2.3	∞
Test Sample Related								
Test Sample Positioning	2.7	N	1	1.0	1.0	2.7	2.7	35
Device Holder Uncertainty	1.67	N	1	1.0	1.0	1.7	1.7	5
Output Power Variation - SAR drift measurement	5.0	R	1.73	1.0	1.0	2.9	2.9	∞
SAR Scaling	0.0	R	1.73	1.0	1.0	0.0	0.0	∞
Phantom & Tissue Parameters								
Phantom Uncertainty (Shape & Thickness tolerances)	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	4.2	N	1	0.78	0.71	3.3	3.0	10
Liquid Permittivity - measurement uncertainty	4.1	N	1	0.23	0.26	1.0	1.1	10
Liquid Conductivity - Temperature Uncertainty	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)		RSS				11.5	11.3	60
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2				23.0	22.6	

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

Table A-1
DSI = 2 P_{Limit} Calculations – NR Band n77 Head SAR

MEASUREMENT RESULTS																
FREQUENCY			Mode	Bandwidth [MHz]	Conducted Power [dBm]	Antenna Config	MPR [dB]	Side	Test Position	Modulation	RB Size	RB Offset	Duty Cycle	SAR (1g)	PLimit	Minimum PLimit
MHz	Ch.													(W/kg)	[dBm]	[dBm]
3930.00	662000	High	NR Band n77	100	13.68	B	0	Right	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	63.68	
3930.00	662000	High	NR Band n77	100	13.58	B	0	Right	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.000	63.58	
3930.00	662000	High	NR Band n77	100	13.68	B	0	Right	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.000	63.68	
3930.00	662000	High	NR Band n77	100	13.58	B	0	Right	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.000	63.58	
3930.00	662000	High	NR Band n77	100	13.68	B	0	Left	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	63.68	46.19
3930.00	662000	High	NR Band n77	100	13.58	B	0	Left	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.000	81.85	
3750.00	650000	Low	NR Band n77	100	12.76	B	0	Left	Cheek	CP-OFDM QPSK	1	1	1:1	0.000	46.19	
3930.00	662000	High	NR Band n77	100	13.68	B	0	Left	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.000	63.68	
3930.00	662000	High	NR Band n77	100	13.58	B	0	Left	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.000	63.58	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Right	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	50.65	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Right	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.001	42.95	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Right	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.001	40.05	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Right	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.000	44.75	
3930.00	662000	High	NR Band n77	100	10.63	G	0	Right	Tilt	CP-OFDM QPSK	1	1	1:1	0.000	60.63	40.05
3930.00	662000	High	NR Band n77	100	11.02	G	0	Left	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	49.91	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Left	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.001	43.11	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Left	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.000	44.19	
3930.00	662000	High	NR Band n77	100	11.02	G	0	Left	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.001	41.94	
3930.00	662000	High	NR Band n77	100	11.88	D	0	Right	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	61.88	
3930.00	662000	High	NR Band n77	100	11.89	D	0	Right	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.000	53.31	
3930.00	662000	High	NR Band n77	100	11.88	D	0	Right	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.000	61.88	
3930.00	662000	High	NR Band n77	100	11.89	D	0	Right	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.000	51.10	
3750.00	650000	Low	NR Band n77	100	11.17	D	0	Right	Tilt	CP-OFDM QPSK	1	1	1:1	0.000	64.67	51.10
3930.00	662000	High	NR Band n77	100	11.88	D	0	Left	Cheek	DFT-S-OFDM QPSK	1	137	1:1	0.000	61.88	
3930.00	662000	High	NR Band n77	100	11.89	D	0	Left	Cheek	DFT-S-OFDM QPSK	135	138	1:1	0.000	61.89	
3930.00	662000	High	NR Band n77	100	11.88	D	0	Left	Tilt	DFT-S-OFDM QPSK	1	137	1:1	0.000	53.79	
3930.00	662000	High	NR Band n77	100	11.89	D	0	Left	Tilt	DFT-S-OFDM QPSK	135	138	1:1	0.000	61.89	

For some bands/modes, a lower P_{Limit} was selected as a more conservative evaluation.

Table A-2
DSI = 0 P_{Limit} Calculations – NR Band n77 Body-Worn SAR

MEASUREMENT RESULTS																	
FREQUENCY			Mode	Bandwidth [MHz]	Conducted Power [dBm]	Antenna Config	MPR [dB]	Modulation	RB Size	RB Offset	Spacing (mm)	Side	Duty Cycle	SAR (1g)	PLimit	Minimum PLimit
MHz	Ch.													(W/kg)	[dBm]	[dBm]
3930.00	662000	High	NR Band n77	100	18.17	B	0	DFT-S-OFDM QPSK	1	137	15 mm	back	1:1	0.035	32.73	30.57
3930.00	662000	High	NR Band n77	100	17.97	B	0	DFT-S-OFDM QPSK	135	69	15 mm	back	1:1	0.055	30.57	
3930.00	662000	High	NR Band n77	100	15.90	B	1.5	CP-OFDM QPSK	1	1	15 mm	back	1:1	0.024	32.10	
3930.00	662000	High	NR Band n77	100	15.71	G	0	DFT-S-OFDM QPSK	1	137	15 mm	back	1:1	0.069	27.32	27.16
3930.00	662000	High	NR Band n77	100	15.55	G	0	DFT-S-OFDM QPSK	135	69	15 mm	back	1:1	0.069	27.16	
3750.00	650000	Low	NR Band n77	100	13.81	G	1.5	CP-OFDM QPSK	1	1	15 mm	back	1:1	0.037	28.13	
3930.00	662000	High	NR Band n77	100	16.28	D	0	DFT-S-OFDM QPSK	1	137	15 mm	back	1:1	0.028	31.81	31.50
3930.00	662000	High	NR Band n77	100	16.22	D	0	DFT-S-OFDM QPSK	135	69	15 mm	back	1:1	0.028	31.75	
3930.00	662000	High	NR Band n77	100	14.29	D	1.5	CP-OFDM QPSK	1	1	15 mm	back	1:1	0.019	31.50	

For some bands/modes, a lower P_{Limit} was selected as a more conservative evaluation.

Table A-3
DSI = 3 P_{Limit} Calculations – NR Band n77 Hotspot SAR

MEASUREMENT RESULTS																
FREQUENCY			Mode	Bandwidth [MHz]	Conducted Power [dBm]	Antenna Config	MPR [dB]	Modulation	RB Size	RB Offset	Spacing (mm)	Side	Duty Cycle	SAR (1g)	PLimit	Minimum PLimit
MHz	Ch.													(W/kg)	[dBm]	[dBm]
#REF!	662000	High	NR Band n77	100	16.26	B	0	DFT-S-OFDM QPSK	1	137	10 mm	back	1:1	0.038	30.50	
3930.00	662000	High	NR Band n77	100	16.16	B	0	DFT-S-OFDM QPSK	135	138	10 mm	back	1:1	0.033	31.01	
3930.00	662000	High	NR Band n77	100	16.26	B	0	DFT-S-OFDM QPSK	1	137	10 mm	front	1:1	0.032	31.15	
3930.00	662000	High	NR Band n77	100	16.16	B	0	DFT-S-OFDM QPSK	135	138	10 mm	front	1:1	0.030	31.43	
3930.00	662000	High	NR Band n77	100	16.26	B	0	DFT-S-OFDM QPSK	1	137	10 mm	bottom	1:1	0.087	26.84	25.11
3930.00	662000	High	NR Band n77	100	16.16	B	0	DFT-S-OFDM QPSK	135	138	10 mm	bottom	1:1	0.076	27.33	
3930.00	662000	High	NR Band n77	100	15.32	B	0	CP-OFDM QPSK	1	1	10 mm	bottom	1:1	0.105	25.11	
3930.00	662000	High	NR Band n77	100	16.26	B	0	DFT-S-OFDM QPSK	1	137	10 mm	left	1:1	0.002	44.27	
3930.00	662000	High	NR Band n77	100	16.16	B	0	DFT-S-OFDM QPSK	135	138	10 mm	left	1:1	0.002	44.04	
3930.00	662000	High	NR Band n77	100	13.65	G	0	DFT-S-OFDM QPSK	1	137	10 mm	back	1:1	0.083	24.48	
3930.00	662000	High	NR Band n77	100	13.66	G	0	DFT-S-OFDM QPSK	135	69	10 mm	back	1:1	0.083	24.46	
3930.00	662000	High	NR Band n77	100	13.17	G	0	CP-OFDM QPSK	1	1	10 mm	back	1:1	0.082	24.05	
3930.00	662000	High	NR Band n77	100	13.65	G	0	DFT-S-OFDM QPSK	1	137	10 mm	front	1:1	0.000	72.01	
3930.00	662000	High	NR Band n77	100	13.66	G	0	DFT-S-OFDM QPSK	135	69	10 mm	front	1:1	0.000	49.46	24.05
3930.00	662000	High	NR Band n77	100	13.65	G	0	DFT-S-OFDM QPSK	1	137	10 mm	top	1:1	0.011	33.24	
3930.00	662000	High	NR Band n77	100	13.66	G	0	DFT-S-OFDM QPSK	135	69	10 mm	top	1:1	0.012	33.05	
3930.00	662000	High	NR Band n77	100	13.65	G	0	DFT-S-OFDM QPSK	1	137	10 mm	left	1:1	0.007	35.43	
3930.00	662000	High	NR Band n77	100	13.66	G	0	DFT-S-OFDM QPSK	135	69	10 mm	left	1:1	0.006	35.60	
3930.00	662000	High	NR Band n77	100	14.31	D	0	DFT-S-OFDM QPSK	1	271	10 mm	back	1:1	0.040	28.34	
3930.00	662000	High	NR Band n77	100	14.59	D	0	DFT-S-OFDM QPSK	135	138	10 mm	back	1:1	0.040	28.60	
3930.00	662000	High	NR Band n77	100	13.72	D	0	CP-OFDM QPSK	1	1	10 mm	back	1:1	0.050	26.70	
3930.00	662000	High	NR Band n77	100	14.31	D	0	DFT-S-OFDM QPSK	1	271	10 mm	front	1:1	0.000	64.31	
3930.00	662000	High	NR Band n77	100	14.59	D	0	DFT-S-OFDM QPSK	135	138	10 mm	front	1:1	0.000	67.66	
3930.00	662000	High	NR Band n77	100	14.31	D	0	DFT-S-OFDM QPSK	1	271	10 mm	bottom	1:1	0.008	35.39	26.70
3930.00	662000	High	NR Band n77	100	14.59	D	0	DFT-S-OFDM QPSK	135	138	10 mm	bottom	1:1	0.007	35.94	
3930.00	662000	High	NR Band n77	100	14.31	D	0	DFT-S-OFDM QPSK	1	271	10 mm	right	1:1	0.003	40.21	
3930.00	662000	High	NR Band n77	100	14.59	D	0	DFT-S-OFDM QPSK	135	138	10 mm	right	1:1	0.002	40.77	
3930.00	662000	High	NR Band n77	100	14.31	D	0	DFT-S-OFDM QPSK	1	271	10 mm	left	1:1	0.002	42.55	
3930.00	662000	High	NR Band n77	100	14.59	D	0	DFT-S-OFDM QPSK	135	138	10 mm	left	1:1	0.000	57.32	

For some bands/modes, a lower P_{Limit} was selected as a more conservative evaluation.