

EX3DV4- SN:3903

September 28, 2017

10303-AAA	IEEE 802.16e WIMAX (31:15, 5ms, 10MHz, 64QAM, PUSC)	X	5.01	65.19	17.61	4.96	50.0	± 9.6 %
		Y	4.83	65.72	17.73		50.0	
		Z	5.35	66.00	18.13		50.0	
10304-AAA	IEEE 802.16e WIMAX (29:18, 5ms, 10MHz, 64QAM, PUSC)	X	4.80	65.03	17.09	4.17	50.0	± 9.6 %
		Y	4.65	65.64	17.26		50.0	
		Z	5.10	65.68	17.51		50.0	
10305-AAA	IEEE 802.16e WIMAX (31:15, 10ms, 10MHz, 64QAM, PUSC, 15 symbols)	X	4.43	66.69	19.15	6.02	35.0	± 9.6 %
		Y	4.31	67.59	19.20		35.0	
		Z	5.04	69.00	20.54		35.0	
10306-AAA	IEEE 802.16e WIMAX (29:18, 10ms, 10MHz, 64QAM, PUSC, 18 symbols)	X	4.77	65.88	18.76	6.02	35.0	± 9.6 %
		Y	4.61	66.59	18.85		35.0	
		Z	5.22	67.43	19.77		35.0	
10307-AAA	IEEE 802.16e WIMAX (29:18, 10ms, 10MHz, QPSK, PUSC, 18 symbols)	X	4.68	66.10	18.76	6.02	35.0	± 9.6 %
		Y	4.50	66.71	18.79		35.0	
		Z	5.17	67.85	19.86		35.0	
10308-AAA	IEEE 802.16e WIMAX (29:18, 10ms, 10MHz, 16QAM, PUSC)	X	4.64	66.23	18.85	6.02	35.0	± 9.6 %
		Y	4.48	66.93	18.94		35.0	
		Z	5.14	68.04	19.98		35.0	
10309-AAA	IEEE 802.16e WIMAX (29:18, 10ms, 10MHz, 16QAM, AMC 2x3, 18 symbols)	X	4.84	66.12	18.90	6.02	35.0	± 9.6 %
		Y	4.64	66.74	18.96		35.0	
		Z	5.31	67.73	19.94		35.0	
10310-AAA	IEEE 802.16e WIMAX (29:18, 10ms, 10MHz, QPSK, AMC 2x3, 18 symbols)	X	4.72	65.94	18.73	6.02	35.0	± 9.6 %
		Y	4.56	66.66	18.83		35.0	
		Z	5.18	67.55	19.76		35.0	
10311-AAC	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)	X	2.96	67.69	15.36	0.00	150.0	± 9.6 %
		Y	3.01	68.96	16.18		150.0	
		Z	3.03	67.76	15.42		150.0	
10313-AAA	IDEN 1:3	X	3.76	72.87	15.92	6.99	70.0	± 9.6 %
		Y	4.91	78.01	18.07		70.0	
		Z	6.65	78.87	18.47		70.0	
10314-AAA	IDEN 1:6	X	5.25	80.37	21.71	10.00	30.0	± 9.6 %
		Y	10.18	92.92	26.15		30.0	
		Z	10.88	90.38	25.28		30.0	
10315-AAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle)	X	1.05	62.62	14.07	0.17	150.0	± 9.6 %
		Y	1.07	63.86	15.07		150.0	
		Z	1.07	62.88	14.31		150.0	
10316-AAB	IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle)	X	4.60	66.34	15.95	0.17	150.0	± 9.6 %
		Y	4.47	66.77	16.17		150.0	
		Z	4.69	66.37	16.08		150.0	
10317-AAB	IEEE 802.11a WiFi 5 GHz (OFDM, 6 Mbps, 96pc duty cycle)	X	4.60	66.34	15.95	0.17	150.0	± 9.6 %
		Y	4.47	66.77	16.17		150.0	
		Z	4.69	66.37	16.08		150.0	
10400-AAC	IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)	X	4.73	66.67	15.93	0.00	150.0	± 9.6 %
		Y	4.56	67.05	16.14		150.0	
		Z	4.81	66.64	15.99		150.0	
10401-AAC	IEEE 802.11ac WiFi (40MHz, 64-QAM, 99pc duty cycle)	X	5.38	66.83	16.06	0.00	150.0	± 9.6 %
		Y	5.22	67.01	16.20		150.0	
		Z	5.44	66.77	16.12		150.0	

EX3DV4- SN:3903

September 28, 2017

10402-AAC	IEEE 802.11ac WiFi (80MHz, 64-QAM, 99pc duty cycle)	X	5.66	67.32	16.18	0.00	150.0	± 9.6 %
		Y	5.52	67.49	16.31		150.0	
		Z	5.74	67.32	16.25		150.0	
10403-AAB	CDMA2000 (1xEV-DO, Rev. 0)	X	1.31	66.30	12.99	0.00	115.0	± 9.6 %
		Y	1.29	68.05	13.15		115.0	
		Z	1.38	66.43	13.32		115.0	
10404-AAB	CDMA2000 (1xEV-DO, Rev. A)	X	1.31	66.30	12.99	0.00	115.0	± 9.6 %
		Y	1.29	68.05	13.15		115.0	
		Z	1.38	66.43	13.32		115.0	
10406-AAB	CDMA2000, RC3, SO32, SCH0, Full Rate	X	25.72	103.59	26.31	0.00	100.0	± 9.6 %
		Y	100.00	115.78	27.16		100.0	
		Z	11.25	93.04	24.33		100.0	
10410-AAC	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	72.84	116.60	29.06	3.23	80.0	± 9.6 %
		Y	100.00	123.52	30.54		80.0	
		Z	100.00	122.55	31.47		80.0	
10415-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)	X	0.98	61.90	13.55	0.00	150.0	± 9.6 %
		Y	1.00	63.07	14.51		150.0	
		Z	0.96	61.65	13.60		150.0	
10416-AAA	IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle)	X	4.55	66.34	15.89	0.00	150.0	± 9.6 %
		Y	4.42	66.77	16.11		150.0	
		Z	4.61	66.27	15.94		150.0	
10417-AAA	IEEE 802.11a/n WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle)	X	4.55	66.34	15.89	0.00	150.0	± 9.6 %
		Y	4.42	66.77	16.11		150.0	
		Z	4.61	66.27	15.94		150.0	
10418-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 99pc duty cycle, Long preamble)	X	4.53	66.47	15.89	0.00	150.0	± 9.6 %
		Y	4.42	66.96	16.14		150.0	
		Z	4.59	66.39	15.93		150.0	
10419-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 99pc duty cycle, Short preamble)	X	4.56	66.43	15.90	0.00	150.0	± 9.6 %
		Y	4.44	66.90	16.14		150.0	
		Z	4.62	66.36	15.95		150.0	
10422-AAA	IEEE 802.11n (HT Greenfield, 7.2 Mbps, BPSK)	X	4.68	66.45	15.93	0.00	150.0	± 9.6 %
		Y	4.55	66.88	16.15		150.0	
		Z	4.75	66.39	15.97		150.0	
10423-AAA	IEEE 802.11n (HT Greenfield, 43.3 Mbps, 16-QAM)	X	4.86	66.79	16.06	0.00	150.0	± 9.6 %
		Y	4.89	67.16	16.25		150.0	
		Z	4.95	66.76	16.11		150.0	
10424-AAA	IEEE 802.11n (HT Greenfield, 72.2 Mbps, 64-QAM)	X	4.78	66.73	16.02	0.00	150.0	± 9.6 %
		Y	4.62	67.12	16.22		150.0	
		Z	4.85	66.69	16.07		150.0	
10425-AAA	IEEE 802.11n (HT Greenfield, 15 Mbps, BPSK)	X	5.35	67.06	16.19	0.00	150.0	± 9.6 %
		Y	5.20	67.30	16.36		150.0	
		Z	5.42	67.02	16.24		150.0	
10426-AAA	IEEE 802.11n (HT Greenfield, 90 Mbps, 16-QAM)	X	5.35	67.06	16.19	0.00	150.0	± 9.6 %
		Y	5.21	67.33	16.37		150.0	
		Z	5.43	67.06	16.26		150.0	

EX3DV4- SN:3903

September 28, 2017

10427-AAA	IEEE 802.11n (HT Greenfield, 150 Mbps, 64-QAM)	X	5.37	67.08	16.20	0.00	150.0	± 9.6 %
		Y	5.21	67.28	16.34		150.0	
		Z	5.45	67.08	16.26		150.0	
10430-AAB	LTE-FDD (OFDMA, 5 MHz, E-TM 3.1)	X	4.26	70.15	17.85	0.00	150.0	± 9.6 %
		Y	4.32	71.99	18.45		150.0	
		Z	4.27	69.61	17.72		150.0	
10431-AAB	LTE-FDD (OFDMA, 10 MHz, E-TM 3.1)	X	4.24	66.77	15.86	0.00	150.0	± 9.6 %
		Y	4.08	67.34	16.07		150.0	
		Z	4.33	66.71	15.94		150.0	
10432-AAB	LTE-FDD (OFDMA, 15 MHz, E-TM 3.1)	X	4.54	66.73	15.95	0.00	150.0	± 9.6 %
		Y	4.38	67.19	16.17		150.0	
		Z	4.62	66.68	16.01		150.0	
10433-AAB	LTE-FDD (OFDMA, 20 MHz, E-TM 3.1)	X	4.79	66.77	16.04	0.00	150.0	± 9.6 %
		Y	4.63	67.15	16.24		150.0	
		Z	4.87	66.73	16.10		150.0	
10434-AAA	W-CDMA (BS Test Model 1, 64 DPCH)	X	4.34	70.89	17.82	0.00	150.0	± 9.6 %
		Y	4.48	73.08	18.45		150.0	
		Z	4.34	70.24	17.68		150.0	
10435-AAC	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	64.35	114.75	28.56	3.23	80.0	± 9.6 %
		Y	100.00	123.24	30.41		80.0	
		Z	100.00	122.37	31.39		80.0	
10447-AAB	LTE-FDD (OFDMA, 5 MHz, E-TM 3.1, Clipping 44%)	X	3.52	66.62	15.20	0.00	150.0	± 9.6 %
		Y	3.36	67.32	15.25		150.0	
		Z	3.62	66.57	15.35		150.0	
10448-AAB	LTE-FDD (OFDMA, 10 MHz, E-TM 3.1, Clipping 44%)	X	4.07	66.54	15.71	0.00	150.0	± 9.6 %
		Y	3.93	67.13	15.93		150.0	
		Z	4.15	66.47	15.79		150.0	
10449-AAB	LTE-FDD (OFDMA, 15 MHz, E-TM 3.1, Clipping 44%)	X	4.34	66.55	15.84	0.00	150.0	± 9.6 %
		Y	4.21	67.03	16.07		150.0	
		Z	4.41	66.49	15.90		150.0	
10450-AAB	LTE-FDD (OFDMA, 20 MHz, E-TM 3.1, Clipping 44%)	X	4.53	66.52	15.89	0.00	150.0	± 9.6 %
		Y	4.42	66.94	16.11		150.0	
		Z	4.60	66.47	15.94		150.0	
10451-AAA	W-CDMA (BS Test Model 1, 64 DPCH, Clipping 44%)	X	3.42	66.78	14.87	0.00	150.0	± 9.6 %
		Y	3.21	67.36	14.74		150.0	
		Z	3.53	66.76	15.06		150.0	
10456-AAA	IEEE 802.11ac WiFi (160MHz, 64-QAM, 99pc duty cycle)	X	6.21	67.70	16.40	0.00	150.0	± 9.6 %
		Y	6.10	67.91	16.54		150.0	
		Z	6.28	67.72	16.47		150.0	
10457-AAA	UMTS-FDD (DC-HSDPA)	X	3.78	64.98	15.59	0.00	150.0	± 9.6 %
		Y	3.73	65.46	15.82		150.0	
		Z	3.81	64.91	15.64		150.0	
10458-AAA	CDMA2000 (1xEV-DO, Rev. B, 2 carriers)	X	3.94	69.89	17.15	0.00	150.0	± 9.6 %
		Y	4.03	71.98	17.58		150.0	
		Z	3.93	69.21	17.04		150.0	
10459-AAA	CDMA2000 (1xEV-DO, Rev. B, 3 carriers)	X	5.16	68.03	18.00	0.00	150.0	± 9.6 %
		Y	5.06	69.27	18.24		150.0	
		Z	5.17	67.42	17.84		150.0	

EX3DV4- SN:3903

September 28, 2017

10460-AAA	UMTS-FDD (WCDMA, AMR)	X	0.77	64.66	13.80	0.00	150.0	± 9.6 %
		Y	0.86	67.88	15.85		150.0	
		Z	0.78	64.75	13.87		150.0	
10461-AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	30.17	107.58	27.80	3.29	80.0	± 9.6 %
		Y	100.00	130.51	33.74		80.0	
		Z	100.00	125.96	33.13		80.0	
10462-AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.82	70.26	13.35	3.23	80.0	± 9.6 %
		Y	2.78	71.15	12.62		80.0	
		Z	100.00	110.76	25.93		80.0	
10463-AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.71	64.63	10.58	3.23	80.0	± 9.6 %
		Y	0.93	61.17	8.01		80.0	
		Z	58.46	101.81	23.12		80.0	
10464-AAA	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	21.96	101.68	25.64	3.23	80.0	± 9.6 %
		Y	100.00	127.29	32.08		80.0	
		Z	100.00	123.96	32.04		80.0	
10465-AAA	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.32	68.22	12.49	3.23	80.0	± 9.6 %
		Y	1.83	67.43	11.20		80.0	
		Z	100.00	110.18	25.64		80.0	
10466-AAA	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.57	63.73	10.12	3.23	80.0	± 9.6 %
		Y	0.86	60.55	7.65		80.0	
		Z	21.22	90.62	20.27		80.0	
10467-AAC	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	26.20	104.15	26.31	3.23	80.0	± 9.6 %
		Y	100.00	127.69	32.26		80.0	
		Z	100.00	124.19	32.14		80.0	
10468-AAC	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.42	68.67	12.69	3.23	80.0	± 9.6 %
		Y	2.02	68.32	11.56		80.0	
		Z	100.00	110.35	25.72		80.0	
10469-AAC	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.57	63.75	10.13	3.23	80.0	± 9.6 %
		Y	0.86	60.56	7.66		80.0	
		Z	21.88	90.96	20.35		80.0	
10470-AAC	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	26.31	104.23	26.32	3.23	80.0	± 9.6 %
		Y	100.00	127.73	32.27		80.0	
		Z	100.00	124.22	32.15		80.0	
10471-AAC	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.41	68.60	12.65	3.23	80.0	± 9.6 %
		Y	1.98	68.12	11.47		80.0	
		Z	100.00	110.30	25.69		80.0	
10472-AAC	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.56	63.70	10.10	3.23	80.0	± 9.6 %
		Y	0.85	60.50	7.61		80.0	
		Z	21.82	90.91	20.32		80.0	
10473-AAC	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	26.16	104.13	26.29	3.23	80.0	± 9.6 %
		Y	100.00	127.69	32.25		80.0	
		Z	100.00	124.19	32.14		80.0	
10474-AAC	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.39	68.54	12.63	3.23	80.0	± 9.6 %
		Y	1.96	68.04	11.44		80.0	
		Z	100.00	110.31	25.69		80.0	
10475-AAC	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.55	63.68	10.09	3.23	80.0	± 9.6 %
		Y	0.85	60.48	7.61		80.0	
		Z	21.33	90.68	20.27		80.0	

Certificate No: EX3-3903_Sep17

Page 27 of 38

EX3DV4- SN:3903

September 28, 2017

10477-AAC	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	2.31	68.16	12.45	3.23	80.0	± 9.6 %
		Y	1.81	67.30	11.13		80.0	
		Z	100.00	110.14	25.61		80.0	
10478-AAC	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.55	63.62	10.05	3.23	80.0	± 9.6 %
		Y	0.85	60.43	7.57		80.0	
		Z	20.81	90.38	20.18		80.0	
10479-AAC	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	5.16	79.49	20.92	3.23	80.0	± 9.6 %
		Y	24.15	104.93	28.32		80.0	
		Z	8.87	87.46	24.29		80.0	
10480-AAC	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	5.95	77.61	18.64	3.23	80.0	± 9.6 %
		Y	30.64	98.91	23.94		80.0	
		Z	11.32	86.43	22.41		80.0	
10481-AAC	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	5.17	75.17	17.42	3.23	80.0	± 9.6 %
		Y	13.29	87.41	20.30		80.0	
		Z	10.14	84.16	21.36		80.0	
10482-AAC	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	2.57	68.99	15.63	2.23	80.0	± 9.6 %
		Y	3.04	72.92	16.76		80.0	
		Z	3.87	73.97	18.10		80.0	
10483-AAC	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	4.32	72.91	17.03	2.23	80.0	± 9.6 %
		Y	5.01	75.54	16.99		80.0	
		Z	7.43	80.32	20.50		80.0	
10484-AAC	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	4.14	72.08	16.71	2.23	80.0	± 9.6 %
		Y	4.36	73.57	16.26		80.0	
		Z	6.91	79.01	20.05		80.0	
10485-AAC	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	2.86	70.08	16.83	2.23	80.0	± 9.6 %
		Y	3.46	74.84	18.69		80.0	
		Z	4.07	74.54	18.96		80.0	
10486-AAC	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.01	67.74	15.48	2.23	80.0	± 9.6 %
		Y	3.16	69.98	16.02		80.0	
		Z	3.84	70.58	17.09		80.0	
10487-AAC	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.04	67.53	15.38	2.23	80.0	± 9.6 %
		Y	3.13	69.46	15.77		80.0	
		Z	3.85	70.25	16.95		80.0	
10488-AAC	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	3.28	70.14	17.37	2.23	80.0	± 9.6 %
		Y	3.55	73.22	18.91		80.0	
		Z	4.33	73.67	19.03		80.0	
10489-AAC	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.36	67.71	16.46	2.23	80.0	± 9.6 %
		Y	3.42	69.57	17.30		80.0	
		Z	4.01	69.84	17.65		80.0	
10490-AAC	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.47	67.63	16.46	2.23	80.0	± 9.6 %
		Y	3.50	69.36	17.22		80.0	
		Z	4.11	69.62	17.58		80.0	
10491-AAC	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	3.62	69.38	17.17	2.23	80.0	± 9.6 %
		Y	3.72	71.45	18.33		80.0	
		Z	4.47	72.05	18.47		80.0	
10492-AAC	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.76	67.37	16.58	2.23	80.0	± 9.6 %
		Y	3.72	68.59	17.23		80.0	
		Z	4.34	69.08	17.55		80.0	

EX3DV4- SN:3903

September 28, 2017

10493-AAC	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.84	67.29	16.57	2.23	80.0	± 9.6 %
		Y	3.78	68.45	17.17		80.0	
		Z	4.41	68.93	17.51		80.0	
10494-AAC	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	3.86	70.63	17.53	2.23	80.0	± 9.6 %
		Y	4.06	73.05	18.86		80.0	
		Z	4.92	73.76	18.97		80.0	
10495-AAC	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.78	67.74	16.74	2.23	80.0	± 9.6 %
		Y	3.75	68.93	17.43		80.0	
		Z	4.40	69.59	17.75		80.0	
10496-AAC	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.88	67.55	16.71	2.23	80.0	± 9.6 %
		Y	3.83	68.66	17.34		80.0	
		Z	4.47	69.26	17.66		80.0	
10497-AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	2.03	66.21	13.63	2.23	80.0	± 9.6 %
		Y	1.92	66.80	12.99		80.0	
		Z	3.14	71.26	16.37		80.0	
10498-AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	1.86	62.85	11.10	2.23	80.0	± 9.6 %
		Y	1.31	60.35	8.66		80.0	
		Z	2.69	66.50	13.45		80.0	
10499-AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	1.85	62.47	10.78	2.23	80.0	± 9.6 %
		Y	1.28	60.00	8.32		80.0	
		Z	2.65	66.02	13.11		80.0	
10500-AAA	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	2.99	69.84	16.96	2.23	80.0	± 9.6 %
		Y	3.42	73.85	18.66		80.0	
		Z	4.07	73.71	18.83		80.0	
10501-AAA	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.17	67.74	15.86	2.23	80.0	± 9.6 %
		Y	3.31	69.99	16.58		80.0	
		Z	3.91	70.20	17.27		80.0	
10502-AAA	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.24	67.68	15.80	2.23	80.0	± 9.6 %
		Y	3.35	69.80	16.43		80.0	
		Z	3.97	70.05	17.17		80.0	
10503-AAC	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	3.25	69.97	17.29	2.23	80.0	± 9.6 %
		Y	3.50	72.99	18.80		80.0	
		Z	4.27	73.46	18.94		80.0	
10504-AAC	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.35	67.63	16.41	2.23	80.0	± 9.6 %
		Y	3.40	69.46	17.24		80.0	
		Z	4.00	69.75	17.59		80.0	
10505-AAC	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.45	67.55	16.40	2.23	80.0	± 9.6 %
		Y	3.48	69.26	17.15		80.0	
		Z	4.08	69.53	17.53		80.0	
10506-AAC	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	3.83	70.50	17.46	2.23	80.0	± 9.6 %
		Y	4.02	72.88	18.78		80.0	
		Z	4.88	73.61	18.89		80.0	
10507-AAC	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	3.77	67.68	16.71	2.23	80.0	± 9.6 %
		Y	3.74	68.86	17.39		80.0	
		Z	4.38	69.52	17.71		80.0	

EX3DV4- SN:3903

September 28, 2017

10508-AAC	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	3.66	67.49	16.67	2.23	80.0	± 9.6 %
		Y	3.81	68.58	17.30		80.0	
		Z	4.45	69.20	17.61		80.0	
10509-AAC	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	4.25	69.66	17.22	2.23	80.0	± 9.6 %
		Y	4.36	71.56	18.23		80.0	
		Z	5.12	72.20	18.35		80.0	
10510-AAC	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	4.29	67.71	16.81	2.23	80.0	± 9.6 %
		Y	4.20	68.50	17.35		80.0	
		Z	4.87	69.28	17.67		80.0	
10511-AAC	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	4.35	67.50	16.78	2.23	80.0	± 9.6 %
		Y	4.25	68.26	17.28		80.0	
		Z	4.91	68.98	17.60		80.0	
10512-AAC	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	X	4.35	71.07	17.56	2.23	80.0	± 9.6 %
		Y	4.56	73.19	18.76		80.0	
		Z	5.45	73.96	18.88		80.0	
10513-AAC	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	X	4.16	67.92	16.88	2.23	80.0	± 9.6 %
		Y	4.09	68.74	17.45		80.0	
		Z	4.78	69.66	17.81		80.0	
10514-AAC	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	X	4.19	67.57	16.80	2.23	80.0	± 9.6 %
		Y	4.11	68.32	17.32		80.0	
		Z	4.77	69.16	17.67		80.0	
10515-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 99pc duty cycle)	X	0.94	61.98	13.54	0.00	150.0	± 9.6 %
		Y	0.96	63.23	14.56		150.0	
		Z	0.94	61.94	13.59		150.0	
10516-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps, 99pc duty cycle)	X	0.45	64.32	13.38	0.00	150.0	± 9.6 %
		Y	0.55	69.14	16.68		150.0	
		Z	0.45	64.51	13.43		150.0	
10517-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps, 99pc duty cycle)	X	0.76	62.97	13.58	0.00	150.0	± 9.6 %
		Y	0.80	64.90	15.09		150.0	
		Z	0.76	63.02	13.65		150.0	
10518-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps, 99pc duty cycle)	X	4.54	66.40	15.87	0.00	150.0	± 9.6 %
		Y	4.42	66.86	16.09		150.0	
		Z	4.60	66.34	15.92		150.0	
10519-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps, 99pc duty cycle)	X	4.74	66.67	16.00	0.00	150.0	± 9.6 %
		Y	4.58	67.05	16.19		150.0	
		Z	4.82	66.63	16.06		150.0	
10520-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps, 99pc duty cycle)	X	4.59	66.62	15.91	0.00	150.0	± 9.6 %
		Y	4.43	67.00	16.11		150.0	
		Z	4.67	66.59	15.97		150.0	
10521-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps, 99pc duty cycle)	X	4.52	66.61	15.89	0.00	150.0	± 9.6 %
		Y	4.37	66.99	16.10		150.0	
		Z	4.60	66.59	15.95		150.0	
10522-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps, 99pc duty cycle)	X	4.58	66.65	15.96	0.00	150.0	± 9.6 %
		Y	4.43	67.10	16.19		150.0	
		Z	4.65	66.57	15.99		150.0	

Certificate No: EX3-3903_Sep17

Page 30 of 36

EX3DV4- SN:3903

September 28, 2017

10523-AAA	IEEE 802.11a/n WiFi 5 GHz (OFDM, 48 Mbps, 99pc duty cycle)	X	4.45	66.53	15.80	0.00	150.0	± 9.6 %
		Y	4.33	67.04	16.08		150.0	
		Z	4.52	66.46	15.84		150.0	
10524-AAA	IEEE 802.11a/n WiFi 5 GHz (OFDM, 54 Mbps, 99pc duty cycle)	X	4.52	66.58	15.93	0.00	150.0	± 9.6 %
		Y	4.37	67.03	16.16		150.0	
		Z	4.60	66.53	15.98		150.0	
10525-AAA	IEEE 802.11ac WiFi (20MHz, MCS0, 99pc duty cycle)	X	4.49	65.63	15.52	0.00	150.0	± 9.6 %
		Y	4.38	66.13	15.78		150.0	
		Z	4.55	65.56	15.57		150.0	
10526-AAA	IEEE 802.11ac WiFi (20MHz, MCS1, 99pc duty cycle)	X	4.67	66.00	15.67	0.00	150.0	± 9.6 %
		Y	4.52	66.44	15.91		150.0	
		Z	4.75	65.95	15.71		150.0	
10527-AAA	IEEE 802.11ac WiFi (20MHz, MCS2, 99pc duty cycle)	X	4.59	65.96	15.61	0.00	150.0	± 9.6 %
		Y	4.45	66.41	15.85		150.0	
		Z	4.66	65.91	15.66		150.0	
10528-AAA	IEEE 802.11ac WiFi (20MHz, MCS3, 99pc duty cycle)	X	4.60	65.98	15.64	0.00	150.0	± 9.6 %
		Y	4.47	66.42	15.88		150.0	
		Z	4.68	65.93	15.69		150.0	
10529-AAA	IEEE 802.11ac WiFi (20MHz, MCS4, 99pc duty cycle)	X	4.60	65.98	15.64	0.00	150.0	± 9.6 %
		Y	4.47	66.42	15.88		150.0	
		Z	4.68	65.93	15.69		150.0	
10531-AAA	IEEE 802.11ac WiFi (20MHz, MCS6, 99pc duty cycle)	X	4.60	66.09	15.65	0.00	150.0	± 9.6 %
		Y	4.44	66.48	15.87		150.0	
		Z	4.69	66.06	15.71		150.0	
10532-AAA	IEEE 802.11ac WiFi (20MHz, MCS7, 99pc duty cycle)	X	4.46	65.94	15.58	0.00	150.0	± 9.6 %
		Y	4.32	66.35	15.81		150.0	
		Z	4.54	65.92	15.64		150.0	
10533-AAA	IEEE 802.11ac WiFi (20MHz, MCS8, 99pc duty cycle)	X	4.61	66.01	15.62	0.00	150.0	± 9.6 %
		Y	4.48	66.49	15.88		150.0	
		Z	4.69	65.96	15.67		150.0	
10534-AAA	IEEE 802.11ac WiFi (40MHz, MCS0, 99pc duty cycle)	X	5.13	66.17	15.74	0.00	150.0	± 9.6 %
		Y	5.00	66.47	15.93		150.0	
		Z	5.20	66.15	15.79		150.0	
10535-AAA	IEEE 802.11ac WiFi (40MHz, MCS1, 99pc duty cycle)	X	5.19	66.31	15.79	0.00	150.0	± 9.6 %
		Y	5.06	66.61	16.00		150.0	
		Z	5.26	66.28	15.84		150.0	
10536-AAA	IEEE 802.11ac WiFi (40MHz, MCS2, 99pc duty cycle)	X	5.06	66.28	15.76	0.00	150.0	± 9.6 %
		Y	4.94	66.60	15.97		150.0	
		Z	5.13	66.26	15.81		150.0	
10537-AAA	IEEE 802.11ac WiFi (40MHz, MCS3, 99pc duty cycle)	X	5.12	66.25	15.75	0.00	150.0	± 9.6 %
		Y	4.99	66.56	15.95		150.0	
		Z	5.20	66.24	15.80		150.0	
10538-AAA	IEEE 802.11ac WiFi (40MHz, MCS4, 99pc duty cycle)	X	5.23	66.31	15.82	0.00	150.0	± 9.6 %
		Y	5.07	66.55	15.99		150.0	
		Z	5.31	66.31	15.88		150.0	
10540-AAA	IEEE 802.11ac WiFi (40MHz, MCS6, 99pc duty cycle)	X	5.14	66.27	15.81	0.00	150.0	± 9.6 %
		Y	5.00	66.53	15.99		150.0	
		Z	5.21	66.25	15.86		150.0	

EX3DV4- SN:3903

September 28, 2017

10541-AAA	IEEE 802.11ac WiFi (40MHz, MCS7, 99pc duty cycle)	X	5.12	66.18	15.76	0.00	150.0	± 9.6 %
		Y	4.99	66.45	15.94		150.0	
		Z	5.20	66.18	15.83		150.0	
10542-AAA	IEEE 802.11ac WiFi (40MHz, MCS8, 99pc duty cycle)	X	5.28	66.25	15.82	0.00	150.0	± 9.6 %
		Y	5.14	66.53	16.00		150.0	
		Z	5.35	66.23	15.87		150.0	
10543-AAA	IEEE 802.11ac WiFi (40MHz, MCS9, 99pc duty cycle)	X	5.36	66.29	15.85	0.00	150.0	± 9.6 %
		Y	5.20	66.54	16.02		150.0	
		Z	5.44	66.26	15.90		150.0	
10544-AAA	IEEE 802.11ac WiFi (80MHz, MCS0, 99pc duty cycle)	X	5.43	66.32	15.75	0.00	150.0	± 9.6 %
		Y	5.33	66.58	15.93		150.0	
		Z	5.48	66.29	15.80		150.0	
10545-AAA	IEEE 802.11ac WiFi (80MHz, MCS1, 99pc duty cycle)	X	5.61	66.67	15.87	0.00	150.0	± 9.6 %
		Y	5.49	66.91	16.05		150.0	
		Z	5.68	66.66	15.93		150.0	
10546-AAA	IEEE 802.11ac WiFi (80MHz, MCS2, 99pc duty cycle)	X	5.50	66.55	15.83	0.00	150.0	± 9.6 %
		Y	5.37	66.73	15.97		150.0	
		Z	5.57	66.56	15.89		150.0	
10547-AAA	IEEE 802.11ac WiFi (80MHz, MCS3, 99pc duty cycle)	X	5.58	66.60	15.85	0.00	150.0	± 9.6 %
		Y	5.44	66.77	15.99		150.0	
		Z	5.66	66.64	15.92		150.0	
10548-AAA	IEEE 802.11ac WiFi (80MHz, MCS4, 99pc duty cycle)	X	5.77	67.33	16.16	0.00	150.0	± 9.6 %
		Y	5.58	67.36	16.26		150.0	
		Z	5.90	67.49	16.31		150.0	
10550-AAA	IEEE 802.11ac WiFi (80MHz, MCS6, 99pc duty cycle)	X	5.52	66.53	15.83	0.00	150.0	± 9.6 %
		Y	5.40	66.78	16.01		150.0	
		Z	5.59	66.52	15.88		150.0	
10551-AAA	IEEE 802.11ac WiFi (80MHz, MCS7, 99pc duty cycle)	X	5.53	66.59	15.82	0.00	150.0	± 9.6 %
		Y	5.39	66.75	15.96		150.0	
		Z	5.60	66.59	15.88		150.0	
10552-AAA	IEEE 802.11ac WiFi (80MHz, MCS8, 99pc duty cycle)	X	5.45	66.40	15.74	0.00	150.0	± 9.6 %
		Y	5.35	66.68	15.93		150.0	
		Z	5.51	66.38	15.79		150.0	
10553-AAA	IEEE 802.11ac WiFi (80MHz, MCS9, 99pc duty cycle)	X	5.54	66.46	15.79	0.00	150.0	± 9.6 %
		Y	5.41	66.67	15.95		150.0	
		Z	5.61	66.44	15.84		150.0	
10554-AAB	IEEE 802.11ac WiFi (160MHz, MCS0, 99pc duty cycle)	X	5.82	66.70	15.85	0.00	150.0	± 9.6 %
		Y	5.74	66.91	16.00		150.0	
		Z	5.88	66.68	15.91		150.0	
10555-AAB	IEEE 802.11ac WiFi (160MHz, MCS1, 99pc duty cycle)	X	5.95	66.98	15.97	0.00	150.0	± 9.6 %
		Y	5.84	67.15	16.10		150.0	
		Z	6.02	67.00	16.03		150.0	
10556-AAB	IEEE 802.11ac WiFi (160MHz, MCS2, 99pc duty cycle)	X	5.97	67.01	15.98	0.00	150.0	± 9.6 %
		Y	5.86	67.20	16.12		150.0	
		Z	6.03	67.01	16.04		150.0	
10557-AAB	IEEE 802.11ac WiFi (160MHz, MCS3, 99pc duty cycle)	X	5.95	66.96	15.97	0.00	150.0	± 9.6 %
		Y	5.83	67.13	16.10		150.0	
		Z	6.02	66.98	16.04		150.0	

EX3DV4- SN:3903

September 28, 2017

10558-AAB	IEEE 802.11ac WiFi (160MHz, MCS4, 99pc duty cycle)	X	5.99	67.11	16.06	0.00	150.0	± 9.6 %
		Y	5.87	67.26	16.18		150.0	
		Z	6.07	67.15	16.14		150.0	
10560-AAB	IEEE 802.11ac WiFi (160MHz, MCS6, 99pc duty cycle)	X	6.00	67.00	16.04	0.00	150.0	± 9.6 %
		Y	5.87	67.14	16.16		150.0	
		Z	6.07	67.01	16.11		150.0	
10561-AAB	IEEE 802.11ac WiFi (160MHz, MCS7, 99pc duty cycle)	X	5.91	66.93	16.05	0.00	150.0	± 9.6 %
		Y	5.79	67.09	16.17		150.0	
		Z	5.98	66.95	16.12		150.0	
10562-AAB	IEEE 802.11ac WiFi (160MHz, MCS8, 99pc duty cycle)	X	6.03	67.30	16.23	0.00	150.0	± 9.6 %
		Y	5.87	67.35	16.30		150.0	
		Z	6.12	67.37	16.33		150.0	
10563-AAB	IEEE 802.11ac WiFi (160MHz, MCS9, 99pc duty cycle)	X	6.33	67.76	16.41	0.00	150.0	± 9.6 %
		Y	5.94	67.20	16.19		150.0	
		Z	6.42	67.82	16.50		150.0	
10564-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 99pc duty cycle)	X	4.87	66.51	16.04	0.46	150.0	± 9.6 %
		Y	4.73	66.89	16.22		150.0	
		Z	4.94	66.48	16.12		150.0	
10565-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 12 Mbps, 99pc duty cycle)	X	5.12	66.99	16.38	0.46	150.0	± 9.6 %
		Y	4.94	67.32	16.54		150.0	
		Z	5.20	66.98	16.45		150.0	
10566-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 18 Mbps, 99pc duty cycle)	X	4.94	66.83	16.18	0.46	150.0	± 9.6 %
		Y	4.78	67.15	16.35		150.0	
		Z	5.03	66.82	16.27		150.0	
10567-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 24 Mbps, 99pc duty cycle)	X	4.97	67.24	16.55	0.46	150.0	± 9.6 %
		Y	4.82	67.59	16.75		150.0	
		Z	5.06	67.20	16.61		150.0	
10568-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 36 Mbps, 99pc duty cycle)	X	4.85	66.54	15.91	0.46	150.0	± 9.6 %
		Y	4.68	66.89	16.09		150.0	
		Z	4.94	66.54	16.01		150.0	
10569-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 48 Mbps, 99pc duty cycle)	X	4.92	67.29	16.59	0.46	150.0	± 9.6 %
		Y	4.80	67.77	16.86		150.0	
		Z	4.99	67.23	16.63		150.0	
10570-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 54 Mbps, 99pc duty cycle)	X	4.96	67.12	16.51	0.46	150.0	± 9.6 %
		Y	4.81	67.54	16.74		150.0	
		Z	5.04	67.08	16.57		150.0	
10571-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 90pc duty cycle)	X	1.13	63.18	14.39	0.46	130.0	± 9.6 %
		Y	1.15	64.40	15.38		130.0	
		Z	1.19	63.85	14.87		130.0	
10572-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 90pc duty cycle)	X	1.13	63.61	14.67	0.46	130.0	± 9.6 %
		Y	1.16	64.96	15.74		130.0	
		Z	1.20	64.34	15.17		130.0	
10573-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps, 90pc duty cycle)	X	0.92	71.08	16.74	0.46	130.0	± 9.6 %
		Y	1.60	82.35	22.16		130.0	
		Z	1.27	74.99	18.33		130.0	
10574-AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps, 90pc duty cycle)	X	1.14	67.38	16.80	0.46	130.0	± 9.6 %
		Y	1.25	70.54	18.66		130.0	
		Z	1.26	68.73	17.31		130.0	

EX30V4- SN:3903

September 28, 2017

10575-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps, 90pc duty cycle)	X	4.65	66.27	16.06	0.46	130.0	± 9.6 %
		Y	4.52	66.68	16.26		130.0	
		Z	4.74	66.30	16.19		130.0	
10576-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 9 Mbps, 90pc duty cycle)	X	4.68	66.43	16.13	0.46	130.0	± 9.6 %
		Y	4.55	66.87	16.35		130.0	
		Z	4.77	66.46	16.26		130.0	
10577-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 12 Mbps, 90pc duty cycle)	X	4.90	66.76	16.32	0.46	130.0	± 9.6 %
		Y	4.73	67.13	16.50		130.0	
		Z	5.00	66.79	16.44		130.0	
10578-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 18 Mbps, 90pc duty cycle)	X	4.79	66.91	16.41	0.46	130.0	± 9.6 %
		Y	4.63	67.30	16.62		130.0	
		Z	4.89	66.95	16.54		130.0	
10579-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 24 Mbps, 90pc duty cycle)	X	4.55	66.17	15.70	0.46	130.0	± 9.6 %
		Y	4.38	66.47	15.86		130.0	
		Z	4.66	66.28	15.87		130.0	
10580-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 36 Mbps, 90pc duty cycle)	X	4.59	66.17	15.70	0.46	130.0	± 9.6 %
		Y	4.42	66.52	15.88		130.0	
		Z	4.71	66.26	15.87		130.0	
10581-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 48 Mbps, 90pc duty cycle)	X	4.68	66.93	16.34	0.46	130.0	± 9.6 %
		Y	4.54	67.35	16.58		130.0	
		Z	4.79	66.99	16.47		130.0	
10582-AAA	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 54 Mbps, 90pc duty cycle)	X	4.50	65.91	15.48	0.46	130.0	± 9.6 %
		Y	4.31	66.20	15.62		130.0	
		Z	4.62	66.03	15.67		130.0	
10583-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 8 Mbps, 90pc duty cycle)	X	4.65	66.27	16.06	0.46	130.0	± 9.6 %
		Y	4.52	66.68	16.26		130.0	
		Z	4.74	66.30	16.19		130.0	
10584-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps, 90pc duty cycle)	X	4.68	66.43	16.13	0.46	130.0	± 9.6 %
		Y	4.55	66.87	16.35		130.0	
		Z	4.77	66.46	16.26		130.0	
10585-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps, 90pc duty cycle)	X	4.90	66.76	16.32	0.46	130.0	± 9.6 %
		Y	4.73	67.13	16.50		130.0	
		Z	5.00	66.79	16.44		130.0	
10586-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps, 90pc duty cycle)	X	4.79	66.91	16.41	0.46	130.0	± 9.6 %
		Y	4.63	67.30	16.62		130.0	
		Z	4.89	66.95	16.54		130.0	
10587-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps, 90pc duty cycle)	X	4.55	66.17	15.70	0.46	130.0	± 9.6 %
		Y	4.38	66.47	15.86		130.0	
		Z	4.66	66.28	15.87		130.0	
10588-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps, 90pc duty cycle)	X	4.59	66.17	15.70	0.46	130.0	± 9.6 %
		Y	4.42	66.52	15.88		130.0	
		Z	4.71	66.26	15.87		130.0	
10589-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 48 Mbps, 90pc duty cycle)	X	4.68	66.93	16.34	0.46	130.0	± 9.6 %
		Y	4.54	67.35	16.58		130.0	
		Z	4.79	66.99	16.47		130.0	
10590-AAA	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps, 90pc duty cycle)	X	4.50	65.91	15.48	0.46	130.0	± 9.6 %
		Y	4.31	66.20	15.62		130.0	
		Z	4.62	66.03	15.67		130.0	

EX3DV4- SN:3903

September 28, 2017

10591-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS0, 90pc duty cycle)	X	4.81	66.36	16.18	0.46	130.0	± 9.6 %
		Y	4.67	66.76	16.38		130.0	
		Z	4.90	66.39	16.31		130.0	
10592-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS1, 90pc duty cycle)	X	4.97	66.70	16.31	0.46	130.0	± 9.6 %
		Y	4.81	67.07	16.51		130.0	
		Z	5.07	66.73	16.43		130.0	
10593-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS2, 90pc duty cycle)	X	4.89	66.61	16.19	0.46	130.0	± 9.6 %
		Y	4.72	66.95	16.37		130.0	
		Z	4.99	66.67	16.33		130.0	
10594-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS3, 90pc duty cycle)	X	4.95	66.78	16.35	0.46	130.0	± 9.6 %
		Y	4.78	67.14	16.54		130.0	
		Z	5.05	66.82	16.47		130.0	
10595-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS4, 90pc duty cycle)	X	4.91	66.72	16.24	0.46	130.0	± 9.6 %
		Y	4.75	67.09	16.44		130.0	
		Z	5.02	66.78	16.38		130.0	
10596-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS5, 90pc duty cycle)	X	4.85	66.70	16.23	0.46	130.0	± 9.6 %
		Y	4.68	67.07	16.43		130.0	
		Z	4.95	66.76	16.36		130.0	
10597-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS6, 90pc duty cycle)	X	4.80	66.61	16.12	0.46	130.0	± 9.6 %
		Y	4.63	66.95	16.29		130.0	
		Z	4.90	66.69	16.27		130.0	
10598-AAA	IEEE 802.11n (HT Mixed, 20MHz, MCS7, 90pc duty cycle)	X	4.78	66.87	16.39	0.46	130.0	± 9.6 %
		Y	4.62	67.21	16.56		130.0	
		Z	4.88	66.94	16.53		130.0	
10599-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS0, 90pc duty cycle)	X	5.47	66.95	16.40	0.46	130.0	± 9.6 %
		Y	5.31	67.15	16.54		130.0	
		Z	5.56	67.01	16.52		130.0	
10600-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS1, 90pc duty cycle)	X	5.59	67.31	16.54	0.46	130.0	± 9.6 %
		Y	5.40	67.43	16.65		130.0	
		Z	5.73	67.50	16.74		130.0	
10601-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS2, 90pc duty cycle)	X	5.49	67.09	16.45	0.46	130.0	± 9.6 %
		Y	5.32	67.29	16.60		130.0	
		Z	5.60	67.21	16.61		130.0	
10602-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS3, 90pc duty cycle)	X	5.57	67.07	16.36	0.46	130.0	± 9.6 %
		Y	5.42	67.35	16.54		130.0	
		Z	5.69	67.20	16.52		130.0	
10603-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS4, 90pc duty cycle)	X	5.67	67.43	16.67	0.46	130.0	± 9.6 %
		Y	5.51	67.70	16.86		130.0	
		Z	5.79	67.56	16.83		130.0	
10604-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS5, 90pc duty cycle)	X	5.47	66.90	16.40	0.46	130.0	± 9.6 %
		Y	5.38	67.34	16.66		130.0	
		Z	5.57	66.98	16.53		130.0	
10605-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS6, 90pc duty cycle)	X	5.56	67.15	16.51	0.46	130.0	± 9.6 %
		Y	5.41	67.39	16.68		130.0	
		Z	5.66	67.23	16.66		130.0	
10606-AAA	IEEE 802.11n (HT Mixed, 40MHz, MCS7, 90pc duty cycle)	X	5.35	66.65	16.13	0.46	130.0	± 9.6 %
		Y	5.17	66.78	16.23		130.0	
		Z	5.45	66.75	16.28		130.0	

EX3DV4- SN:3903

September 28, 2017

10607-AAA	IEEE 802.11ac WiFi (20MHz, MCS0, 90pc duty cycle)	X	4.63	65.63	15.78	0.46	130.0	± 9.6 %
		Y	4.52	66.11	16.03		130.0	
		Z	4.72	65.64	15.89		130.0	
10608-AAA	IEEE 802.11ac WiFi (20MHz, MCS1, 90pc duty cycle)	X	4.83	66.04	15.94	0.46	130.0	± 9.6 %
		Y	4.68	66.47	16.18		130.0	
		Z	4.93	66.07	16.06		130.0	
10609-AAA	IEEE 802.11ac WiFi (20MHz, MCS2, 90pc duty cycle)	X	4.71	65.88	15.78	0.46	130.0	± 9.6 %
		Y	4.57	66.30	16.00		130.0	
		Z	4.81	65.93	15.91		130.0	
10610-AAA	IEEE 802.11ac WiFi (20MHz, MCS3, 90pc duty cycle)	X	4.77	66.05	15.94	0.46	130.0	± 9.6 %
		Y	4.62	66.47	16.18		130.0	
		Z	4.87	66.09	16.07		130.0	
10611-AAA	IEEE 802.11ac WiFi (20MHz, MCS4, 90pc duty cycle)	X	4.68	65.85	15.79	0.46	130.0	± 9.6 %
		Y	4.54	66.27	16.02		130.0	
		Z	4.79	65.92	15.93		130.0	
10612-AAA	IEEE 802.11ac WiFi (20MHz, MCS5, 90pc duty cycle)	X	4.69	65.98	15.81	0.46	130.0	± 9.6 %
		Y	4.53	66.40	16.05		130.0	
		Z	4.80	66.04	15.95		130.0	
10613-AAA	IEEE 802.11ac WiFi (20MHz, MCS6, 90pc duty cycle)	X	4.70	65.86	15.71	0.46	130.0	± 9.6 %
		Y	4.53	66.24	15.91		130.0	
		Z	4.81	65.97	15.86		130.0	
10614-AAA	IEEE 802.11ac WiFi (20MHz, MCS7, 90pc duty cycle)	X	4.64	66.08	15.95	0.46	130.0	± 9.6 %
		Y	4.49	66.48	16.18		130.0	
		Z	4.74	66.15	16.09		130.0	
10615-AAA	IEEE 802.11ac WiFi (20MHz, MCS8, 90pc duty cycle)	X	4.68	65.66	15.55	0.46	130.0	± 9.6 %
		Y	4.53	66.08	15.76		130.0	
		Z	4.79	65.73	15.70		130.0	
10616-AAA	IEEE 802.11ac WiFi (40MHz, MCS0, 90pc duty cycle)	X	5.28	66.20	16.01	0.46	130.0	± 9.6 %
		Y	5.15	66.47	16.19		130.0	
		Z	5.37	66.25	16.12		130.0	
10617-AAA	IEEE 802.11ac WiFi (40MHz, MCS1, 90pc duty cycle)	X	5.33	66.30	16.02	0.46	130.0	± 9.6 %
		Y	5.20	66.61	16.24		130.0	
		Z	5.43	66.34	16.14		130.0	
10618-AAA	IEEE 802.11ac WiFi (40MHz, MCS2, 90pc duty cycle)	X	5.23	66.35	16.07	0.46	130.0	± 9.6 %
		Y	5.10	66.67	16.28		130.0	
		Z	5.32	66.41	16.19		130.0	
10619-AAA	IEEE 802.11ac WiFi (40MHz, MCS3, 90pc duty cycle)	X	5.25	66.17	15.91	0.46	130.0	± 9.6 %
		Y	5.11	66.44	16.10		130.0	
		Z	5.35	66.24	16.04		130.0	
10620-AAA	IEEE 802.11ac WiFi (40MHz, MCS4, 90pc duty cycle)	X	5.35	66.25	16.00	0.46	130.0	± 9.6 %
		Y	5.19	66.46	16.16		130.0	
		Z	5.46	66.35	16.15		130.0	
10621-AAA	IEEE 802.11ac WiFi (40MHz, MCS5, 90pc duty cycle)	X	5.35	66.38	16.19	0.46	130.0	± 9.6 %
		Y	5.21	66.65	16.37		130.0	
		Z	5.44	66.43	16.30		130.0	
10622-AAA	IEEE 802.11ac WiFi (40MHz, MCS6, 90pc duty cycle)	X	5.34	66.47	16.22	0.46	130.0	± 9.6 %
		Y	5.20	66.74	16.41		130.0	
		Z	5.43	66.52	16.33		130.0	

EX3DV4- SN:3903

September 28, 2017

10623-AAA	IEEE 802.11ac WiFi (40MHz, MCS7, 90pc duty cycle)	X	5.23	66.04	15.88	0.46	130.0	± 9.6 %
		Y	5.09	66.29	16.05		130.0	
		Z	5.33	66.12	16.02		130.0	
10624-AAA	IEEE 802.11ac WiFi (40MHz, MCS8, 90pc duty cycle)	X	5.42	66.24	16.05	0.46	130.0	± 9.6 %
		Y	5.28	66.50	16.22		130.0	
		Z	5.52	66.30	16.17		130.0	
10625-AAA	IEEE 802.11ac WiFi (40MHz, MCS9, 90pc duty cycle)	X	5.77	67.14	16.55	0.46	130.0	± 9.6 %
		Y	5.49	67.00	16.53		130.0	
		Z	5.88	67.23	16.68		130.0	
10626-AAA	IEEE 802.11ac WiFi (80MHz, MCS0, 90pc duty cycle)	X	5.56	66.29	15.98	0.46	130.0	± 9.6 %
		Y	5.46	66.54	16.15		130.0	
		Z	5.63	66.32	16.09		130.0	
10627-AAA	IEEE 802.11ac WiFi (80MHz, MCS1, 90pc duty cycle)	X	5.78	66.76	16.17	0.46	130.0	± 9.6 %
		Y	5.66	67.01	16.36		130.0	
		Z	5.87	66.82	16.29		130.0	
10628-AAA	IEEE 802.11ac WiFi (80MHz, MCS2, 90pc duty cycle)	X	5.60	66.38	15.92	0.46	130.0	± 9.6 %
		Y	5.46	66.53	16.05		130.0	
		Z	5.69	66.47	16.05		130.0	
10629-AAA	IEEE 802.11ac WiFi (80MHz, MCS3, 90pc duty cycle)	X	5.69	66.48	15.96	0.46	130.0	± 9.6 %
		Y	5.54	66.60	16.08		130.0	
		Z	5.78	66.54	16.08		130.0	
10630-AAA	IEEE 802.11ac WiFi (80MHz, MCS4, 90pc duty cycle)	X	6.06	67.73	16.58	0.46	130.0	± 9.6 %
		Y	5.78	67.53	16.54		130.0	
		Z	6.24	68.07	16.84		130.0	
10631-AAA	IEEE 802.11ac WiFi (80MHz, MCS5, 90pc duty cycle)	X	6.02	67.75	16.79	0.46	130.0	± 9.6 %
		Y	5.80	67.70	16.83		130.0	
		Z	6.16	67.94	16.96		130.0	
10632-AAA	IEEE 802.11ac WiFi (80MHz, MCS6, 90pc duty cycle)	X	5.77	66.89	16.38	0.46	130.0	± 9.6 %
		Y	5.65	67.14	16.57		130.0	
		Z	5.86	66.93	16.48		130.0	
10633-AAA	IEEE 802.11ac WiFi (80MHz, MCS7, 90pc duty cycle)	X	5.68	66.58	16.05	0.46	130.0	± 9.6 %
		Y	5.53	66.74	16.19		130.0	
		Z	5.79	66.72	16.20		130.0	
10634-AAA	IEEE 802.11ac WiFi (80MHz, MCS8, 90pc duty cycle)	X	5.66	66.62	16.13	0.46	130.0	± 9.6 %
		Y	5.53	66.81	16.28		130.0	
		Z	5.77	66.72	16.26		130.0	
10635-AAA	IEEE 802.11ac WiFi (80MHz, MCS9, 90pc duty cycle)	X	5.55	65.94	15.52	0.46	130.0	± 9.6 %
		Y	5.38	66.05	15.62		130.0	
		Z	5.65	66.06	15.67		130.0	
10636-AAB	IEEE 802.11ac WiFi (160MHz, MCS0, 90pc duty cycle)	X	5.97	66.68	16.08	0.46	130.0	± 9.6 %
		Y	5.87	66.88	16.23		130.0	
		Z	6.04	66.72	16.19		130.0	
10637-AAB	IEEE 802.11ac WiFi (160MHz, MCS1, 90pc duty cycle)	X	6.11	67.01	16.23	0.46	130.0	± 9.6 %
		Y	6.00	67.18	16.37		130.0	
		Z	6.20	67.09	16.35		130.0	
10638-AAB	IEEE 802.11ac WiFi (160MHz, MCS2, 90pc duty cycle)	X	6.11	66.99	16.20	0.46	130.0	± 9.6 %
		Y	6.01	67.20	16.35		130.0	
		Z	6.20	67.06	16.32		130.0	

EX3DV4- SN-3903

September 28, 2017

10639-AAB	IEEE 802.11ac WiFi (160MHz, MCS3, 90pc duty cycle)	X	6.11	66.99	16.25	0.46	130.0	± 9.6 %
		Y	5.96	67.14	16.37		130.0	
		Z	6.20	67.09	16.38		130.0	
10640-AAB	IEEE 802.11ac WiFi (160MHz, MCS4, 90pc duty cycle)	X	6.11	67.00	16.16	0.46	130.0	± 9.6 %
		Y	5.97	67.10	16.29		130.0	
		Z	6.22	67.13	16.34		130.0	
10641-AAB	IEEE 802.11ac WiFi (160MHz, MCS5, 90pc duty cycle)	X	6.14	66.85	16.13	0.46	130.0	± 9.6 %
		Y	6.03	67.04	16.28		130.0	
		Z	6.23	66.91	16.25		130.0	
10642-AAB	IEEE 802.11ac WiFi (160MHz, MCS6, 90pc duty cycle)	X	6.21	67.19	16.48	0.46	130.0	± 9.6 %
		Y	6.08	67.34	16.60		130.0	
		Z	6.30	67.26	16.59		130.0	
10643-AAB	IEEE 802.11ac WiFi (160MHz, MCS7, 90pc duty cycle)	X	6.03	66.81	16.18	0.46	130.0	± 9.6 %
		Y	5.91	66.97	16.31		130.0	
		Z	6.12	66.91	16.31		130.0	
10644-AAB	IEEE 802.11ac WiFi (160MHz, MCS8, 90pc duty cycle)	X	6.20	67.34	16.48	0.46	130.0	± 9.6 %
		Y	6.01	67.30	16.49		130.0	
		Z	6.33	67.53	16.65		130.0	
10645-AAB	IEEE 802.11ac WiFi (160MHz, MCS9, 90pc duty cycle)	X	6.58	68.03	16.75	0.46	130.0	± 9.6 %
		Y	6.10	67.22	16.41		130.0	
		Z	6.66	68.05	16.85		130.0	
10646-AAB	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, QPSK, UL Subframe=2,7)	X	14.16	100.58	33.72	9.30	60.0	± 9.6 %
		Y	16.39	109.36	37.64		60.0	
		Z	28.10	114.77	38.50		60.0	
10647-AAB	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK, UL Subframe=2,7)	X	12.81	98.94	33.31	9.30	60.0	± 9.6 %
		Y	13.55	105.58	36.60		60.0	
		Z	25.78	113.54	38.28		60.0	
10648-AAB	CDMA2000 (1x Advanced)	X	0.68	62.37	10.24	0.00	150.0	± 9.6 %
		Y	0.61	62.94	9.90		150.0	
		Z	0.71	62.50	10.56		150.0	
10652-AAB	LTE-TDD (OFDMA, 5 MHz, E-TM 3.1, Clipping 44%)	X	3.56	65.99	15.98	2.23	80.0	± 9.6 %
		Y	3.54	67.19	16.48		80.0	
		Z	3.93	67.04	16.69		80.0	
10653-AAB	LTE-TDD (OFDMA, 10 MHz, E-TM 3.1, Clipping 44%)	X	4.12	65.70	16.25	2.23	80.0	± 9.6 %
		Y	4.04	66.39	16.60		80.0	
		Z	4.46	66.56	16.82		80.0	
10654-AAB	LTE-TDD (OFDMA, 15 MHz, E-TM 3.1, Clipping 44%)	X	4.10	65.42	16.26	2.23	80.0	± 9.6 %
		Y	4.04	66.01	16.60		80.0	
		Z	4.40	66.25	16.82		80.0	
10655-AAB	LTE-TDD (OFDMA, 20 MHz, E-TM 3.1, Clipping 44%)	X	4.15	65.45	16.31	2.23	80.0	± 9.6 %
		Y	4.10	65.96	16.63		80.0	
		Z	4.46	66.30	16.86		80.0	

[†] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Attachment 6. – Dipole Calibration Data

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D835V2-441_Sep17**

CALIBRATION CERTIFICATE

Object **D835V2 - SN:441**

Calibration procedure(s) **QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **September 21, 2017**

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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	26-Mar-17 (No. DAE4-601_Mar17)	Mar-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	in house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	in house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	in house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	in house check: Oct-18
Network Analyzer HP 8753E	SN: US37390565	18-Oct-01 (in house check Oct-16)	in house check: Oct-17

Calibrated by: **Michael Weber** Function: **Laboratory Technician** Signature: 

Approved by: **Katja Pokovic** Technical Manager Signature: 

Issued: September 21, 2017

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

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

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:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY4/5 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 dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. 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	DASY5	V52.10.0
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 $\pm$ 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 $\pm$ 0.2) °C	40.9 $\pm$ 6 %	0.93 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.38 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.55 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.07 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	55.3 $\pm$ 6 %	0.98 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.41 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.16 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	51.1 Ω - 2.3 j Ω
Return Loss	- 32.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.6 Ω - 5.0 j Ω
Return Loss	- 24.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.371 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
Manufactured on	March 09, 2001

DASY5 Validation Report for Head TSL

Date: 21.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:441

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835$ MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 40.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.07, 10.07, 10.07); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

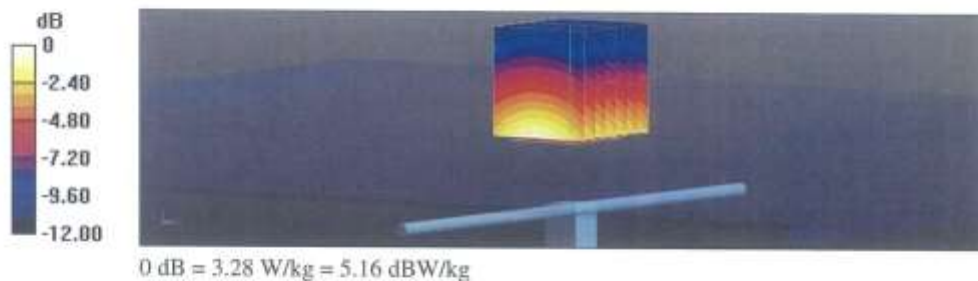
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 62.34 V/m; Power Drift = -0.08 dB

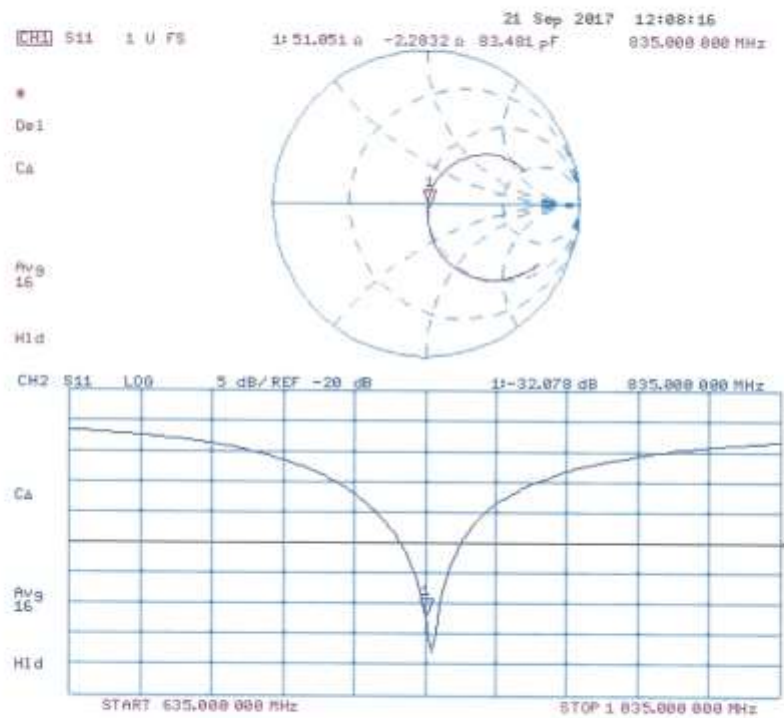
Peak SAR (extrapolated) = 3.75 W/kg

SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.55 W/kg

Maximum value of SAR (measured) = 3.28 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 21.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:441

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: $f = 835$ MHz; $\sigma = 0.98$ S/m; $\epsilon_r = 55.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.2, 10.2, 10.2); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

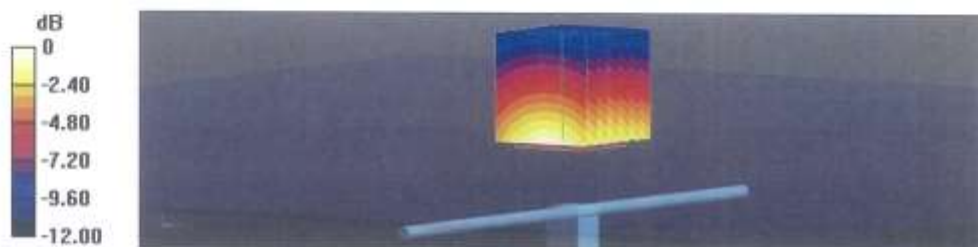
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 59.66 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 3.57 W/kg

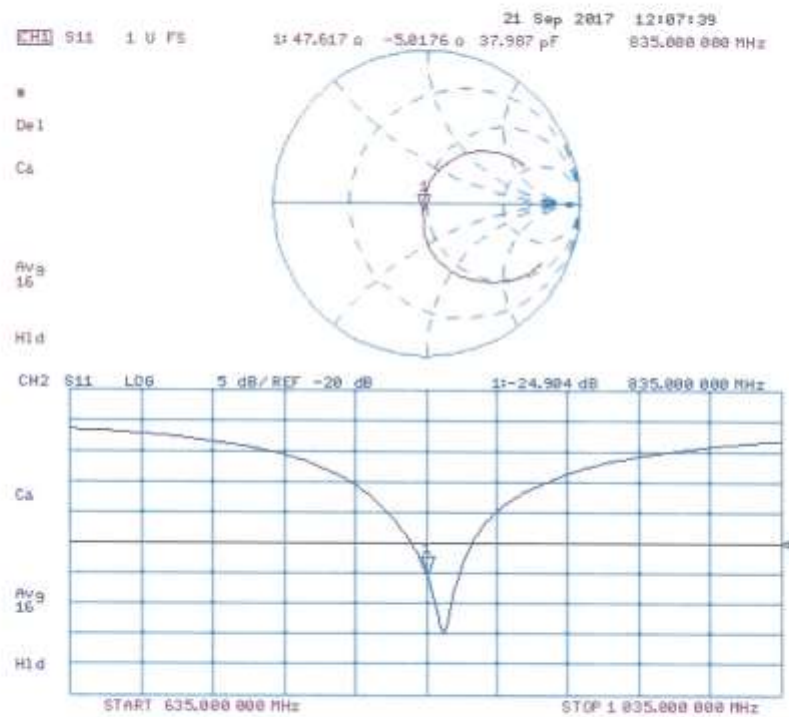
SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.55 W/kg

Maximum value of SAR (measured) = 3.12 W/kg



0 dB = 3.12 W/kg = 4.94 dBW/kg

Impedance Measurement Plot for Body TSL



**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

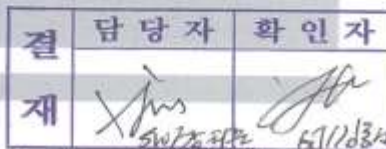
Certificate No: **D1900V2-5d061_Mar18**

CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d061**

Calibration procedure(s) **QA CAL-05.v10
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **March 15, 2018**



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 NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	25-Oct-17 (No. DAE4-601_Oct17)	Oct-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Claudio Leubler** Name: Claudio Leubler Function: Laboratory Technician

Approved by: **Katja Pokovic** Name: Katja Pokovic Function: Technical Manager

Issued: March 15, 2018

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

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

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:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY4/5 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 dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. 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	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	40.5 $\pm$ 6 %	1.37 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.88 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.0 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	55.2 $\pm$ 6 %	1.47 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.64 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.6 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$51.4 \Omega + 8.2 j\Omega$
Return Loss	- 24.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$47.7 \Omega + 4.9 j\Omega$
Return Loss	- 25.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.194 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
Manufactured on	December 10, 2004

DASY5 Validation Report for Head TSL

Date: 15.03.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d061

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.37$ S/m; $\epsilon_r = 40.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.18, 8.18, 8.18); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

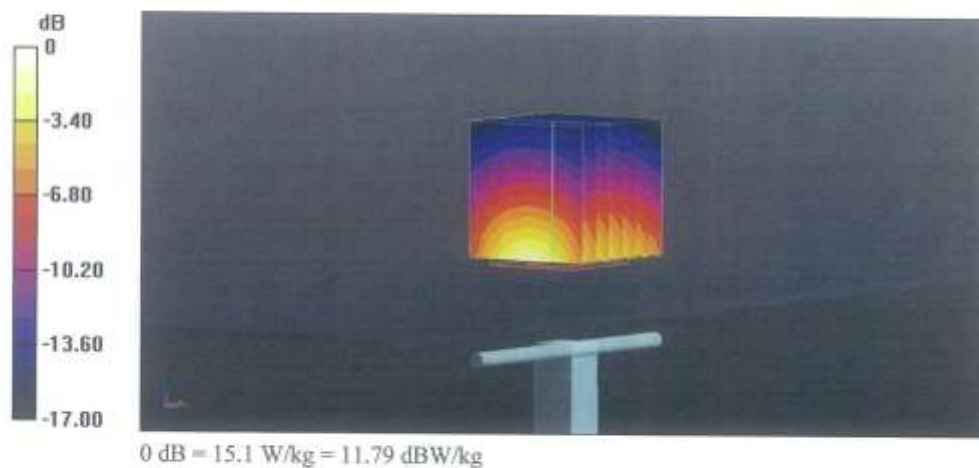
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.8 V/m; Power Drift = -0.09 dB

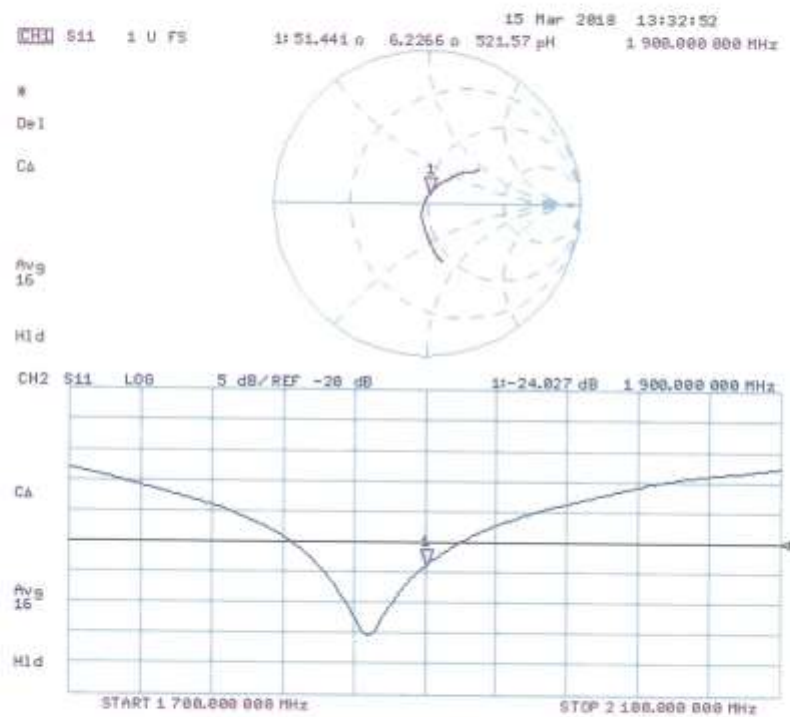
Peak SAR (extrapolated) = 18.3 W/kg

SAR(1 g) = 9.88 W/kg; SAR(10 g) = 5.19 W/kg

Maximum value of SAR (measured) = 15.1 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 15.03.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d061

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.47$ S/m; $\epsilon_r = 55.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.15, 8.15, 8.15); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

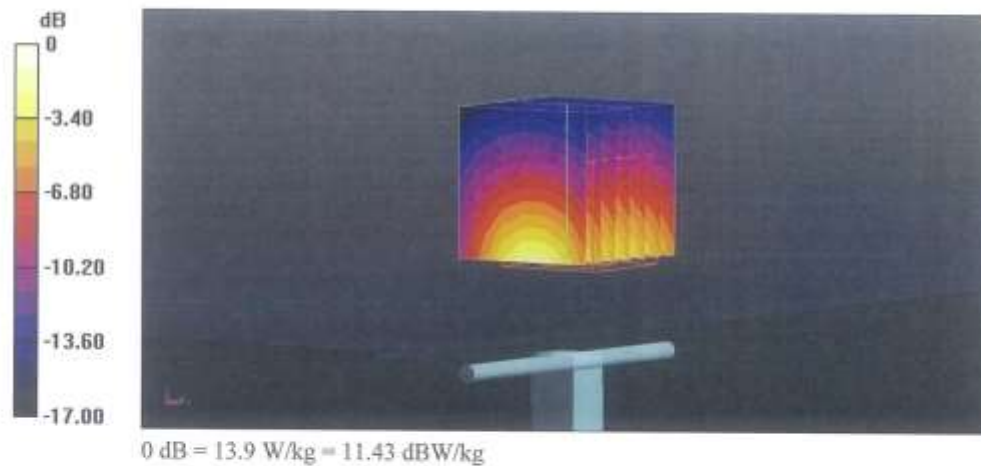
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.9 V/m; Power Drift = -0.04 dB

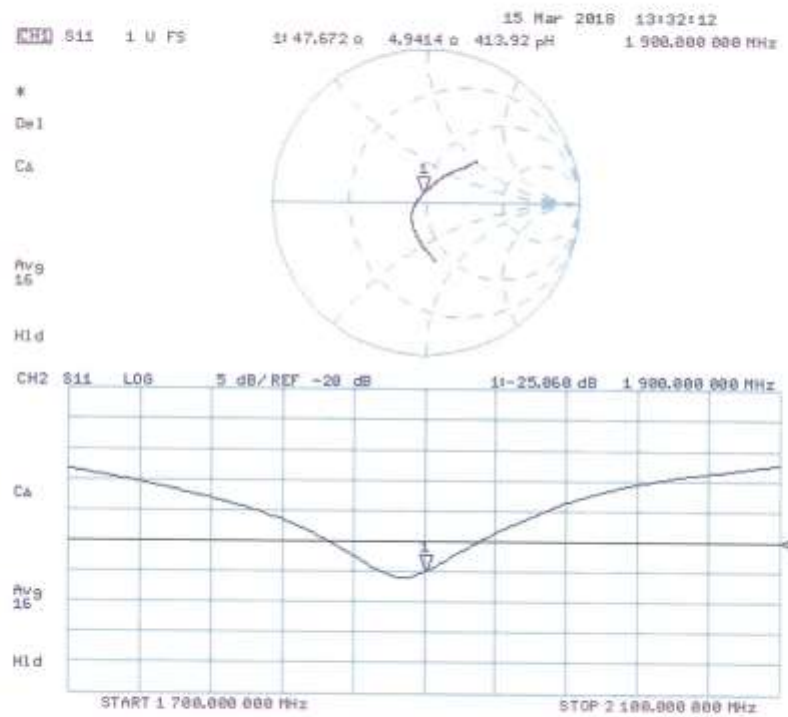
Peak SAR (extrapolated) = 17.1 W/kg

SAR(1 g) = 9.64 W/kg; SAR(10 g) = 5.14 W/kg

Maximum value of SAR (measured) = 13.9 W/kg



Impedance Measurement Plot for Body TSL



**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2450V2-965_Feb18**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:965**

Calibration procedure(s) **QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **February 16, 2018**

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 NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292785	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: February 19, 2018

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

Certificate No: D2450V2-965_Feb18

Page 1 of 8

결 재	담당자	확인자
직위/성명	6N / 김진	6J / 김준희
일 자	2018 / 02.06	2018 / 02.06

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

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:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY4/5 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 dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. 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	DASY5	V52.10.0
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 $\pm$ 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 $\pm$ 0.2) °C	37.9 $\pm$ 6 %	1.87 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (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	51.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.9 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.4 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.2 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.98 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.6 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	$54.9 \Omega + 4.2 j\Omega$
Return Loss	- 24.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$50.9 \Omega + 6.3 j\Omega$
Return Loss	- 24.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.163 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
Manufactured on	November 19, 2014

DASY5 Validation Report for Head TSL

Date: 16.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.87$ S/m; $\epsilon_r = 37.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.88, 7.88, 7.88); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

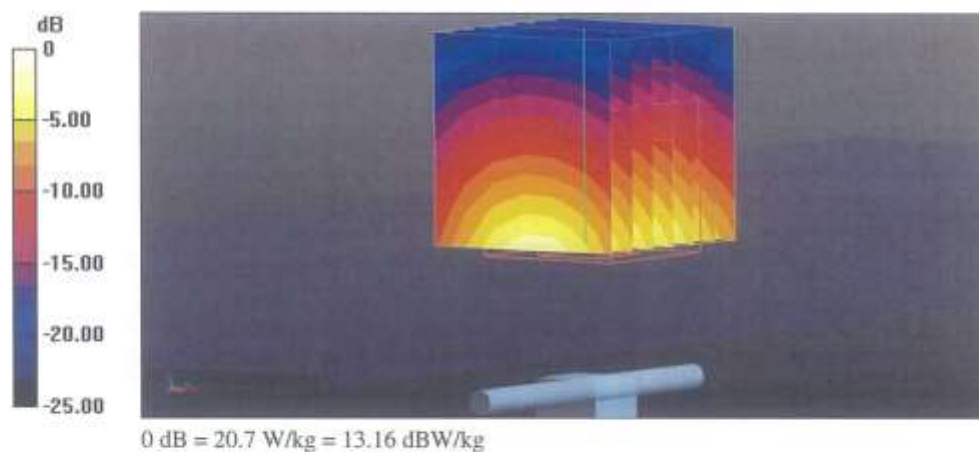
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.7 V/m; Power Drift = -0.05 dB

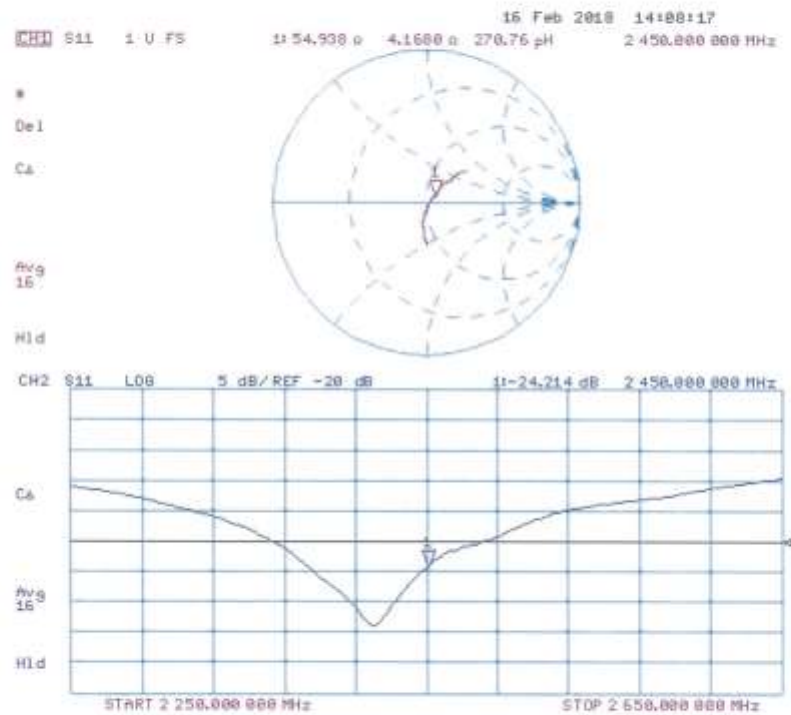
Peak SAR (extrapolated) = 26.2 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.07 W/kg

Maximum value of SAR (measured) = 20.7 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 16.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 51.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.01, 8.01, 8.01); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

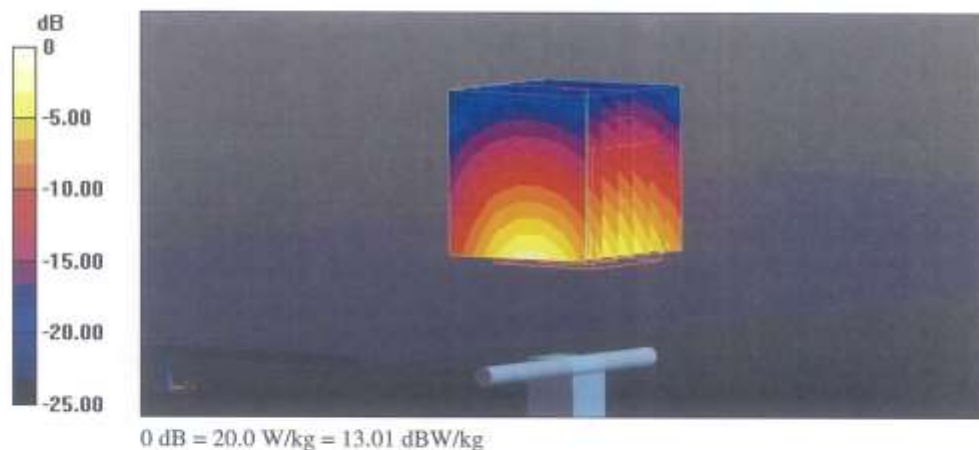
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.7 V/m; Power Drift = -0.03 dB

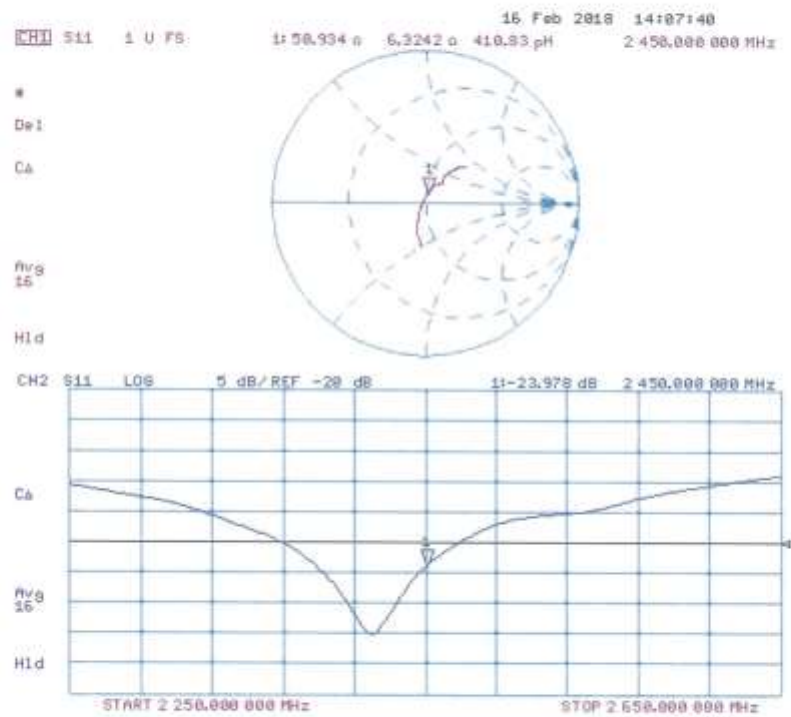
Peak SAR (extrapolated) = 25.8 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 5.98 W/kg

Maximum value of SAR (measured) = 20.0 W/kg



Impedance Measurement Plot for Body TSL



**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

Client **Dymstec**

Certificate No: **OCP-DAKS-1031_Apr18**

CALIBRATION CERTIFICATE

Object **DAKS-3.5 - SN: 1031**

Calibration procedure(s) **QA CAL-33.v2
Calibration of dielectric parameter probes**

Calibration date: **April 17, 2018**

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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
OCP DAK-3.5 (weighted)	SN: 1249	10-Oct-17 (OCP-DAK3.5-1249_Oct17)	Oct-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Rohde & Schwarz ZVA50	T0170	6-Jun-17 (in house check Jun-17)	Jun-18
Digital Thermometer DTM3000	2148	19-May-17 (DTM-2148_May17)	May-18
Methanol 99.9% Type 34860	STBH4051	04-Apr-18 (bottle opened, check Apr-18)	Apr-19
Head Liquid, HBBL U16	170714-1	25-Jul-17 (in house check Jul-17)	Jul-18
0.1 mol/L NaCl solution Type 35275	SZBF3280V	20-Apr-17 (in house check Apr-17)	Apr-18
0.05 mol/L NaCl solution	160413-1	20-Apr-17 (in house check Apr-17)	Apr-18
Head Gel, SL AGH U08 AB-B	150430	20-Apr-17 (in house check Apr-17)	Apr-18
Solid Substrate	AK9	20-Apr-17 (in house check Apr-17)	Apr-18

Calibrated by: **Name: Michael Weber**
Function: Laboratory Technician

Signature



Approved by: **Katja Pokovic**
Technical Manager



Issued: April 19, 2018

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

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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

Accreditation No.: **SCS 0108**

References

- [1] IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- [2] IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- [3] IEC 62209-2 Ed.1, "Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices – Human models, Instrumentation, and Procedures Part 2: Procedure to determine the specific absorption rate (SAR) for mobile wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- [4] A. P. Gregory and R. N. Clarke, "NPL Report MAT 23", January 2012
- [5] Tables of the Complex Permittivity of Dielectric Reference Liquids at Frequencies up to 5 GHz
- [6] DAK Professional Handbook, SPEAG, February 2018
- [7] A. Toropainen et al, "Method for accurate measurement of complex permittivity of tissue equivalent liquids", Electronics Letters 36 (1) 2000 pp32-34
- [8] J. Hilland, "Simple sensor system for measuring the dielectric properties of saline solutions", Meas. Sci. Technol. 8 pp901–910 (1997)
- [9] K. Nörtemann, J. Hilland and U. Kaatz, "Dielectric Properties of Aqueous NaCl Solutions at Microwave Frequencies", J. Phys. Chem. A 101 pp6864-6869 (1997)
- [9] R. Buchner, G. T. Hefter and Peter M. May, "Dielectric Relaxation of Aqueous NaCl Solutions", J. Phys. Chem. A 103 (1) (1999)

Description of the dielectric probe

Dielectric probes are used to measure the dielectric parameters of tissue simulating media in a wide frequency range. The complex permittivity $\epsilon_r = (\epsilon'/\epsilon_0) - j(\epsilon''/\epsilon_0)$ is determined from the S parameters measured with a vector network analyzer (VNA) with software specific to the probe type. The parameters of interest e.g. in standards [1, 2, 3] and for other applications are presented are calculated as follows:

(Relative) permittivity ϵ' (real part of $\epsilon_r = (\epsilon'/\epsilon_0) - j(\epsilon''/\epsilon_0)$ where $\epsilon_0 = 8.854 \text{ pF/m}$ is the permittivity in free space)

Conductivity $\sigma = 2 \pi f \epsilon'' \epsilon_0$,

Loss Tangent = (ϵ''/ϵ')

The **OCP** (open ended coaxial) is a cut off section of 50 Ohm transmission line, similar to the system described in [1, 2, 3, 5], used for contact measurement. The material is measured either by touching the probe to the surface of a solid/gelly or by immersing it into a liquid media. The electromagnetic fields at the probe end fringe into the material to be measured, and its parameters are determined from the change of the S_{11} parameters. With larger diameter of the dielectrics, the probe can be used down to lower frequencies.

The flange surrounding the active area shapes the near field similar to a semi-infinite geometry and is inserted fully into the measured lossy liquid.

The probe is connected with a phase and amplitude stable cable to a VNA which is then calibrated with Open, Short and a Liquid with well-known parameters. All parts in the setup influencing the amplitude and phase of the signal are important and shall remain stable.

Handling of the item

Before usage, the active probe area has to be cleaned from any material residuals potentially contaminating the reference standards. The metal and dielectric surface must be protected to keep the precision of the critical mechanical dimensions. The connector and cable quality are critical; any movements between calibration and measurement shall be avoided. The temperature must be stable and must not differ from the material temperature.

Methods Applied and Interpretation of Parameters

The calibration of the dielectric probe system is done in the steps described below for the desired frequency range and calibration package (SAR/MRI liquids, Semi-solid/solid material). Because the standard calibration in step 3 is critical for the results in steps 4 to 8, the sequence 3 to 8 is repeated 3 times. As a result, the result from these 3 sets is represented.

1. Configuration and mechanical / optical status.
2. Measurement resolution is 5 MHz from 10 to 300 MHz, 50 MHz from 300 to 6000 MHz and 250 MHz from 6 to 20 GHz.
3. Standard calibration uses Air / Short / Liquid. 1 liter liquid quantity is used to reduce the influence the reflections. The liquid type is selected depending on the lowest frequency and probe diameter:
DAK-1.2, DAK-3.5, Agilent OCP: de-ionized water (approx. 22 °C)
DAK-12: saline solution with static conductivity 1 S/m (approx. 22 °C)
NPL OCP: pure ethanol (approx. 22 °C)
4. The cable used in the setup stays in a fixed position, i.e. the probe is fixed and measuring from the top in an angle of typ. 20° from the vertical axis. For DAK and Agilent probes, the refresh function (air standard) is used previous to the individual measurements in order to compensate for possible deviations from cable movements. After insertion of the probe into a liquid, the possible air bubbles are removed from the active surface.
5. Measurement of multiple shorts if not already available from the calibration in the previous step (NPL). Evaluation of the deviation from the previous calibration short with graphical representation of the complex quantities and magnitude over the frequency range. Probe specific short is used. This assessment shows ability to define a short circuit at the end of the probe for the VNA calibration in the setup which is essential at high frequencies and depends on the probe surface quality.
6. Measurement of validation liquids in a quantity of 1 liter at well defined temperature. Evaluation of the deviations from the target. The targets base on traceable data from reference sources. The deviation of the measurement is graphically presented for permittivity and conductivity (for lossy liquids) or loss tangent (for low losses at low frequencies).
7. Measurement of lossy liquids in a quantity of 1 liter at well defined temperature. Head tissue simulating liquid or saline solution with 0.5 S/m static conductivity are representative. The target data base on traceable data from reference sources or from multiple measurements with precision reference probes or different evaluations such as transmission line or slotted line methods. Evaluation of the deviation from the target and graphical representation for permittivity and conductivity over the frequency range
8. Semi-solid / solid material calibration:
Measurements of an elastic lossy broadband semi-solid gel with parameters close to the head tissue target. Measurements of a planar very low loss solid microwave-substrate. The average of 4 measurements of the same sample at different location is shown as a single result. The deviation of the permittivity and conductivity from the reference data is evaluated.
Measurements of a planar very low loss solid microwave-substrate. The average of 4 measurements of the same sample at different location is shown as a single result. The relative deviation of the permittivity and the absolute deviation of the loss tangent is evaluated.
The targets base on multiple measurements (on the same material batch at identical temperature) on convex and planar surfaces with precision reference OCP.

- The measurement on semi-solid / solid materials is sensitive to the quality and planarity of the probe contact area, such as air gaps due to imperfect probes (resulting lower permittivity values).
9. Table for the probe uncertainty: The uncertainty of the probe depending on probe type, size, material parameter range and frequency is given in a table. It represents the best measurement capability of the specific probe but does not include the material (deviation from the target values).
 10. Appendix with detailed results of all measurements with the uncertainties for the specific measurement. In addition to the probe uncertainty (see above), it includes the uncertainty of the reference material used for the measurement. A set of results from independent calibrations represents the capability of the setup and the lossy materials used, including the precision of the measured material and the influence of temperature deviations. Temperature and operator influence was minimized and gives a good indication of the achievable repeatability of a measurement.
 11. Summary assessment of the measured deviations and detailed comments if not typical for the probe type.

Dielectric probe identification and configuration data

Item description

Probe type	OCP Open-ended coaxial probe
Probe name	SPEAG Dielectric Assessment Kit DAK-3.5
Type No	SM DAK 520 AA
Serial No	0010
Description	Open-ended coaxial probe with flange Flange diameter: 19.0 mm Dielectric diameter: 3.5 mm Material: stainless steel
Connector 1	N pos.
Software version	DAK Measurement Solver 2.4.0.814 Calibration Type: Air / short / water (set to measured water temp.) Probe type: "DAK3.5" (software setting)
Further settings	VNA bandwidth setting: 50 Hz

SCS 0108 Accessories used for customer probe calibration

Cable	Huber & Suhner Sucoflex 404, SN: 4361, length 1 m, PC3.5 neg. – PC3.5 neg.
Short	DAK-3.5 shorting block, type SM DAK 200 BA Contact area covered with cleaned Cu stripe

Additional items used during measurements

Adapter 1	PC3.5 pos. – PC2.4 (VNA side)
Adapter 2	PC3.5 pos. – PC3.5 neg. (probe side)
Adapter 3	N neg. – PC3.5 neg. (probe side, between probe and cable)

Notes

- Before the calibration, the connectors of the probe and cable were inspected and cleaned.
- Probe visual inspection: according to requirements
- Short inspection: according to the requirements

Probe Uncertainty

The following tables provide material and frequency specific uncertainties (k=2) for the dielectric probe. The values in the tables represent the measurement capability for the probe when measuring a material in the indicated parameter range. They include all uncertainties of

- probe system
- possible systematic errors due to the design
- calibration
- temperature differences during the calibration and measurements, as described,
- VNA noise

Apart from the material used for the calibration (de-ionized water), material uncertainties of the reference materials used during the measurement in Appendix A are not included in these tables.

DAK-3.5				
Permittivity range		Frequency range	(sigma / LT range)	Unc. (k=2)
1 – 15		10 MHz - 20 MHz		---
		20 MHz - 200 MHz		---
		200 MHz - 3 GHz	LT < 0.1	2.4%
		3 GHz - 6 GHz	LT < 0.1	2.0%
		6 GHz - 20 GHz	LT < 0.1	2.1%
10 – 40		10 MHz - 20 MHz		---
		20 MHz - 200 MHz		---
		200 MHz - 3 GHz	sigma : 1 – 10 S/m	1.9%
		3 GHz - 6 GHz	sigma : 1 – 10 S/m	2.3%
		6 GHz - 20 GHz	sigma > 10 S/m	3.5%
35 – 100		10 MHz - 20 MHz		---
		20 MHz - 200 MHz		---
		200 MHz - 3 GHz	sigma : 1 – 10 S/m	1.8%
		3 GHz - 6 GHz	sigma : 1 – 10 S/m	1.9%
		6 GHz - 20 GHz	sigma > 10 S/m	2.4%
Conductivity range (S/m)		Frequency range	(epsilon / LT range)	Unc. (k=2)
1 – 10		10 MHz - 20 MHz		---
		20 MHz - 200 MHz		---
		200 MHz - 3 GHz	eps : 35 - 100	2.7%
		3 GHz - 6 GHz	eps : 35 - 100	3.0%
		6 GHz - 20 GHz	eps : 10 - 40	3.0%
Loss tangent range		Frequency range	(epsilon / LT range)	Unc. (k=2)
< 0.1		10 MHz - 20 MHz		---
		20 MHz - 200 MHz		---
		200 MHz - 3 GHz	eps : 1 - 15	0.03
		3 GHz - 6 GHz	eps : 1 - 15	0.03
		6 GHz - 20 GHz	eps : 1 - 15	0.03

Calibration Results

Uncertainty limits ($k=2$) for the material measurements in the figures of Appendix A are represented with red dashed lines. These uncertainties contain - in addition to probe uncertainty - the uncertainty of the material target parameter determination.

The measurements show the results obtained from independent calibrations for the same material. The differences between the individual measurement curves give therefore an indication for the obtainable repeatability and shall lie within the uncertainties stated in the tables.

Materials for DAK-3.5 calibration:

Appendix A with curves for Methanol, HSL, and 0.05 mol/L NaCl solution (200 MHz - 6 GHz, optional 14 GHz), HS gel and low loss solid substrate are optional.

Appendix A: Detailed Results (additional assessments outside the scope of SCS0108)**A.1 Probe appearance and calibration sequence****A.1.1 Appearance**

The OCP appearance is fully according to the expectations:

- the flange surface is intact

A.1.2 Calibration sequence

The following sequence was repeated 3 times in the low frequency range from 200 – 300 MHz in 5 MHz steps and in the high frequency range from 300 to 6000 MHz in 50 MHz steps, and from 6 GHz to 14 GHz in 250 MHz steps.

- Air
- Short 1 short, then immediate verification with a second short (with eventual repetition)
- Water De-ionized water, temperature measured and set in the software (for DAK-12 0.1 mol/L saline solution, temperature measured and set in the software)
- Methanol Pure methanol, temperature measured and set in the software
- Liquids Measurement of further liquids (e.g. Head tissue simulating liquid and 0.05 mol/l saline)
- Cleaning Probe washed with water and isopropanol at the end of the sequence.
- Shorts 4 additional separate short measurements to determine the deviation from the original
- Refresh Refresh with Air
- Solid 4 separate solid low loss planar substrate measurements to determine one average (optional)
- Semisolid 4 separate head gel measurements on fresh intact surface to determine one average (optional)
- Cleaning Probe washed with water and isopropanol at the end of the sequence

Evaluation of the additional shorts from the calibrated (ideal) short point at the left edge of the Smith Chart, represented as magnitude over the frequency range (fig. 2.1.x) and in polar representation (fig. 2.2.x).

Evaluation of the Liquid measurements and representation of the permittivity and conductivity deviation from their reference data at the measurement temperature. The results of each of the 3 calibrations is shown in the appendix for each material (fig. 3ff) in black, red, blue. The red dashed line shows the uncertainty of the reference material parameter determination.

Evaluation of the Semisolid measurements (optional) by representing the 3 average deviations (each resulting from the 4 separate measurements per set), equivalent to the liquid measurement. Representation of the permittivity and conductivity deviation from their reference data at the nominal temperature.

Evaluation of the Solid measurements (optional) by representing the 3 average deviations (each resulting from the 4 separate measurements per set), equivalent to the liquid measurement. Representation of the permittivity deviation from their reference data and the loss tangent at the nominal temperature.

A.2 Short residual magnitudes

After each of the 3 calibrations with a single short (as per the DAK software), 4 additional separate, short measurements were performed after the liquid measurements and evaluated from the S11 data. The residuals in the graphs represent the deviation from the ideal short point on the polar representation on the VNA screen.

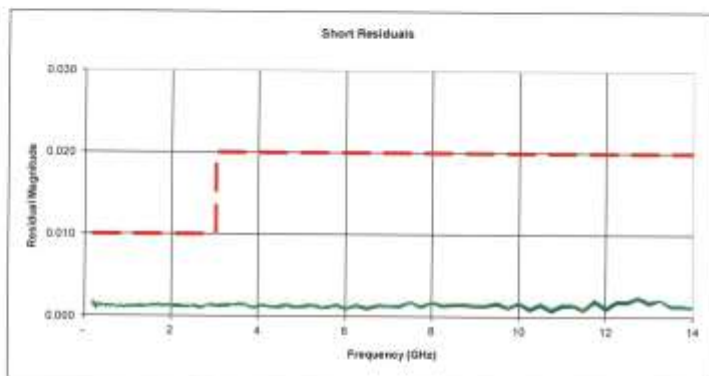


Fig. 2.1a Magnitude of the residual of the shorts, 200 MHz – 14 GHz, after calibration a)

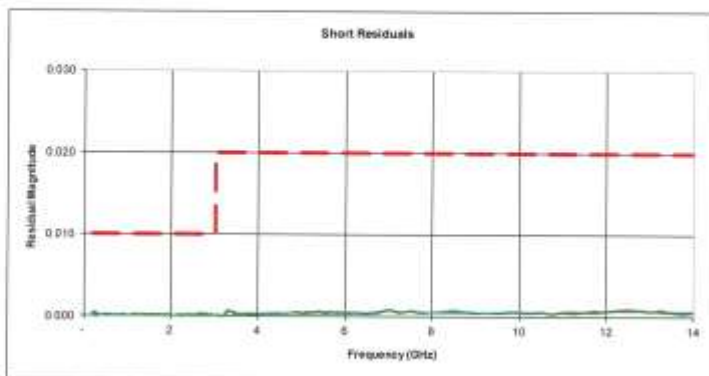


Fig. 2.1b Magnitude of the residual of the shorts, 200 MHz – 14 GHz, after calibration b)

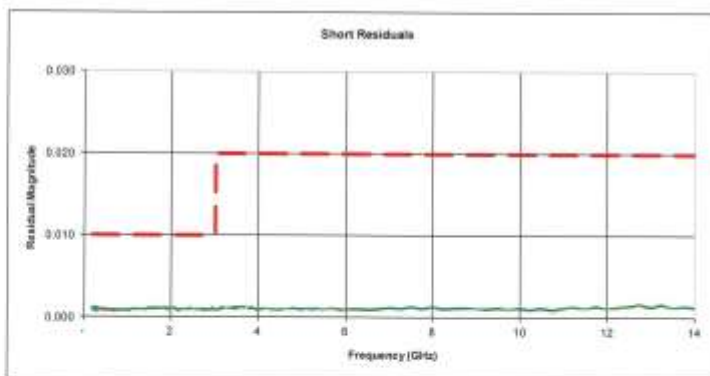


Fig. 2.1c Magnitude of the residual of the shorts, 200 MHz – 14 GHz, after calibration c)

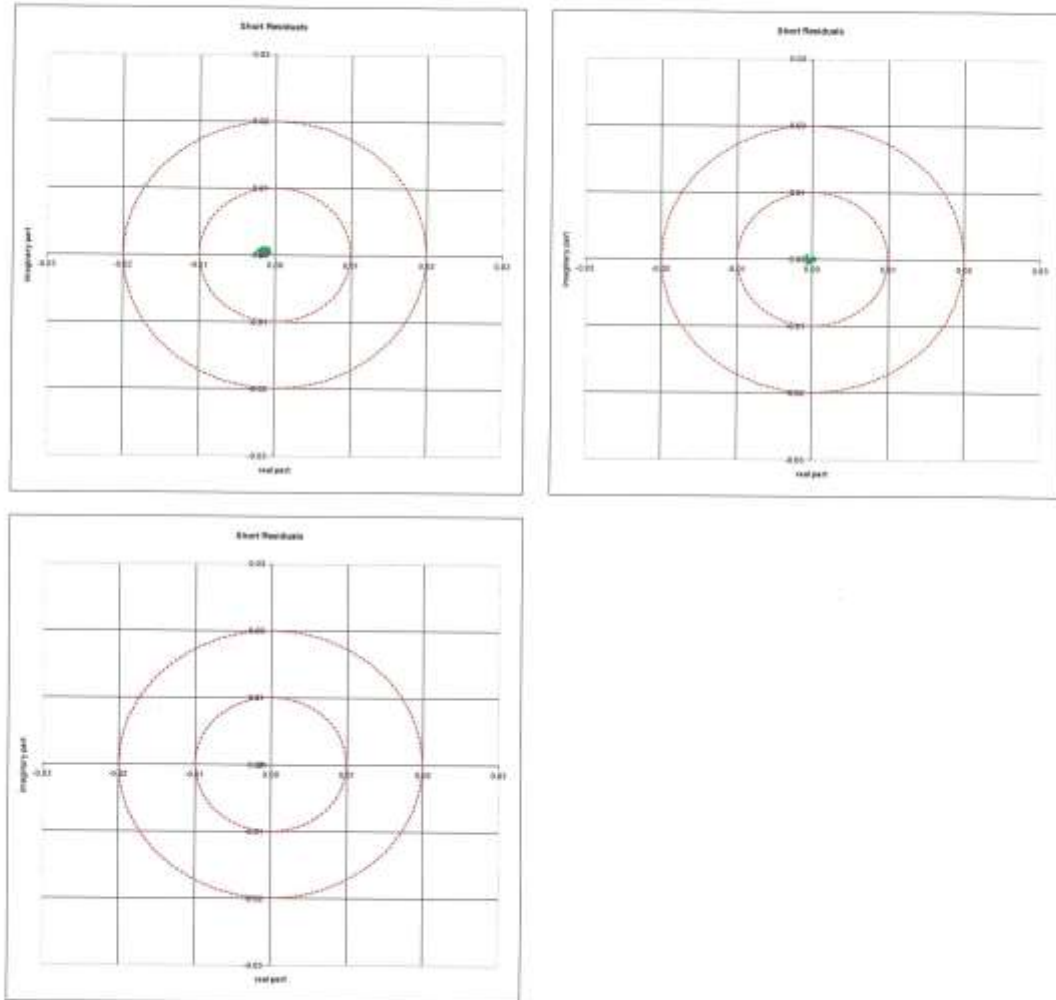


Fig. 2.2a-c Complex representation of the residuals of the shorts, 200 MHz - 14 GHz, after calibrations a)-b) in the top and c) in the bottom

All shorts have good quality. Some minor deviations might be visible from contact quality (left - right).

A.3 Methanol

Methanol (99.9% pure) was measured at a temperature of 22 ± 2 °C. The liquid temperature was stabilized within 0.05 °C of the desired temperature. Deviations are presented relative to the nominal material parameters at this temperature, calculated from NPL data for this temperature. For the measurements the Noise Filter was activated in the software.

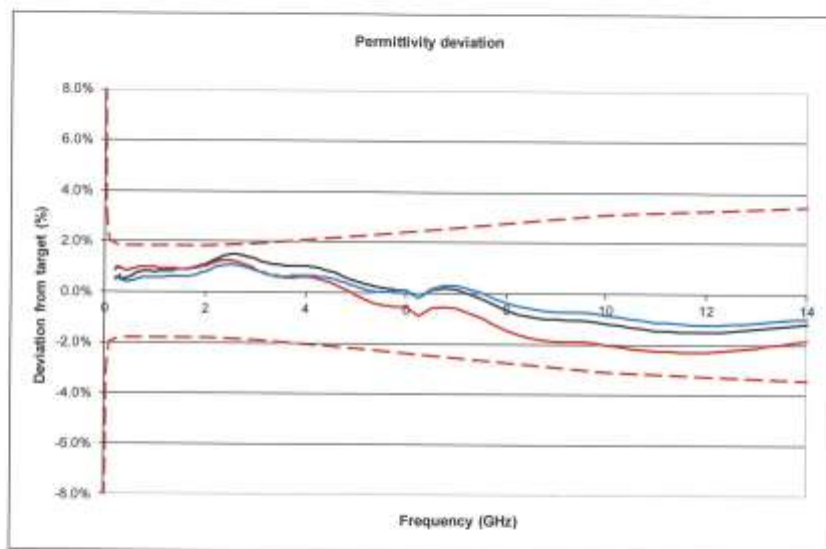


Fig. 3.1 Methanol permittivity deviation from target, 200 MHz – 14 GHz

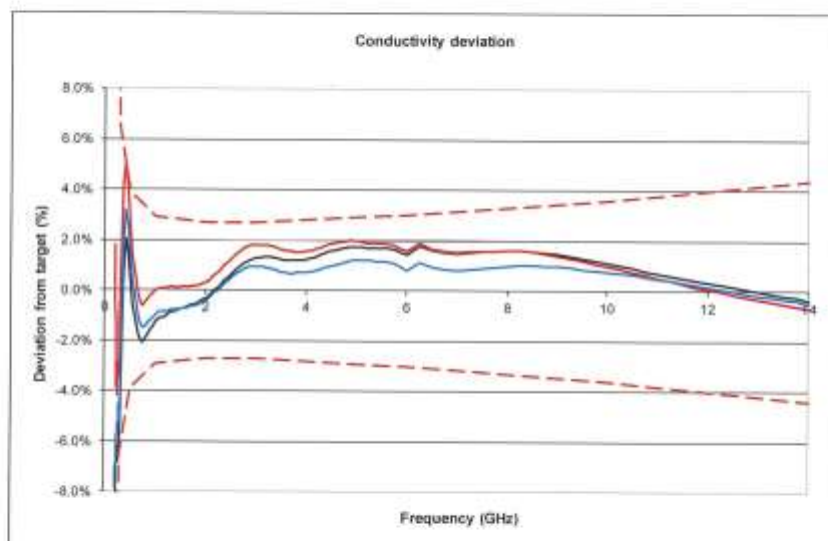


Fig. 3.2 Methanol conductivity deviation from target, 200 MHz – 20 GHz

Note: Conductivity error can be high at low frequencies due to the low absolute conductivity values.

A.4 Head Tissue

Broadband head simulating liquid was measured at a temperature of 22 ± 2 °C. The liquid temperature was stabilized within 0.05 °C of the desired temperature. Deviations are presented relative to the reference data for this material. Those parameters have been evaluated from multiple measurements on the used bath with precision reference OCP and further methods. For the measurements the Noise Filter was activated in the software.

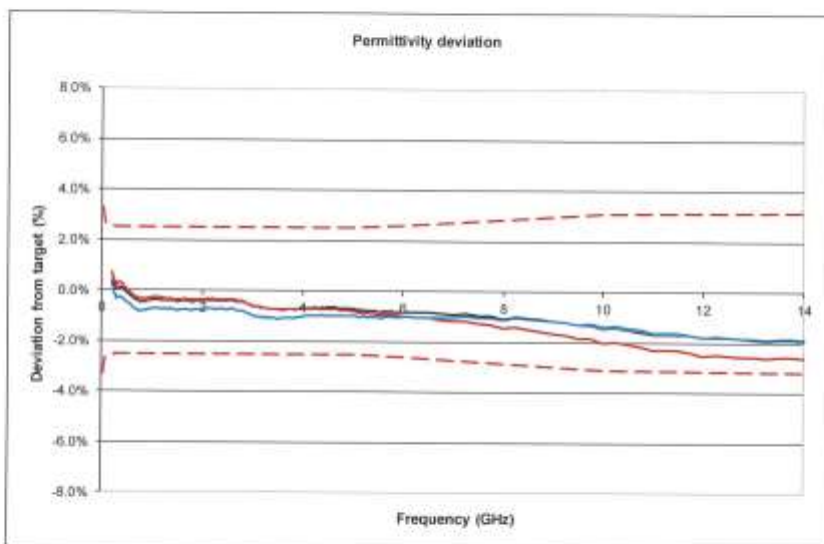


Fig. 4.1 HSL permittivity deviation from target, 200 MHz – 14 GHz

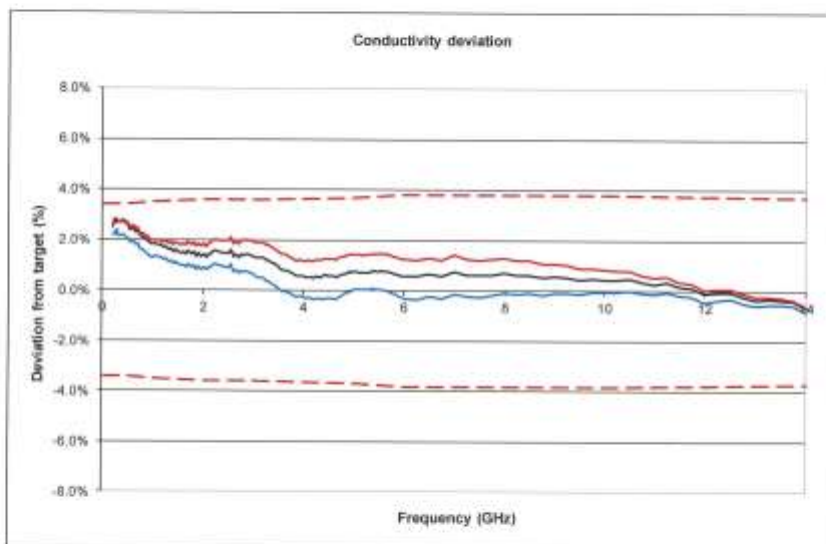


Fig. 4.2 HSL conductivity deviation from target, 200 MHz – 14 GHz

A.5 0.05 mol/L NaCl solution

0.05 mol/L NaCl / water solution has a static conductivity of 0.5 S/m, similar to MRI HCL (High Conductivity Liquid). It was measured at a temperature of 22 +/- 2 °C. The liquid temperature was stabilized within 0.05 °C of the desired temperature. Deviations are presented relative to the reference data for this material. These parameters have been derived from the theoretical model according to [7], matched to the measurements from reference probes and other sources. A quantity of 1 liter was used for the measurement. For the measurements the Noise Filter was activated in the software.

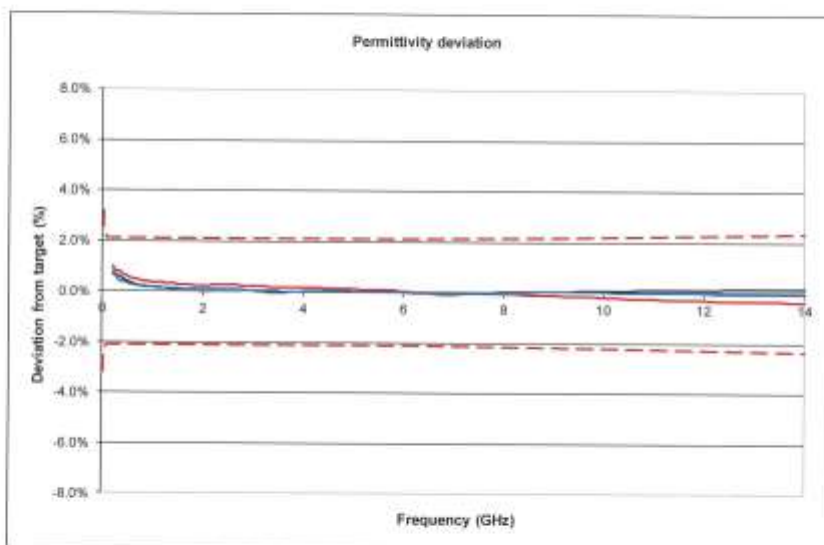


Fig. 5.1 0.05 mol/L solution permittivity deviation from target, 200 MHz – 14 GHz

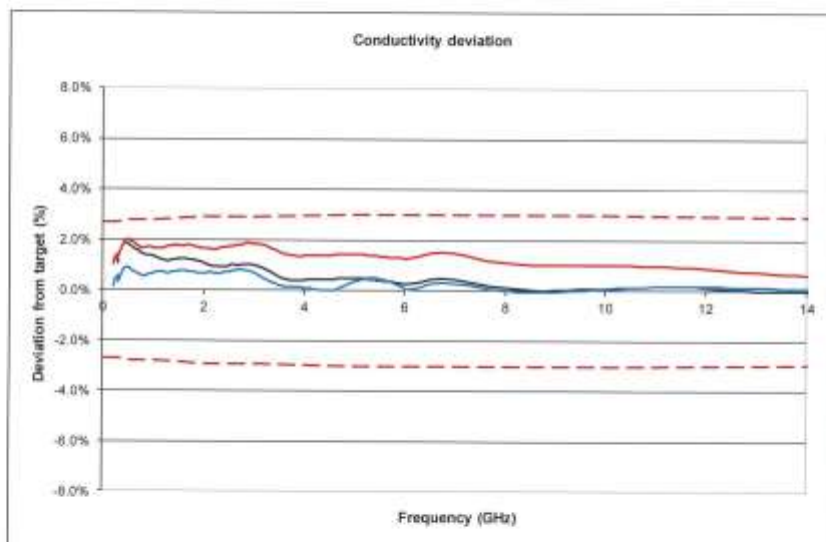


Fig. 5.2 0.05 mol/L solution conductivity deviation from target, 200 MHz – 14 GHz

Appendix B: Nominal parameters of reference materials used for calibration (additional assessments outside the scope of SCS0108)

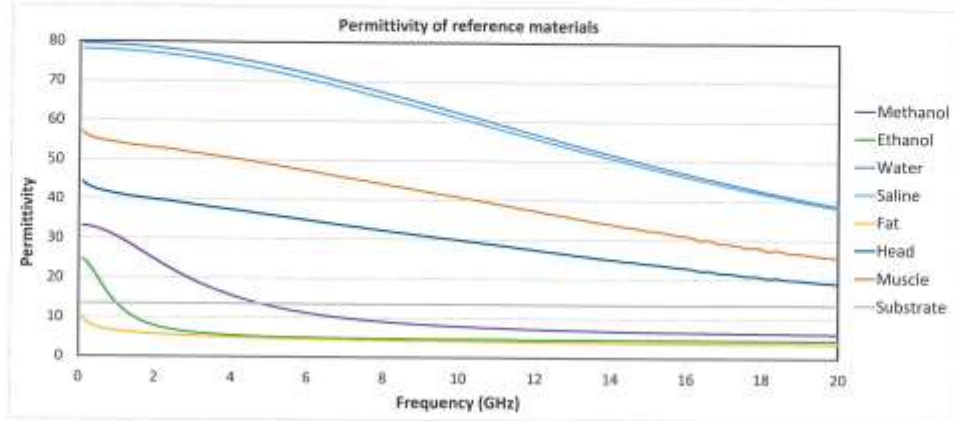


Fig. B.1 Permittivity of reference materials

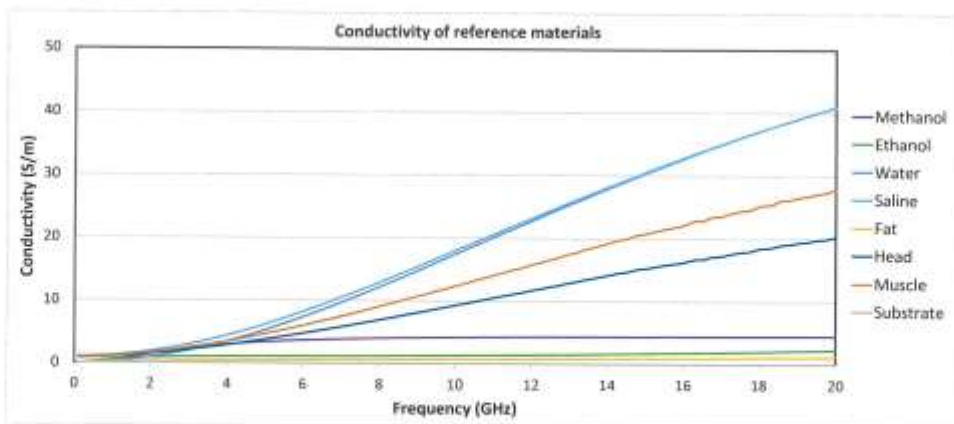


Fig. B.2 Conductivity of reference materials

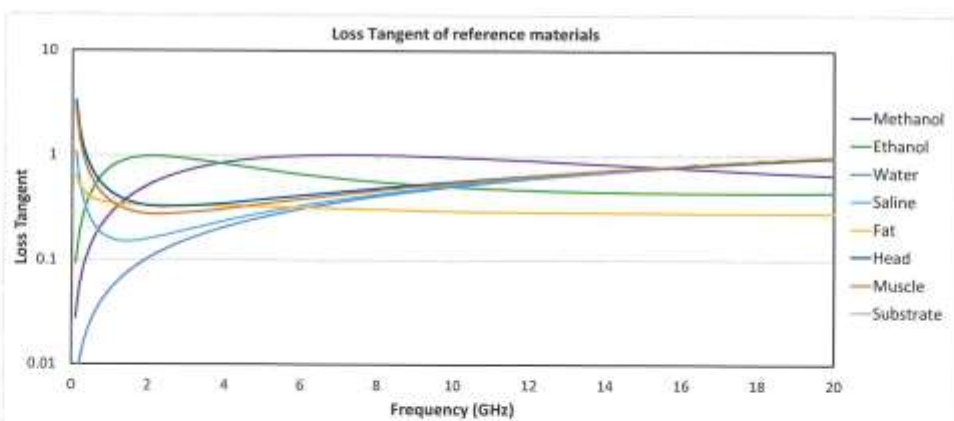


Fig. B.3 Loss tangent of reference materials