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RF EXPOSURE PART 0 TEST REPORT

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Date of Testing:
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Element, Columbia, MD, USA
Element Morgan Hill, CA, USA
Element, Suwon, Korea
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FCC ID:	**A3LSMS938U**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD**

Report Type:	Part 0 SAR Characterization
DUT Type:	Portable Handset
Model(s):	SM-S938U
Additional Model:	SM-S938U1

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

ilac-MRA
ACCREDITED
CERT #2041.01

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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 modes are 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 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	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 30	Voice/Data	2307.5 - 2312.5 MHz
LTE Band 7	Voice/Data	2502.5 - 2567.5 MHz
LTE Band 41	Voice/Data	2498.5 - 2687.5 MHz
LTE Band 38	Voice/Data	2572.5 - 2617.5 MHz
LTE Band 48	Voice/Data	3552.5 - 3697.5 MHz
NR Band n71	Voice/Data	665.5 - 695.5 MHz
NR Band n12	Voice/Data	701.5 - 713.5 MHz
NR Band n14	Voice/Data	790.5 - 795.5 MHz
NR Band n26	Voice/Data	816.5 - 846.5 MHz
NR Band n5	Voice/Data	826.5 - 846.5 MHz
NR Band n70	Voice/Data	1697.5 - 1707.5 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 n30	Voice/Data	2307.5 - 2312.5 MHz
NR Band n7	Voice/Data	2502.5 - 2567.5 MHz
NR Band n41	Voice/Data	2501.01 - 2685 MHz
NR Band n38	Voice/Data	2575 - 2615 MHz
NR Band n48	Voice/Data	3555 - 3694.98 MHz
NR Band n78	Voice/Data	3455.01 - 3544.98 MHz; 3705 - 3795 MHz
NR Band n77	Voice/Data	3455.01 - 3544.98 MHz; 3705 - 3975 MHz
NTN Band 255	Data	1629 - 1658 MHz
NR Band n258	Data	24250 - 24450 MHz; 24750 - 25250 MHz
NR Band n260	Data	37000 - 40000 MHz
NR Band n261	Data	27500 - 28350 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: 5935 - 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

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 and WLAN/BT radios. Characterization is achieved by determining P_{Limit} for 2G/3G/4G/5G Sub-6 NR/WLAN/BT 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/WLAN/BT 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 *Plimit* for all technologies and bands

1.4 Bibliography

Report Type	Report Serial Number
Near Field PD Report (Part 0)	
RF Exposure SAR Evaluation Report (Part 1)	1M2408260067-23.A3L
Near Field PD Report (Part 1)	1M2408260067-25.A3L
RF Exposure Part 2 Test Report	1M2408260067-24.A3L
RF Exposure Compliance Summary	1M2408260067-26.A3L

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:

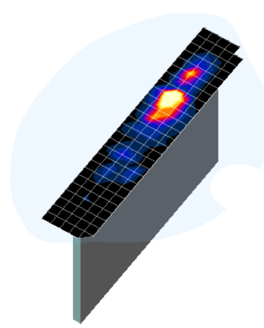

Figure 2-1
Sample SAR Area Scan

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

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) (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

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**

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

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_target*+ 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
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 spacing for back, front, top, bottom, right and left. 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.

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	25.3	29.7	31.5
GSM 850	E	AG1	25.3	27.7	20.3
GSM 1900	A	AG0	22.1	18.8	28.8
UMTS 850	A	AG0	24.0	25.9	29.0
UMTS 850	E	AG1	24.0	26.9	20.5
UMTS 1750	A	AG0	23.0	19.0	29.4
UMTS 1900	A	AG0	23.0	18.0	29.0
LTE Band 71	A	AG0	24.0	27.2	28.6
LTE Band 71	E	AG1	24.0	27.0	21.5
LTE Band 12	A	AG0	24.0	27.0	28.5
LTE Band 12	E	AG1	24.0	26.2	21.5
LTE Band 13	A	AG0	24.0	27.0	28.0
LTE Band 13	E	AG1	24.0	25.9	21.5
LTE Band 14	A	AG0	24.0	26.7	28.3
LTE Band 14	E	AG1	24.0	26.2	21.5
LTE Band 26/5	A	AG0	24.0	27.1	29.3
LTE Band 26/5	E	AG1	24.0	26.4	21.0
LTE Band 66/4	A	AG0	23.5	19.0	29.0
LTE Band 66/4	F	AG1	23.5	20.5	18.5
LTE Band 25/2	A	AG0	23.5	18.0	28.5
LTE Band 25/2	F	AG1	23.5	20.0	18.5
LTE Band 30	A	AG0	22.5	19.5	34.2
LTE Band 30	F	AG1	22.0	20.0	17.0
LTE Band 7	B	AG0	23.5	20.0	29.2
LTE Band 7	F	AG1	23.5	19.5	16.0
LTE Band 41/38	B	AG0	22.0	20.0	30.1
LTE Band 41/38	F	AG1	22.0	19.5	16.0
LTE Band 48	F	AG1	20.0	19.5	16.0
NR Band n71	A	AG0	24.0	26.4	29.5
NR Band n71	E	AG1	24.0	27.6	21.5
NR Band n12	A	AG0	24.0	26.2	28.2
NR Band n12	E	AG1	24.0	27.0	21.5
NR Band n14	A	AG0	24.0	26.7	29.3
NR Band n14	E	AG1	24.0	26.9	21.5
NR Band n26/n5	A	AG0	24.0	28.1	30.2
NR Band n26/n5	E	AG1	24.0	27.3	21.0
NR Band n70	A	AG0	23.5	19.0	29.0
NR Band n70	F	AG1	23.5	21.0	18.5
NR Band n66	A	AG0	23.5	19.0	29.2
NR Band n66	F	AG1	23.5	20.5	18.5
NR Band n25/n2	A	AG0	23.5	18.0	29.1
NR Band n25/n2	F	AG1	23.5	20.0	18.5
NR Band n30	A	AG0	22.5	19.5	33.9
NR Band n30	F	AG1	22.0	20.0	17.0
NR Band n7	B	AG0	23.5	20.0	28.2
NR Band n7	F	AG1	23.5	19.5	16.0
NR Band n41 PC2 (Path 1)	F	AG1	26.0	19.5	16.5
NR Band n41 PC2 (Path 1)	B	AG0	23.0	19.5	16.5
NR Band n41 PC2 (Path 1)	E	AG1	23.5	18.0	15.0
NR Band n41 PC2 (Path 1)	D	AG0	22.0	19.5	16.5
NR Band n41 PC2 (Path 2)	B	AG0	26.0	20.0	21.0
NR Band n41 PC2 (Path 2)	F	AG1	21.5	19.5	16.5
NR Band n41 PC2 (Path 2)	D	AG0	25.0	20.0	21.0
NR Band n41 PC2 (Path 2)	E	AG1	20.0	17.5	17.5
NR Band n41 PC1.5 UL-MIMO	F	AG1	26.0	19.5	16.5
NR Band n41 PC1.5 UL-MIMO	B	AG0	26.0	20.0	21.0
NR Band n41 PC1.5	E	AG1	23.5	18.0	15.0
NR Band n41 PC1.5	D	AG0	25.0	19.5	16.5
NR Band n38 (Path 1)	F	AG1	24.0	19.5	16.5
NR Band n38 (Path 2)	B	AG0	24.0	20.0	21.0
NR Band n48	F	AG1	22.0	19.5	16.0
NR Band n48	C	AG0	16.5	14.5	11.0
NR Band n48	I	AG1	21.0	19.0	15.5
NR Band n48	D	AG0	16.5	14.5	11.0
NR Band n78 PC2	F	AG1	26.0	18.0	16.0
NR Band n78 PC2	C	AG0	21.0	17.0	21.0
NR Band n78 PC2	I	AG1	25.5	18.0	15.5
NR Band n78 PC2	D	AG0	20.0	13.0	10.5
NR Band n77 PC2	F	AG1	26.0	18.0	16.0
NR Band n77 PC2	C	AG0	21.0	17.0	21.0
NR Band n77 PC2	I	AG1	25.5	18.0	15.5
NR Band n77 PC2	D	AG0	20.0	13.0	10.5
NR Band n77 PC1.5 UL-MIMO	F	AG1	26.0	18.0	16.0
NR Band n77 PC1.5 UL-MIMO	C	AG0	26.0	17.0	21.0
NR Band n77 PC1.5	I	AG1	25.5	18.0	15.5
NR Band n77 PC1.5	D	AG0	26.0	13.0	10.5
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	18.4
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	18.7
2.4 GHz Bluetooth	J	AG1	17.4	25.9	20.4
2.4 GHz Bluetooth	MIMO	AG1	13.4	18.7	17.8
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	13.9	18.7	17.8

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	MY45113242
Agilent	E4438C	ESG Vector Signal Generator	11/14/2023	Annual	11/14/2024	MY45093852
Agilent	E4438C	ESG Vector Signal Generator	11/15/2023	Annual	11/15/2024	MY45092078
Agilent	N5182A	MXG Vector Signal Generator	10/12/2023	Annual	10/12/2024	MY47400015
Agilent	N5182A	MXG Vector Signal Generator	3/7/2024	Annual	3/7/2025	MY47420603
Agilent	N9020A	MXG Vector Signal Generator	7/8/2024	Annual	7/8/2025	MY48010233
Agilent	8753ES	S-Parameter Vector Network Analyzer	1/10/2024	Annual	1/10/2025	MY40001472
Agilent	8753ES	S-Parameter Vector Network Analyzer	9/25/2024	Annual	9/25/2025	US39170118
Agilent	E5515C	Wireless Communications Test Set	CBT	N/A	CBT	GB46310798
Agilent	E5515C	Wireless Communications Test Set	CBT	N/A	CBT	US41140256
Agilent	E5515C	Wireless Communications Test Set	1/10/2024	Annual	1/10/2025	MY50262130
Agilent	N4010A	Wireless Connectivity Test Set	N/A	N/A	N/A	GB46170464
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433973
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433974
Amplifier Research	150A100C	Amplifier	CBT	N/A	CBT	350132
Amplifier Research	15S1G6M3	Amplifier	7/10/2024	Annual	7/10/2025	390882
Anritsu	MN8110B	I/O Adaptor	CBT	N/A	CBT	6261747881
Anritsu	ML2496A	Power Meter	6/24/2024	Annual	6/24/2025	1840005
Anritsu	ML2495A	Power Meter	7/8/2024	Annual	7/8/2025	1039008
Anritsu	MA2411B	Pulse Power Sensor	7/10/2024	Annual	7/10/2025	1126066
Anritsu	MA2411B	Pulse Power Sensor	11/8/2023	Annual	11/8/2024	1027293
Anritsu	MA24408A	Microwace Peak Power Sensor	4/8/2024	Annual	4/8/2025	11679
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	12/15/2023	Annual	12/15/2024	6200901190
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	5/15/2024	Annual	5/15/2025	6262150047
Anritsu	MT8821C	Radio Communication Analyzer MT8821C	5/30/2024	Annual	5/30/2025	6262044715
Anritsu	MT8000A	Radio Communication Test Station	5/14/2024	N/A	5/14/2025	6272337419
Anritsu	MT8000A	Radio Communication Test Station	4/10/2024	Annual	4/10/2025	6261987983
Anritsu	MT8000A	Radio Communication Test Station	5/2/2024	Annual	5/2/2025	6272337436
Anritsu	MA24106A	USB Power Sensor	12/4/2023	Annual	12/4/2024	1520501
Anritsu	MA24106A	USB Power Sensor	4/15/2024	Annual	4/15/2025	1827528
Anritsu	MA24106A	USB Power Sensor	7/9/2024	Annual	7/9/2025	1244512
Anritsu	MA24106A	USB Power Sensor	1/10/2024	Annual	1/10/2025	1344557
Mini-Circuits	PWR-4GHS	USB Power Sensor	6/12/2024	Annual	6/12/2025	12001070013
Control Company	4052	Long Stem Thermometer	2/27/2024	Biennial	2/27/2026	240174346
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	240171059
Control Company	4352	Ultra Long Stem Thermometer	1/15/2024	Annual	1/15/2025	160508097
Control Company	4040	Therm./ Clock/ Humidity Monitor	4/15/2024	Biennial	4/15/2026	240310280
Control Company	4040	Therm./ Clock/ Humidity Monitor	4/15/2024	Biennial	4/15/2026	240310282
Control Company	S66279	Therm./ Clock/ Humidity Monitor	2/16/2024	Biennial	2/16/2026	240140051
Testo	608-H1	ALARM-HYGROMETER	4/11/2024	Annual	4/11/2025	83316971
Testo	608-H1	ALARM-HYGROMETER	4/11/2024	Annual	4/11/2025	83316952
Testo	608-H1	ALARM-HYGROMETER	4/11/2024	Annual	4/11/2025	83316953
Mitutoyo	500-196-30	CD-6"ASX 6Inch Digital Caliper	2/16/2022	Triennial	2/16/2025	A20238413
Keysight Technologies	N9020A	MXA Signal Analyzer	4/11/2024	Annual	4/11/2025	MY54500644
Agilent	N9020A	MXA Signal Analyzer	6/14/2024	Annual	6/14/2025	MY56470202
Keysight Technologies	N9020A	MXA Signal Analyzer	7/8/2024	Annual	7/8/2025	MY48010233
MCL	BW-N10W5+	Attenuator	7/9/2024	Annual	7/9/2025	1507
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Mini-Circuits	VLF-6000+	Low Pass Filter DC to 6000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	VLF-6000+	Low Pass Filter DC to 6000 MHz	7/10/2024	Annual	7/10/2025	31634
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 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	UU13301538
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	7/10/2024	Annual	7/10/2025	UU19201507
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	CBT	N/A	CBT	2050
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	7/9/2024	Annual	7/9/2025	2111
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Narda	BW-S3W2	Attenuator (3dB)	CBT	N/A	CBT	120
MCL	BW-N3W5+	Attenuator	7/9/2024	Annual	7/9/2025	1608
Seekonk	NC-100	Torque Wrench	CBT	N/A	CBT	22217
Seekonk	NC-100	Torque Wrench	4/2/2024	Biennial	4/2/2026	1262
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	1/10/2024	Annual	1/10/2025	131454
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	7/8/2024	Annual	7/8/2025	166818
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	DAKS-3.5	Portable Dielectric Assessment Kit	8/7/2024	Annual	8/7/2025	1041
SPEAG	DAKS-3.5	Portable Dielectric Assessment Kit	7/8/2024	Annual	7/8/2025	1039
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	1331
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1390
SPEAG	DAK-12	Dielectric Assessment Kit (4MHz - 3GHz)	3/11/2024	Annual	3/11/2025	1102
SPEAG	CLA-13	Confined Loop Antenna	11/9/2023	Annual	11/9/2024	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	D750V3	750 MHz SAR Dipole	9/13/2023	Biennial	9/13/2025	1097
SPEAG	D835V2	835 MHz SAR Dipole	11/18/2022	Biennial	11/18/2024	4d108
SPEAG	D835V2	835 MHz SAR Dipole	4/8/2024	Annual	4/8/2025	4d119
SPEAG	D835V2	835 MHz SAR Dipole	3/14/2022	Triennial	3/14/2025	4d047
SPEAG	D1640V2	1640 MHz SAR Dipole	12/13/2022	Biennial	12/13/2024	321
SPEAG	D1750V2	1750 MHz SAR Dipole	10/22/2021	Triennial	10/22/2024	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	8/8/2022	Triennial	8/8/2025	5d080
SPEAG	D1900V2	1900 MHz SAR Dipole	2/21/2022	Triennial	2/21/2025	5d148
SPEAG	D1900V2	1900 MHz SAR Dipole	4/12/2024	Annual	4/12/2025	5d141
SPEAG	D1900V2	1900 MHz SAR Dipole	5/10/2024	Annual	5/10/2025	5d026
SPEAG	D2300V2	2300 MHz SAR Dipole	11/14/2023	Annual	11/14/2024	1064
SPEAG	D2300V2	2300 MHz SAR Dipole	3/11/2024	Annual	3/11/2025	1038
SPEAG	D2450V2	2450 MHz SAR Dipole	2/8/2024	Annual	2/8/2025	882
SPEAG	D2450V2	2450 MHz SAR Dipole	5/10/2024	Annual	5/10/2025	945
SPEAG	D2450V2	2450 MHz SAR Dipole	5/11/2022	Triennial	5/11/2025	750
SPEAG	D2450V2	2450 MHz SAR Dipole	11/15/2022	Biennial	11/15/2024	855
SPEAG	D2600V2	2600 MHz SAR Dipole	5/11/2022	Triennial	5/11/2025	1042
SPEAG	D2600V2	2600 MHz SAR Dipole	11/15/2022	Biennial	11/15/2024	1068
SPEAG	D2600V2	2600 MHz SAR Dipole	6/14/2024	Annual	6/14/2025	1009
SPEAG	D3500V2	3500 MHz SAR Dipole	12/13/2023	Annual	12/13/2024	1068
SPEAG	D3500V2	3500 MHz SAR Dipole	1/10/2023	Biennial	1/10/2025	1097
SPEAG	D3700V2	3700 MHz SAR Dipole	12/13/2023	Annual	12/13/2024	1029
SPEAG	D3700V2	3700 MHz SAR Dipole	1/13/2023	Biennial	1/13/2025	1067
SPEAG	D3700V2	3700 MHz SAR Dipole	1/9/2024	Annual	1/9/2025	1018
SPEAG	D3900V2	3900 MHz SAR Dipole	10/19/2023	Annual	10/19/2024	1056
SPEAG	D3900V2	3900 MHz SAR Dipole	6/10/2024	Annual	6/10/2025	1073
SPEAG	D5GHzV2	5 GHz SAR Dipole	4/9/2024	Annual	4/9/2025	1237
SPEAG	D6.5GHzV2	6.5 GHz SAR Dipole	10/11/2023	Annual	10/11/2024	1019
SPEAG	D6.5GHzV2	6.5 GHz SAR Dipole	2/22/2024	Annual	2/22/2025	1111
SPEAG	D8GHzV2	8GHz SAR Dipole	3/4/2024	Annual	3/4/2025	1007
SPEAG	5G Verification Source 10GHz	10GHz System Verification Antenna	3/5/2024	Annual	3/5/2025	1002
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/16/2024	Annual	1/16/2025	1582
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/8/2024	Annual	7/8/2025	1677
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/9/2024	Annual	4/9/2025	1415
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	701
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	1678
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	728
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/10/2024	Annual	9/10/2025	1364
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/16/2024	Annual	1/16/2025	1466
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/8/2024	Annual	8/8/2025	1532
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/11/2024	Annual	6/11/2025	1334
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/8/2024	Annual	7/8/2025	1583
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/18/2024	Annual	4/18/2025	1407
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/9/2024	Annual	2/9/2025	467
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	1683
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/9/2024	Annual	4/9/2025	1652
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/9/2024	Annual	2/9/2025	1645
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	1502
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/6/2024	Annual	3/6/2025	604
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/6/2024	Annual	3/6/2025	534
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/12/2024	Annual	3/12/2025	1272
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/16/2024	Annual	1/16/2025	1530
SPEAG	EX3DV4	SAR Probe	4/16/2024	Annual	4/16/2025	7357
SPEAG	EX3DV4	SAR Probe	7/18/2024	Annual	7/18/2025	7406
SPEAG	EX3DV4	SAR Probe	9/11/2024	Annual	9/11/2025	7558
SPEAG	EX3DV4	SAR Probe	5/13/2024	Annual	5/13/2025	7416
SPEAG	EX3DV4	SAR Probe	1/16/2024	Annual	1/16/2025	7565
SPEAG	EX3DV4	SAR Probe	9/2/2024	Annual	9/2/2025	7491
SPEAG	EX3DV4	SAR Probe	3/8/2024	Annual	3/8/2025	7488
SPEAG	EX3DV4	SAR Probe	6/17/2024	Annual	6/17/2025	7409
SPEAG	EX3DV4	SAR Probe	5/8/2024	Annual	5/8/2025	7660
SPEAG	EX3DV4	SAR Probe	6/28/2024	Annual	6/28/2025	7803
SPEAG	EX3DV4	SAR Probe	2/9/2024	Annual	2/9/2025	7427
SPEAG	EX3DV4	SAR Probe	4/17/2024	Annual	4/17/2025	7659
SPEAG	EX3DV4	SAR Probe	5/13/2024	Annual	5/13/2025	7682
SPEAG	EX3DV4	SAR Probe	4/17/2024	Annual	4/17/2025	7637
SPEAG	EX3DV4	SAR Probe	2/9/2024	Annual	2/9/2025	7640
SPEAG	EX3DV4	SAR Probe	5/10/2024	Annual	5/10/2025	7402
SPEAG	EX3DV4	SAR Probe	3/11/2024	Annual	3/11/2025	7421
SPEAG	EX3DV4	SAR Probe	3/8/2024	Annual	3/8/2025	7527
SPEAG	EX3DV4	SAR Probe	2/9/2024	Annual	2/9/2025	7308
SPEAG	EX3DV4	SAR Probe	1/15/2024	Annual	1/15/2025	7570
SPEAG	EX3DV4	SAR Probe	5/10/2024	Annual	5/10/2025	3914
SPEAG	EUmmWV4	EUmmWV4 Probe	2/2/2024	Annual	2/2/2025	9622
SPEAG	EUmmWV4	EUmmWV4 Probe	3/4/2024	Annual	3/4/2025	9421

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	7	N	1	1	1	7.0	7.0	∞
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	∞
Modulation Response	E.2.5	4.8	R	1.732	1	1	2.8	2.8	∞
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				12.2	12.0	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				24.4	24.0	

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

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	E.2.1	9.3	N	1	1	1	9.3	9.3	∞
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	1.73	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	1.73	1	1	0.1	0.1	∞
Modulation Response	E.2.5	4.8	R	1.73	1	1	2.8	2.8	∞
Readout Electronics	E.2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E.2.7	0.8	R	1.73	1	1	0.5	0.5	∞
Integration Time	E.2.8	2.6	R	1.73	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.8	R	1.73	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E.6.3	6.7	R	1.73	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E.5	4	R	1.73	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	1.73	1	1	2.9	2.9	∞
SAR Scaling	E.6.5	0	R	1.73	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	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E.3.4	0.6	R	1.73	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				13.8	13.6	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				27.6	27.1	

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