

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>



RF EXPOSURE PART 0 TEST REPORT

Applicant Name:

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

Date of Testing:

09/15/2024 – 11/04/2024

Test Site/Location:

Element, Columbia, MD, USA
Element Morgan Hill, CA, USA
Element, Suwon, Korea

Document Serial No.:

1M2408260069-27.A3L

FCC ID:

A3LSMS938B

APPLICANT:

SAMSUNG ELECTRONICS CO., LTD

Report Type:

Part 0 SAR Characterization

DUT Type:

Portable Handset

Model(s):

SM-S938B/DS

Additional Model:

SM-S938B

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 A: PART 0 SAR TEST RESULTS FOR P_{LIMIT} CALCULATIONS

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1 DEVICE UNDER TEST

1.1 Device Overview

This device uses the Qualcomm® Gen2 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, and WLAN/BT operations. Additionally, this device supports NFC/MST technologies, but the output power of these modems is not controlled by the Smart Transmit algorithm.

Band & Mode	Operating Modes	Tx Frequency
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 12	Voice/Data	699.7 - 715.3 MHz
LTE Band 17	Voice/Data	706.5 - 713.5 MHz
LTE Band 13	Voice/Data	779.5 - 784.5 MHz
LTE Band 26	Voice/Data	814.7 - 848.3 MHz
LTE Band 5	Voice/Data	824.7 - 848.3 MHz
LTE Band 66	Voice/Data	1710.7 - 1779.3 MHz
LTE Band 4	Voice/Data	1710.7 - 1754.3 MHz
LTE Band 25	Voice/Data	1850.7 - 1914.3 MHz
LTE Band 2	Voice/Data	1850.7 - 1909.3 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
NR Band n5	Voice/Data	826.5 - 846.5 MHz
NR Band n66	Voice/Data	1712.5 - 1777.5 MHz
NR Band n25	Voice/Data	1852.5 - 1912.5 MHz
NR Band n2	Voice/Data	1852.5 - 1907.5 MHz
NR Band n41	Voice/Data	2501.01 - 2685 MHz
NR Band n77	Voice/Data	3455.01 - 3544.98 MHz; 3705 - 3975 MHz
2.4 GHz WIFI	Voice/Data	2412 - 2462 MHz
5 GHz WIFI	Voice/Data	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz U-NII-4: 5845 - 5885 MHz
6 GHz WIFI	Voice/Data	U-NII-5: 5945 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz
2.4 GHz Bluetooth	Data	2402 - 2480 MHz
NFC	Data	13.56 MHz
UWB	Data	6489.6 - 7987.2 MHz

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1.2 Time-Averaging for SAR and Power Density

This device is enabled with Qualcomm® Gen2 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 and WLAN/BT 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).

1.3 Nomenclature for Part 0 Report

Technology	Term	Description
2G/3G/4G/5G Sub-6 NR/WLAN/BT	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 P_{limit} for all technologies and bands

1.4 Bibliography

Report Type	Report Serial Number
RF Exposure Part 1 Test Report	1M2408260069-01.A3L
RF Exposure Part 2 Test Report	1M2408260069-02.A3L
RF Exposure Compliance Summary	1M2408260069-03.A3L
RF Exposure Part 0 Test Report – Reference Model	1M2408260067-31.A3L
RF Exposure Part 1 Test Report – Reference Model	1M2408260067-23.A3L
RF Exposure Part 2 Test Report – Reference Model	1M2408260069-02.A3L

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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 Table 2-1) and IEEE 1528-2013.
2. 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.
3. 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

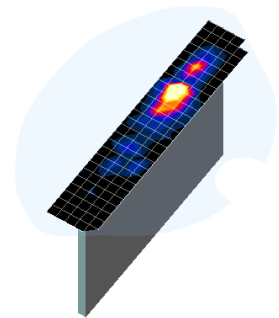


Figure 2-1
Sample SAR Area Scan

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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 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).

b. 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.

c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

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

*Also compliant to IEEE 1528-2013 Table 6

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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 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 3-1
DSI and Corresponding Exposure Scenarios

Scenario	Description	SAR Test Cases
Head (DSI = 1)	- Device positioned next to head - Receiver Active	Head SAR per KDB Publication 648474 D04
Hotspot mode (DSI = 0)	- Device transmits in hotspot mode near body - Hotspot Mode Active	Hotspot SAR per KDB Publication 941225 D06
Phablet (DSI = 0)	Device is held with hand	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

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**

<i>SAR_design_target</i>			
$SAR_design_target < SAR_regulatory_limit \times 10^{\frac{-Total\ Uncertainty}{10}}$			
1g SAR (W/kg)		10g SAR (W/kg)	
<i>Total Uncertainty</i>	1.0 dB	<i>Total Uncertainty</i>	1.0 dB
<i>SAR_regulatory_limit</i>	1.6 W/kg	<i>SAR_regulatory_limit</i>	4.0 W/kg
<i>SAR_design_target</i>	1.0 W/kg	<i>SAR_design_target</i>	2.5 W/kg

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3.3 SAR Char

SAR test results corresponding to P_{max} for each antenna/technology/band/DSI can be found in Appendix A.

P_{limit} is calculated by linearly scaling with the measured SAR at the P_{part0} to correspond to the SAR_{design_target} . When $P_{limit} < P_{max}$, P_{part0} was used as P_{limit} in the Smart Transmit EFS. When $P_{limit} > P_{max}$ and $P_{part0}=P_{max}$, calculated P_{limit} was used in the Smart Transmit EFS. All reported SAR obtained from the P_{part0} SAR tests was less than $SAR_{Design_target}+ 1$ dB Uncertainty. The final P_{limit} determination for each exposure scenario corresponding to SAR_{design_target} are shown in Table 3-3.

Table 3-3
 P_{Limit} Determination

Device State Index (DSI)	P_{Limit} Determination Scenarios
0	The worst-case SAR exposure is determined as maximum SAR normalized to the limit (i.e. lowest P_{limit}) among: 1. Body Worn SAR 2. Extremity SAR measured at 0 mm for all surfaces. 3. Hotspot SAR at 10 mm
1	P_{limit} is calculated based on 1g Head SAR

Notes:

- When $P_{max} < P_{limit}$ EFS, the DUT will operate at a power level up to P_{max}
- All P_{limit} EFS and maximum tune up output power P_{max} levels entered in above Table correspond to average power levels after accounting for duty cycle in the case of TDD, GMSK, or OFDM modulation schemes (e.g. GSM, LTE TDD and WLAN/BT).
- Maximum tune up output power P_{max} is used to configure EUT during RF tune up procedure. The maximum allowed output power is equal to maximum Tune up output power + 1dB device design uncertainty.
- All MIMO P_{max} and P_{limit} are defined per antenna chain.

Measurement Condition: All conducted power and SAR measurements in this report (Part 1 test) were performed by setting Reserve_power_margin (Smart Transmit EFS entry) to 0dB.

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Table 3-4
SAR Characterizations

Exposure Scenario			Maximum Tune-Up Output Power*	Body-Worn Hotspot, or Phablet	Head
Averaging Volume				1g/10g	1g
Spacing				10mm, 0mm	0mm
DSI				0	1
Technology/Band	Antenna	Antenna Group	P _{max}	P _{limit}	P _{limit}
GSM 850	A	AG0	25.1	29.8	29.8
GSM 850	E	AG1	25.1	26.5	21.0
GSM 1900	A	AG0	22.1	18.8	32.7
UMTS 850	A	AG0	24.0	28.5	30.3
UMTS 850	E	AG1	24.0	27.0	20.5
UMTS 1750	A	AG0	23.0	19.0	30.6
UMTS 1900	A	AG0	23.0	18.0	30.2
LTE Band 12/17	A	AG0	24.3	27.5	28.5
LTE Band 12/17	E	AG1	24.3	26.0	21.5
LTE Band 13	A	AG0	24.0	27.2	28.1
LTE Band 13	E	AG1	24.0	26.4	21.5
LTE Band 26/5	A	AG0	24.0	28.2	29.5
LTE Band 26/5	E	AG1	24.0	26.5	21.0
LTE Band 66/4	A	AG0	23.5	19.0	31.2
LTE Band 66/4	F	AG1	23.5	21.0	18.5
LTE Band 25/2	A	AG0	23.0	18.0	30.3
LTE Band 25/2	F	AG1	23.0	20.0	19.0
LTE Band 41 PC3	B	AG0	22.0	19.0	34.0
LTE Band 41 PC3	F	AG1	22.0	19.0	15.5
LTE Band 41 PC2	B	AG0	21.4	19.0	34.0
LTE Band 41 PC2	F	AG1	21.4	19.0	15.5
NR Band n5	A	AG0	24.0	25.9	30.1
NR Band n5	E	AG1	24.0	26.5	21.0
NR Band n66	A	AG0	23.0	19.0	31.5
NR Band n66	F	AG1	22.5	21.0	18.5
NR Band n25/n2	A	AG0	22.5	18.0	28.9
NR Band n25/n2	F	AG1	22.5	20.0	19.0
NR Band n41 PC3 (Path 1)	F	AG1	24.0	18.5	16.5
NR Band n41 PC3 (Path 1)	B	AG0	21.0	19.0	16.5
NR Band n41 PC3 (Path 1)	E	AG1	20.0	16.0	13.5
NR Band n41 PC3 (Path 1)	D	AG0	19.0	16.0	13.5
NR Band n41 PC3 (Path 2)	B	AG0	24.0	20.0	21.0
NR Band n41 PC3 (Path 2)	F	AG1	21.0	18.5	16.5
NR Band n41 PC3 (Path 2)	D	AG0	22.0	18.0	19.0
NR Band n41 PC3 (Path 2)	E	AG1	18.0	16.0	16.0
NR Band n77 PC2	F	AG1	25.0	18.5	14.5
NR Band n77 PC2	C	AG0	19.0	14.0	10.0
NR Band n77 PC2	I	AG1	24.0	18.5	14.5
NR Band n77 PC2	D	AG0	19.0	14.0	10.0
2.4 GHz WIFI	H	AG1	19.0	19.5	16.0
2.4 GHz WIFI	J	AG1	19.0	25.4	16.0
2.4 GHz WIFI	MIMO	AG1	17.0	19.4	16.0
5 GHz WIFI	H	AG1	17.0	15.0	15.0
5 GHz WIFI	E	AG1	17.0	15.0	15.0
5 GHz WIFI	MIMO	AG1	17.0	15.0	15.0
6 GHz WIFI	H	AG1	16.0	8.0	16.8
6 GHz WIFI	E	AG1	16.0	8.0	22.9
6 GHz WIFI	MIMO	AG1	16.0	8.0	17.0
2.4 GHz Bluetooth	H	AG1	17.4	21.3	18.5
2.4 GHz Bluetooth	J	AG1	17.4	25.9	20.4
2.4 GHz Bluetooth	MIMO	AG1	12.9	17.9	17.2
2.4 GHz Bluetooth LE	H	AG1	18.9	21.3	18.9
2.4 GHz Bluetooth LE	J	AG1	18.4	25.9	20.4
2.4 GHz Bluetooth LE	MIMO	AG1	12.9	17.9	17.2

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4 EQUIPMENT LIST

For SAR measurements

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	E4404B	Spectrum Analyzer	N/A	N/A	N/A	MH4111142
Agilent	E4438C	ESG Vector Signal Generator	11/14/2023	Annual	11/14/2024	MH400038272
Agilent	E4438C	ESG Vector Signal Generator	11/15/2023	Annual	11/15/2024	MH40003078
Agilent	N9020A	MMV Vector Signal Generator	7/8/2024	Annual	7/8/2025	MH48002333
Agilent	N1518A	MMV Vector Signal Generator	3/7/2024	Annual	3/7/2025	MH47426019
Agilent	87331S	S-Parameter Vector Network Analyzer	1/20/2024	Annual	1/20/2025	MH40001472
Agilent	87331S	S-Parameter Vector Network Analyzer	3/6/2024	Annual	3/6/2025	MH4000670
Agilent	E5515C	Wireless Communications Test Set	CBT	N/A	CBT	0846101788
Agilent	E5515C	Wireless Communications Test Set	CBT	N/A	CBT	0581146266
Agilent	E5515C	Wireless Communications Test Set	1/30/2024	Annual	1/30/2025	MH50262130
Agilent	N4610A	Wireless Connectivity Test Set	N/A	N/A	N/A	0846101788
Amplifier Research	LS516B	Amplifier	CBT	N/A	CBT	433979
Amplifier Research	LS516B	Amplifier	CBT	N/A	CBT	433974
Amplifier Research	LS516B	Amplifier	CBT	N/A	CBT	501432
Amplifier Research	LS516B	Amplifier	7/30/2024	Annual	7/30/2025	390880
Anritsu	MM1110B	I/O Adapter	CBT	N/A	CBT	6261747885
Anritsu	ML2496A	Power Meter	6/24/2024	Annual	6/24/2025	184005
Anritsu	ML2496A	Power Meter	7/8/2024	Annual	7/8/2025	1030008
Anritsu	MA2411B	Pulse Power Sensor	9/5/2024	Annual	9/5/2025	1726262
Anritsu	MA2411B	Pulse Power Sensor	11/8/2023	Annual	11/8/2024	1027729
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	12/15/2023	Annual	12/15/2024	6260965190
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	5/15/2024	Annual	5/15/2025	6262150047
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	1/30/2024	Annual	1/30/2025	6262044715
Anritsu	MT8000A	Radio Communication Test Station	4/23/2024	N/A	4/23/2025	6272337498
Anritsu	MT8000A	Radio Communication Test Station	4/10/2024	Annual	4/10/2025	6261687963
Anritsu	MT8000A	Radio Communication Test Station	5/2/2024	Annual	5/2/2025	6272337498
Anritsu	MA24106A	USB Power Sensor	12/16/2023	Annual	12/16/2024	5235051
Anritsu	MA24106A	USB Power Sensor	4/15/2024	Annual	4/15/2025	1877528
Mini-Circuits	PWB-4G50E	USB Power Sensor	6/12/2024	Annual	6/12/2025	1280707003
Anritsu	MA24106A	Microstrip Peak Power Sensor	4/9/2024	Annual	4/9/2025	14267
Anritsu	MA24106A	USB Power Sensor	7/8/2024	Annual	7/8/2025	1244512
Anritsu	MA24106A	USB Power Sensor	1/10/2024	Annual	1/10/2025	1244512
Control Company	4052	Long Stem Thermometer	2/27/2024	Biennial	2/27/2026	240114346
Control Company	4052	Long Stem Thermometer	2/27/2024	Biennial	2/27/2026	240171096
Control Company	4052	Long Stem Thermometer	2/27/2024	Biennial	2/27/2026	240171099
Control Company	4132	Long Stem Thermometer	1/15/2024	Biennial	1/15/2026	100580997
Control Company	4040	Therm / Chock/Humidity Monitor	4/13/2024	Biennial	4/13/2026	240310380
Control Company	4040	Therm / Chock/Humidity Monitor	4/13/2024	Biennial	4/13/2026	240310382
Control Company	56679	Therm / Chock/Humidity Monitor	2/16/2024	Biennial	2/16/2026	240340551
Testo	608-H1	ALUMA-HYGROMETER	4/13/2024	Annual	4/13/2025	83316071
Testo	608-H1	ALUMA-HYGROMETER	4/13/2024	Annual	4/13/2025	83316052
Testo	608-H1	ALUMA-HYGROMETER	4/13/2024	Annual	4/13/2025	83316053
Mitutoyo	500-196-30	CD-0 ASX drench Digital Caliper	2/16/2022	Triennial	2/16/2025	A20238413
Keysight Technologies	N9020A	MMA Signal Analyzer	4/13/2024	Annual	4/13/2025	MH5450644
Agilent	N9020A	MMA Signal Analyzer	6/24/2024	Annual	6/24/2025	MH54502023
Agilent	N9020A	MMA Signal Analyzer	7/8/2024	Annual	7/8/2025	MH48002333
MACL	BW-NDV5+	SGB Attenuator	CBT	N/A	CBT	1139
MACL	BW-NDV5+	Attenuator	7/9/2024	Annual	7/9/2025	1507
Mini-Circuits	VLF-4000+	Low Pass Filter DC to 6000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	VLF-4000+	Low Pass Filter DC to 6000 MHz	7/10/2024	Annual	7/10/2025	13634
Mini-Circuits	BW-NDV5+	DC to 30 GHz Precision Fixed 50 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter DC to 1000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter DC to 1000 MHz	7/10/2024	Annual	7/10/2025	UU1930338
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	7/10/2024	Annual	7/10/2025	UU19303107
Mini-Circuits	BW-NDV5+	Power Attenuator	CBT	N/A	CBT	1236
Mini-Circuits	200K10-83-5+	Directional Coupler	CBT	N/A	CBT	2055
Mini-Circuits	200K10-83-5+	Directional Coupler	7/8/2024	Annual	7/8/2025	2111
Narda	4772-3	Attenuator (SDB)	CBT	N/A	CBT	9406
MACL	BW-NDV5+	Attenuator	7/9/2024	Annual	7/9/2025	1507
Narda	BW-53W2	Attenuator (SDB)	CBT	N/A	CBT	120
Seabrook	NC-100	Torque Wrench	CBT	N/A	CBT	22217
Seabrook	NC-100	Torque Wrench	4/22/2024	Biennial	4/22/2026	1262
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	1/10/2024	Annual	1/10/2025	131454
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	8/10/2023	Biennial	8/10/2025	140144
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	4/9/2024	Annual	4/9/2025	148176
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	7/8/2024	Annual	7/8/2025	166838
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	1/10/2024	Annual	1/10/2025	150117
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	1/11/2024	Annual	1/11/2025	171075
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/13/2023	Annual	11/13/2024	1277
SPEAG	DAK5-3.5	Portable Dielectric Assessment Kit	8/7/2024	Annual	8/7/2025	1045
SPEAG	DAK5-3.5	Portable Dielectric Assessment Kit	7/8/2024	Annual	7/8/2025	1038
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1237
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1335
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1523
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1390
SPEAG	DAK-12	Dielectric Assessment Kit (MHz - 3GHz)	3/13/2024	Annual	3/13/2025	1102
SPEAG	CLA-13	Confined Loop Antenna	11/16/2023	Annual	11/16/2024	1004
SPEAG	D750V3	750 MHz SAR Dipole	10/19/2021	Triennial	10/19/2024	1161
SPEAG	D750V3	750 MHz SAR Dipole	3/14/2022	Triennial	3/14/2025	1054
SPEAG	D85V2	855 MHz SAR Dipole	4/8/2024	Annual	4/8/2025	40519
SPEAG	D85V2	855 MHz SAR Dipole	3/14/2022	Triennial	3/14/2025	40847
SPEAG	D1750V2	1750 MHz SAR Dipole	5/10/2024	Annual	5/10/2025	1092
SPEAG	D1750V2	1750 MHz SAR Dipole	10/23/2023	Triennial	10/23/2024	1150
SPEAG	D1750V2	1750 MHz SAR Dipole	4/15/2024	Annual	4/15/2025	1051
SPEAG	D1750V2	1750 MHz SAR Dipole	1/8/2024	Triennial	1/8/2025	1148
SPEAG	D1900V2	1900 MHz SAR Dipole	4/8/2023	Triennial	4/8/2025	14880
SPEAG	D1900V2	1900 MHz SAR Dipole	2/21/2022	Triennial	2/21/2025	14048
SPEAG	D1900V2	1900 MHz SAR Dipole	4/12/2024	Annual	4/12/2025	14041
SPEAG	D1900V2	1900 MHz SAR Dipole	5/10/2024	Annual	5/10/2025	14026
SPEAG	D2450V2	2450 MHz SAR Dipole	5/10/2024	Annual	5/10/2025	945
SPEAG	D2450V2	2450 MHz SAR Dipole	2/8/2024	Annual	2/8/2025	882
SPEAG	D2600V2	2600 MHz SAR Dipole	6/14/2024	Annual	6/14/2025	1098
SPEAG	D3500V2	3500 MHz SAR Dipole	6/10/2024	Annual	6/10/2025	1127
SPEAG	D3700V2	3700 MHz SAR Dipole	6/10/2024	Annual	6/10/2025	1096
SPEAG	D3800V2	3800 MHz SAR Dipole	6/10/2024	Annual	6/10/2025	1074
SPEAG	D590V2	5 GHz SAR Dipole	4/9/2024	Annual	4/9/2025	1237
SPEAG	D610V2	6.1 GHz SAR Dipole	2/22/2024	Annual	2/22/2025	1111
SPEAG	D610V2	6.1 GHz SAR Dipole	1/10/2024	Annual	1/10/2025	828
SPEAG	D85HV2	855 MHz SAR Dipole	3/4/2024	Annual	3/4/2025	1007
SPEAG	5G Verification Source 100Hz	100Hz System Verification Antenna	3/5/2024	Annual	3/5/2025	1002
SPEAG	DAE4	Day Data Acquisition Electronics	9/10/2024	Annual	9/10/2025	1344
SPEAG	DAE4	Day Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	1503
SPEAG	DAE4	Day Data Acquisition Electronics	1/16/2024	Annual	1/16/2025	1446
SPEAG	DAE4	Day Data Acquisition Electronics	2/9/2024	Annual	2/9/2025	1445
SPEAG	DAE4	Day Data Acquisition Electronics	7/8/2024	Annual	7/8/2025	1477
SPEAG	DAE4	Day Data Acquisition Electronics	6/11/2024	Annual	6/11/2025	1334
SPEAG	DAE4	Day Data Acquisition Electronics	4/18/2024	Annual	4/18/2025	1407
SPEAG	DAE4	Day Data Acquisition Electronics	3/8/2024	Annual	3/8/2025	128
SPEAG	DAE4	Day Data Acquisition Electronics	3/12/2024	Annual	3/12/2025	1272
SPEAG	DAE4	Day Data Acquisition Electronics	3/8/2024	Annual	3/8/2025	804
SPEAG	DAE4	Day Data Acquisition Electronics	3/6/2024	Annual	3/6/2025	524
SPEAG	DAE4	Day Data Acquisition Electronics	9/10/2024	Annual	9/10/2025	1449
SPEAG	EK30V4	SAR Probe	9/11/2024	Annual	9/11/2025	7558
SPEAG	EK30V4	SAR Probe	5/10/2024	Annual	5/10/2025	7462
SPEAG	EK30V4	SAR Probe	1/16/2024	Annual	1/16/2025	7565
SPEAG	EK30V4	SAR Probe	2/9/2024	Annual	2/9/2025	7460
SPEAG	EK30V4	SAR Probe	7/18/2024	Annual	7/18/2025	7499
SPEAG	EK30V4	SAR Probe	6/28/2024	Annual	6/28/2025	7803
SPEAG	EK30V4	SAR Probe	6/17/2024	Annual	6/17/2025	7499
SPEAG	EK30V4	SAR Probe	4/17/2024	Annual	4/17/2025	7499
SPEAG	EK30V4	SAR Probe	5/10/2024	Annual	5/10/2025	3514
SPEAG	EK30V4	SAR Probe	3/8/2024	Annual	3/8/2025	7127
SPEAG	EK30V4	SAR Probe	3/13/2024	Annual	3/13/2025	7423
SPEAG	EK30V4	SAR Probe	2/9/2024	Annual	2/9/2025	7388
SPEAG	CommeV4	CommeV4 Probe	2/2/2024	Annual	2/2/2025	9622

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

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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.

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5 MEASUREMENT UNCERTAINTIES

Applicable for SAR measurements < 6GHz:

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	E2.1	7	N	1	1	1	7.0	7.0	∞
Axial Isotropy	E2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E2.3	2	R	1.73	1	1	1.2	1.2	∞
Linearity	E2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E2.4	0.25	R	1.73	1	1	0.1	0.1	∞
Modulation Response	E2.5	4.8	R	1.73	1	1	2.8	2.8	∞
Readout Electronics	E2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E2.7	0.8	R	1.73	1	1	0.5	0.5	∞
Integration Time	E2.8	2.6	R	1.73	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E6.1	3	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E6.1	3	R	1.73	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.8	R	1.73	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E6.3	6.7	R	1.73	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E5	4	R	1.73	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E2.9	5	R	1.73	1	1	2.9	2.9	∞
SAR Scaling	E6.5	0	R	1.73	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E3.4	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Uncertainty	E3.4	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)							RSS	12.2	12.0
Expanded Uncertainty (95% CONFIDENCE LEVEL)							k=2	24.4	24.0

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

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Applicable for SAR measurements > 6GHz:

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	E2.1	9.3	N	1	1	1	9.3	9.3	∞
Axial Isotropy	E2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E2.3	2	R	1.73	1	1	1.2	1.2	∞
Linearity	E2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E2.4	0.25	R	1.73	1	1	0.1	0.1	∞
Modulation Response	E2.5	4.8	R	1.73	1	1	2.8	2.8	∞
Readout Electronics	E2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E2.7	0.8	R	1.73	1	1	0.5	0.5	∞
Integration Time	E2.8	2.6	R	1.73	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E6.1	3	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E6.1	3	R	1.73	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.8	R	1.73	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E6.3	6.7	R	1.73	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E5	4	R	1.73	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E2.9	5	R	1.73	1	1	2.9	2.9	∞
SAR Scaling	E6.5	0	R	1.73	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E3.4	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Uncertainty	E3.4	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)							RSS	13.8	13.6
Expanded Uncertainty (95% CONFIDENCE LEVEL)							k=2	27.6	27.1

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

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