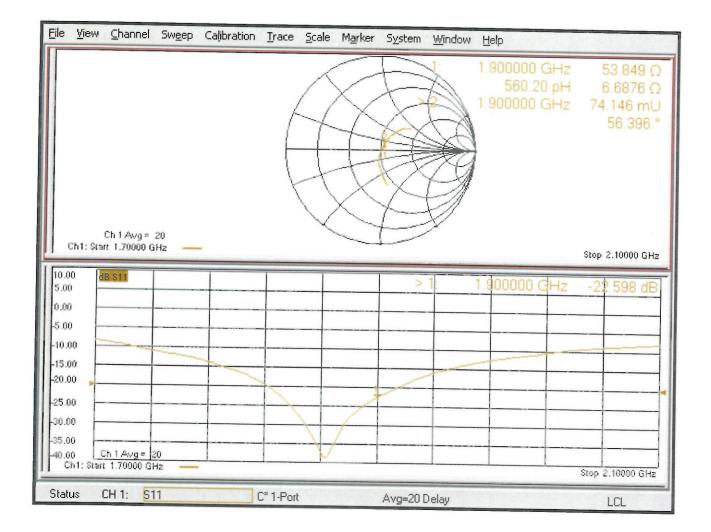
# Impedance Measurement Plot for Head TSL



#### Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

`

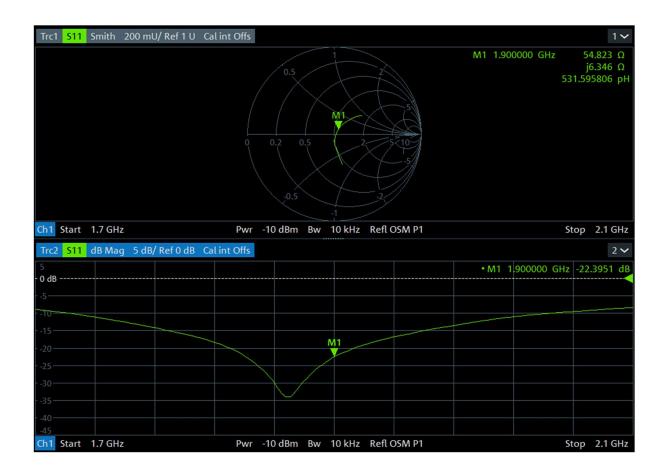
a) return loss : < - 20 dB, within 20% of previous measurement

b ) impedance : within 5  $\Omega$  from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ	
D1900V2-SN : 5d190	Head	2022.11.16	-22.598	0.89	53.849	0.074	
D1900V2-SN . 50190	пеай	2023.11.09	-22.395	0.89	54.823	-0.974	

c ) extrapolated peak SAR : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	extrapolated peak SAR (W/kg)	Δ%
	Llood	2022.11.16	18.3	-5.46
D1900V2-SN : 5d190	Head	2023.11.13	3.11.13 19.3	



#### **Calibration Laboratory of** Schmid & Partner **Engineering AG**

Zeughausstrasse 43, 8004 Zurich, Switzerland

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Client UL

Gyeonggi-do, Republic of Korea

Calibration Equipment used (M&TE critical for calibration)   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103244   30-Mar-23 (No. 217-03805)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03805)   Mar-24     Reference 20 dB Attenuator   SN: BH9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     System   SN: 310982 / 06327   30-Mar-23 (No. 217-03810)   Mar-24     SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: GB39512475   30-Oct-14 (in house check Oct-22)   In house check: Oct-20     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct-20     Power sensor HP 8481A   SN: W141093315   07-Oct-15 (in house check Oct-22)   In house check: Oct-20     Power sensor HP 8481A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct-20	Object	D835V2 - SN:4d	1194	
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz       Calibration date:     March 11, 2024       This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.       All calibration shave been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.       Calibration Equipment used (M&TE critical for calibration)       Primary Standards     ID #     Cal Date (Certificate No.)     Scheduled Calibration       Power meter NRP2     SN: 104778     30-Mar-23 (No. 217-03804/03805)     Mar-24       Power sensor NRP-Z91     SN: 103245     30-Mar-23 (No. 217-03804)     Mar-24       Power sensor NRP-Z91     SN: 103245     30-Mar-23 (No. 217-03805)     Mar-24       Reference 20 dB Attenuator     SN: 8149394 (20k)     30-Mar-23 (No. 217-03809)     Mar-24       Reference Probe EX3DV4     SN: 3749     03-Mar-23 (No. 217-03809)     Mar-24       Secondary Standards     ID #     Check Date (in house)     Scheduled Check       Power sensor HP 8481A     SN: US37282783     07-Oct-15 (in house check Oct-22)     In house check: Oct-       Power sens	Calibration procedure(s)			
Calibration date:     March 11, 2024       This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.			edure for SAR Validation Source	s hotwoon 072CH-
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).     The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.				
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).     The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.				
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).     The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.	Calibration date:	March 11, 2024		
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.     Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03804)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03805)   Mar-24     Reference 20 dB Attenuator   SN: 8H9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     Type-N mismatch combination   SN: 310982 / 06327   30-Mar-23 (No. 217-03809)   Mar-24     SN: 010982 / 06327   30-Mar-23 (No. 217-03801)   Mar-24     DAE4   SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: GB39512475   30-Oct-14 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In hous		,		
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.     Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03804)   Mar-24     Reference 20 dB Attenuator   SN: BH9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     SN: 103245   30-Mar-23 (No. 217-03809)   Mar-24   Mar-24     Reference 20 dB Attenuator   SN: BH9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     SN: 310982 / 06327   30-Mar-23 (No. 217-03809)   Mar-24   Mar-24     SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25   Mar-24     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: GB39512475   30-Oct-14 (in house check Oct-22)   In house check: Oct-3N: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct-3N: 100972   SN: 10972   15-Ju	This selling it and the			
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.     Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103244   30-Mar-23 (No. 217-03804)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03805)   Mar-24     Reference 20 dB Attenuator   SN: 8H9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     Type-N mismatch combination   SN: 310982 / 06327   30-Mar-23 (No. 217-03810)   Mar-24     Reference Probe EX3DV4   SN: 7349   03-Nov-23 (No. EX3-7349_Nov23)   Nov-24     DAE4   SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: US37292783   07-Oct-14 (in house check Oct-22)   In house check: Oct-22)     Power sensor HP 8481A   SN: 10972   15-Jun-15 (in house check Oct-22)   In house check: Oct-22)     Power sensor HP 8481A   SN: US41080477   31-Mar-14 (in house check Oct-	This calibration certificate docume	nts the traceability to nati	ional standards, which realize the physical u	nits of measurements (SI).
Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103244   30-Mar-23 (No. 217-03804)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03805)   Mar-24     Reference 20 dB Attenuator   SN: 8H9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     Type-N mismatch combination   SN: 310982 / 06327   30-Mar-23 (No. 217-03810)   Mar-24     Reference Probe EX3DV4   SN: 7349   03-Nov-23 (No. EX3-7349_Nov23)   Nov-24     DAE4   SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: 109321   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: US41080477   31-Mar-14 (in house check	the measurements and the uncert	ainties with confidence p	probability are given on the following pages a	ind are part of the certificate.
Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Scheduled Calibration     Power meter NRP2   SN: 104778   30-Mar-23 (No. 217-03804/03805)   Mar-24     Power sensor NRP-Z91   SN: 103244   30-Mar-23 (No. 217-03804)   Mar-24     Power sensor NRP-Z91   SN: 103245   30-Mar-23 (No. 217-03805)   Mar-24     Reference 20 dB Attenuator   SN: 8H9394 (20k)   30-Mar-23 (No. 217-03809)   Mar-24     Type-N mismatch combination   SN: 7349   03-Nov-23 (No. 217-03809)   Mar-24     Reference Probe EX3DV4   SN: 7349   03-Nov-23 (No. EX3-7349_Nov23)   Nov-24     DAE4   SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power sensor HP 8481A   SN: US37292783   07-Oct-14 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: W10972   15-Jun-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct-     RF generator R&S SMT-06   SN: US41080477   31-Mar-14 (in house check Oct-22)	All calibrations have been conduct	ed in the closed laborate		
Primary StandardsID #Cal Date (Certificate No.)Scheduled CalibrationPower meter NRP2SN: 10477830-Mar-23 (No. 217-03804/03805)Mar-24Power sensor NRP-Z91SN: 10324430-Mar-23 (No. 217-03804)Mar-24Power sensor NRP-Z91SN: 10324530-Mar-23 (No. 217-03805)Mar-24Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03809)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 734903-Nov-23 (No. EX3-7349_Nov23)Nov-24DAE4SN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower sensor HP 8481ASN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: WY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: US4108047731-Mar-14 (in house check Oct-22)In house check: Oct-NameFunctionSignatureCalibrated by:NameFunctionSignature	an samplations have been conduct	ed in the closed laborato	ry facility: environment temperature $(22 \pm 3)^{\circ}$	°C and humidity < 70%.
Primary StandardsID #Cal Date (Certificate No.)Scheduled CalibrationPower meter NRP2SN: 10477830-Mar-23 (No. 217-03804/03805)Mar-24Power sensor NRP-Z91SN: 10324430-Mar-23 (No. 217-03804)Mar-24Power sensor NRP-Z91SN: 10324530-Mar-23 (No. 217-03805)Mar-24Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03809)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 734903-Nov-23 (No. EX3-7349_Nov23)Nov-24DAE4SN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower sensor HP 8481ASN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: WY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-SN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Network Analyzer Agilent E8358ASN: US4108047731-Mar-14 (in house check Oct-22)In house check: Oct-NameFunctionSignatureCalibrated by:Laboratory TechnicianSignature	Calibration Equipment used (M&TF	E critical for calibration)		
Power meter NRP2SN: 10477830-Mar-23 (No. 217-03804/03805)Mar-24Power sensor NRP-Z91SN: 10324430-Mar-23 (No. 217-03804)Mar-24Power sensor NRP-Z91SN: 10324530-Mar-23 (No. 217-03805)Mar-24Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03809)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 734903-Nov-23 (No. 217-03810)Mar-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower meter E4419BSN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Power sensor HP 8481ASN: US3729278307-Oct-15 (in house check Oct-22)In house check: Oct-20Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-20Power sensor HP 8481ASN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-21Ref generator R&S SMT-06SN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-22NameFunctionSignatureCalibrated by:Leif KlysnerLaboratory Technician		· · · · · · · · · · · · · · · · · · ·		
Power meter NRP2     SN: 104778     30-Mar-23 (No. 217-03804/03805)     Mar-24       Power sensor NRP-Z91     SN: 103244     30-Mar-23 (No. 217-03804)     Mar-24       Power sensor NRP-Z91     SN: 103245     30-Mar-23 (No. 217-03805)     Mar-24       Reference 20 dB Attenuator     SN: BH9394 (20k)     30-Mar-23 (No. 217-03809)     Mar-24       Type-N mismatch combination     SN: 310982 / 06327     30-Mar-23 (No. 217-03810)     Mar-24       SN: 310982 / 06327     30-Mar-23 (No. 217-03810)     Mar-24       DAE4     SN: 601     30-Jan-24 (No. DAE4-601_Jan24)     Jan-25       Secondary Standards     ID #     Check Date (in house)     Scheduled Check       Power sensor HP 8481A     SN: GB39512475     30-Oct-14 (in house check Oct-22)     In house check: Oct-22)       Power sensor HP 8481A     SN: MY41093315     07-Oct-15 (in house check Oct-22)     In house check: Oct-22)       Power sensor HP 8481A     SN: 100972     15-Jun-15 (in house check Oct-22)     In house check: Oct-22)       Power sensor HP 8481A     SN: US41080477     31-Mar-14 (in house check Oct-22)     In house check: Oct-22)       Power sensor HP 8481A     SN: US41080477     31-Mar-14 (in house check Oct		ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power sensor NRP-Z91SN: 10324530-Mar-23 (No. 217-03804)Mar-24Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03805)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 734903-Nov-23 (No. EX3-7349_Nov23)Nov-24DAE4SN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower meter E4419BSN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: US3729278307-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-RF generator R&S SMT-06SN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-NameFunctionSignatureCalibrated by:Leif KlysnerLaboratory Technician	Power meter NRP2	SN: 104778		
Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03809)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24DAE4SN: 734903-Nov-23 (No. EX3-7349_Nov23)Nov-24DAE4SN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower meter E4419BSN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: US3729278307-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Network Analyzer Agilent E8358ASN: US4108047731-Mar-14 (in house check Oct-22)In house check: Oct-NameFunctionSignatureCalibrated by:Leif KlysnerLaboratory TechnicianSignature	Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	
Reference 20 dB AttenuatorSN: BH9394 (20k)30-Mar-23 (No. 217-03809)Mar-24Type-N mismatch combinationSN: 310982 / 0632730-Mar-23 (No. 217-03810)Mar-24Reference Probe EX3DV4SN: 734903-Nov-23 (No. EX3-7349_Nov23)Nov-24DAE4SN: 60130-Jan-24 (No. DAE4-601_Jan24)Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower meter E4419BSN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: US3729278307-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Ref generator R&S SMT-06SN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Network Analyzer Agilent E8358ASN: US4108047731-Mar-14 (in house check Oct-22)In house check: Oct-NameFunctionSignaturecalibrated by:Leif KlysnerLaboratory TechnicianSignature	ower sensor NRP-Z91	SN: 103245	30-Mar-23 (No. 217-03805)	Mar-24
Type-N mismatch combination Reference Probe EX3DV4SN: 310982 / 06327 SN: 734930-Mar-23 (No. 217-03810) SN: 7349Mar-24 Nov-23DAE4SN: 734903-Nov-23 (No. EX3-7349_Nov23) SN: 601Nov-24 Jan-25Decondary StandardsID #Check Date (in house)Scheduled Check Scheduled CheckDower meter E4419B Power sensor HP 8481A Power sensor HP 8481ASN: GB39512475 	Reference 20 dB Attenuator	SN: BH9394 (20k)		
Reference Probe EX3DV4 DAE4SN: 7349 SN: 60103-Nov-23 (No. EX3-7349_Nov23) 30-Jan-24 (No. DAE4-601_Jan24)Nov-24 Jan-25Secondary StandardsID #Check Date (in house)Scheduled CheckPower meter E4419B Power sensor HP 8481ASN: GB39512475 SN: US3729278330-Oct-14 (in house check Oct-22) Or-Oct-15 (in house check Oct-22)In house check: Oct- In house check: Oct- In house check: Oct- In house check: Oct- SN: 100972Power sensor HP 8481A Power sensor HP 8481A SN: MY41093315SN: Or-Oct-15 (in house check Oct-22) In house check: Oct- SN: 100972In house check: Oct- In house check: Oct- In house check: Oct- SN: 100972RF generator R&S SMT-06 Network Analyzer Agilent E8358ASN: US41080477 SN: US41080477S1-Mar-14 (in house check Oct-22) In house check: Oct- In house	Type-N mismatch combination	SN: 310982 / 06327		
DAE4   SN: 601   30-Jan-24 (No. DAE4-601_Jan24)   Jan-25     Secondary Standards   ID #   Check Date (in house)   Scheduled Check     Power meter E4419B   SN: GB39512475   30-Oct-14 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: MY41093315   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct-     SN: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct-   In house check: Oct-     Network Analyzer Agilent E8358A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct-     Name   Function   Signature     Calibrated by:   Leif Klysner   Laboratory Technician   Signature	Reference Probe EX3DV4	SN: 7349		
Power meter E4419B   SN: GB39512475   30-Oct-14 (in house check Oct-22)   In house check: Oct- In house check: Oct- SN: US37292783     Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct- In house check: Oct- SN: MY41093315   In house check: Oct- SN: 100972     Power Kanalyzer Agilent E8358A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct- In house check: Oct- Signature     Calibrated by:   Leif Klysner   Laboratory Technician   Signature	DAE4	SN: 601		
Power meter E4419BSN: GB3951247530-Oct-14 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: US3729278307-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-Power sensor HP 8481ASN: MY4109331507-Oct-15 (in house check Oct-22)In house check: Oct-RF generator R&S SMT-06SN: 10097215-Jun-15 (in house check Oct-22)In house check: Oct-Network Analyzer Agilent E8358ASN: US4108047731-Mar-14 (in house check Oct-22)In house check: Oct-NameFunctionSignatureCalibrated by:Leif KlysnerLaboratory Technician	Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A   SN: US37292783   07-Oct-15 (in house check Oct-22)   In house check: Oct-     Power sensor HP 8481A   SN: MY41093315   07-Oct-15 (in house check Oct-22)   In house check: Oct-     RF generator R&S SMT-06   SN: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct-     Network Analyzer Agilent E8358A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct-     Name   Function   Signature     Calibrated by:   Leif Klysner   Laboratory Technician	<sup>o</sup> ower meter E4419B	SN: GB39512475		
Power sensor HP 8481A   SN: MY41093315   07-Oct-15 (in house check Oct-22)   In house check: Oct- In house check: Oct- SN: 100972     RF generator R&S SMT-06   SN: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct- In house check: Oct- SN: US41080477     Network Analyzer Agilent E8358A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct- In house check: Oct- In house check: Oct- Signature     Calibrated by:   Leif Klysner   Laboratory Technician	ower sensor HP 8481A	SN: US37292783		
RF generator R&S SMT-06   SN: 100972   15-Jun-15 (in house check Oct-22)   In house check: Oct- In house check: Oct- SN: US41080477     Network Analyzer Agilent E8358A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In house check: Oct- In house check: Oct- Signature     Name   Function   Signature     Calibrated by:   Leif Klysner   Laboratory Technician		SN: MY41093315		
Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-22) In house check: Oct-   Name Function Signature   Calibrated by: Leif Klysner Laboratory Technician	Power sensor HP 8481A	SN: 100972		
Calibrated by: Leif Klysner Laboratory Technician				In house check: Oct-24
Calibrated by: Leif Klysner Laboratory Technician	RF generator R&S SMT-06	SN: US41080477	(	
	RF generator R&S SMT-06			Signatura
Approved by: Sven Kühn Technical Manager	RF generator R&S SMT-06 Network Analyzer Agilent E8358A	Name	Function	Signature
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A	Name	Function	0.1 100
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0:0 100
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0.1.10
Issued: March 12, 202 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0.1.10

S

Swiss Calibration Service

Certificate No. D835V2-4d194\_Mar24

Accreditation No.: SCS 0108

Schweizerischer Kalibrierdienst



Schweizerischer Kalibrierdienst S

Service suisse d'étalonnage

С Servizio svizzero di taratura S

Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### **Glossary:**

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

# Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### **Additional Documentation:**

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss: This parameter is measured with the source positioned under the liquid filled • phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna . connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

#### **Measurement Conditions**

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	· · · · · · · · · · · · · · · · · · ·
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz ± 1 MHz	

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity	
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m	
Measured Head TSL parameters	(22.0 ± 0.2) °C	42.8 ± 6 %	0.92 mho/m ± 6 %	
Head TSL temperature change during test	< 0.5 °C			

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.86 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.63 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.45 W/kg ± 16.5 % (k=2)

# Appendix (Additional assessments outside the scope of SCS 0108)

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.4 Ω - 3.7 jΩ
Return Loss	- 28.7 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	
Electrical Delay (one direction)	1.393 ns
	1.000115

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 11.03.2024

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d194

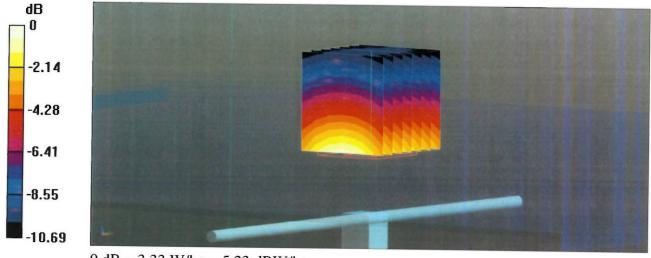
Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz;  $\sigma = 0.92$  S/m;  $\epsilon_r = 42.8$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.69, 9.69, 9.69) @ 835 MHz; Calibrated: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.01.2024
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

# Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 64.69 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 3.73 W/kg**SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.63 W/kg** Smallest distance from peaks to all points 3 dB below = 19.8 mm Ratio of SAR at M2 to SAR at M1 = 66.4% Maximum value of SAR (measured) = 3.33 W/kg



0 dB = 3.33 W/kg = 5.23 dBW/kg

# Impedance Measurement Plot for Head TSL

File	View	<u>C</u> hannel	Sweep	Calibration	Trace	<u>S</u> cale	Marker	System	<u>W</u> indow	Help	1.246		
		Ch 1 Avg = rt 635.000 M			Ę				A	5	100 MHz 1.705 pF 100 MHz	36.886 m -82.195	ΩU
		-	1H2									Stop 1.03500 GF	Hz
10.00 5.00 -5.00 -10.0 -15.0 -20.0 -25.0 -25.0 -30.0 -35.0 -40.0 C		E S11 Ch 1 Avg = 1 t 635.000 M	20 Hz					>	1: 835	5.0000		-28.663 d	
Statu	l sı	CH 1: 51	11		C* 1-Port			Avg=20 D	elau			LCL	_



Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
- Servizio svizzero di taratura

S

S Swiss Calibration Service

Certificate No. D2450V2-960\_Mar24

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Client UL

Gyeonggi-do, Republic of Korea

CALIBRATION CERTIFICATE			
Object	D2450V2 - SN:96	60	
Calibration procedure(s)	OA CAL-05 v12		
Calibration procedure(s)	QA CAL-05.v12 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz		
Calibration date:	March 14, 2024		
This calibration certificate documen	ts the traceability to natio	onal standards, which realize the physical un	its of measurements (SI).
The measurements and the uncerta	ainties with confidence pr	robability are given on the following pages ar	nd are part of the certificate.
All calibrations have been conducte	ed in the closed laborator	y facility: environment temperature (22 $\pm$ 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
Power sensor NRP-Z91	SN: 103245	30-Mar-23 (No. 217-03805)	Mar-24
Reference 20 dB Attenuator	SN: BH9394 (20k)	30-Mar-23 (No. 217-03809)	Mar-24
Type-N mismatch combination	SN: 310982 / 06327	30-Mar-23 (No. 217-03810)	Mar-24
Reference Probe EX3DV4	SN: 7349	03-Nov-23 (No. EX3-7349_Nov23)	Nov-24
DAE4	SN: 601	30-Jan-24 (No. DAE4-601_Jan24)	Jan-25
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
	Name	Function	Signature
Calibrated by:	Krešimir Franjić	Laboratory Technician	X
Approved by:	Sven Kühn	Technical Manager	Sil
			Issued: March 15, 2024

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage

С Servizio svizzero di taratura

S

S **Swiss Calibration Service** 

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### **Glossarv:**

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

#### Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

c) DASY System Handbook

#### Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss: This parameter is measured with the source positioned under the liquid filled • phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the . nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

#### **Measurement Conditions**

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.5 ± 6 %	1.83 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.8 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 250 mW input power	6.07 W/kg

#### Appendix (Additional assessments outside the scope of SCS 0108)

#### **Antenna Parameters with Head TSL**

Impedance, transformed to feed point	54.9 Ω + 2.5 jΩ
Return Loss	- 25.6 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.160 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 14.03.2024

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:960

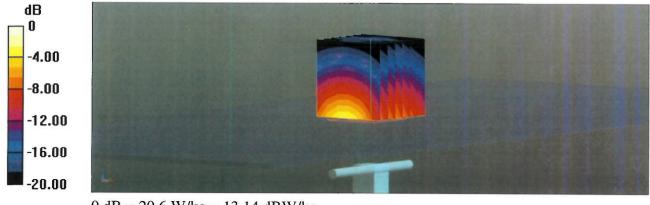
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 1.83$  S/m;  $\epsilon_r = 38.5$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.01.2024
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

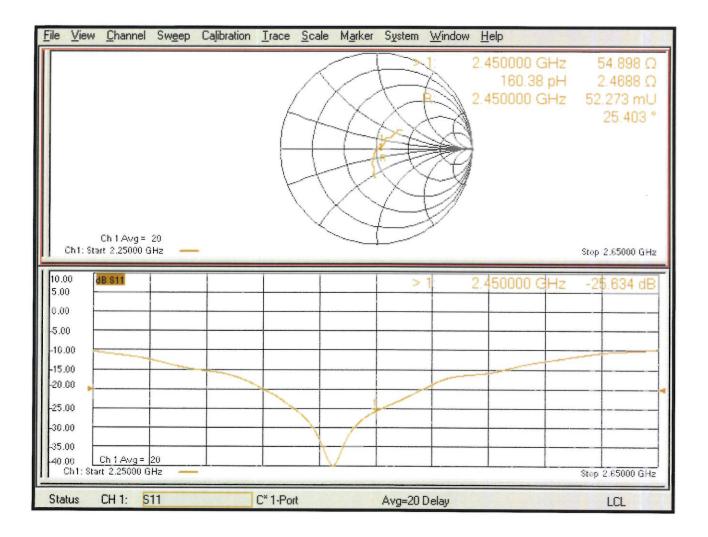
#### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 114.0 V/m; Power Drift = 0.07 dB Peak SAR (extrapolated) = 26.2 W/kg SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.07 W/kg Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 50.8% Maximum value of SAR (measured) = 20.6 W/kg



0 dB = 20.6 W/kg = 13.14 dBW/kg

#### Impedance Measurement Plot for Head TSL





Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage

S

S

Servizio svizzero di taratura

Swiss Calibration Service

Certificate No. D2600V2-1097\_Sep23

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Client UL

Gyeonggi-do, Republic of Korea

CALIBRATION CERTIFICATE Object D2600V2 - SN:1097 Calibration procedure(s) QA CAL-05.v12 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz Calibration date: September 26, 2023 This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%. Calibration Equipment used (M&TE critical for calibration) **Primary Standards** ID # Cal Date (Certificate No.) Scheduled Calibration Power meter NRP2 SN: 104778 30-Mar-23 (No. 217-03804/03805) Mar-24 Power sensor NRP-Z91 SN: 103244 30-Mar-23 (No. 217-03804) Mar-24 Power sensor NRP-Z91 SN: 103245 30-Mar-23 (No. 217-03805) Mar-24 Reference 20 dB Attenuator SN: BH9394 (20k) 30-Mar-23 (No. 217-03809) Mar-24 Type-N mismatch combination SN: 310982 / 06327 30-Mar-23 (No. 217-03810) Mar-24 Reference Probe EX3DV4 SN: 7349 10-Jan-23 (No. EX3-7349\_Jan23) Jan-24 DAE4 SN: 654 27-Jan-23 (No. DAE4-654\_Jan23) Jan-24 Secondary Standards ID # Check Date (in house) Scheduled Check Power meter E4419B SN: GB39512475 30-Oct-14 (in house check Oct-22) In house check: Oct-24 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-22) In house check: Oct-24 Power sensor HP 8481A SN: MY41093315 07-Oct-15 (in house check Oct-22) In house check: Oct-24 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-22) In house check: Oct-24 Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-22) In house check: Oct-24 Name Function Signature Calibrated by: Krešimir Franjić Laboratory Technician Approved by: Sven Kühn Technical Manager Issued: September 26, 2023 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
- Servizio svizzero di taratura
- S Swiss Calibration Service

S

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

#### Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

c) DASY System Handbook

#### Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss: This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

#### **Measurement Conditions**

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	· · · · · · · · · · · · · · · · · · ·
Phantom	Modular Flat Phantom	<u>, , , , , , , , , , , , , , , , , , , </u>
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	· · · · · · · · · · · · · · · · · · ·
Frequency	2600 MHz ± 1 MHz	

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.2 ± 6 %	2.00 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	57.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.7 W/kg ± 16.5 % (k=2)

#### Appendix (Additional assessments outside the scope of SCS 0108)

#### **Antenna Parameters with Head TSL**

Impedance, transformed to feed point	48.2 Ω - 4.6 jΩ
Return Loss	- 25.9 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.153 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 26.09.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1097

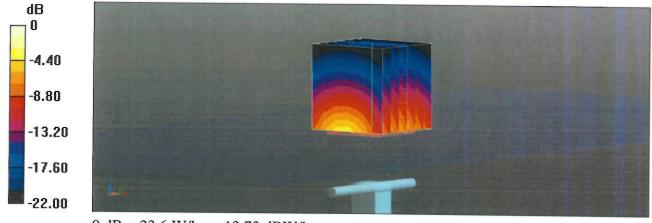
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma = 2$  S/m;  $\varepsilon_r = 37.2$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.68, 7.68, 7.68) @ 2600 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 27.01.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

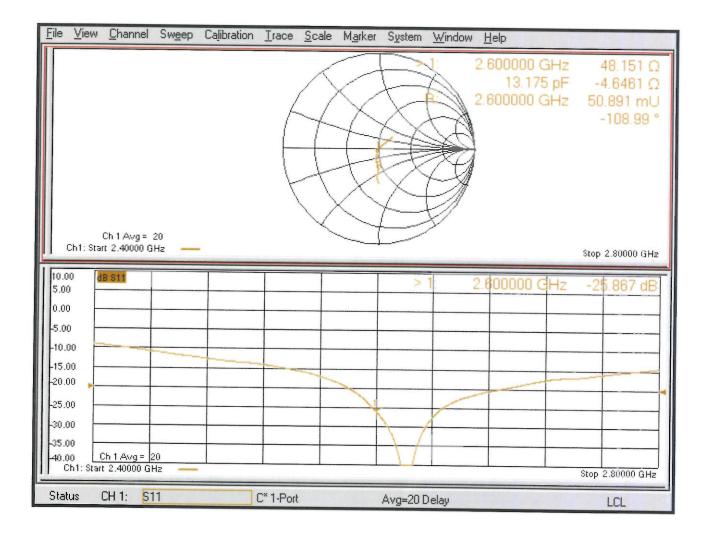
# Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 121.0 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 28.5 W/kg SAR(1 g) = 14.6 W/kg; SAR(10 g) = 6.52 W/kg Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 51% Maximum value of SAR (measured) = 23.6 W/kg



0 dB = 23.6 W/kg = 13.73 dBW/kg

#### Impedance Measurement Plot for Head TSL



**UL Korea** 

Client



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage

С Servizio svizzero di taratura

S **Swiss Calibration Service** 

Accreditation No.: SCS 0108

S

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Certificate No: D5GHzV2-1209\_Feb23

# **CALIBRATION CERTIFICATE**

Object	D5GHzV2 - SN:1	209	
Calibration procedure(s)	QA CAL-22.v7		
	<b>Calibration Proce</b>	dure for SAR Validation Sources	s between 3-10 GHz
Calibration date:	February 28, 202	3	
This calibration cortificate documen	to the treeschility to notic	not standards, which realize the physical up	ite of monoursents (OI)
		nal standards, which realize the physical un	NOT ALL THE REPORT OF A CONTRACT
The measurements and the uncerta	anues with confidence pr	obability are given on the following pages a	id are part of the certificate.
All calibrations have been conducte	d in the closed laborator	y facility: environment temperature (22 ± 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)		
	1		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 3503	08-Mar-22 (No. EX3-3503_Mar22)	Mar-23
DAE4	SN: 601	19-Dec-22 (No. DAE4-601_Dec22)	Dec-23
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
AlfaD index			
	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	11-
		$\bigcirc$	- 112
Approved by:	Sven Kühn	Technical Manager	/ /
			6.5
		C	
			Issued: February 28, 2023
This calibration cortificate shall not	he reproduced exection	full without writton approval of the lobarate	•
rins calibration certificate shall not	ne reproduced except in	full without written approval of the laborator	у.

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
- Servizio svizzero di taratura
  - Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

#### Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

c) DASY System Handbook

#### Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

#### **Measurement Conditions**

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5800 MHz ± 1 MHz	

# Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.0 ± 6 %	4.67 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

# SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.04 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	5.06 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	, <u>, ,, ,,, ,,,, ,,, ,, ,, ,, ,, ,, ,, ,</u>
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	5.17 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.88 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.2 W/kg ± 19.5 % (k=2)

# Head TSL parameters at 5800 MHz The following parameters and calculations were applied.

······	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.6 ± 6 %	5.21 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

# SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	······································
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 W/kg ± 19.5 % (k=2)

#### Appendix (Additional assessments outside the scope of SCS 0108)

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	46.3 Ω - 1.2 jΩ
Return Loss	- 27.9 dB

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	51.2 Ω + 3.7 jΩ
Return Loss	- 28.2 dB

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	53.5 Ω + 3.3 jΩ
Return Loss	- 26.6 dB

#### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	53.5 Ω + 3.3 jΩ
Return Loss	- 26.7 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1 100
	1.192 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG
	SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 28.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1209

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 4.67$  S/m;  $\varepsilon_r = 36$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 5.06$  S/m;  $\varepsilon_r = 35.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 5.17$  S/m;  $\varepsilon_r = 35.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5800 MHz;  $\sigma = 5.21$  S/m;  $\varepsilon_r = 35.6$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5800 MHz;  $\sigma = 5.21$  S/m;  $\varepsilon_r = 35.6$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5800 MHz;  $\sigma = 5.21$  S/m;  $\varepsilon_r = 35.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.81 V/m; Power Drift = -0.00 dB Peak SAR (extrapolated) = 27.5 W/kg SAR(1 g) = 8.04 W/kg; SAR(10 g) = 2.29 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 71.2% Maximum value of SAR (measured) = 18.0 W/kg

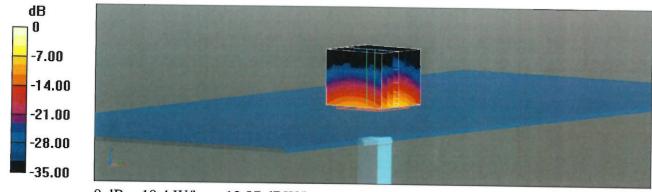
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.05 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 30.6 W/kg SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.35 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 67.8% Maximum value of SAR (measured) = 19.2 W/kg

# Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 72.78 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 30.5 W/kg SAR(1 g) = 7.88 W/kg; SAR(10 g) = 2.22 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.5% Maximum value of SAR (measured) = 18.5 W/kg

# Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 73.16 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 31.6 W/kg SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.28 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.9% Maximum value of SAR (measured) = 19.4 W/kg



0 dB = 19.4 W/kg = 12.87 dBW/kg

# Impedance Measurement Plot for Head TSL

File	⊻iew	Channel	Sw <u>e</u> ep	Calibration	Trace	<u>S</u> cale	M <u>a</u> rker	System	<u>W</u> indow	Help		
						/		$\square$	~	1:	5.250000 GHz 24.428 pF	46.340 Ω -1.2410 Ω
						$\wedge$		1	$\Delta$	2:	5.600000 GHz	51.248 Q
					/	- /	$\sim$	$\sim$	12-7	3:	106.09 pH 5.750000 GHz	3.7330 Q 53.530 Q
					$\sim$		$\sim$	$\sim$	K-Y	0.	90.904 pH	3.2842 Q
					(			A-A	St	> 4:	5.800000 GHz	53.478 Q
									R	R:	89.187 pH 5.500000 GHz	3.2502 Ω 32.934 mU
					/	4	-	$\mathcal{X}\mathcal{Y}$	$\Box $			118.30 *
					K	/	$\times$	X	$\square$			
					,	$\langle \rangle$	$\times$ `	×	11			
						X		1	Y			
		Ch 1 Avg = rt 5.00000 (						5	-		<u></u>	0.00000.000
1	onn. sta	11 9.00000 1	one								Stop	6.00000 GHz
10.0		IB S11			1				1	1:	5.250000 GHz	-27.935 dB
5.0			1			İ	Anna an an Anna an An	İ	-	3:	5.800000 GHz 5.750000 GHz	-28-212 dB -26.642 dB
0.0			1		1					> 4;	5.800000 GHz	-26.749 dB
-5.0	0 -				-							
-10.	00 -											
-15.	00 -											
-20.	00 🔶		<u> </u>									
-25.	00 -										4	
30.			$\sim$	1					-	1 2		
-35.				1	~		$\sim$		4			
40	00	Ch 1 Avg =	20									
1	Ch1: Sta	rt 5.00000 (	GHz —	_		1		and the second second second second			Stop	6.00000 GHz
1 .												
Sta		CH 1: 5	511		C* 1-Por			Avg=20	<b>D</b> 1			LCL

#### Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

`

a) return loss : < - 20 dB, within 20% of previous measurement

b ) impedance : within 5  $\boldsymbol{\Omega}$  from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
	zV2-SN : 1209 Head	2023.02.28	-28.212	4.36	51.248	-3.17
D5GH2V2-5N . 1209		2024.02.15	-26.982	4.50	54.417	-5.17

c ) peak SAR (1g) : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	Peak SAR (1g) (W/kg)	Δ%	
D5GHzV2-SN : 1209	Head	2023.02.28	8.29	2.77	
		2024.02.16	8.52	2.77	

