Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

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"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- *DCPx,y,z*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- *PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ±50 MHz to ±100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7620

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.64	0.63	0.59	±10.1%
DCP (mV) [B]	108.8	100.2	109.4	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $dB\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] $k = 2$
0	CW	X	0.00	0.00	1.00	0.00	124.1	±1.2%	±4.7%
		Y	0.00	0.00	1.00		138.9		
		Z	0.00	0.00	1.00		148.5		

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%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EX3DV4 - SN:7620

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	6.3°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

Parameters of Probe: EX3DV4 - SN:7620

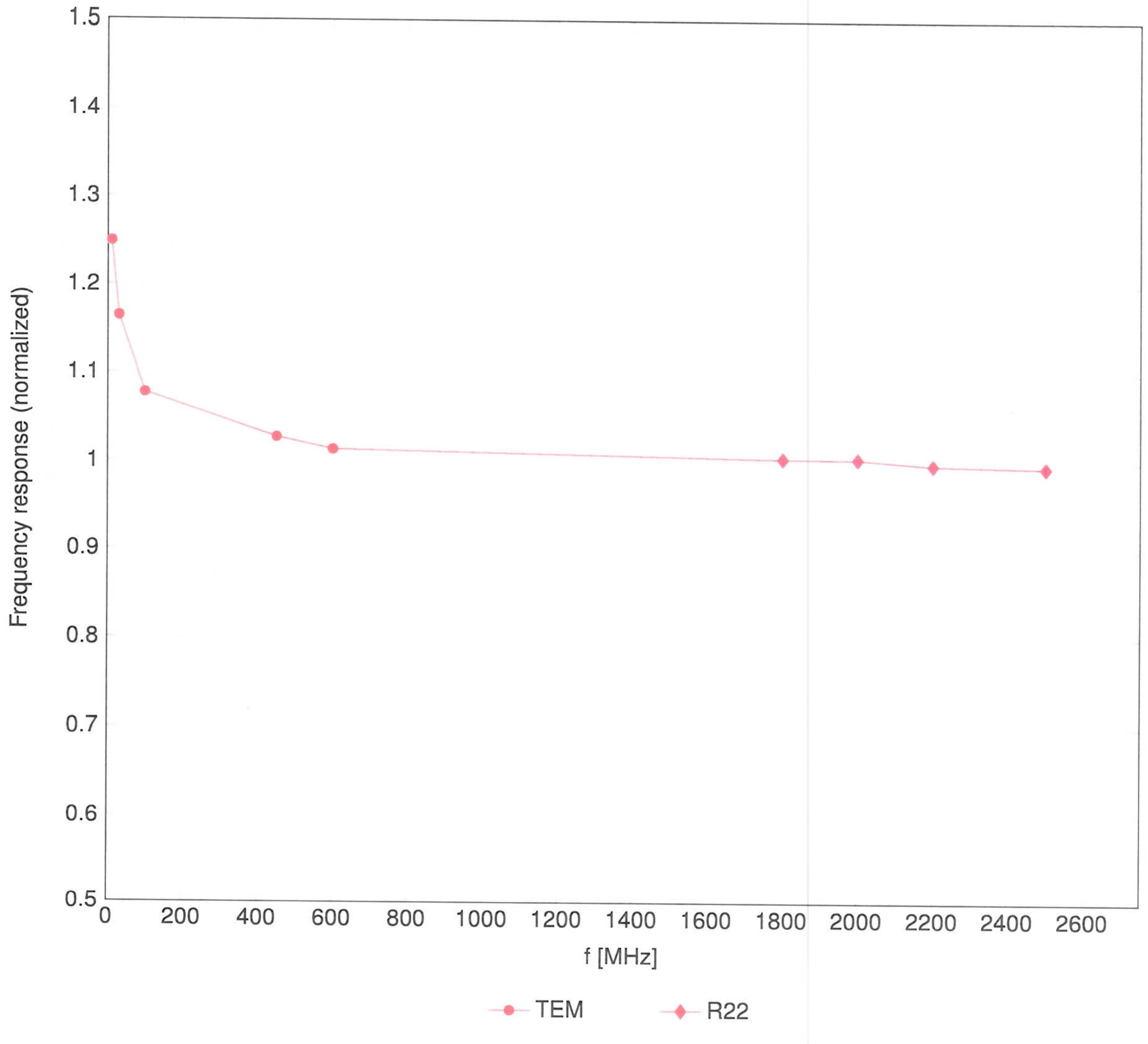
Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc[H] ($k=2$)
750	41.9	0.89	10.10	10.82	10.65	0.38	1.27	±11.0%
835	41.5	0.90	9.87	10.58	10.42	0.38	1.27	±11.0%
2450	39.2	1.80	7.32	7.85	7.73	0.36	1.27	±11.0%
2600	39.0	1.96	7.26	7.78	7.66	0.36	1.27	±11.0%

[C] Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.
[H] The stated uncertainty is the total calibration uncertainty ($k=2$) of Norm·ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

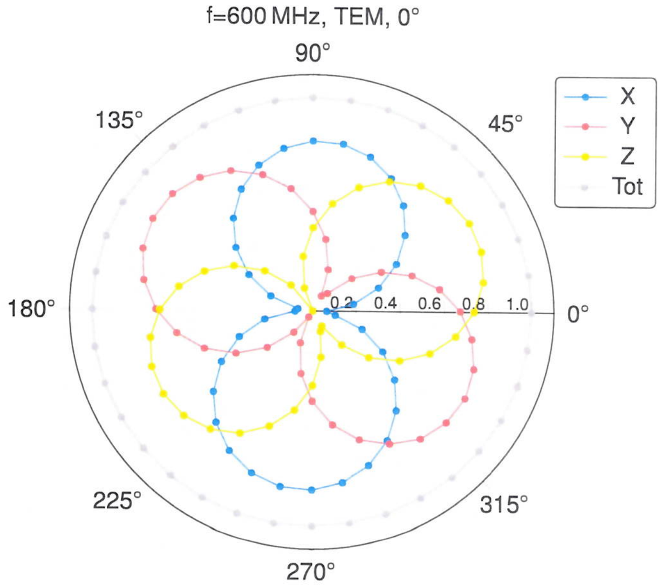
Frequency Response of E-Field

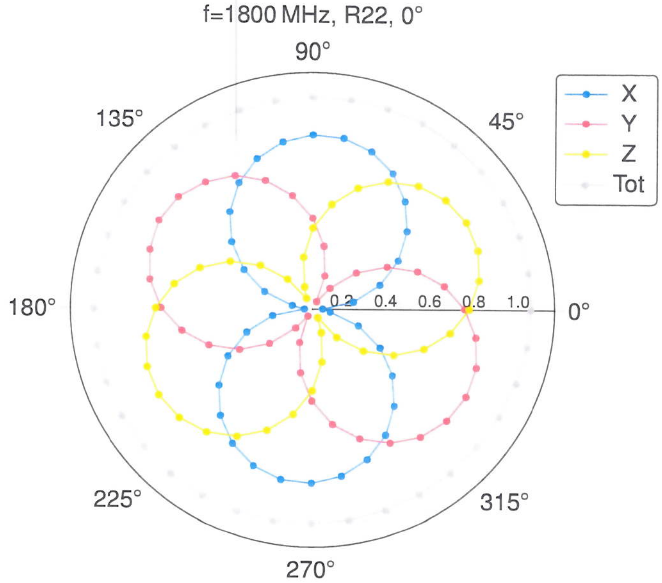
(TEM-Cell:ifi110 EXX, Waveguide:R22)

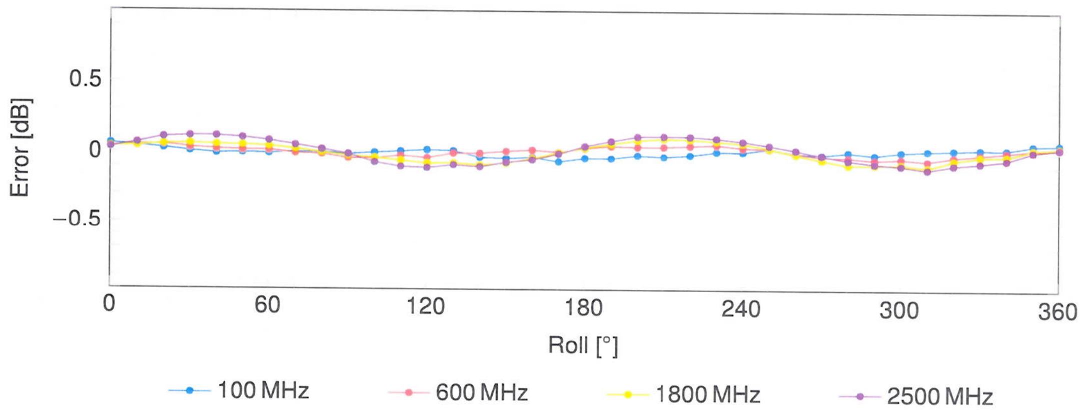


Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$



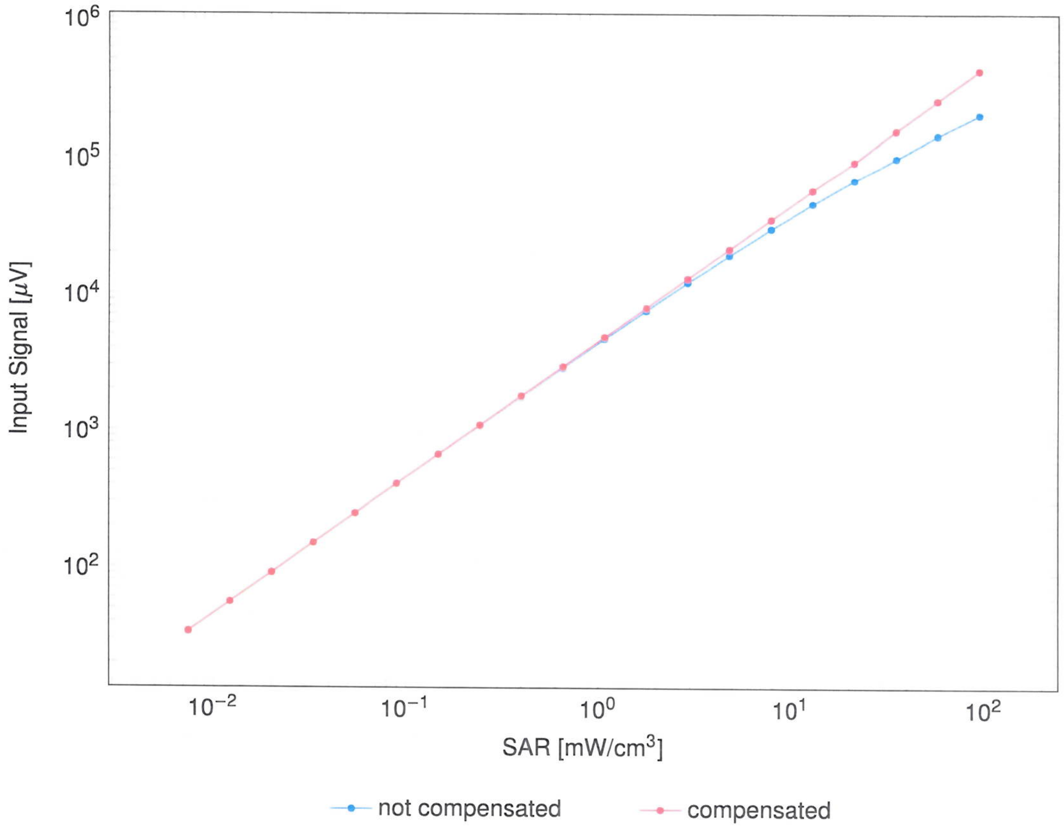


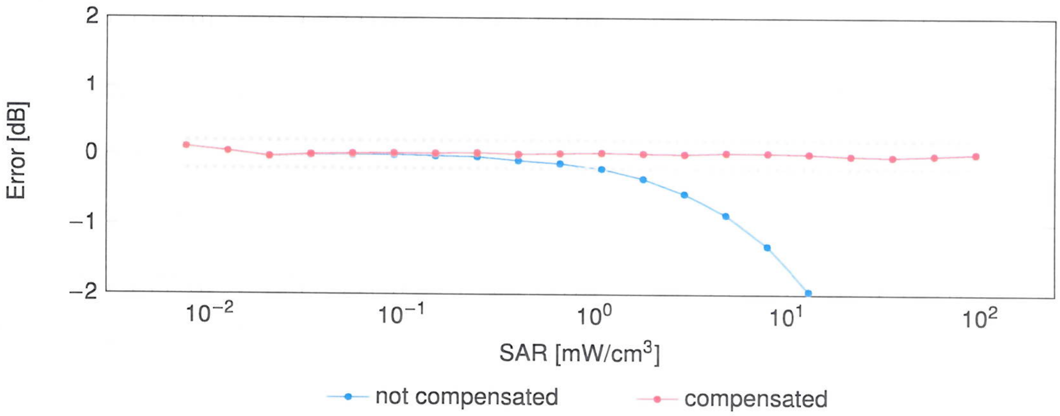


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{head})

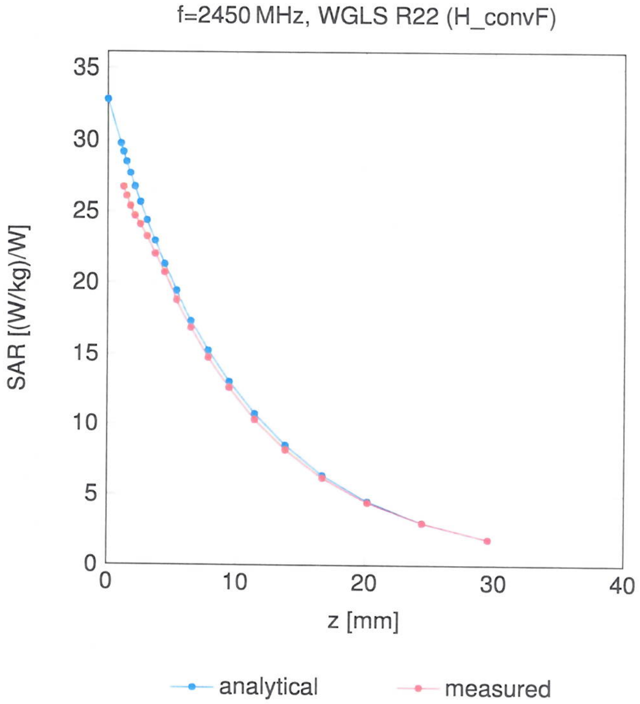
(TEM cell, f_{eval} = 1900 MHz)



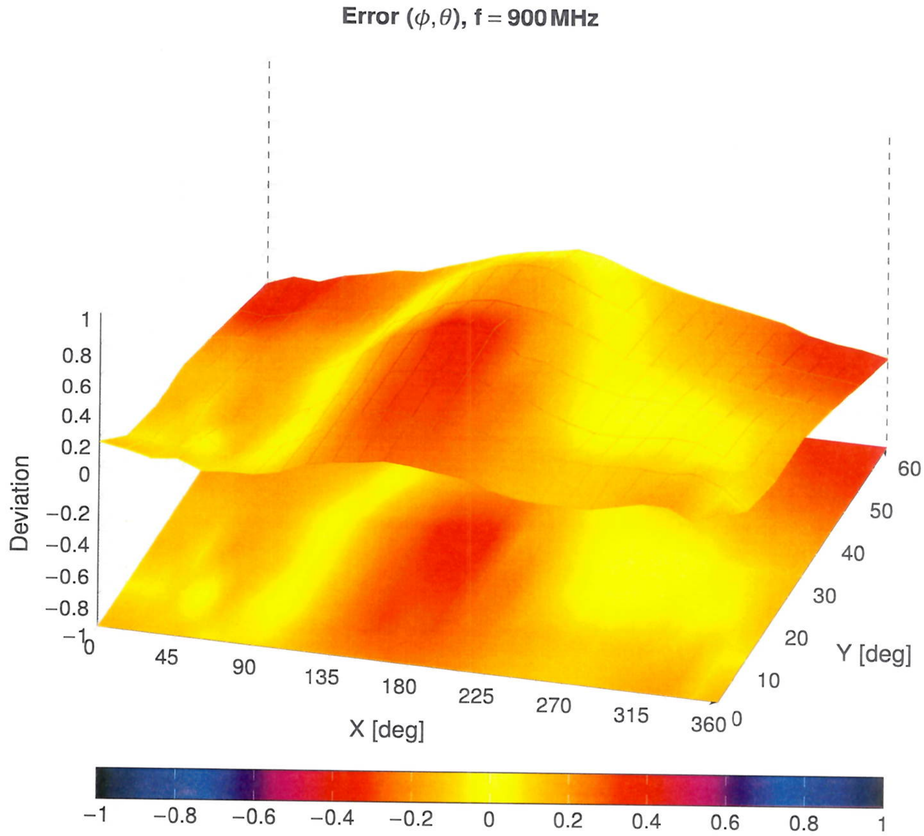


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

Dipole D750V3 SN 1160				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/6/6	-29.6	/	51.4	/
2024/6/3	-30.7	3.72%	52.6	1.2Ω

Dipole D835V2- SN 4d105				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/11/2	-27.5	/	50.3	/
2024/10/31	-27.2	1.10%	50.6	0.3Ω

Dipole D1450V2-SN 1040				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/6/17	-25	/	56	/
2024/6/13	-25.8	3.20%	56.9	0.9Ω

Dipole D1750V2 SN 1149				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/6/17	-31.9	/	47.6	/
2024/6/13	-32.5	1.88%	49.4	1.8Ω

Dipole D1900V2 SN 5d028				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/11/2	-21.1	/	51.5	/
2024/10/31	-21.6	2.37%	52.2	0.7Ω

Dipole D1950V3 SN 1138				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/10/31	-31.2	/	49.5	/
2024/10/29	-31.8	1.92%	50.1	0.6Ω

Dipole D2300V2 SN 1072				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/6/16	-26	/	47.9	/
2024/6/13	-25.1	3.59%	49.2	1.3Ω

Dipole D2450V2 SN 733				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/11/2	-28.7	/	50.2	/
2024/10/31	-28.1	2.14%	50.7	0.5Ω

Dipole D2600V2 SN 1125				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/6/14	-25.1	/	46.9	/
2024/6/12	-25.9	3.19%	48.2	1.3Ω

Dipole D2600V2 SN 1058				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2024/6/17	-25.9	/	48.3	/
2025/6/16	-25.6	1.17%	47.8	1.3Ω

Dipole D3500V2 SN 1082					
Head Liquid					
Frequency(MHz)	Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ
3400	2022/9/19	-21.3	/	42.3	/
	2024/9/17	-20.7	2.90%	42.7	0.4Ω
3500	2022/9/19	-25.1	/	46.7	/
	2024/9/17	-24.6	2.03%	46.9	0.2Ω

Dipole D3700V2 SN 1046				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ
2022/9/15	-34.5	/	48.4	/
2024/9/13	-35.1	1.74%	49.2	0.8Ω

Dipole D3900V2 SN 1026					
Head Liquid					
Frequency(MHz)	Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ
3900	2022/9/16	-20	/	44.9	/
	2024/9/13	-19.1	4.71%	45.3	0.4Ω
4100	2022/9/16	-21.4	/	58.4	/
	2024/9/13	-22.1	3.27%	58.9	0.5Ω

Dipole D4600V2 SN 1026					
Head Liquid					
Frequency(MHz)	Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ
4500	2022/9/16	-24.7	/	47.4	/
	2024/9/13	-24.1	2.49%	48.1	0.7Ω
4700	2022/9/16	-23.4	/	57	/
	2024/9/13	-22.7	3.08%	57.9	0.9Ω

Dipole D4900V2 SN 1017				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/9/15	-21.8	/	53	/
2024/9/13	-21.1	3.32%	53.6	0.6Ω

Dipole 5GHzV2 SN 1165					
Head Liquid					
Frequency(MHz)	Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ
5250	2022/11/1	-26.3	/	49	/
	2024/10/30	-26.0	1.15%	49.7	0.7Ω
5600	2022/11/1	-28.9	/	53.5	/
	2024/10/30	-29.4	1.73%	53.7	0.2Ω
5750	2022/11/1	-26.5	/	54.6	/
	2024/10/30	-26.9	1.51%	54.9	0.3Ω

Dipole D6.5GHzV2 SN 1030				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2023/9/11	-29.9	/	50.3	/
2024/9/10	-29.7	0.67%	50.1	0.2Ω

- End of Appendix -

Dipole D835V2- SN 4d105				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/11/2	-27.5	/	50.3	/
2024/10/31	-27.2	1.10%	50.6	0.3Ω

Dipole D1950V3 SN 1138				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/10/31	-31.2	/	49.5	/
2024/10/29	-31.8	1.92%	50.1	0.6Ω

Dipole D2450V2 SN 733				
Head Liquid				
Date of Measurement	Return Loss(dB)	Δ %	Impedance (Ω)	ΔΩ()
2022/11/2	-28.7	/	50.2	/
2024/10/31	-28.1	2.14%	50.7	0.5Ω

- End of Appendix -