

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) CDD - 5GHz ANTlower	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	14.00	12.50	14.00	12.50				
		40	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		44	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		48	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		52	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		56	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		60	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		64	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		100	7.00	5.50	10.00	8.50	12.75	11.25	12.75	11.25				
		104	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		108	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		112	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		116	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		120	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		124	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		128	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		132	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		136	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		140	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
	144	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00					
	149	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00					
	153	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00					
	157	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00					
	161	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00					
	165	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00					
	40 MHz Bandwidth	38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		46	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50		
		54	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		118	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		126	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		134	7.00	5.50	10.00	8.50	13.00	11.50	13.75	12.25	13.75	12.25		
		142	7.00	5.50	10.00	8.50	13.00	11.50	10.50	9.00	15.50	14.00		
		151	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00		
		159	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00		
		80 MHz Bandwidth	42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50
	58		8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
	106		7.00	5.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
	122		7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00	15.50	14.00
	138		7.00	5.50	10.00	8.50	13.00	11.50	10.50	9.00	13.75	12.25	15.50	14.00
	155		14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50

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Mode/ Band		Tones	26T		52T		106T		242T		484T		996T		
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	
Modulated Average - 2 Tx Chain (dBm) SDM - 5GHz ANTlower	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	14.00	12.50	14.00	12.50					
		40	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50					
		44	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50					
		48	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50					
		52	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25					
		56	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25					
		60	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25					
		64	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50					
		100	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25					
		104	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		108	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		112	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		116	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		120	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		124	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		128	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		132	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		136	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
		140	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00					
		144	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00					
	149	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00						
	153	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00						
	157	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00						
	161	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00						
	165	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00						
	40 MHz Bandwidth	38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00			
		46	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50			
		54	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25			
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75			
		102	8.00	6.50	11.00	9.50	10.50	9.00	10.50	9.00	10.50	9.00			
		110	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00			
		118	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00			
		126	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00			
		134	8.00	6.50	11.00	9.50	13.75	12.25	13.75	12.25	13.75	12.25			
		142	8.00	6.50	11.00	9.50	14.00	12.50	10.50	9.00	15.50	14.00			
		151	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00			
		159	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00			
		80 MHz Bandwidth	42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
			58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
	106		8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	
	122		8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00	
	138		8.00	6.50	11.00	9.50	14.00	12.50	10.50	9.00	13.75	12.25	15.50	14.00	
	155		14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	

Note: In MIMO operations, 5GHz ANTlower transmits at maximum allowed powers as indicated above for both 2 Tx CDD and 2 Tx SDM.

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D. 5GHz ANTupper

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm) - 5GHz ANTupper	20 MHz Bandwidth	36	11.00	9.50	14.00	12.50	15.00	13.50	15.00	13.50				
		40	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50				
		44	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50				
		48	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50				
		52	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25				
		56	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25				
		60	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25				
		64	11.00	9.50	14.00	12.50	14.00	12.50	14.00	12.50				
		100	11.00	9.50	14.00	12.50	14.00	12.50	14.00	12.50				
		104	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		108	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		112	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		116	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		120	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		124	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		128	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		132	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		136	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		140	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00				
		144	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00				
		149	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		153	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		157	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		161	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		165	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
	40 MHz Bandwidth	38	11.00	9.50	12.50	11.00	12.50	11.00	12.50	11.00	12.50	11.00		
		46	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50	17.00	15.50		
		54	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25	16.75	15.25		
		62	11.00	9.50	12.50	11.00	12.50	11.00	12.50	11.00	12.50	11.00		
		102	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50		
		110	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00		
		118	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00		
		126	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00		
		134	11.00	9.50	14.00	12.50	15.00	13.50	15.00	13.50	15.00	13.50		
		142	11.00	9.50	14.00	12.50	15.50	14.00	11.50	10.00	15.50	14.00		
		151	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
		159	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
	80 MHz Bandwidth	42	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50
		58	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		106	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50
		122	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00
		138	11.00	9.50	14.00	12.50	15.50	14.00	11.50	10.00	15.00	13.50	15.50	14.00
		155	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00	15.50	14.00

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Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) CDD - 5GHz ANTupper	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	14.00	12.50	14.00	12.50				
		40	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		44	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		48	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		52	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		56	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		60	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		64	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		100	7.00	5.50	10.00	8.50	12.75	11.25	12.75	11.25				
		104	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		108	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		112	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		116	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		120	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		124	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		128	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		132	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		136	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		140	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		144	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00				
		149	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		153	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		157	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		161	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		165	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
	40 MHz Bandwidth	38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50		
		54	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		118	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		126	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00		
		134	7.00	5.50	10.00	8.50	13.00	11.50	13.75	12.25	13.75	12.25		
		142	7.00	5.50	10.00	8.50	13.00	11.50	10.50	9.00	15.50	14.00		
		151	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
		159	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
		42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
	80 MHz Bandwidth	106	7.00	5.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		122	7.00	5.50	10.00	8.50	13.00	11.50	15.50	14.00	15.50	14.00	15.50	14.00
		138	7.00	5.50	10.00	8.50	13.00	11.50	10.50	9.00	10.50	9.00	15.50	14.00
		155	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50

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Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) SDM - 5GHz ANTupper	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	14.00	12.50	14.00	12.50				
		40	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		44	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		48	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50				
		52	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		56	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		60	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25				
		64	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		100	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		104	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		108	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		112	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		116	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		120	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		124	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		128	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		132	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		136	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		140	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		144	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00				
		149	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		153	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		157	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		161	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
		165	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25				
	40 MHz Bandwidth	38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	14.00	12.50	17.00	15.50	17.00	15.50		
		54	8.00	6.50	11.00	9.50	14.00	12.50	16.75	15.25	16.75	15.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	8.00	6.50	11.00	9.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00		
		118	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00		
		126	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00		
		134	8.00	6.50	11.00	9.50	13.75	12.25	13.75	12.25	13.75	12.25		
		142	8.00	6.50	11.00	9.50	14.00	12.50	10.50	9.00	15.50	14.00		
		151	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
		159	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25	15.75	14.25		
	80 MHz Bandwidth	42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		106	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		122	8.00	6.50	11.00	9.50	14.00	12.50	15.50	14.00	15.50	14.00	15.50	14.00
		138	8.00	6.50	11.00	9.50	14.00	12.50	13.75	12.25	13.75	12.25	15.50	14.00
		155	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50	14.00	12.50

Note: In MIMO operations, 5GHz ANTupper transmits at maximum allowed powers as indicated above for both 2 Tx CDD and 2 Tx SDM.

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1.2.2 Reduced 802.11ax RU WLAN Output Power

A. Antenna 2A

Below table is applicable in the following conditions:

- Simultaneous conditions with Licensed Bands Antenna 2A/2B
- Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm) - Antenna 2A	20 MHz Bandwidth	1	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		2	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		3	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		4	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		5	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		6	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		7	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		8	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		9	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		10	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		11	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		12	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Below table is applicable in the following conditions:

- Simultaneous conditions with Licensed Bands Antenna 2A/2B
- Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) - Antenna 2A	20 MHz Bandwidth	1	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		2	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		3	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		4	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		5	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		6	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		7	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		8	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		9	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		10	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		11	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		12	7.00	5.50	7.00	5.50	7.00	5.50	7.00	5.50
		13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: In MIMO operations, Antenna 2A transmits at maximum allowed powers at indicated above.

B. Antenna 4A

Below table is applicable in the following conditions:

- Simultaneous conditions with Licensed Bands Antenna 4A/4B
- Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm) - Antenna 4A	20 MHz Bandwidth	1	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		2	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		3	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		4	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		5	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		6	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		7	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		8	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		9	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		10	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		11	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		12	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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Below table is applicable in the following conditions:

- Simultaneous conditions with Licensed Bands Antenna 4A/4B
- Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) - Antenna 4A	20 MHz Bandwidth	1	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		2	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		3	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		4	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		5	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		6	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		7	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		8	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		9	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		10	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		11	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		12	6.75	5.25	6.75	5.25	6.75	5.25	6.75	5.25
		13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: In MIMO operations, Antenna 4A transmits at maximum allowed powers at indicated above.

C. 5GHz ANTlower

Below table is applicable in the following conditions:

- Simultaneous conditions with Licensed Bands Antenna 2A
- Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm) - 5GHz ANTlower	20 MHz Bandwidth	36	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50				
		40	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50				
		44	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50				
		48	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50				
		52	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25				
		56	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25				
		60	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25				
		64	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25				
		100	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		104	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		108	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		112	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		116	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		120	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		124	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		128	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		132	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		136	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		140	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00				
		144	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00				
		149	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		153	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		157	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		161	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		165	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
	40 MHz Bandwidth	38	11.00	9.50	12.50	11.00	12.50	11.00	12.50	11.00	12.50	11.00	12.00	11.50
		46	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50	13.00	11.50	13.00	11.50
		54	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25	12.75	11.25	12.50	11.00
		62	11.00	9.50	12.50	11.00	12.50	11.00	12.50	11.00	12.50	11.00	12.50	11.00
		102	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		110	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		118	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		126	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		134	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		142	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		151	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		159	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
	80 MHz Bandwidth	42	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50
		58	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		106	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50	11.00	9.50
		122	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		138	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		155	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00

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Below table is applicable in the following conditions:

-Simultaneous conditions with Licensed Bands Antenna 2A

-Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) CDD - 5GHz ANTTower	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		40	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		44	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		48	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		52	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		56	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		60	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		64	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		100	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		104	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		108	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		112	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		116	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		120	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		124	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		128	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		132	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		136	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		140	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		144	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00				
		149	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		153	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		157	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		161	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		165	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
	40 MHz Bandwidth	38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50		
		54	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00		
		118	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00		
		126	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00		
		134	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00		
		142	7.00	5.50	10.00	8.50	11.50	10.00	10.50	9.00	11.50	10.00		
		151	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00		
		159	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00		
	80 MHz Bandwidth	42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		106	7.00	5.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		122	7.00	5.50	10.00	8.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		138	7.00	5.50	10.00	8.50	11.50	10.00	10.50	9.00	11.50	10.00	11.50	10.00
		155	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00

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Below table is applicable in the following conditions:

-Simultaneous conditions with Licensed Bands Antenna 2A

-Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) SDM - 5GHz ANTlower	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		40	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		44	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		48	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50				
		52	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		56	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		60	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		64	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25				
		100	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		104	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		108	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		112	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		116	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		120	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		124	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		128	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		132	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		136	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00				
		140	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		144	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		149	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
	153	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00					
	157	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00					
	40 MHz Bandwidth	161	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		165	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00				
		38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	13.00	11.50	13.00	11.50	13.00	11.50		
		54	8.00	6.50	11.00	9.50	12.75	11.25	12.75	11.25	12.75	11.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	8.00	6.50	11.00	9.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		118	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		126	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
	80 MHz Bandwidth	134	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		142	8.00	6.50	11.00	9.50	11.50	10.00	10.50	9.00	11.50	10.00		
		151	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00		
		159	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00		
		42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	
		106	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	
		122	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	
		138	8.00	6.50	11.00	9.50	11.50	10.00	10.50	9.00	11.50	10.00	11.50	
	155	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50		

Note: In MIMO operations, 5GHz ANTlower transmits at maximum allowed powers as indicated above for both 2 Tx CDD and 2 Tx SDM.

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D. 5GHz ANTupper

Below table is applicable in the following conditions:

-Simultaneous conditions with Licensed Bands Antenna 3

-Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm) - 5GHz ANTupper	20 MHz Bandwidth	36	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50				
		40	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50				
		44	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50				
		48	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50				
		52	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25				
		56	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25				
		60	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25				
		64	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25				
		100	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		104	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		108	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		112	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		116	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		120	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		124	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		128	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		132	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		136	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		140	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00				
		144	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00				
		149	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		153	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		157	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		161	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		165	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
	40 MHz Bandwidth	38	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50		
		46	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50		
		54	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25	11.75	10.25		
		62	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25	11.75	10.25		
		102	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		110	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		118	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		126	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		134	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		142	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		151	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
		159	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
	80 MHz Bandwidth	42	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50	12.00	10.50
		58	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00	11.50	10.00
		106	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	11.00	9.50	10.50	9.00
		122	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		138	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		155	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25

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Below table is applicable in the following conditions:

-Simultaneous conditions with Licensed Bands Antenna 3

-Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) CDD - 5GHz ANTupper	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		40	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		44	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		48	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		52	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		56	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		60	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		64	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		100	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		104	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		108	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		112	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		116	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		120	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		124	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		128	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		132	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		136	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		140	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
		144	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00				
	40 MHz Bandwidth	149	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		153	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		157	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		161	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		165	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50		
		54	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		110	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		118	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		126	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		134	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
	80 MHz Bandwidth	142	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00		
		151	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
		159	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
		42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		106	7.00	5.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		122	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		138	7.00	5.50	10.00	8.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		155	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25

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Below table is applicable in the following conditions:

-Simultaneous conditions with Licensed Bands Antenna 3

-Simultaneous conditions with LTE Inter-band ULCA

Mode/ Band		Tones	26T		52T		106T		242T		484T		996T	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - 2 Tx Chain (dBm) SDM - 5GHz ANTupper	20 MHz Bandwidth	36	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		40	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		44	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		48	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50				
		52	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		56	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		60	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		64	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25				
		100	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		104	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		108	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		112	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		116	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		120	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		124	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		128	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		132	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		136	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		140	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
		144	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00				
	40 MHz Bandwidth	149	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		153	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		157	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		161	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		165	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25				
		38	8.00	6.50	11.00	9.50	11.50	10.00	11.50	10.00	11.50	10.00		
		46	8.00	6.50	11.00	9.50	12.00	10.50	12.00	10.50	12.00	10.50		
		54	8.00	6.50	11.00	9.50	11.75	10.25	11.75	10.25	11.75	10.25		
		62	8.00	6.50	11.00	9.50	11.25	9.75	11.25	9.75	11.25	9.75		
		102	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		110	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		118	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		126	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		134	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		142	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00		
		151	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
		159	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25		
	80 MHz Bandwidth	42	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		58	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		106	8.00	6.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	8.50
		122	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		138	8.00	6.50	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00	10.50	9.00
		155	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25	10.75	9.25

Note: In MIMO operations, 5GHz ANTupper transmits at maximum allowed powers as indicated above for both 2 Tx CDD and 2 Tx SDM.

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1.3 IEEE 802.11ax Measured Powers

Table 1
Maximum 2.4 GHz 802.11ax RU Output Power – Ant 2a

Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)	Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)
2412	1	26T	0	9.61	2412	1	52T	37	10.38
			4	10.15				38	10.42
			8	10.47				40	10.50
2417	2	26T	0	13.06	2417	2	52T	37	13.85
			4	13.65				38	14.00
			8	13.98				40	13.90
2437	6	26T	0	13.70	2437	6	52T	37	13.83
			4	13.56				38	14.00
			8	13.91				40	13.70
2452	9	26T	0	12.32	2452	9	52T	37	13.85
			4	13.99				38	14.00
			8	12.89				40	14.00
2457	10	26T	0	11.50	2457	10	52T	37	11.42
			4	11.01				38	11.49
			8	10.28				40	11.38
2462	11	26T	0	9.95	2462	11	52T	37	10.00
			4	9.98				38	10.00
			8	9.90				40	9.93
2467	12	26T	0	7.91	2467	12	52T	37	8.00
			4	8.00				38	7.87
			8	6.02				40	8.00

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Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)					
2412	1	106T	53	10.30					
			54	10.50					
2417	2	106T	53	13.93					
			54	13.93					
2437	6	106T	53	13.92					
			54	14.00					
2452	9	106T	53	14.00					
			54	13.92					
2457	10	106T	53	11.50					
			54	11.48					
2462	11	106T	53	10.00					
			54	10.00					
2467	12	106T	53	8.00					
			54	7.99					
Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)					
2412	1	242T	61	10.45					
2417	2	242T	61	13.90					
2437	6	242T	61	14.00					
2452	9	242T	61	13.93					
2457	10	242T	61	11.40					
2462	11	242T	61	9.74					
2467	12	242T	61	8.00					

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Table 2
Maximum 2.4 GHz 802.11ax RU Output Power – Ant 4a

Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)	Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)
2412	1	26T	0	12.45	2412	1	52T	37	12.45
			4	12.50				38	12.50
			8	12.40				40	12.44
2417	2	26T	0	13.70	2417	2	52T	37	13.75
			4	13.68				38	13.64
			8	13.75				40	13.75
2437	6	26T	0	13.75	2437	6	52T	37	13.75
			4	13.73				38	13.73
			8	13.75				40	13.45
2452	9	26T	0	13.75	2452	9	52T	37	13.75
			4	13.63				38	13.55
			8	13.75				40	13.75
2457	10	26T	0	13.47	2457	10	52T	37	13.50
			4	13.35				38	13.50
			8	13.41				40	13.47
2462	11	26T	0	12.00	2462	11	52T	37	11.83
			4	11.99				38	11.77
			8	11.96				40	12.00
2467	12	26T	0	9.87	2467	12	52T	37	9.88
			4	10.00				38	10.00
			8	9.96				40	9.60
Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)					
2412	1	106T	53	12.46					
			54	12.48					
2417	2	106T	53	13.68					
			54	13.69					
2437	6	106T	53	13.67	Freq [MHz]	Channel	Tones	RU Index	Avg Conducted Powers (dBm)
			54	13.75					
2452	9	106T	53	13.75	2412	1	242T	61	12.49
			54	13.63	2417	2	242T	61	13.75
2457	10	106T	53	13.50	2437	6	242T	61	13.75
			54	13.46	2452	9	242T	61	13.64
2462	11	106T	53	12.00	2457	10	242T	61	13.21
			54	12.00	2462	11	242T	61	12.00
2467	12	106T	53	10.00	2462	11	242T	61	12.00
			54	9.92	2467	12	242T	61	9.95

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Table 3
Maximum 5 GHz 802.11ax RU Output Power – 5GHz ANTlower

20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					0	4	8						37	39	40
	1	5180	36	26T	10.15	10.74	10.91		1	5180	36	52T	13.28	13.99	13.99
5200		40	26T	10.04	10.74	10.87	5200	40		52T	13.45	14.00	14.00		
5240		48	26T	10.06	10.68	10.83	5240	48		52T	13.25	13.97	13.91		
2A	5260	52	26T	10.08	10.98	10.76	2A	5260	52	52T	13.27	13.91	14.00		
	5300	60	26T	10.04	10.59	10.61		5280	56	52T	13.23	13.92	13.87		
	5320	64	26T	10.32	10.87	10.95		5320	64	52T	13.64	14.00	13.98		
2C	5500	100	26T	10.65	10.96	10.86	2C	5500	100	52T	13.63	14.00	13.93		
	5520	104	26T	10.53	11.00	10.92		5520	104	52T	13.66	13.90	14.00		
	5580	116	26T	10.50	10.98	11.00		5580	116	52T	13.79	14.00	13.98		
	5660	132	26T	9.94	10.33	10.28		5660	132	52T	13.34	13.54	13.34		
	5680	136	26T	10.83	11.00	11.00		5680	136	52T	13.62	14.00	13.89		
	5700	140	26T	9.59	9.85	9.70		5700	140	52T	11.18	11.47	11.40		
	5720	144	26T	10.76	11.00	11.00		5720	144	52T	13.70	13.85	13.82		
3	5745	149	26T	15.21	15.50	15.37	3	5745	149	52T	15.28	15.50	15.38		
	5785	157	26T	15.30	15.50	15.45		5785	157	52T	15.43	15.50	15.50		
	5825	165	26T	15.15	15.50	15.35		5825	165	52T	15.22	15.40	15.50		

20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					53	54	N/A						61	N/A	N/A
	1	5180	36	106T	14.51	15.00			1	5180	36	242T	15.00		
		5200	40	106T	16.43	16.94				5200	40	242T	16.81		
		5240	48	106T	16.56	16.99				5240	48	242T	16.86		
	2A	5260	52	106T	16.43	16.75			2A	5260	52	242T	16.73		
		5300	60	106T	16.26	16.73				5300	60	242T	16.70		
		5320	64	106T	13.70	14.00				5320	64	242T	13.98		
	2C	5500	100	106T	13.75	13.96			2C	5500	100	242T	14.00		
		5520	104	106T	15.18	15.41				5520	104	242T	15.50		
		5580	116	106T	15.16	15.50				5580	116	242T	15.49		
		5660	132	106T	15.13	15.42				5660	132	242T	15.14		
		5680	136	106T	15.07	15.34				5680	136	242T	15.50		
		5700	140	106T	11.12	11.13				5700	140	242T	11.50		
		5720	144	106T	15.34	15.48				5720	144	242T	15.44		
	3	5745	149	106T	15.36	15.50			3	5745	149	242T	15.45		
		5785	157	106T	15.39	15.50				5785	157	242T	15.49		
		5825	165	106T	15.39	15.50				5825	165	242T	15.50		

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40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index							RU Index		
					0	8	17					37	40	44
	1	5190	38	26T	10.05	11.00	10.91	1	5190	38	52T	11.39	12.50	11.94
5230		46	26T	10.34	11.00	11.00	5230		46	52T	13.41	14.00	13.87	
2A	5270	54	26T	10.43	11.00	11.00	2A	5270	54	52T	13.45	14.00	13.90	
	5310	62	26T	10.51	11.00	11.00		5310	62	52T	12.08	12.50	12.44	
2C	5510	102	26T	10.80	11.00	11.00	2C	5510	102	52T	11.80	12.00	11.89	
	5550	110	26T	10.98	11.00	11.00		5550	110	52T	13.76	14.00	13.92	
	5590	118	26T	10.68	10.97	11.00		5590	118	52T	13.77	14.00	13.88	
	5630	126	26T	10.94	11.00	11.00		5630	126	52T	13.81	13.95	13.84	
	5670	134	26T	10.87	11.00	11.00		5670	134	52T	13.80	14.00	13.88	
	5710	142	26T	10.89	11.00	11.00		5710	142	52T	13.95	13.91	13.88	
3	5755	151	26T	15.50	15.50	15.50	3	5755	151	52T	15.45	15.50	15.50	
	5795	159	26T	15.33	15.50	15.50		5795	159	52T	15.41	15.38	15.30	

40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index							RU Index		
					53	54	56					61	62	N/A
	1	5190	38	106T	12.01	12.50	12.50	1	5190	38	242T	12.50	12.50	
5230		46	106T	16.68	16.97	17.00	5230		46	242T	16.98	16.92		
2A	5270	54	106T	16.55	16.50	16.51	2A	5270	54	242T	16.75	16.75		
	5310	62	106T	12.08	12.49	12.50		5310	62	242T	12.42	12.50		
2C	5510	102	106T	11.87	12.00	12.00	2C	5510	102	242T	12.00	12.00		
	5550	110	106T	15.07	15.30	15.32		5550	110	242T	15.50	15.50		
	5590	118	106T	15.38	15.50	15.50		5590	118	242T	15.37	15.50		
	5630	126	106T	15.39	15.50	15.50		5630	126	242T	15.00	15.38		
	5670	134	106T	14.84	14.99	14.93		5670	134	242T	14.94	15.00		
	5710	142	106T	15.39	15.50	15.50		5710	142	242T	11.49	11.50		
3	5755	151	106T	15.48	15.50	15.50	3	5755	151	242T	15.00	15.06		
	5795	159	106T	15.49	15.50	15.50		5795	159	242T	15.06	15.18		

40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					65	N/A	N/A
	1	5190	38	484T	12.02		
		5230	46	484T	16.94		
	2A	5270	54	484T	16.75		
		5310	62	484T	12.42		
	2C	5510	102	484T	11.98		
		5550	110	484T	15.50		
		5590	118	484T	15.42		
		5630	126	484T	15.50		
		5670	134	484T	15.00		
		5710	142	484T	15.40		
	3	5755	151	484T	15.40		
		5795	159	484T	15.26		

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80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					0	18	36
80MHz BW	1	5210	42	26T	10.53	11.00	11.00
	2A	5290	58	26T	10.61	11.00	11.00
	2C	5530	106	26T	10.65	10.92	10.96
		5610	122	26T	10.70	11.00	11.00
		5690	138	26T	10.39	11.00	10.68
	3	5775	155	26T	15.39	15.50	15.45
80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					53	56	60
80MHz BW	1	5210	42	106T	11.59	12.00	11.82
	2A	5290	58	106T	11.17	11.50	11.50
	2C	5530	106	106T	10.74	11.00	11.00
		5610	122	106T	15.27	15.50	15.50
		5690	138	106T	15.40	15.50	15.48
	3	5775	155	106T	15.50	15.50	15.50
80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					65	66	N/A
80MHz BW	1	5210	42	484T	11.95	11.94	
	2A	5290	58	484T	11.42	11.50	
	2C	5530	106	484T	11.00	11.00	
		5610	122	484T	15.50	15.49	
		5690	138	484T	15.00	15.00	
	3	5775	155	484T	15.47	15.50	

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Table 4
Maximum 5 GHz 802.11ax RU Output Power – 5GHz ANTupper

20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					0	4	8						37	39	40
	1	5180	36	26T	10.06	10.68	10.92		1	5180	36	52T	13.31	14.00	13.97
5200		40	26T	10.16	10.79	10.98	5200	40		52T	13.42	14.00	14.00		
5240		48	26T	10.41	10.99	11.00	5240	48		52T	13.39	13.79	13.86		
2A	5260	52	26T	10.32	10.89	11.00	2A	5260	52	52T	13.52	13.87	13.74		
	5300	60	26T	10.31	10.84	11.00		5280	56	52T	13.45	13.89	13.82		
	5320	64	26T	10.48	10.96	11.00		5320	64	52T	13.81	14.00	14.00		
2C	5500	100	26T	10.62	11.00	10.80	2C	5500	100	52T	13.90	14.00	14.00		
	5520	104	26T	10.46	10.95	11.00		5520	104	52T	13.88	14.00	14.00		
	5580	116	26T	10.69	11.00	10.98		5580	116	52T	14.00	14.00	14.00		
	5660	132	26T	10.43	10.81	10.71		5660	132	52T	13.71	13.93	13.94		
	5680	136	26T	10.54	10.94	10.91		5680	136	52T	13.59	14.00	13.91		
	5700	140	26T	9.51	10.00	9.94		5700	140	52T	11.03	11.41	11.34		
	5720	144	26T	10.62	10.96	10.87		5720	144	52T	13.63	14.00	13.89		
3	5745	149	26T	15.40	15.75	15.69	3	5745	149	52T	15.44	15.75	15.75		
	5785	157	26T	15.32	15.73	15.64		5785	157	52T	15.25	15.70	15.59		
	5825	165	26T	15.30	15.70	15.62		5825	165	52T	15.17	15.51	15.46		

20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			20MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					53	54	N/A						61	N/A	N/A
	1	5180	36	106T	14.63	15.00			1	5180	36	242T	14.19		
5200		40	106T	16.69	16.98		5200	40		242T	16.81				
5240		48	106T	16.69	17.00		5240	48		242T	16.15				
2A	5260	52	106T	16.43	16.75		2A	5260	52	242T	16.75				
	5300	60	106T	16.58	16.75			5300	60	242T	16.69				
	5320	64	106T	13.48	13.99			5320	64	242T	14.00				
2C	5500	100	106T	13.41	13.58		2C	5500	100	242T	14.00				
	5520	104	106T	15.24	15.40			5520	104	242T	15.50				
	5580	116	106T	15.28	15.47			5580	116	242T	15.43				
	5660	132	106T	15.39	15.40			5660	132	242T	15.29				
	5680	136	106T	15.33	15.50			5680	136	242T	15.45				
	5700	140	106T	11.35	11.50			5700	140	242T	11.47				
	5720	144	106T	15.44	15.50			5720	144	242T	15.50				
3	5745	149	106T	15.72	15.75		3	5745	149	242T	15.74				
	5785	157	106T	15.54	15.67			5785	157	242T	15.68				
	5825	165	106T	15.43	15.66			5825	165	242T	15.75				

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40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					0	8	17						37	40	44
	1	5190	38	26T	9.89	11.00	10.55		1	5190	38	52T	11.35	12.47	12.16
		5230	46	26T	10.24	10.69	11.00			5230	46	52T	13.08	13.75	13.96
	2A	5270	54	26T	10.28	10.93	10.96		2A	5270	54	52T	13.25	13.83	13.94
		5310	62	26T	10.21	10.80	10.94			5310	62	52T	11.64	12.34	12.49
	2C	5510	102	26T	11.00	11.00	11.00		2C	5510	102	52T	11.67	11.93	11.94
		5550	110	26T	10.98	11.00	11.00			5550	110	52T	13.95	13.98	14.00
		5590	118	26T	11.00	10.98	10.93			5590	118	52T	13.82	13.89	14.00
5630		126	26T	10.75	10.81	10.97	5630	126		52T	13.93	13.94	14.00		
5670		134	26T	10.52	10.92	10.98	5670	134		52T	14.00	14.00	14.00		
5710		142	26T	10.79	10.93	11.00	5710	142		52T	13.65	13.80	13.99		
3	5755	151	26T	15.38	15.45	15.50	3	5755	151	52T	15.48	15.41	15.75		
	5795	159	26T	15.02	15.32	15.42		5795	159	52T	15.51	15.48	15.74		

40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)			40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index								RU Index		
					53	54	56						61	62	N/A
	1	5190	38	106T	11.57	12.42	11.72		1	5190	38	242T	12.50	12.48	
		5230	46	106T	16.65	17.00	16.98			5230	46	242T	16.77	16.91	
	2A	5270	54	106T	16.26	16.70	16.36		2A	5270	54	242T	16.74	16.61	
		5310	62	106T	12.07	12.42	12.14			5310	62	242T	12.32	12.50	
	2C	5510	102	106T	11.77	11.91	11.75		2C	5510	102	242T	11.90	11.99	
		5550	110	106T	15.35	15.50	15.23			5550	110	242T	15.31	15.50	
		5590	118	106T	15.31	15.47	15.23			5590	118	242T	15.49	15.50	
5630		126	106T	15.35	15.39	15.16	5630	126		242T	15.50	15.46			
5670		134	106T	14.80	14.95	14.76	5670	134		242T	14.92	15.00			
5710		142	106T	15.32	15.50	15.40	5710	142		242T	11.49	11.50			
3	5755	151	106T	15.55	15.70	15.60	3	5755	151	242T	15.60	15.69			
	5795	159	106T	15.60	15.75	15.51		5795	159	242T	15.72	15.65			

40MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					65	N/A	N/A
	1	5190	38	484T	12.35		
		5230	46	484T	17.00		
	2A	5270	54	484T	16.67		
		5310	62	484T	12.47		
	2C	5510	102	484T	11.98		
		5550	110	484T	15.50		
		5590	118	484T	15.50		
		5630	126	484T	15.50		
		5670	134	484T	15.00		
		5710	142	484T	15.50		
	3	5755	151	484T	15.68		
		5795	159	484T	15.75		

FCC ID: BCGA2232	 SAR EVALUATION REPORT	Reviewed by: Quality Manager
Test Dates: 12/20/2019 – 02/05/2020	DUT Type: Tablet Device	APPENDIX H: Page 24 of 25

80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					0	18	36
80MHz BW	1	5210	42	26T	10.31	10.93	10.72
	2A	5290	58	26T	10.37	10.90	10.83
	2C	5530	106	26T	10.58	10.96	10.48
		5610	122	26T	10.67	11.00	10.66
		5690	138	26T	10.98	10.99	10.74
	3	5775	155	26T	15.26	15.48	15.10
80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					53	56	60
80MHz BW	1	5210	42	106T	11.32	11.78	11.81
	2A	5290	58	106T	10.97	11.50	11.38
	2C	5530	106	106T	10.77	10.88	10.81
		5610	122	106T	15.24	15.50	15.29
		5690	138	106T	15.29	15.48	15.35
	3	5775	155	106T	15.36	15.50	15.45
80MHz BW	Band	Freq [MHz]	Channel	Tones	Avg Conducted Power (dBm)		
					RU Index		
					65	66	N/A
80MHz BW	1	5210	42	484T	12.00	12.00	
	2A	5290	58	484T	11.47	11.49	
	2C	5530	106	484T	10.97	11.00	
		5610	122	484T	15.49	15.50	
		5690	138	484T	15.00	15.00	
	3	5775	155	484T	15.50	15.50	

FCC ID: BCGA2232	 PCTEST	SAR EVALUATION REPORT	Reviewed by: Quality Manager
Test Dates: 12/20/2019 – 02/05/2020	DUT Type: Tablet Device		APPENDIX H: Page 25 of 25

APPENDIX I: PROBE AND DIPOLE CALIBRATION CERTIFICATES

**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: **PG Test**

Certificate No.: **D750V3-1097_Sep17**

CALIBRATION CERTIFICATE

Object: **D750V3 - SN:1097**

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

Calibration date: **September 08, 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	28-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: US37292763	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-16)	In house check: Oct-17

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

Approved by: **Katja Pokóvic** Technical Manager

Signature:

Signature:

Issued: September 8, 2017

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



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	750 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	41.2 $\pm$ 6 %	0.90 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.22 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.39 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	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	55.5 $\pm$ 6 %	0.96 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.56 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.68 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	54.4 Ω - 0.6 j Ω
Return Loss	- 27.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.0 Ω - 3.6 j Ω
Return Loss	- 28.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.034 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	July 05, 2013

DASY5 Validation Report for Head TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1097

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: $f = 750 \text{ MHz}$; $\sigma = 0.9 \text{ S/m}$; $\epsilon_r = 41.2$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.49, 10.49, 10.49); 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:

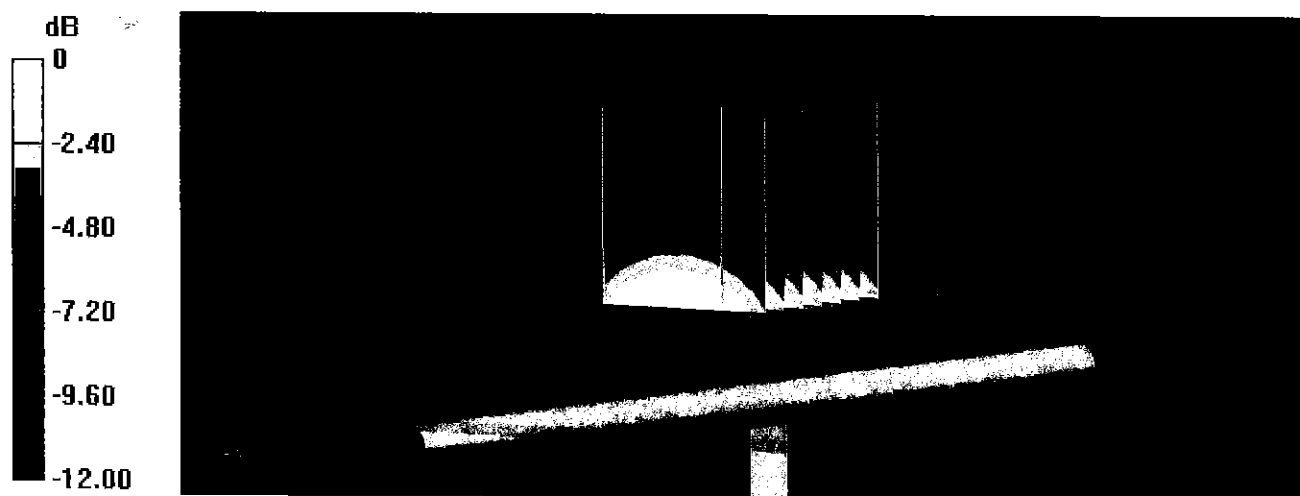
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 58.59 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.19 W/kg

SAR(1 g) = 2.08 W/kg; SAR(10 g) = 1.36 W/kg

Maximum value of SAR (measured) = 2.80 W/kg



0 dB = 2.80 W/kg = 4.47 dBW/kg

Impedance Measurement Plot for Head TSL

8 Sep 2017 13:09:24
 CH1 S11 1 U FS 1: 54.383 Ω -552.73 m Ω 383.92 pF 750.000 000 MHz

*

De1

CA

Avg
16

H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-27.463 dB 750.000 000 MHz

CA

Avg
16

H1d

START 550.000 000 MHz

STOP 950.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 08.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1097

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: $f = 750$ MHz; $\sigma = 0.96$ S/m; $\epsilon_r = 55.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.35, 10.35, 10.35); 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:

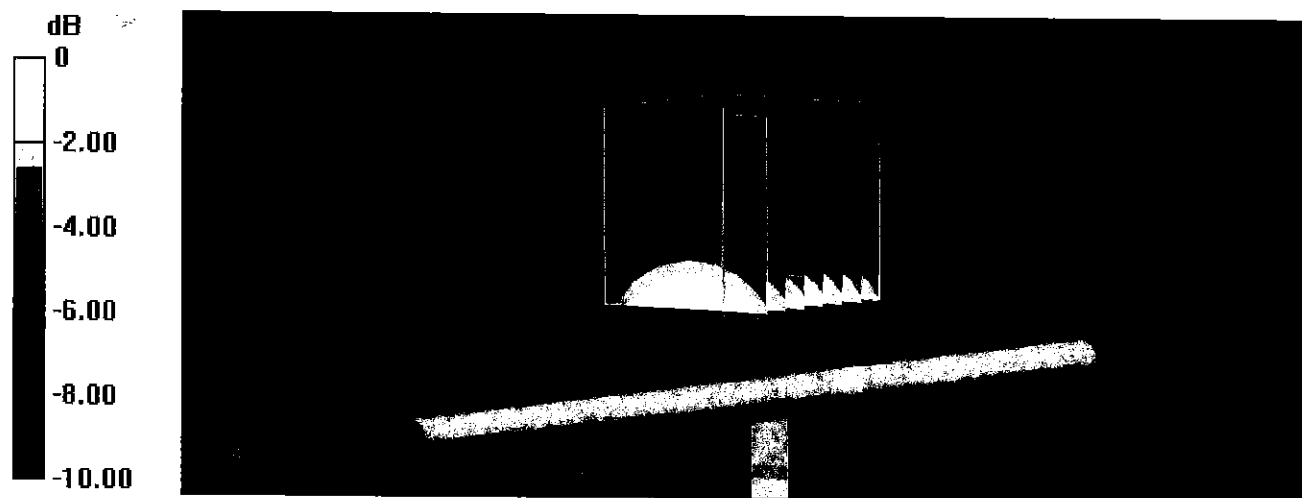
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 56.96 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 3.16 W/kg

SAR(1 g) = 2.14 W/kg; SAR(10 g) = 1.42 W/kg

Maximum value of SAR (measured) = 2.81 W/kg



0 dB = 2.81 W/kg = 4.49 dBW/kg

Impedance Measurement Plot for Body TSL

8 Sep 2017 13:08:43
 CH1 S11 1 U FS 1: 49.951 Ω -3.6172 Ω 58.666 pF 750.000 000 MHz

*
 De1
 CA

Avg
 15

H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -28.833 dB 750.000 000 MHz

CA

Avg
 16

H1d

START 550.000 000 MHz

STOP 950.000 000 MHz

Certification of Calibration

Object D750V3 – SN: 1097

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

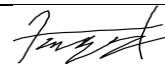
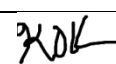
Extended Calibration date: September 08, 2018

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1533
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/18/2018	Annual	1/18/2019	793

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

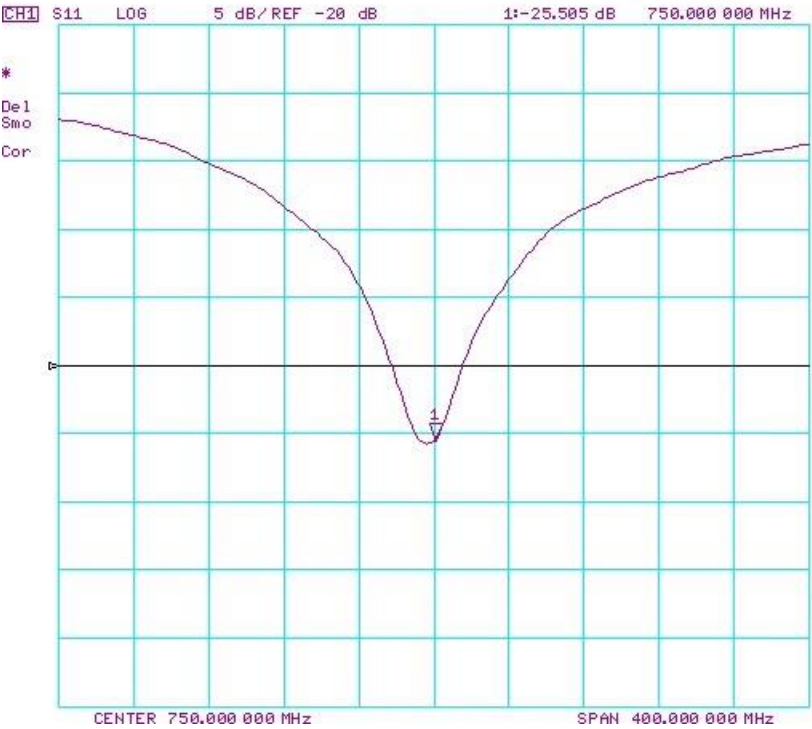
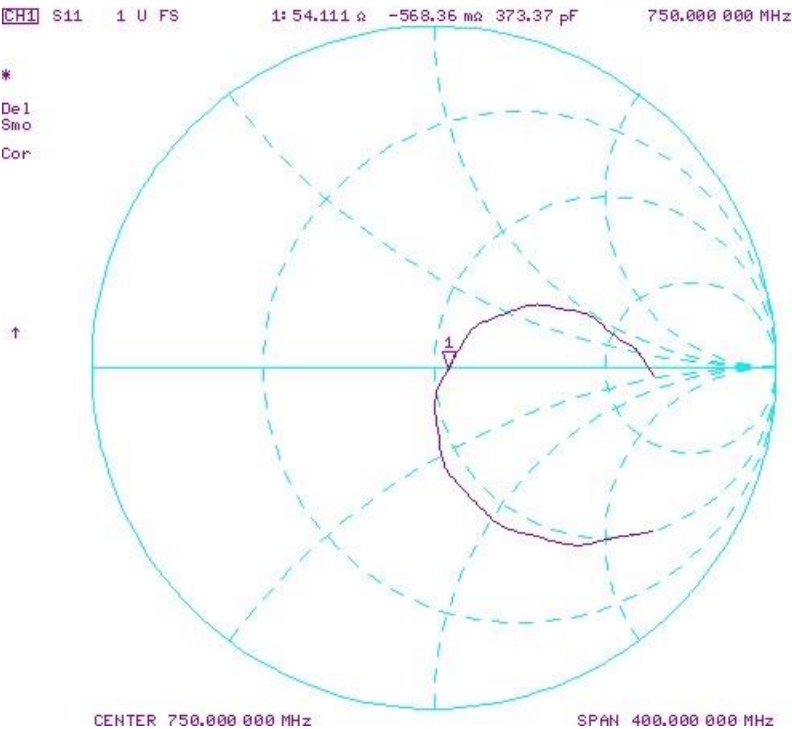
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

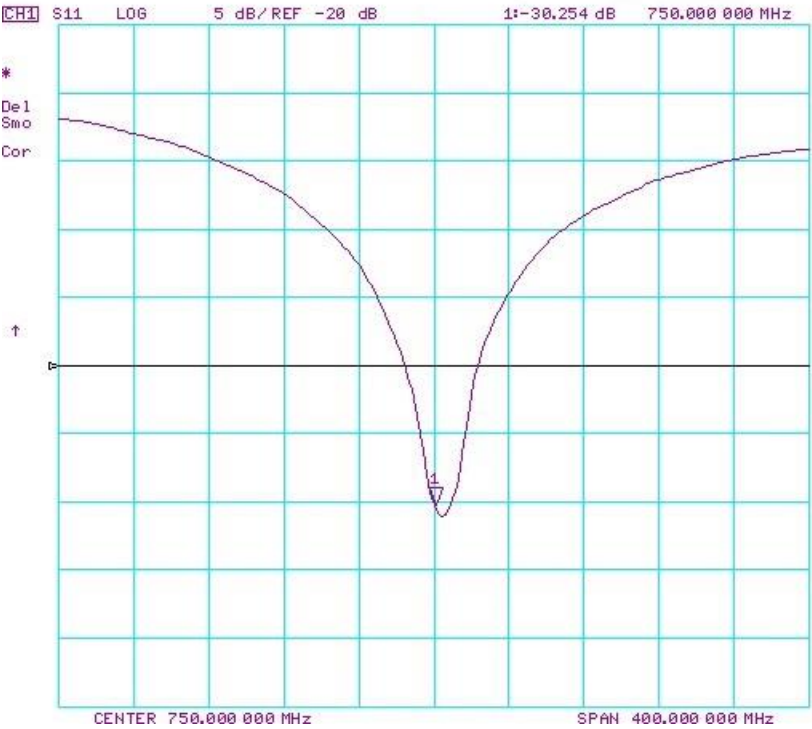
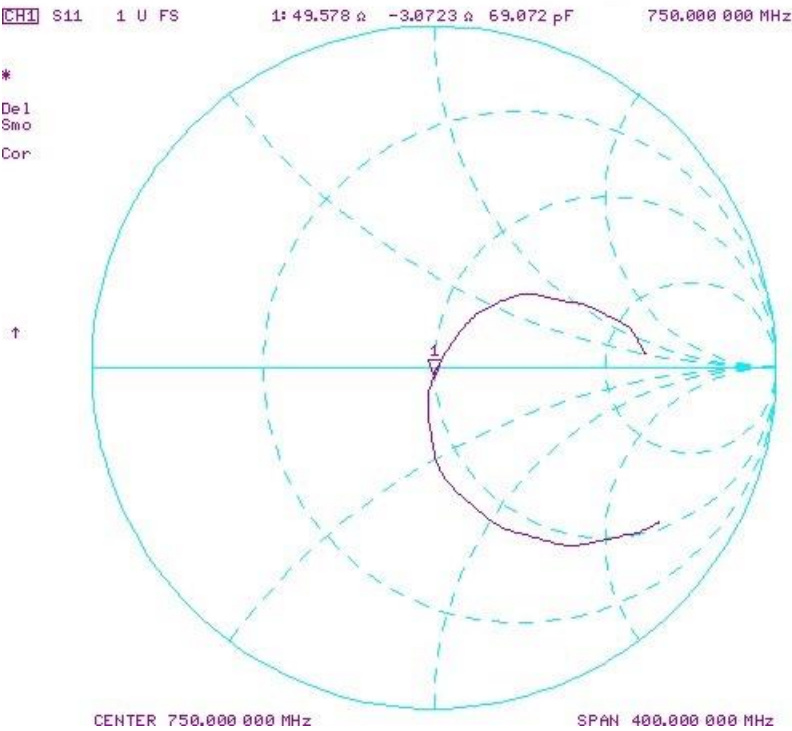
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2018	1.034	1.644	1.7	3.41%	1.078	1.12	3.90%	54.4	54.1	0.3	-0.6	-0.6	0	-27.5	-25.5	7.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2018	1.034	1.712	1.78	3.97%	1.136	1.17	2.99%	50	49.6	0.4	-3.6	-3.1	0.5	-28.8	-30.3	-5.20%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL



Certification of Calibration

Object D750V3 – SN: 1097

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 8, 2019

Description: SAR Validation Dipole at 750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

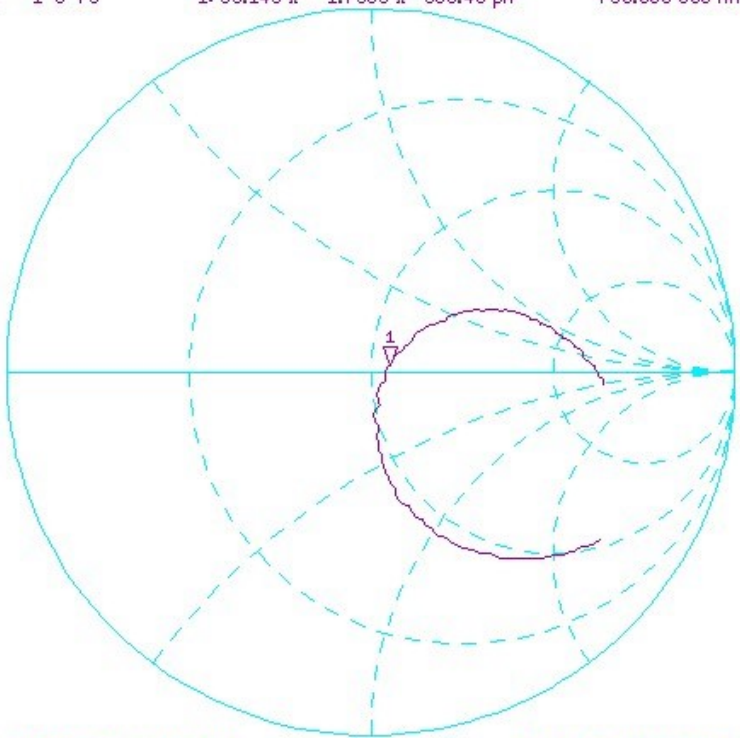
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.034	1.644	1.55	-5.11%	1.078	1.03	-4.45%	54.4	55.1	0.7	-0.6	1.7	2.3	-27.5	-25	5.50%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/8/2017	9/8/2019	1.034	1.712	1.65	-3.62%	1.136	1.1	-3.17%	50	51	1	-3.6	-1.3	2.3	-28.8	-31.9	-10.80%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL

CH1 S11 1 U FS 1: 55.143 Ω 1.7363 Ω 368.46 pF 750.000 000 MHz

*
De1
Cor

↑



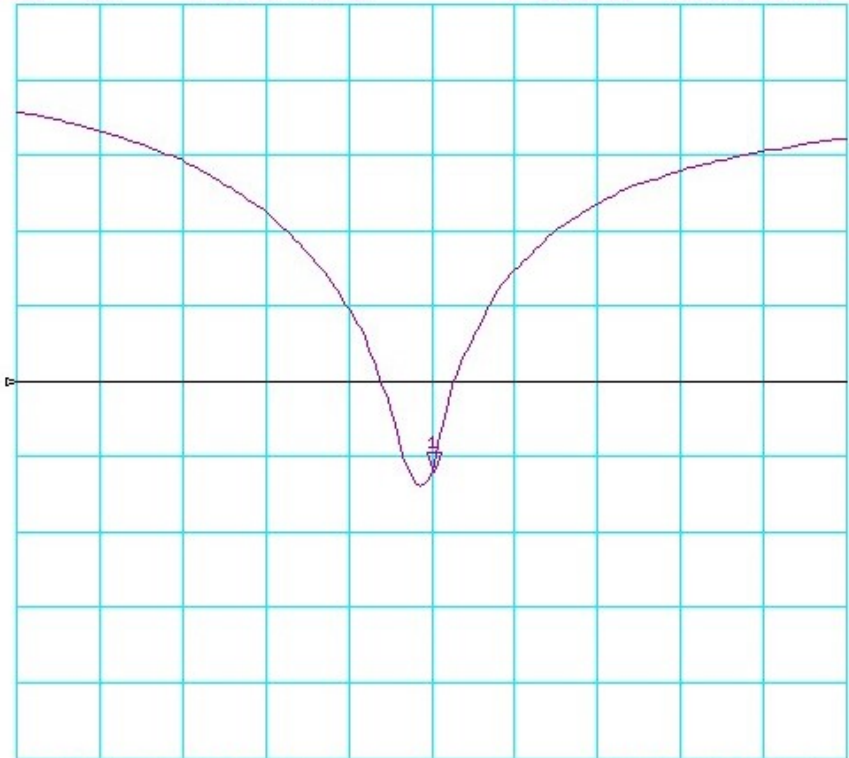
CENTER 750.000 000 MHz

SPAN 400.000 000 MHz

CH1 S11 LOG 5 dB/REF -20 dB 1:-26.011 dB 750.000 000 MHz

*
De1
Smo
Cor

↑



CENTER 750.000 000 MHz

SPAN 400.000 000 MHz

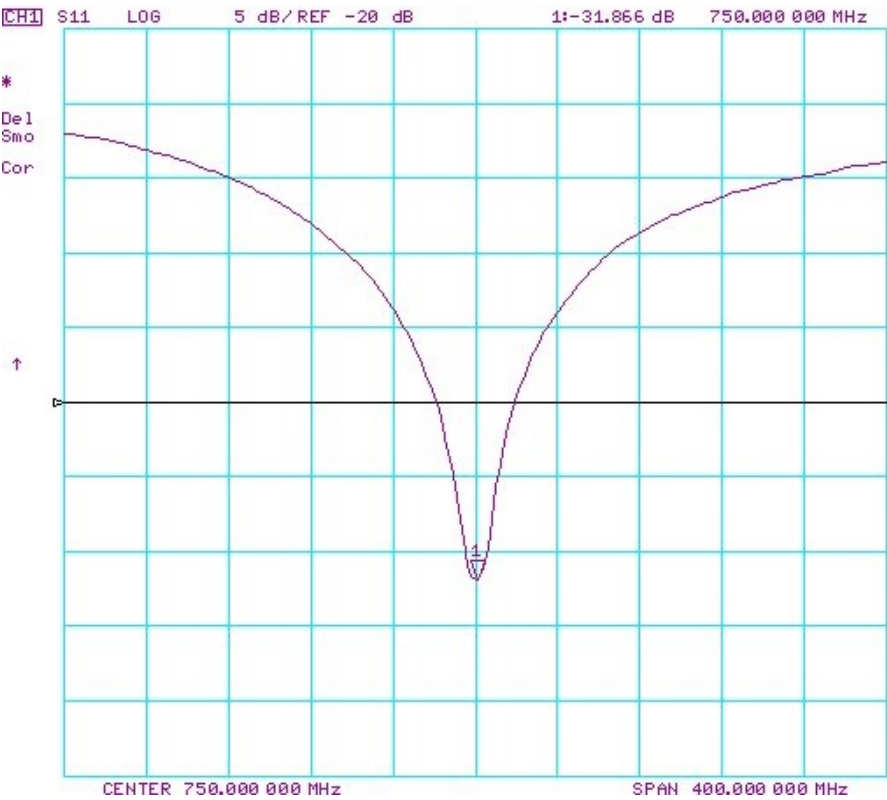
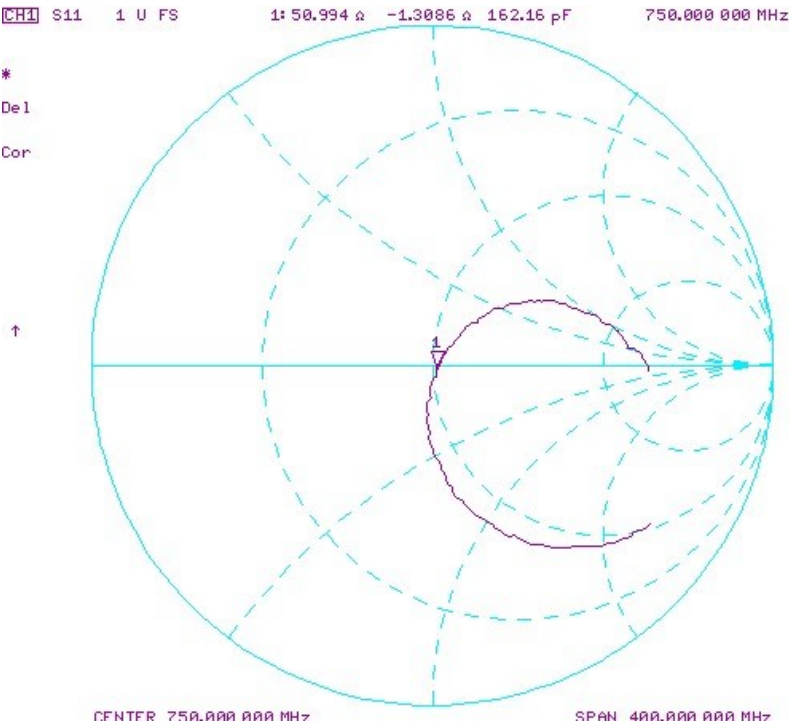
Object:

D750V3 – SN: 1097

Date Issued:

09/08/2019

Impedance & Return-Loss Measurement Plot for Body TSL





Accredited by the Swiss Accreditation Service (SAS)
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D835V2-4d040_Jun19**

CALIBRATION CERTIFICATE

Object **D835V2 - SN:4d040**

Calibration procedure(s) **QA CAL-05.v11**
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz

✓
 ATM
 6/28/19

Calibration date: **June 20, 2019**

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	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

Calibrated by: **Manu Seitz** **Laboratory Technician**

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

Signature

Issued: June 21, 2019

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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	V52.10.2
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	41.8 $\pm$ 6 %	0.91 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.50 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.54 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.13 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	55.4 $\pm$ 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 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.40 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.53 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.57 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.24 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	49.6 Ω - 4.1 j Ω
Return Loss	- 27.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.6 Ω - 6.5 j Ω
Return Loss	- 22.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.393 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
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DASY5 Validation Report for Head TSL

Date: 20.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d040

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

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.91 \text{ S/m}$; $\epsilon_r = 41.8$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.89, 9.89, 9.89) @ 835 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Dipole Calibration for Head Tissue/ $P_{in}=250 \text{ mW}$, $d=15\text{mm}$ /Zoom Scan (7x7x7)/Cube 0:

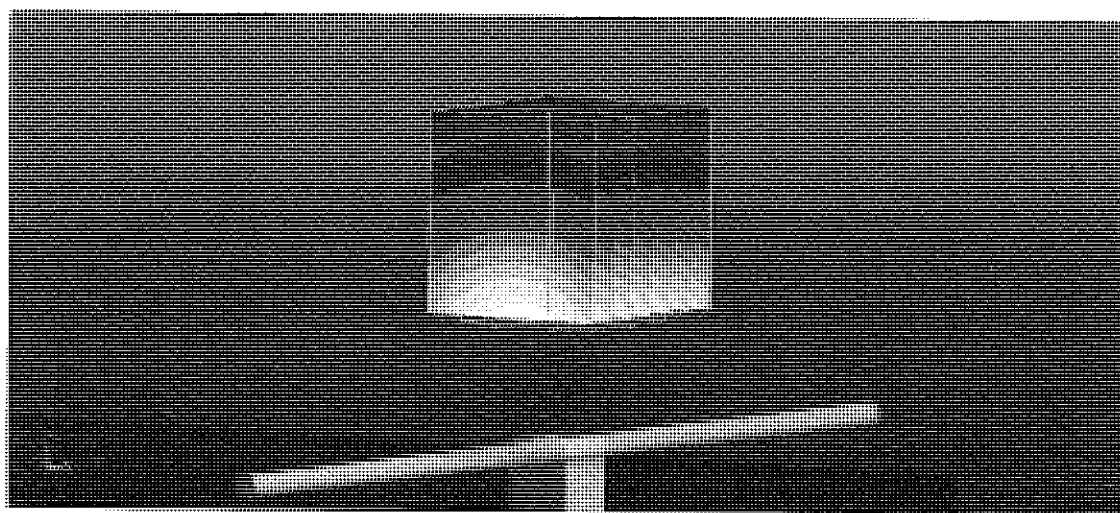
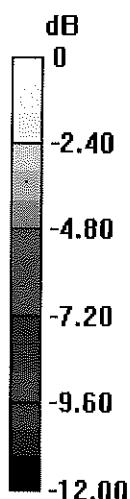
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 63.05 V/m ; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 3.60 W/kg

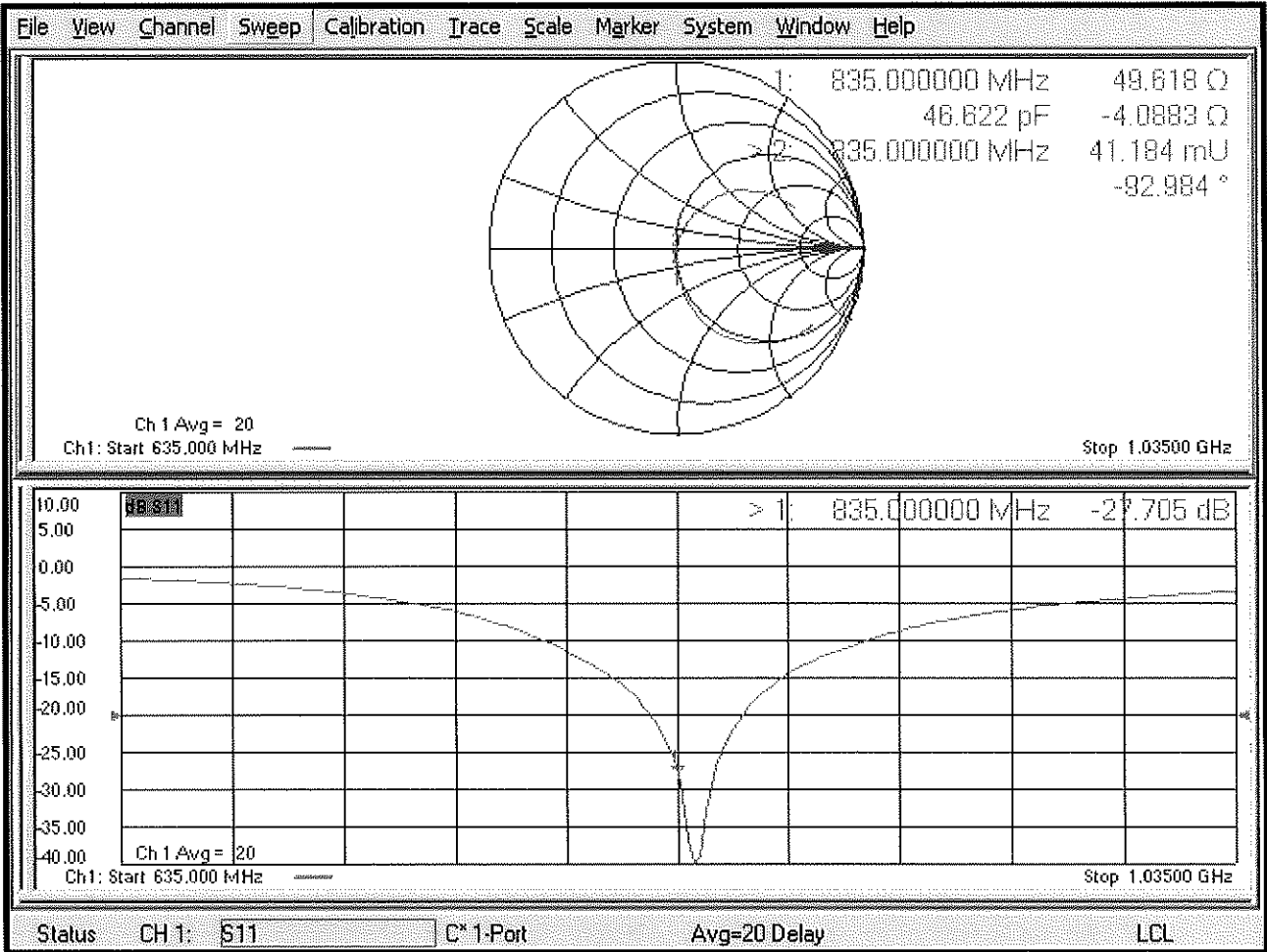
SAR(1 g) = 2.39 W/kg ; SAR(10 g) = 1.54 W/kg

Maximum value of SAR (measured) = 3.19 W/kg



0 dB = 3.19 W/kg = 5.04 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 13.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d040

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

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.98 \text{ S/m}$; $\epsilon_r = 55.4$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.16, 10.16, 10.16) @ 835 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

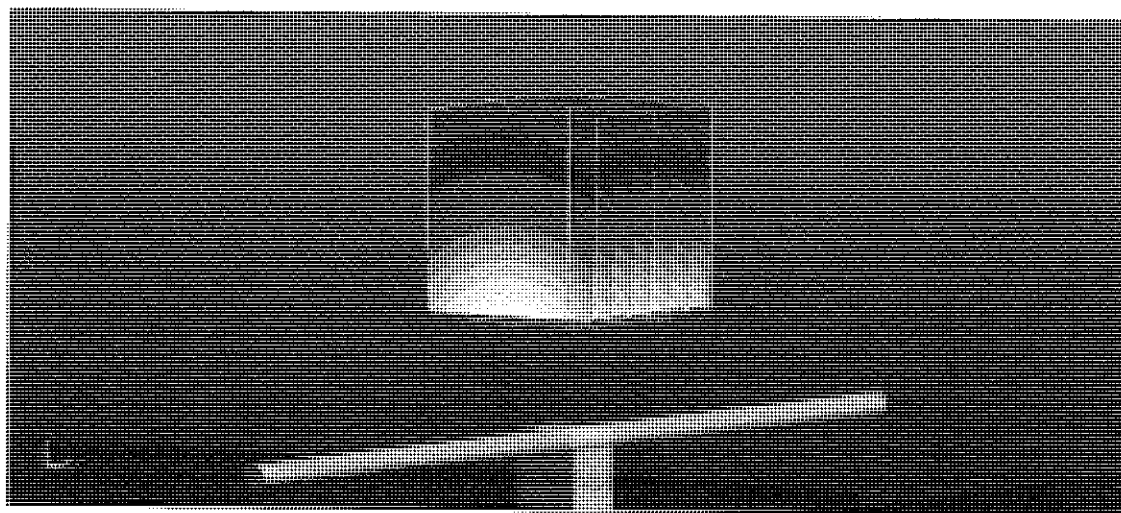
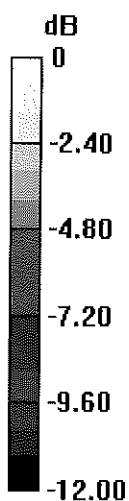
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 57.73 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 3.59 W/kg

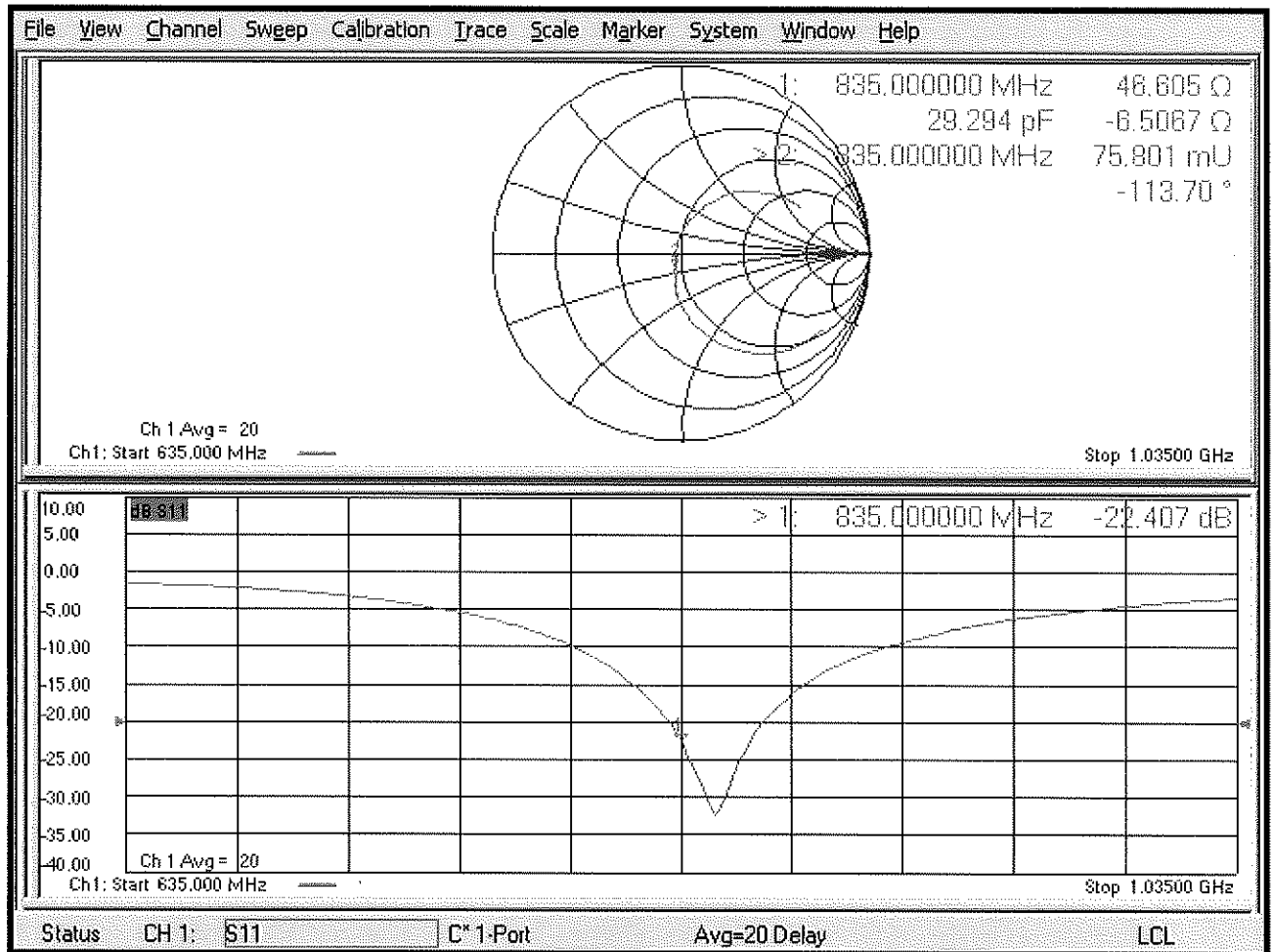
SAR(1 g) = 2.4 W/kg; SAR(10 g) = 1.57 W/kg

Maximum value of SAR (measured) = 3.21 W/kg



0 dB = 3.21 W/kg = 5.07 dBW/kg

Impedance Measurement Plot for Body TSL





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

Client **PC Test**

Certificate No: **D1750V2-1083_Jun19**

CALIBRATION CERTIFICATE

Object **D1750V2 - SN:1083**

Calibration procedure(s) **QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **June 19, 2019**

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	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

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

Signature

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

Issued: June 20, 2019

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	40.0 $\pm$ 6 %	1.34 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	8.91 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.70 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.0 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	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	53.9 $\pm$ 6 %	1.46 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.88 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.7 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	50.6 Ω - 1.1 j Ω
Return Loss	- 38.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.1 Ω - 2.4 j Ω
Return Loss	- 28.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.220 ns
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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
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DASY5 Validation Report for Head TSL

Date: 19.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1083

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used: $f = 1750$ MHz; $\sigma = 1.34$ S/m; $\epsilon_r = 40$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.67, 8.67, 8.67) @ 1750 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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 = 105.8 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 16.7 W/kg

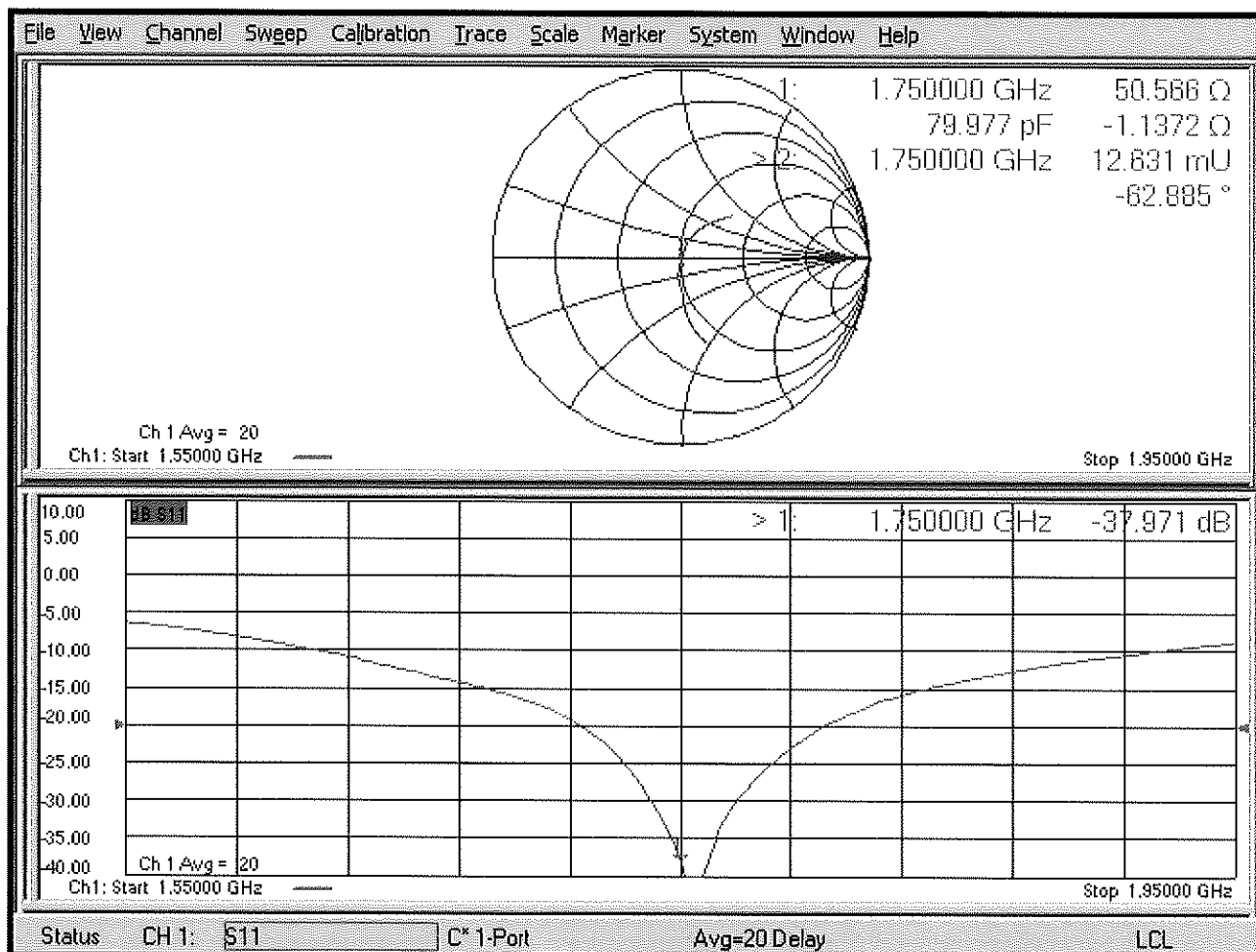
SAR(1 g) = 8.91 W/kg; SAR(10 g) = 4.7 W/kg

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



0 dB = 13.9 W/kg = 11.43 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 13.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1083

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used: $f = 1750$ MHz; $\sigma = 1.46$ S/m; $\epsilon_r = 53.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.45, 8.45, 8.45) @ 1750 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

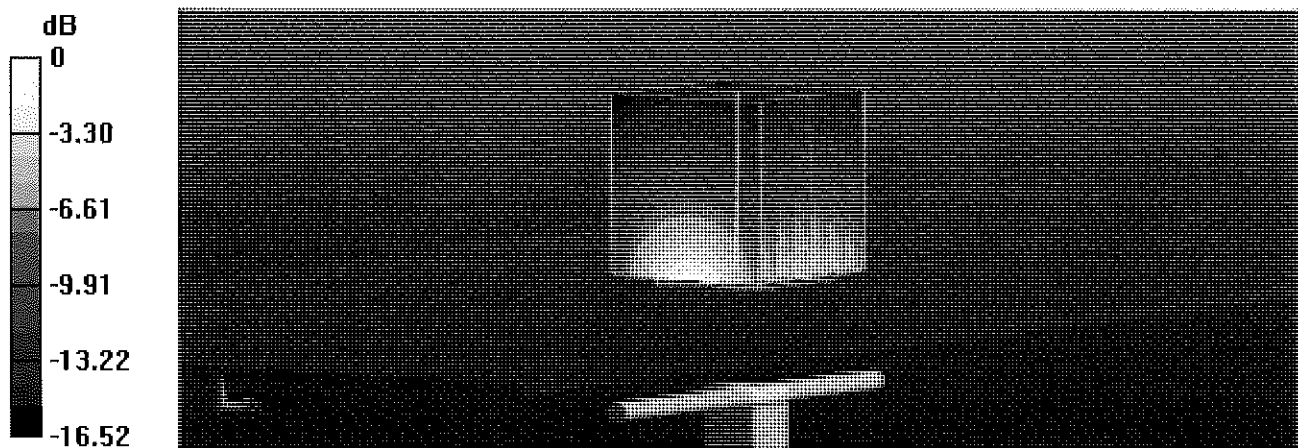
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.8 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 16.2 W/kg

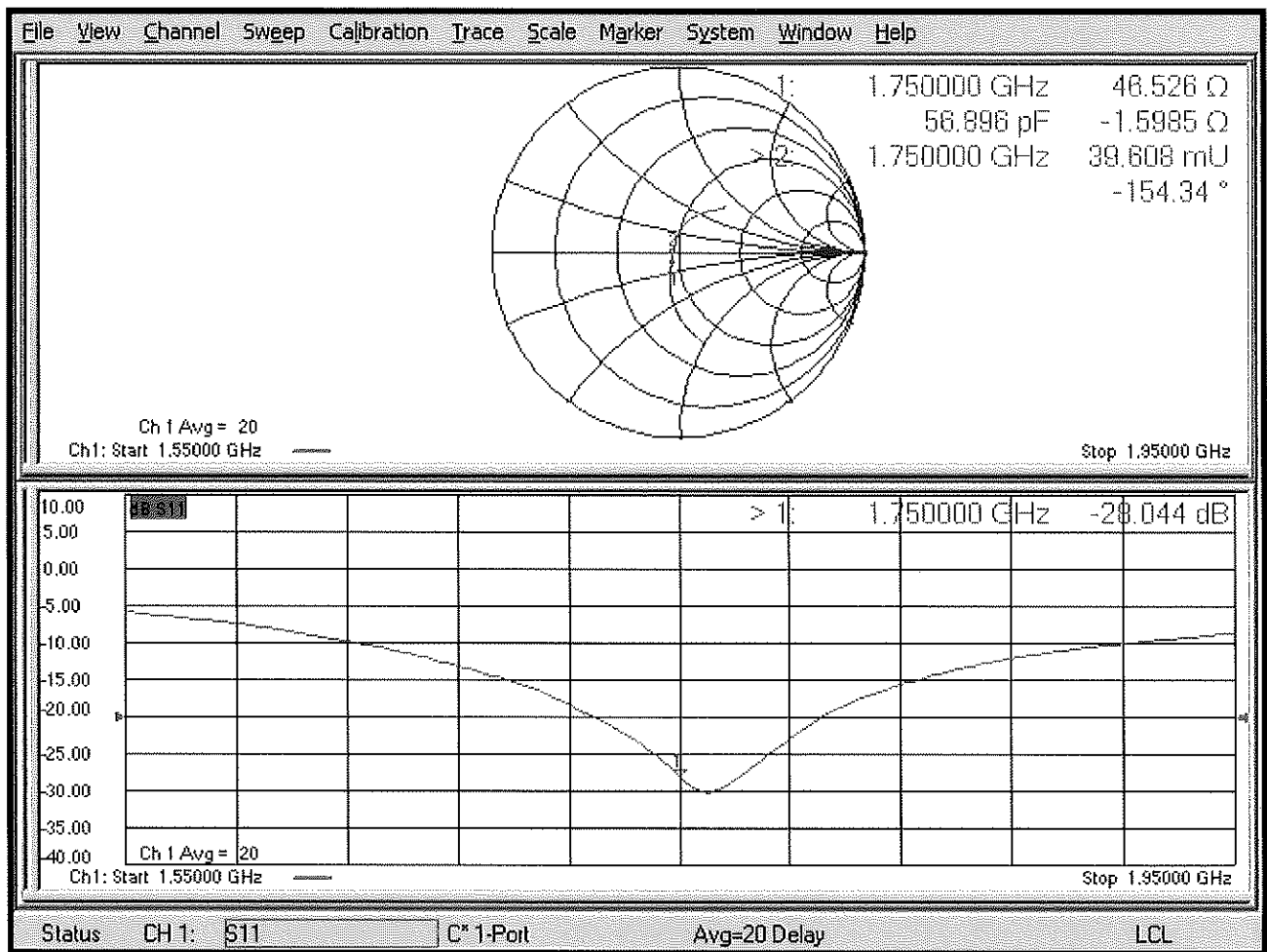
SAR(1 g) = 9.14 W/kg; SAR(10 g) = 4.88 W/kg

Maximum value of SAR (measured) = 13.7 W/kg



0 dB = 13.7 W/kg = 11.37 dBW/kg

Impedance Measurement Plot for Body TSL





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 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 **PC Test**

Certificate No: **D1900V2-5d026_May18**

CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d026**

Calibration procedure(s) **Cal. Cal-15 v10
 Calibration procedure for cable validation with above 700 MHz**

Calibration date: **May 14, 2018**

SC ✓
 7/31/2018

BN ✓
 06/01/2019

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-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
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: 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: **Jeton Kastrati** Name **Laboratory Technician** Function

Signature

Approved by: **Katja Pokovic** Technical Manager

Signature

Issued: May 14, 2018

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



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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	V52.10.1
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	41.2 $\pm$ 6 %	1.35 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	9.78 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.2 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	21.1 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	55.3 $\pm$ 6 %	1.46 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	9.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.9 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	5.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 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	$53.0 \Omega + 8.0 j\Omega$
Return Loss	- 21.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$47.1 \Omega + 7.4 j\Omega$
Return Loss	- 21.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 ns
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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 17, 2002

DASY5 Validation Report for Head TSL

Date: 14.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d026

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

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.35$ S/m; $\epsilon_r = 41.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.18, 8.18, 8.18) @ 1900 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

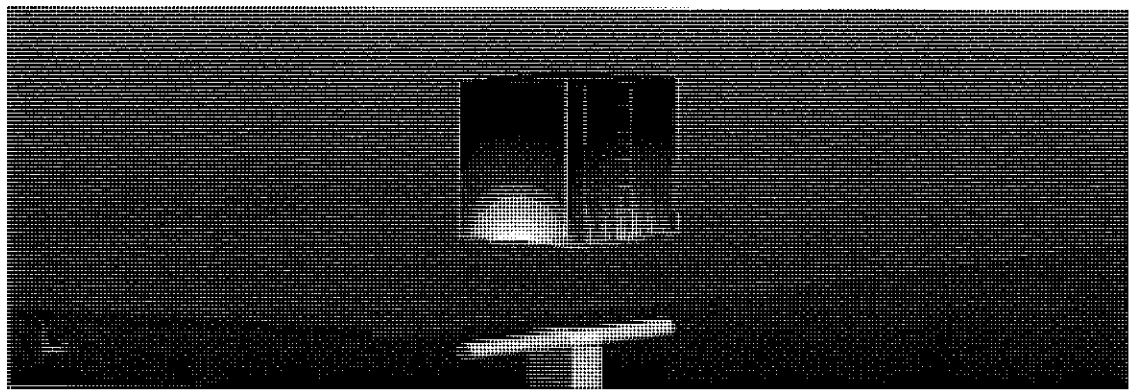
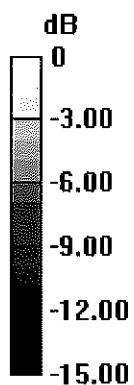
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 109.9 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 17.8 W/kg

SAR(1 g) = 9.78 W/kg; SAR(10 g) = 5.19 W/kg

Maximum value of SAR (measured) = 15.0 W/kg

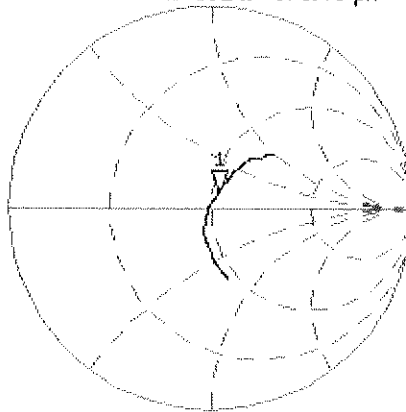


0 dB = 15.0 W/kg = 11.76 dBW/kg

Impedance Measurement Plot for Head TSL

14 May 2018 09:14:41
 [CH1] S11 1 U FS 1: 52.955 Ω 8.0391 Ω 673.40 μ H 1 900.000 000 MHz

*
 Del
 CA



Avg
 16

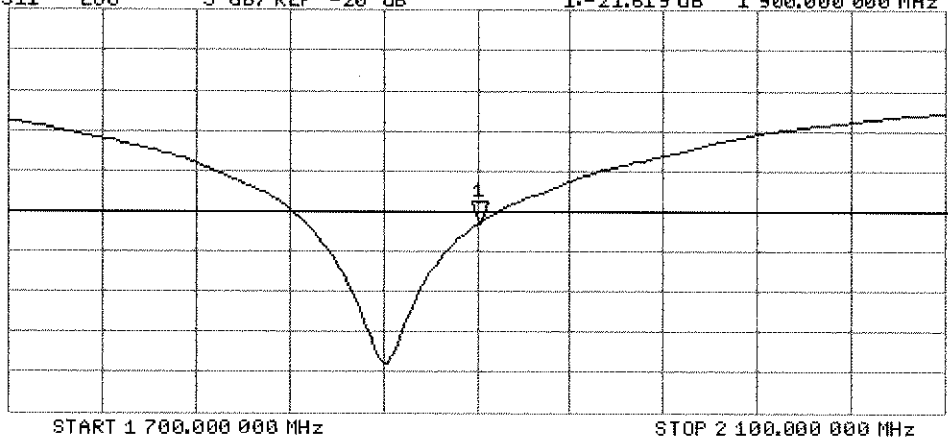
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-21.619 dB 1 900.000 000 MHz

CA

Avg
 16

H1d



DASY5 Validation Report for Body TSL

Date: 14.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d026

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

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.46$ 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(8.15, 8.15, 8.15) @ 1900 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

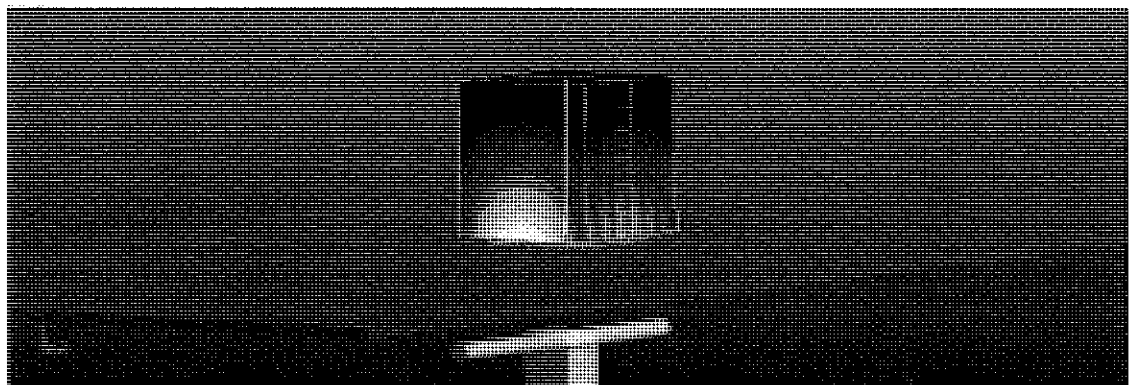
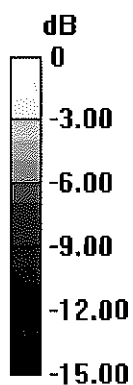
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.5 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 16.7 W/kg

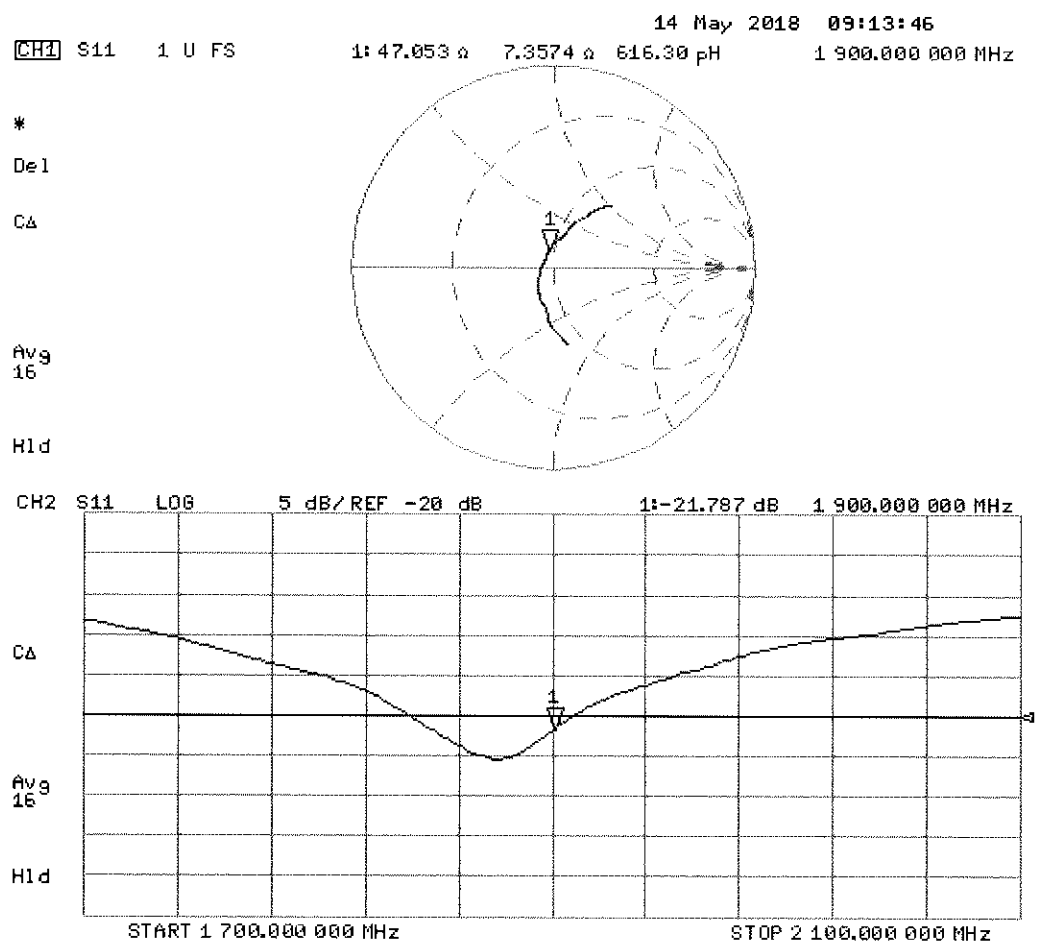
SAR(1 g) = 9.65 W/kg; SAR(10 g) = 5.19 W/kg

Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 11.58 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D1900V2 – SN: 5d026

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 14, 2019

Description: SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/15/2018	Annual	6/15/2019	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/10/2018	Annual	7/10/2019	1402

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

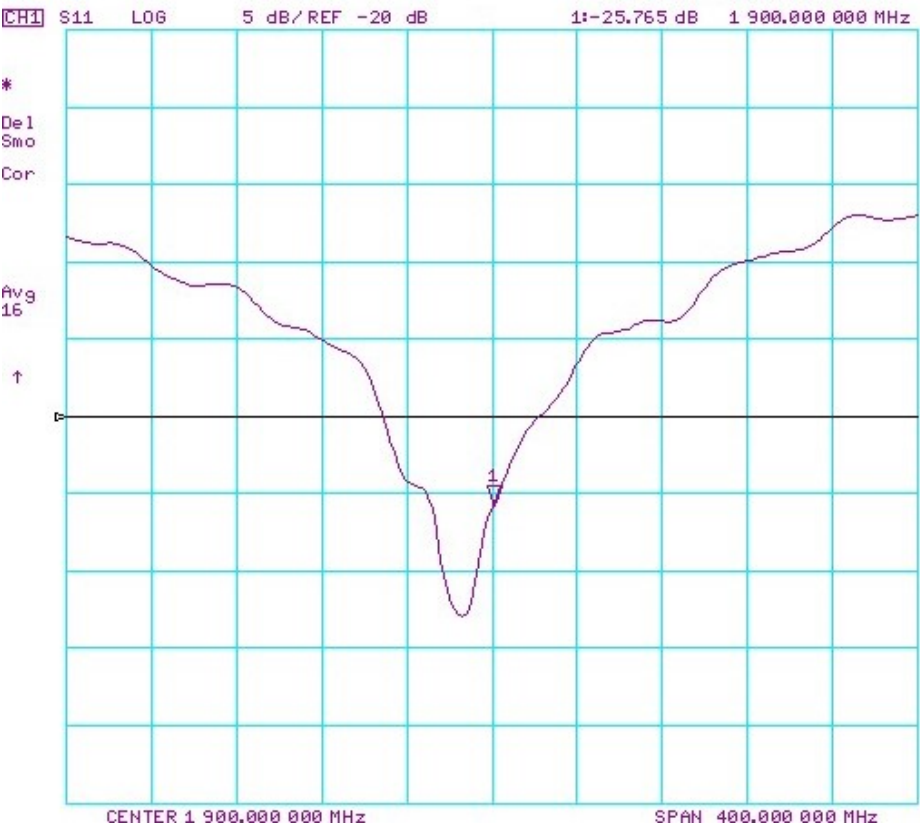
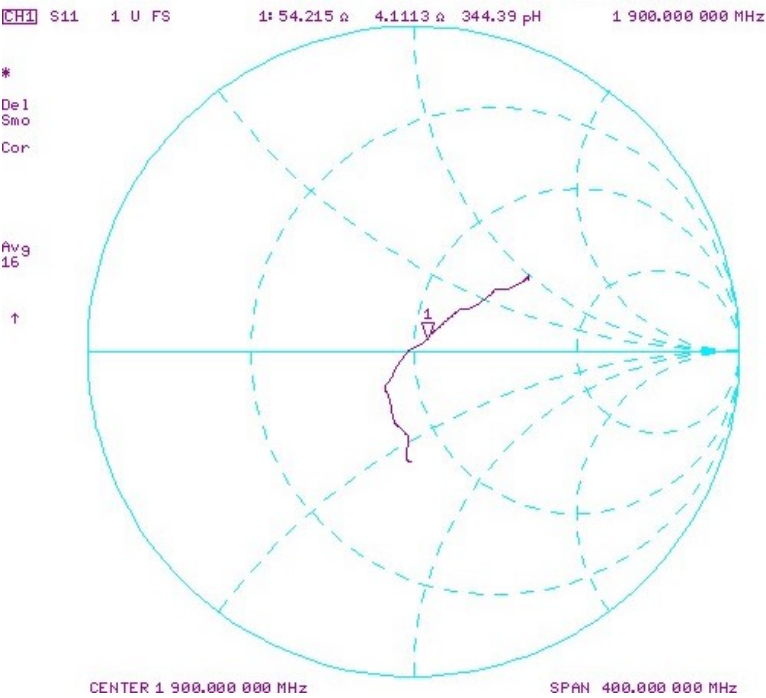
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

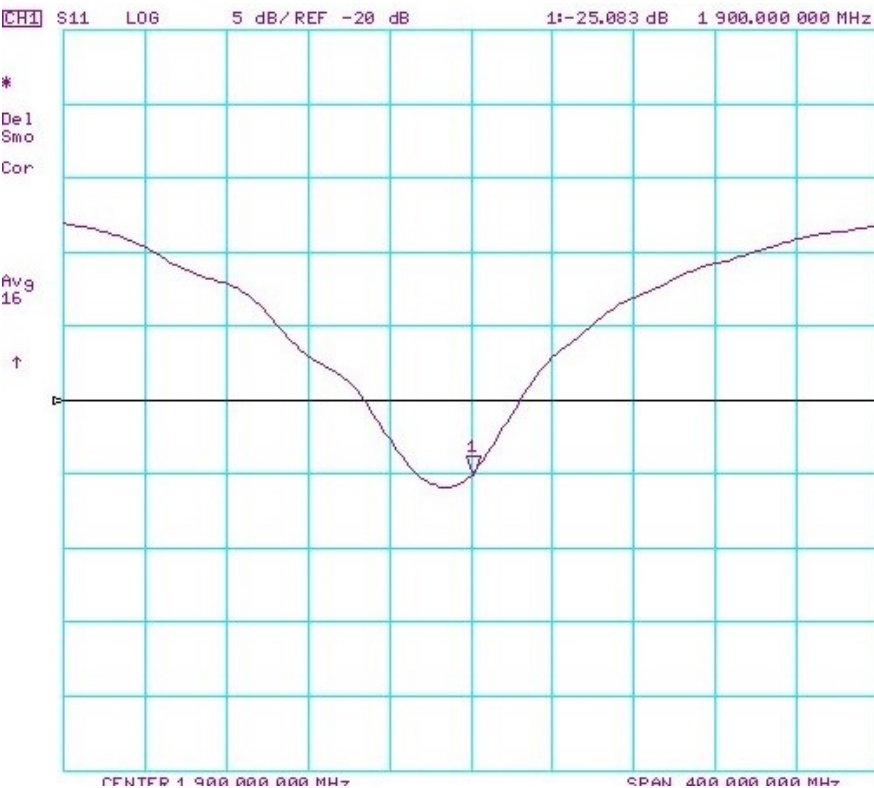
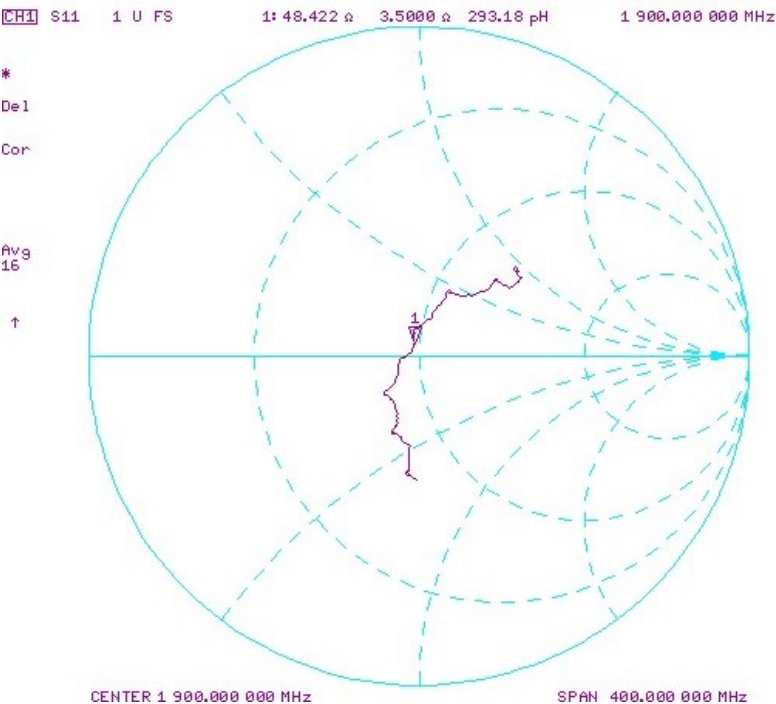
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/14/2018	5/14/2019	1.199	4.02	3.98	-1.00%	2.11	2.05	-2.84%	53	54.2	1.2	8	4.1	3.9	-21.6	-25.8	-19.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/14/2018	5/14/2019	1.199	3.99	3.97	-0.50%	2.12	2.04	-3.77%	47.1	46.4	1.3	7.4	3.5	3.9	-21.8	-25.1	-15.10%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2300V2-1038_Mar18**

CALIBRATION CERTIFICATE

Object **D2300V2 - SN:1038**

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

Calibration date: **March 07, 2018**

SC ✓
 3/21/18
 SC ✓
 4/25/19

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	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: 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** **Laboratory Technician**

Signature

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

Issued: March 9, 2018

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



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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	2300 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.5	1.67 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.6 $\pm$ 6 %	1.70 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	12.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	49.3 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	5.94 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 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	52.9	1.81 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.6 $\pm$ 6 %	1.86 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	11.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	46.7 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	5.69 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.5 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	47.8 Ω - 4.9 j Ω
Return Loss	- 25.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.9 Ω - 3.4 j Ω
Return Loss	- 25.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.170 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	July 02, 2013

DASY5 Validation Report for Head TSL

Date: 07.03.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1038

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used: $f = 2300$ MHz; $\sigma = 1.7$ S/m; $\epsilon_r = 38.6$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.08, 8.08, 8.08); 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:

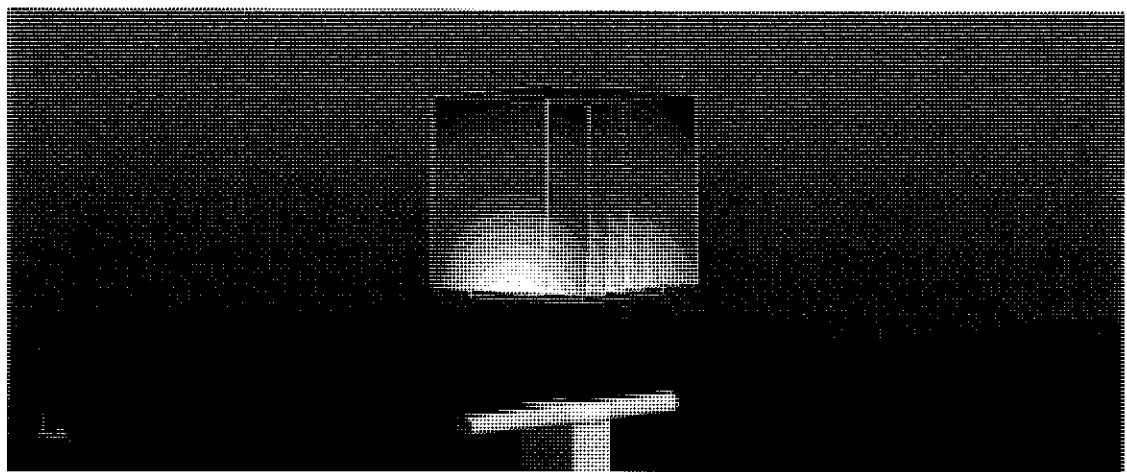
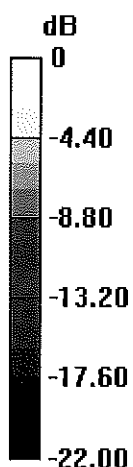
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.4 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 24.5 W/kg

SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.94 W/kg

Maximum value of SAR (measured) = 19.6 W/kg



0 dB = 19.6 W/kg = 12.92 dBW/kg

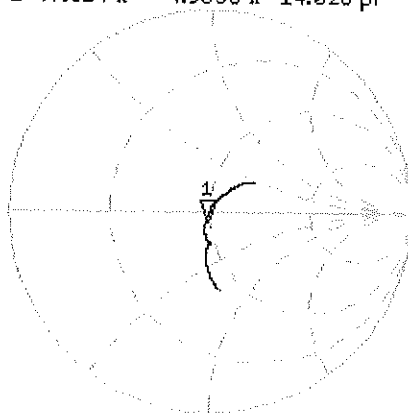
Impedance Measurement Plot for Head TSL

7 Mar 2018 13:16:07
 CH1 S11 1 U FS 1: 47.824 Ω -4.9336 Ω 14.026 pF 2 300.000 000 MHz

*
 Del
 Cor

Avg
 16

H1d

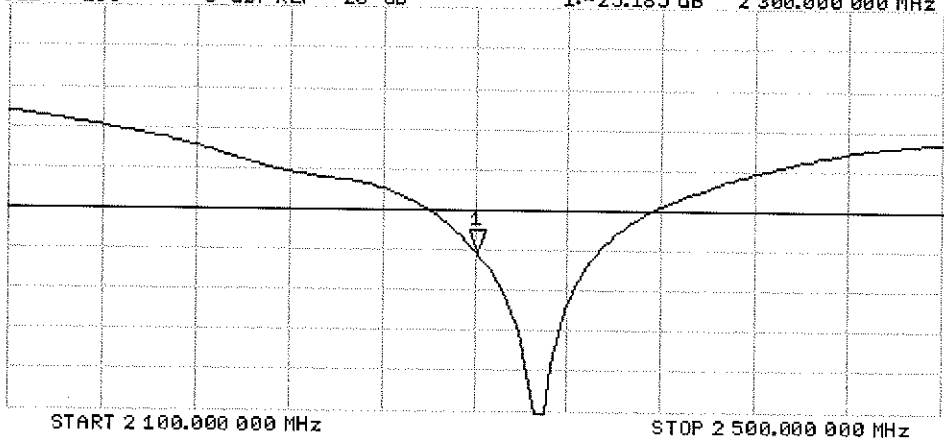


CH2 S11 LOG 5 dB/REF -20 dB 1:-25.185 dB 2 300.000 000 MHz

Cor

Avg
 16

H1d



START 2 100.000 000 MHz

STOP 2 250.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 07.03.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1038

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used: $f = 2300$ MHz; $\sigma = 1.86$ S/m; $\epsilon_r = 51.6$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.08, 8.08, 8.08); 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:

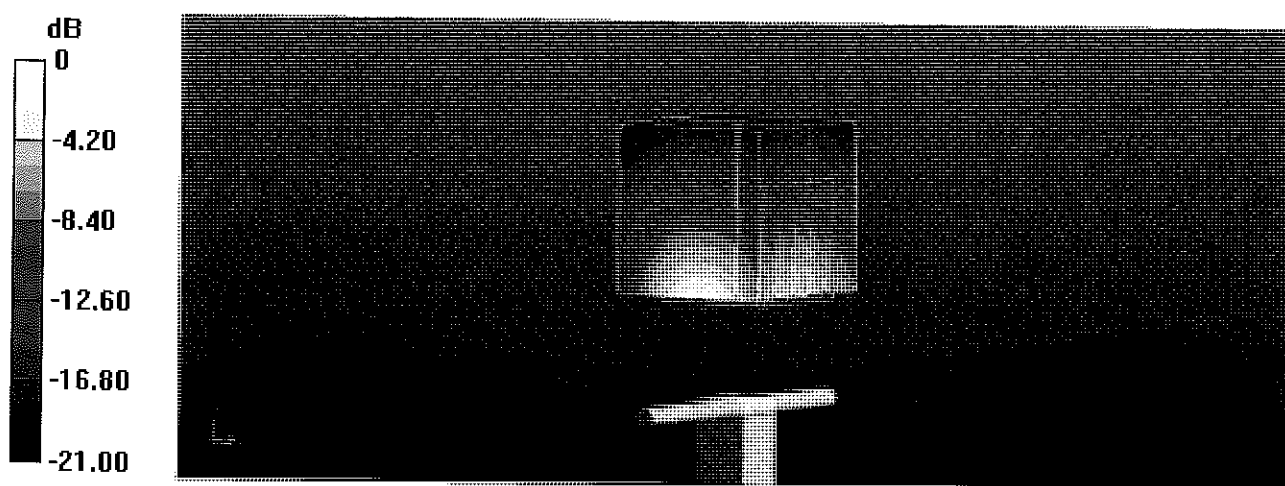
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.5 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 23.0 W/kg

SAR(1 g) = 11.9 W/kg; SAR(10 g) = 5.69 W/kg

Maximum value of SAR (measured) = 18.2 W/kg

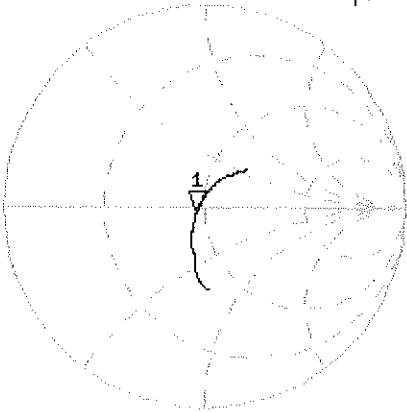


0 dB = 18.2 W/kg = 12.60 dBW/kg

Impedance Measurement Plot for Body TSL

7 Mar 2018 13:11:08
CH1 S11 1 U FS 1: 45.861 Ω -3.4160 Ω 20.257 pF 2 300.000 000 MHz

*
De1
Cor

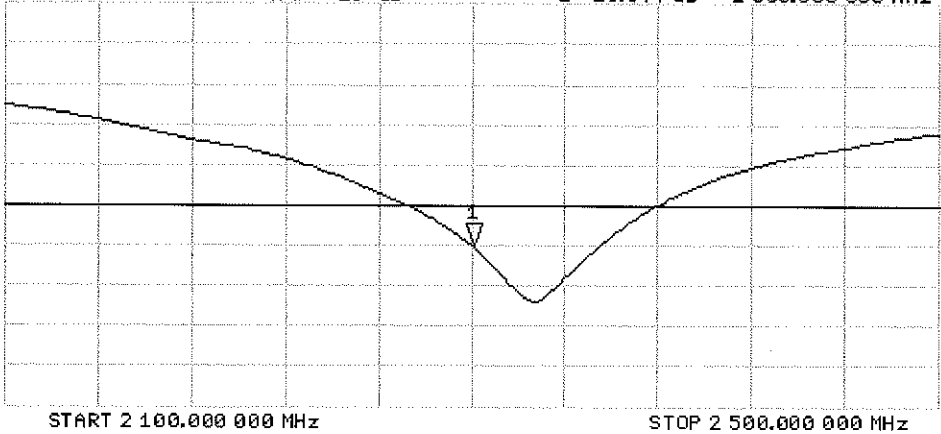


Avg
16
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-25.044 dB 2 300.000 000 MHz

Cor

Avg
16
H1d



Certification of Calibration

Object D2300V2 – SN: 1038

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

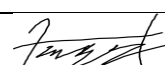
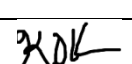
Extended Calibration date: February 25, 2019

Description: SAR Validation Dipole at 2300 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/15/2018	Annual	6/15/2019	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Anritsu	ML2496A	Power Meter	10/21/2018	Annual	10/21/2019	1138001
Control Company	4040	Therm./Clock/Humidity Monitor	3/31/2017	Biennial	3/31/2019	170232394
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Agilent	85033E	3.5mm Standard Calibration Kit	8/13/2018	Annual	8/13/2019	MY53402352
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Seekonk	NC-100	Torque Wrench	7/11/2018	Annual	7/11/2019	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/12/2018	Annual	4/12/2019	501
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/18/2018	Annual	10/18/2019	1364
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	4/12/2018	Annual	4/12/2019	3275
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7491

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Managing Director	

DIPOLE CALIBRATION EXTENSION

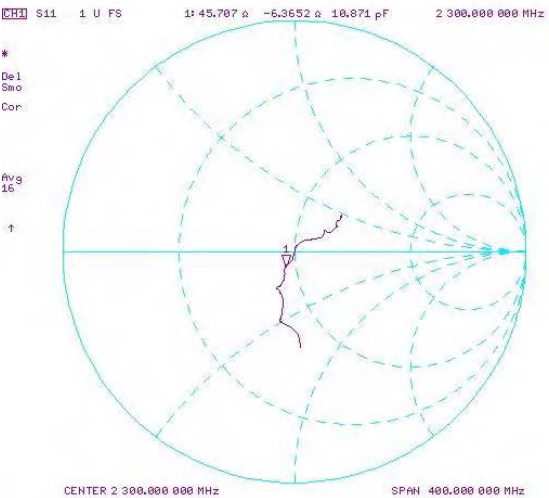
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

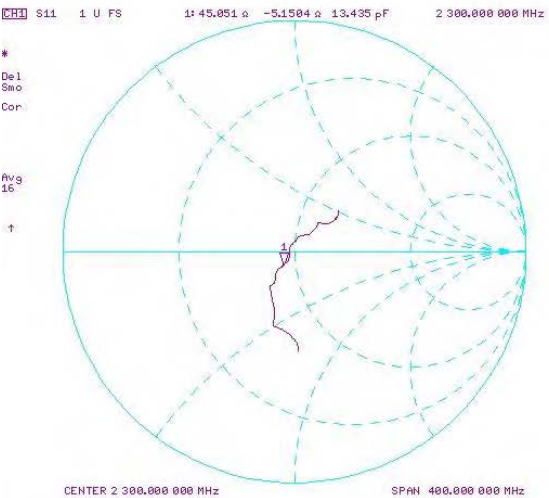
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
3/7/2018	2/25/2019	1.17	4.93	4.77	-3.25%	2.36	2.29	-2.97%	47.8	45.7	2.1	-4.9	-6.4	1.5	-25.2	-22.1	12.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
3/7/2018	2/25/2019	1.17	4.67	4.82	3.21%	2.25	2.27	0.89%	45.9	45.1	0.8	-3.4	-5.2	1.8	-25	-22.7	9.20%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **D2450V2-921 Nov18**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:921**

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

Calibration date: **November 12, 2018**

SC ✓
 12/11/2018
 BNV ✓
 12/31/2019

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-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	04-Oct-18 (No. DAE4-601_Oct18)	Oct-19
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

Calibrated by: **Manu Seitz** **Laboratory Technician**

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

Signature

Issued: November 12, 2018

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



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	V52.10.2
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 %	1.86 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.8 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 %	2.02 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.8 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	$54.7 \Omega + 6.5 j\Omega$
Return Loss	- 22.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$50.7 \Omega + 7.8 j\Omega$
Return Loss	- 22.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 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	September 26, 2013

DASY5 Validation Report for Head TSL

Date: 12.11.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:921

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.86$ 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) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

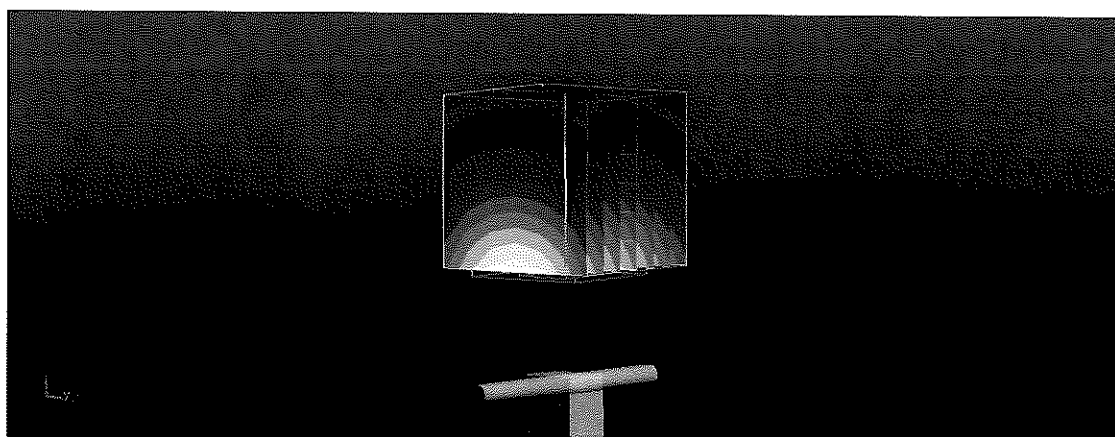
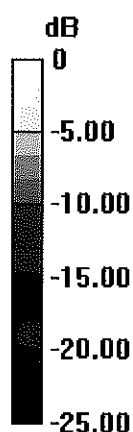
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 117.7 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 27.4 W/kg

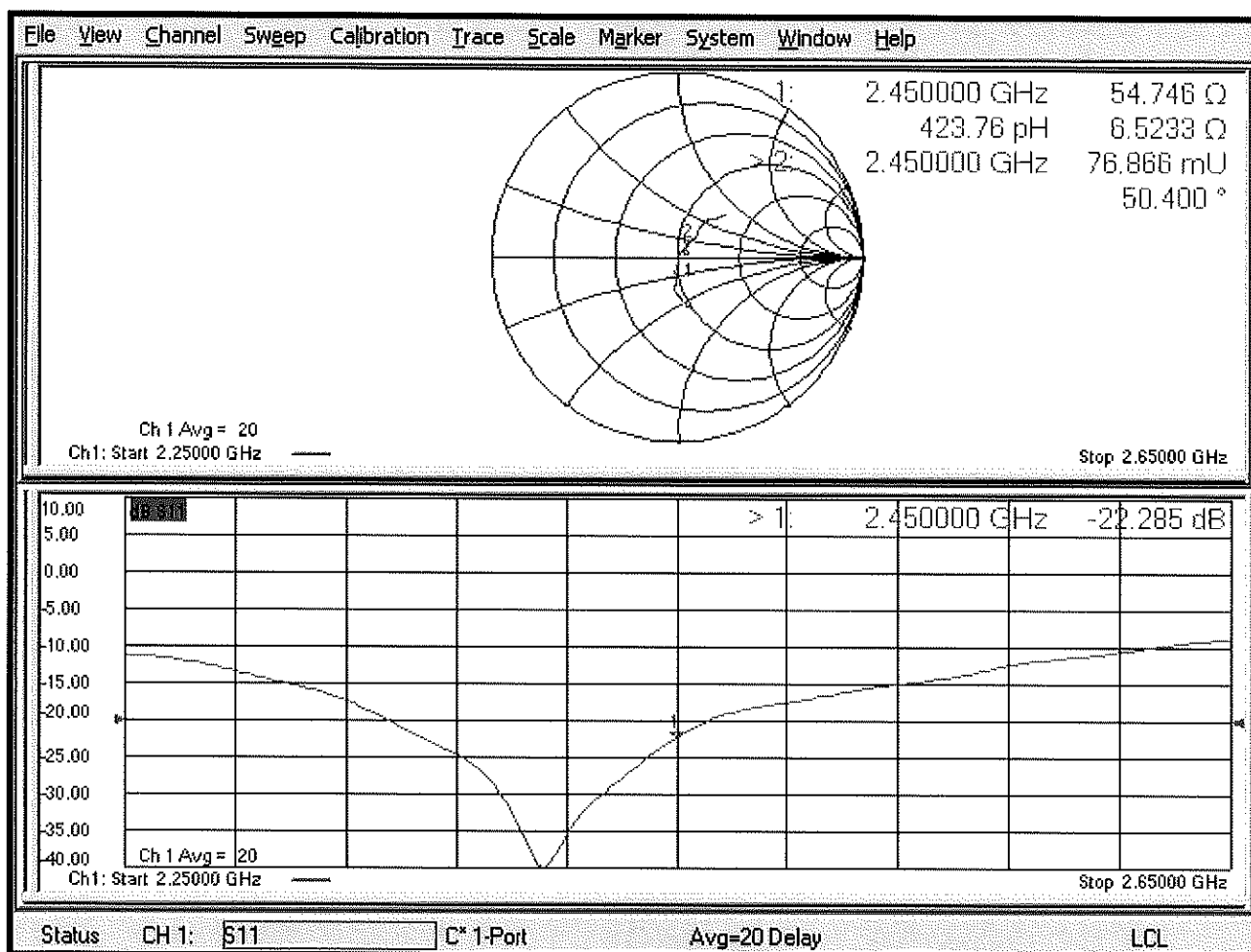
SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.28 W/kg

Maximum value of SAR (measured) = 22.4 W/kg



0 dB = 22.4 W/kg = 13.50 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 12.11.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:921

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ 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) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

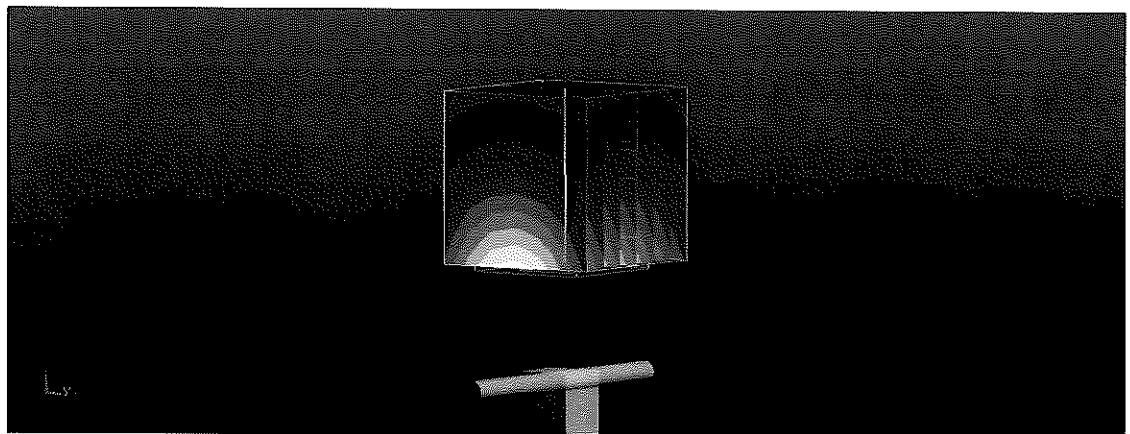
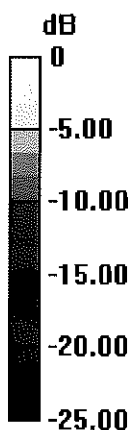
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 108.6 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 26.1 W/kg

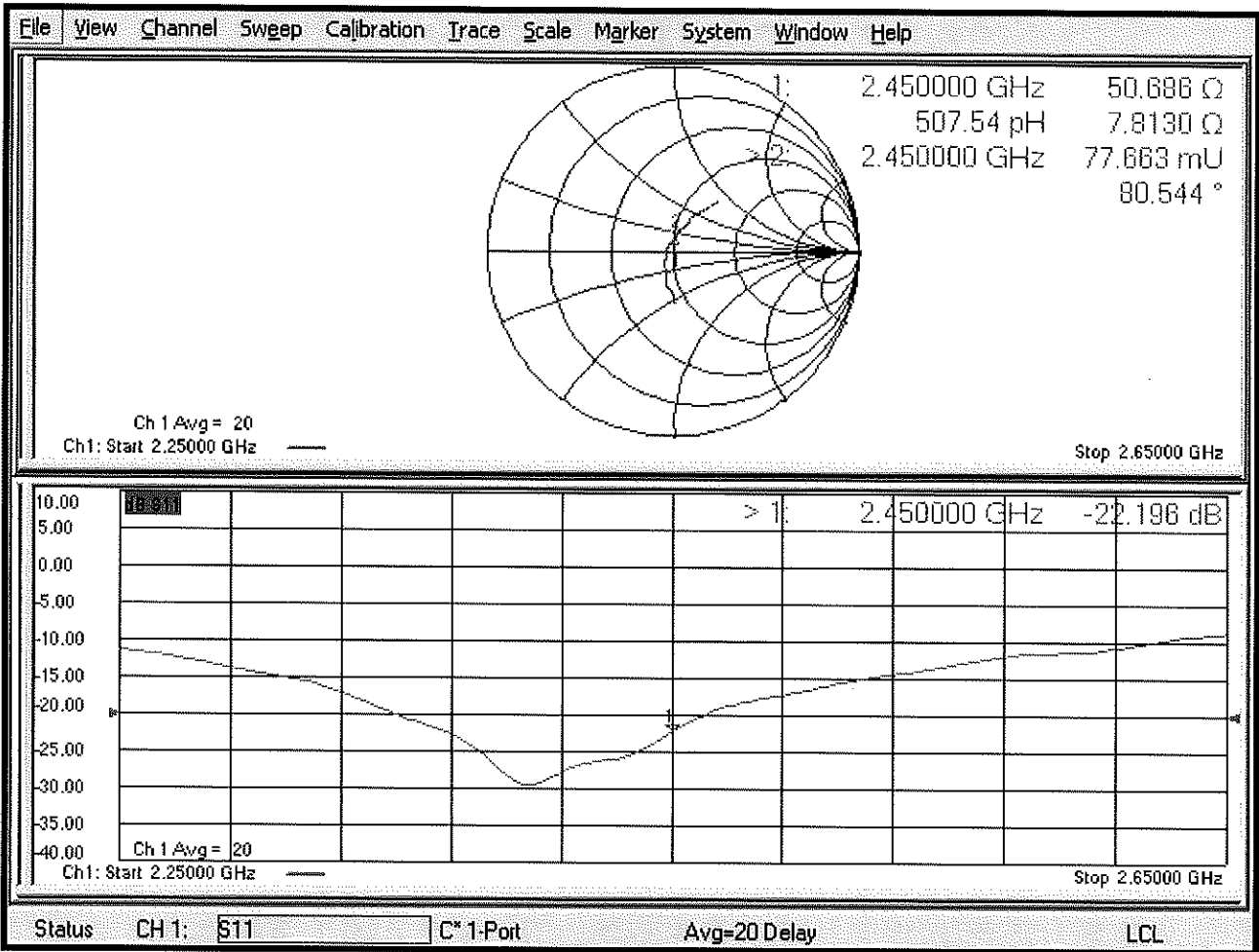
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.03 W/kg

Maximum value of SAR (measured) = 21.3 W/kg



0 dB = 21.3 W/kg = 13.28 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object: D2450V2 – SN: 921

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: November 11, 2019

Description: SAR Validation Dipole at 2450 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	8/26/2019	Annual	8/26/2020	MY40000670
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	11/20/2018	Annual	11/20/2019	1039008
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1027293
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Seekonk	NC-100	Torque Wrench	5/4/2018	Biennial	5/4/2020	22216
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

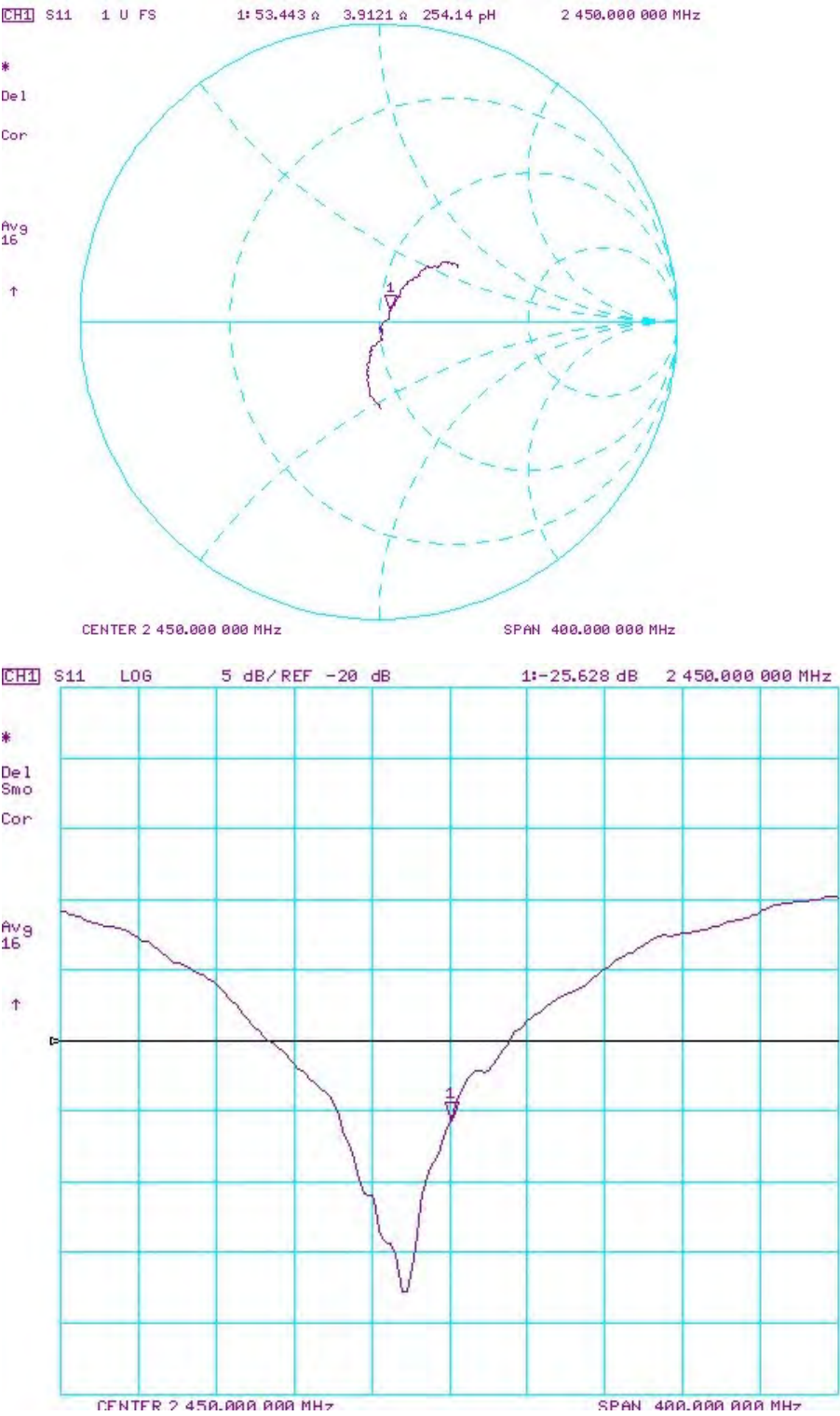
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

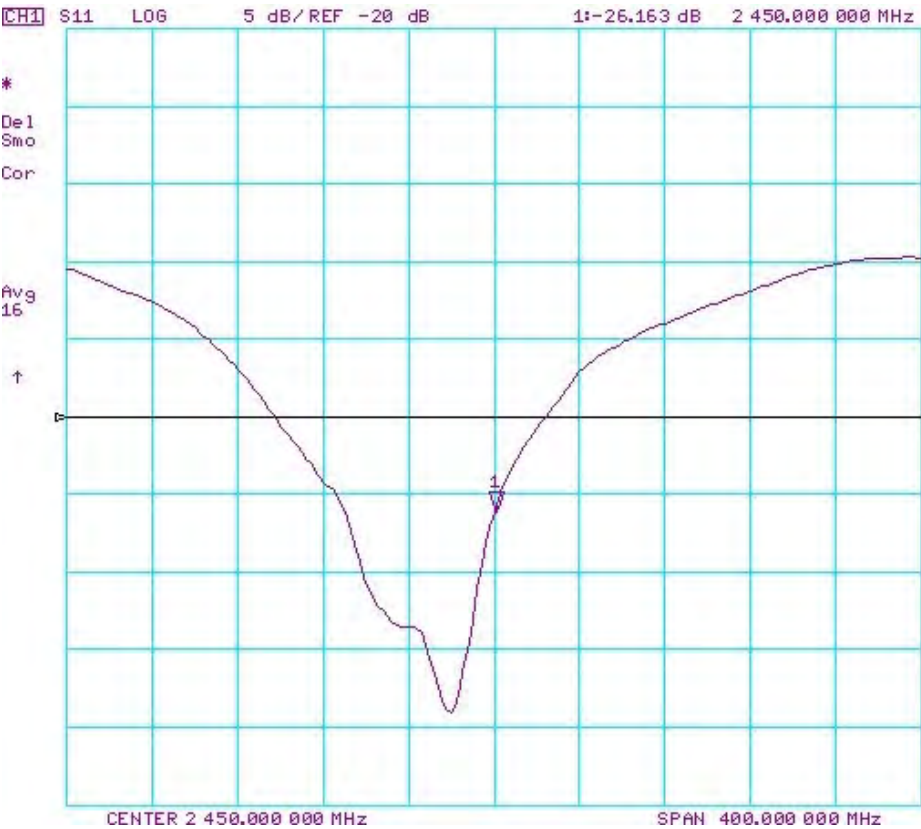
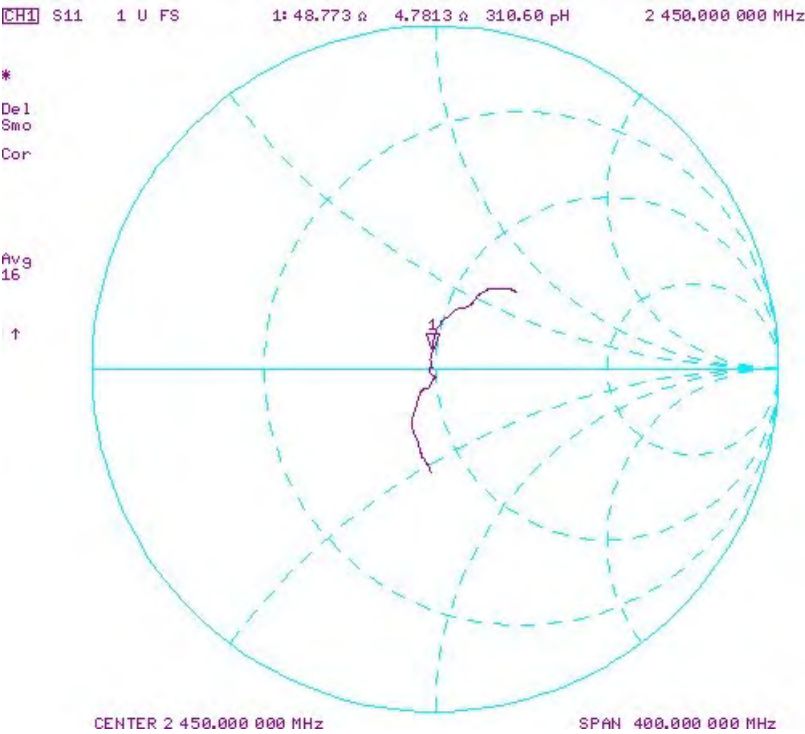
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
11/12/2018	11/11/2019	1.157	5.31	5.28	-0.56%	2.48	2.38	-4.03%	54.7	53.4	1.3	6.5	3.9	2.6	-22.3	-25.6	-14.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
11/12/2018	11/11/2019	1.157	5.08	5.41	6.50%	2.38	2.47	3.78%	50.7	48.8	1.9	7.8	4.8	3	-22.2	-26.2	-18.00%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **D2450V2-945_May18**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:945**

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

Calibration date: **May 16, 2018**

SCV
5/31/2018
BNV
06/01/2019

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-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
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: 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

	Name	Function	Signature
Calibrated by:	Manu Seltz	Laboratory Technician	<i>[Signature]</i>
Approved by:	Katja Pokovic	Technical Manager	<i>[Signature]</i>

Issued: May 17, 2018

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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	V52.10.1
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	38.2 $\pm$ 6 %	1.85 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.0 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 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	52.3 $\pm$ 6 %	1.99 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.83 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.2 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	$56.1 \Omega + 3.7 j\Omega$
Return Loss	- 23.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$51.9 \Omega + 5.0 j\Omega$
Return Loss	- 25.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 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 15, 2014

DASY5 Validation Report for Head TSL

Date: 16.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:945

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.85$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ 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) @ 2450 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

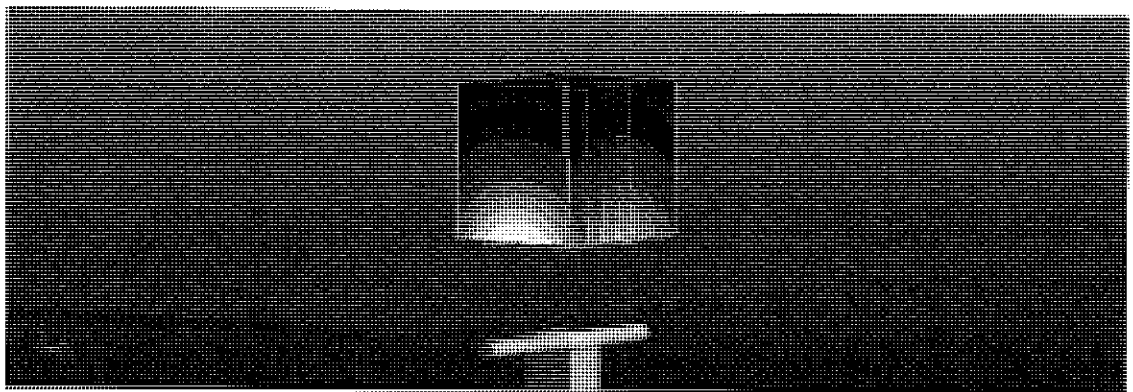
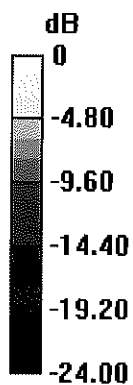
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 114.8 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 25.9 W/kg

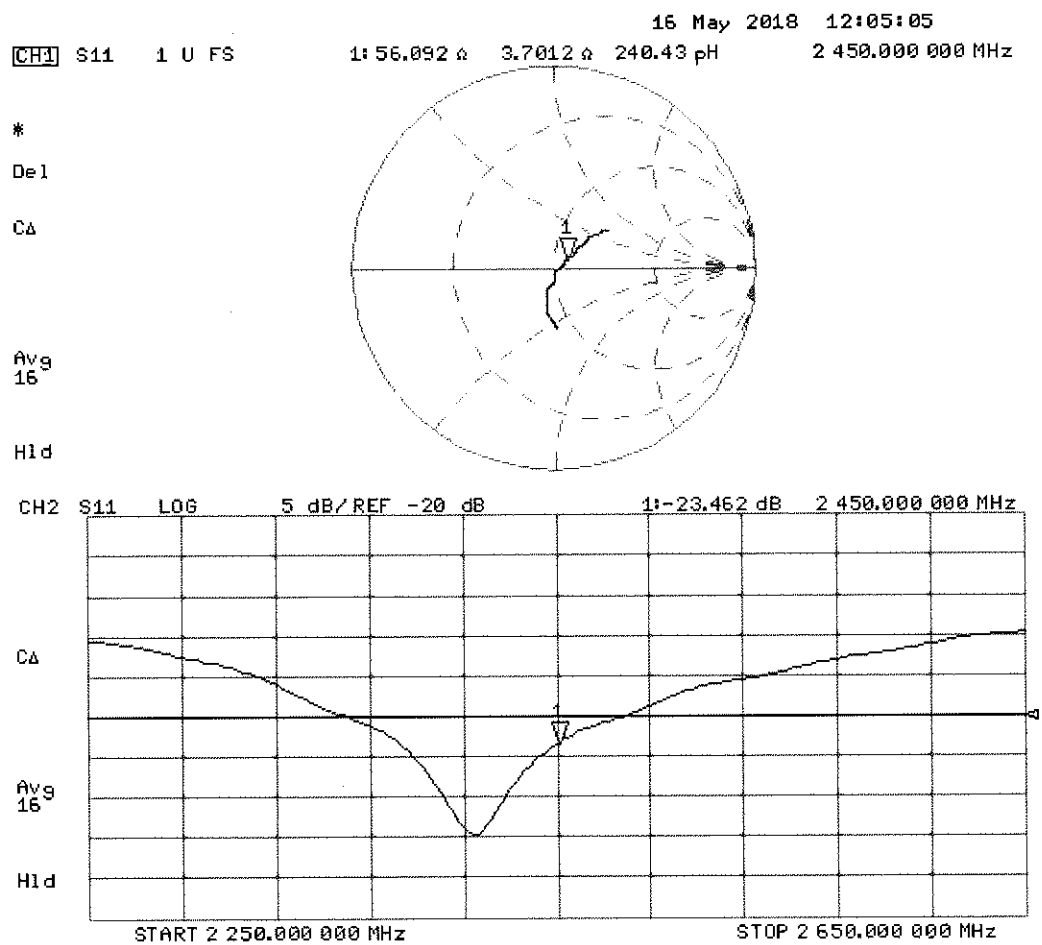
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.02 W/kg

Maximum value of SAR (measured) = 21.4 W/kg



0 dB = 21.4 W/kg = 13.30 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 16.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:945

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.99$ S/m; $\epsilon_r = 52.3$; $\rho = 1000$ 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) @ 2450 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

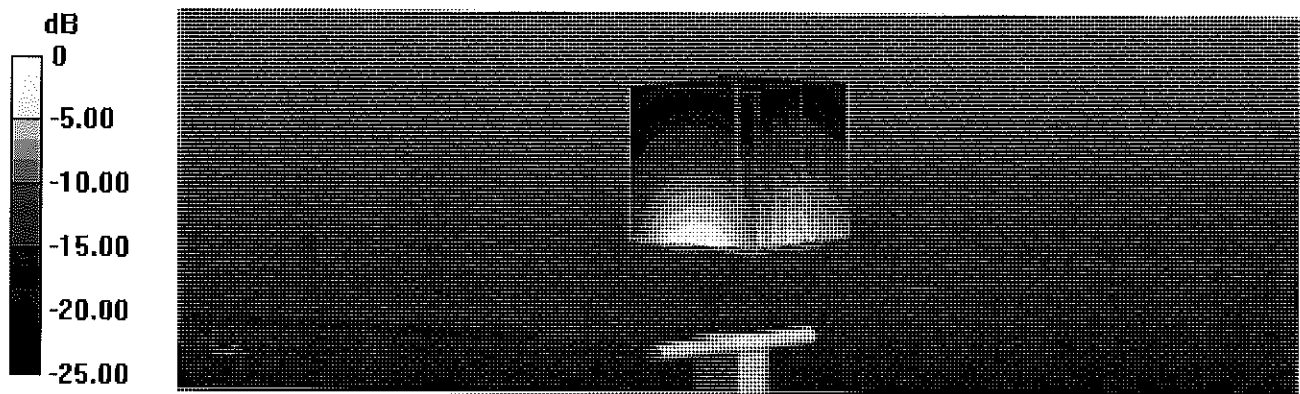
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.8 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 25.0 W/kg

SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.83 W/kg

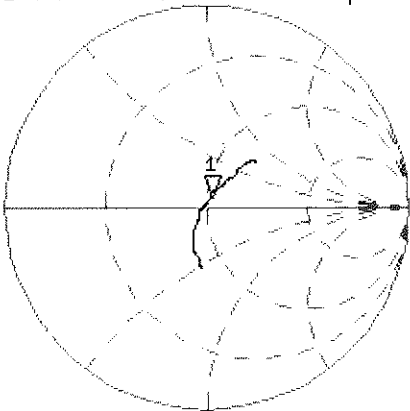
Maximum value of SAR (measured) = 20.2 W/kg



Impedance Measurement Plot for Body TSL

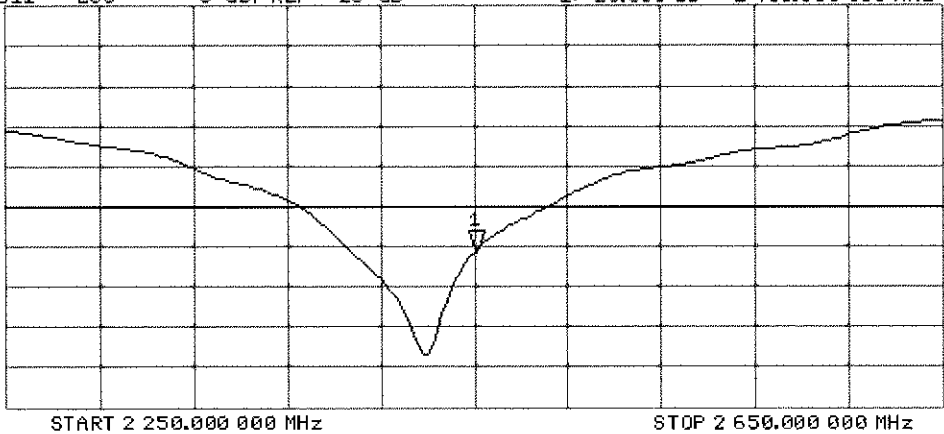
16 May 2018 12:03:43
[CH1] S11 1 U FS 1: 51.910 Ω 4.9629 Ω 322.40 μ H 2 450.000 000 MHz

*
De1
CA
Avg
16
H1d



CH2 S11 LOG 5 dB/REF -20 dB 1:-25.659 dB 2 450.000 000 MHz

CA
Avg
16
H1d



Certification of Calibration

Object D2450V2 – SN: 945

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: May 16, 2019

Description: SAR Validation Dipole at 2450 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/15/2018	Annual	6/15/2019	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	EX3DV4	SAR Probe	7/20/2018	Annual	7/20/2019	7416
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/10/2018	Annual	7/10/2019	1402

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

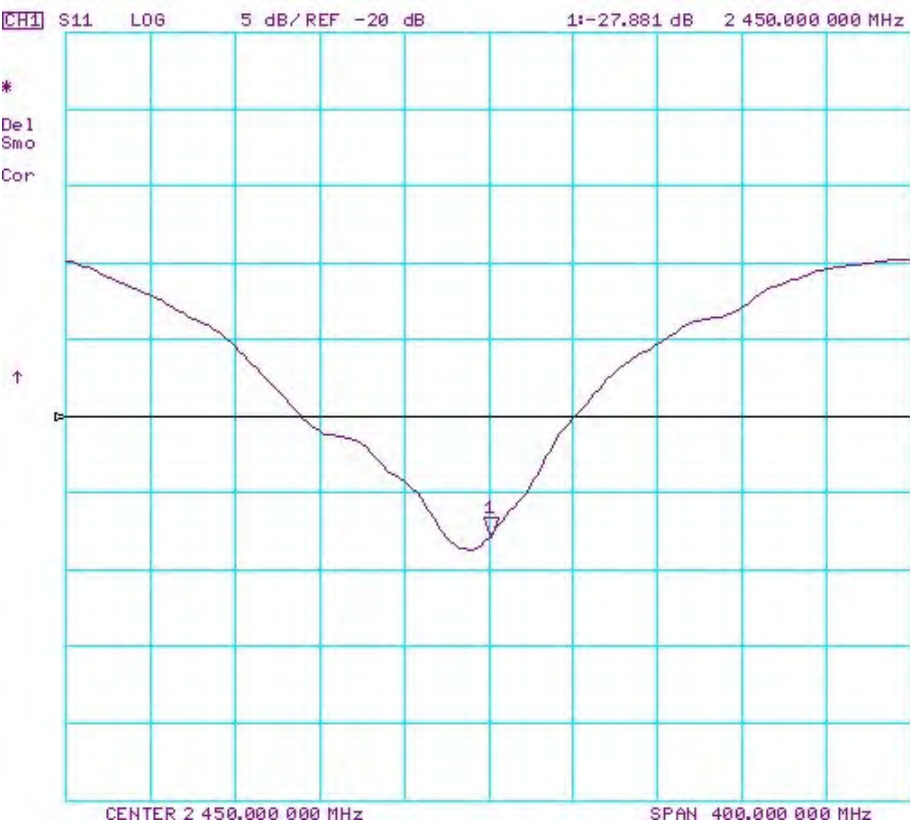
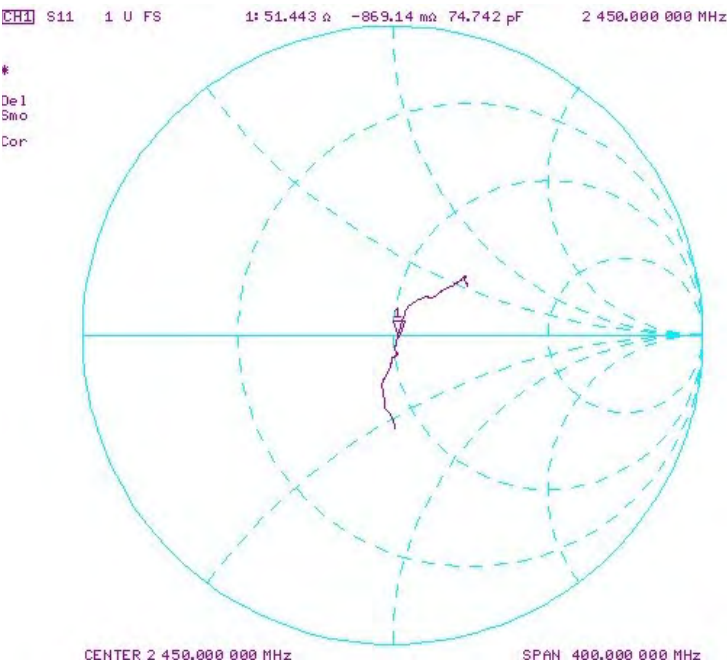
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

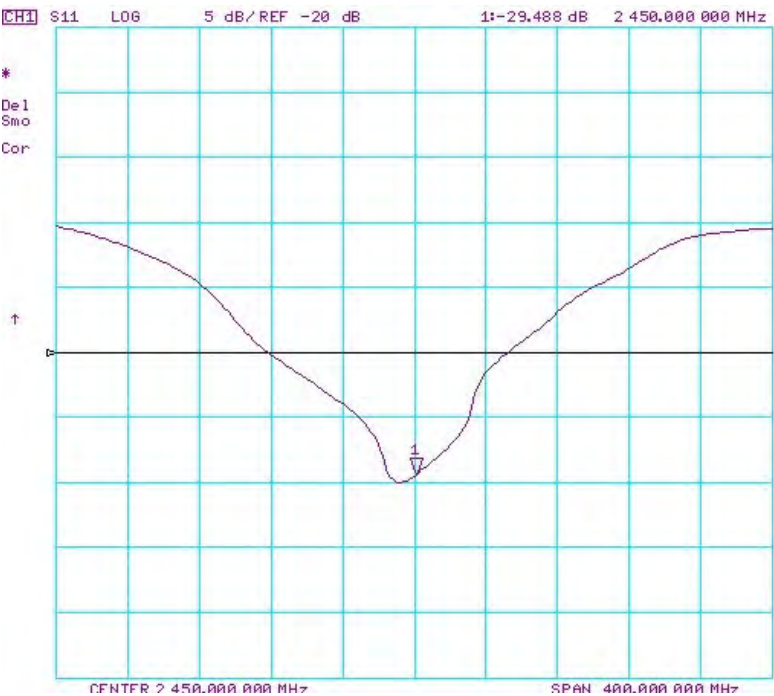
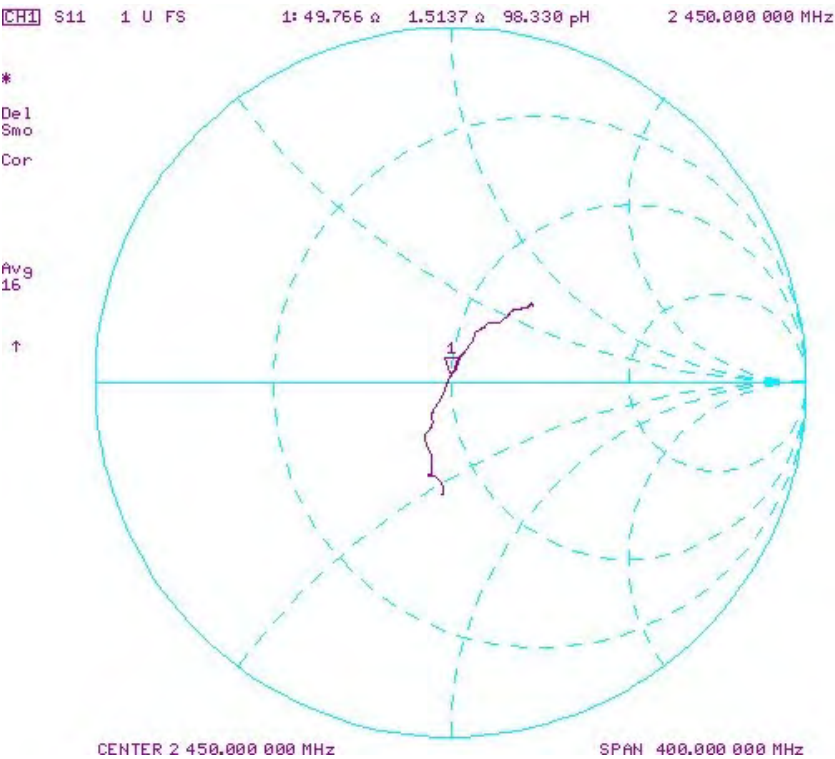
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5/16/2018	5/16/2019	1.157	5.1	5.23	3.73%	2.38	2.44	2.52%	56.1	51.4	4.7	3.7	-0.9	4.6	-23.5	-27.9	-18.60%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5/16/2018	5/16/2019	1.157	4.94	5.21	5.47%	2.32	2.38	2.59%	51.9	49.8	2.1	5	1.5	3.5	-25.7	-29.5	-14.70%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **D2600V2-1009 Jun18**

CALIBRATION CERTIFICATE

Object **D2600V2 - SN:1009**

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

Calibration date: **June 19, 2018**

SC ✓
 6/28/18

BN ✓
 7/01/18

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-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
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: 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** **Laboratory Technician**

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

Signature

Issued: June 21, 2018

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



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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	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.4 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	55.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.1 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	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.8 $\pm$ 6 %	2.22 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	14.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	55.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.31 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.0 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	49.8 Ω - 5.0 j Ω
Return Loss	- 26.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.3 Ω - 4.8 j Ω
Return Loss	- 22.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.153 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	April 12, 2007

DASY5 Validation Report for Head TSL

Date: 13.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 37.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.7, 7.7, 7.7) @ 2600 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

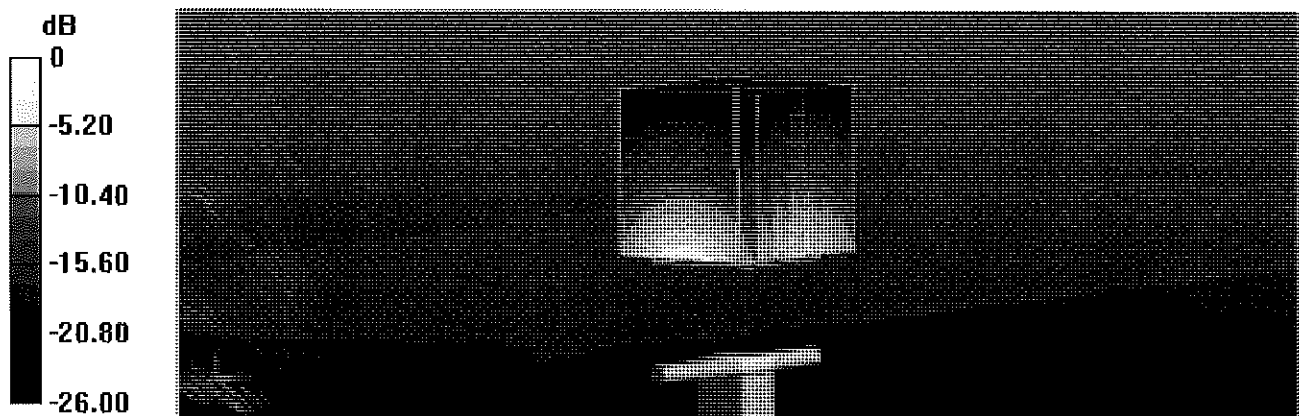
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 117.9 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 28.4 W/kg

SAR(1 g) = 14.3 W/kg; SAR(10 g) = 6.38 W/kg

Maximum value of SAR (measured) = 23.7 W/kg



0 dB = 23.7 W/kg = 13.75 dBW/kg

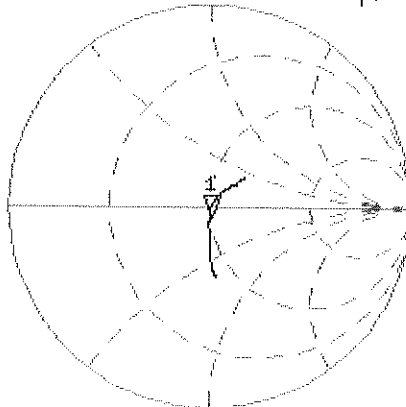
Impedance Measurement Plot for Head TSL

13 Jun 2018 12:15:33
 CH1 S11 1 U FS 1: 49.844 Ω -4.9863 Ω 12.276 pF 2 500.000 000 MHz

*
 Del
 CA

Avg
 16

H1d

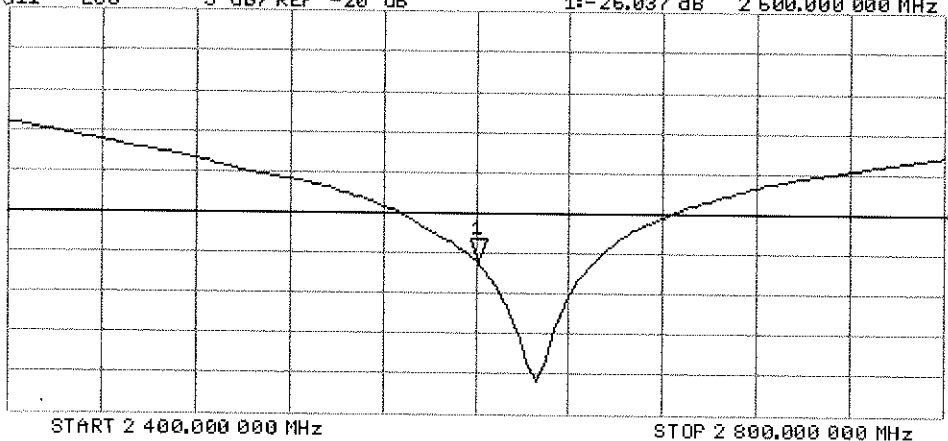


CH2 S11 LOG 5 dB/REF -20 dB 1: -26.037 dB 2 500.000 000 MHz

CA

Avg
 16

H1d



DASY5 Validation Report for Body TSL

Date: 19.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.22$ S/m; $\epsilon_r = 51.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.81, 7.81, 7.81) @ 2600 MHz; 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 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

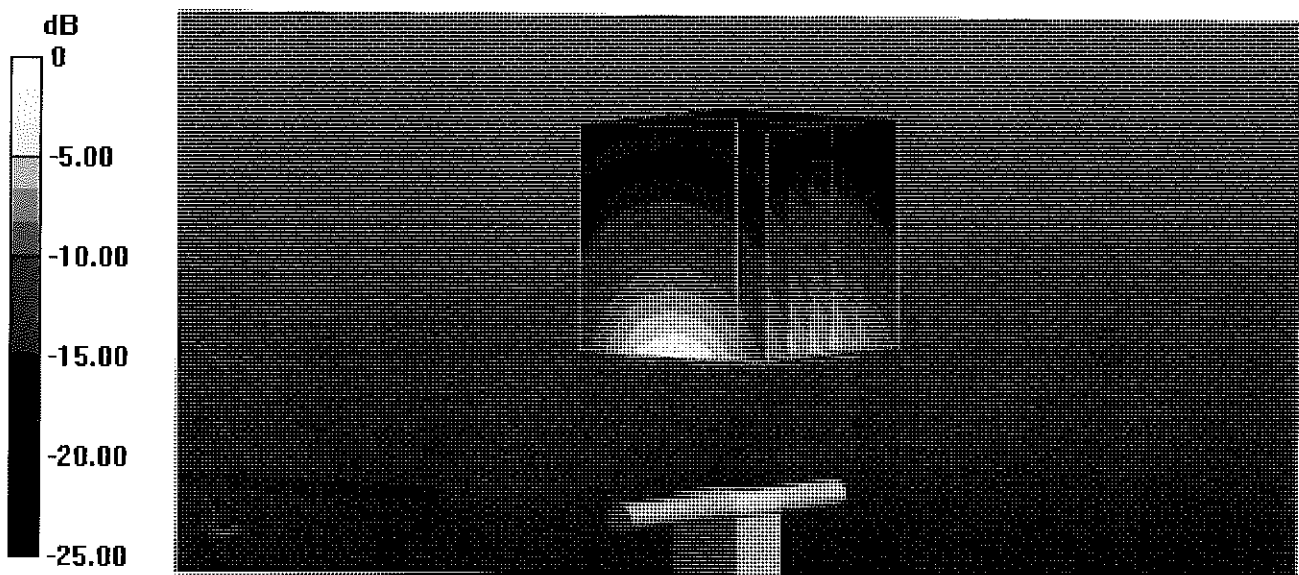
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 109.4 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 28.7 W/kg

SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.31 W/kg

Maximum value of SAR (measured) = 23.7 W/kg

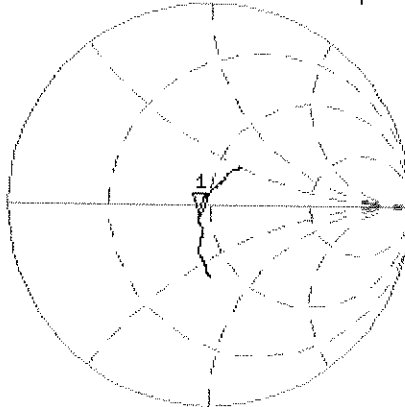


0 dB = 23.7 W/kg = 13.75 dBW/kg

Impedance Measurement Plot for Body TSL

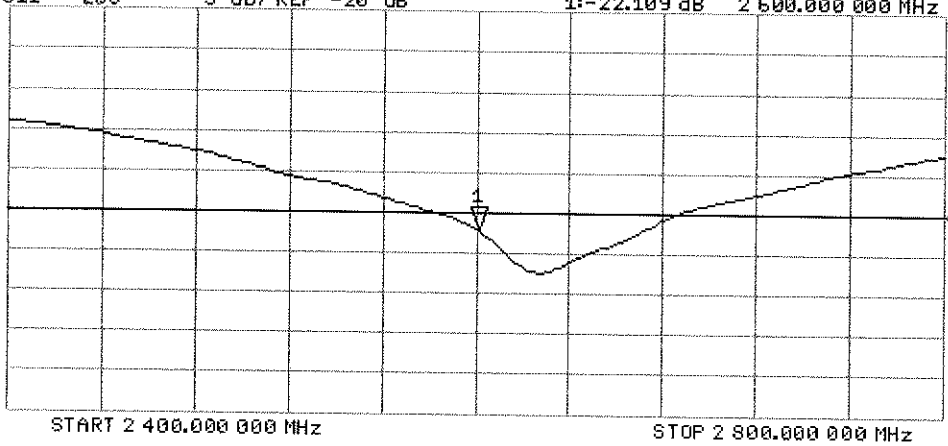
19 Jun 2018 10:04:18
 CH1 S11 1 U FS 1: 44.344 Ω -4.7832 Ω 12.798 pF 2 500.000 000 MHz

*
 Del
 CA
 Avg
 16
 H1d



CH2 S11 LOG 5 dB/REF -20 dB 1:-22.109 dB 2 500.000 000 MHz

CA
 Avg
 16
 H1d



Certification of Calibration

Object D2600V2 – SN: 1009

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: June 19, 2019

Description: SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/26/2018	Annual	6/26/2019	MY42081752
Agilent	85033E	3.5mm Standard Calibration Kit	8/13/2018	Annual	8/13/2019	MY53402352
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAKS-3.5	Portable DAK	9/11/2018	Annual	9/11/2019	1045
SPEAG	ES3DV3	SAR Probe	11/19/2018	Annual	11/19/2019	3318
SPEAG	EX3DV4	E-field Probes	2/19/2019	Annual	2/19/2020	7427
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/14/2018	Annual	8/14/2019	1408
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/13/2019	Annual	2/13/2020	1403

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

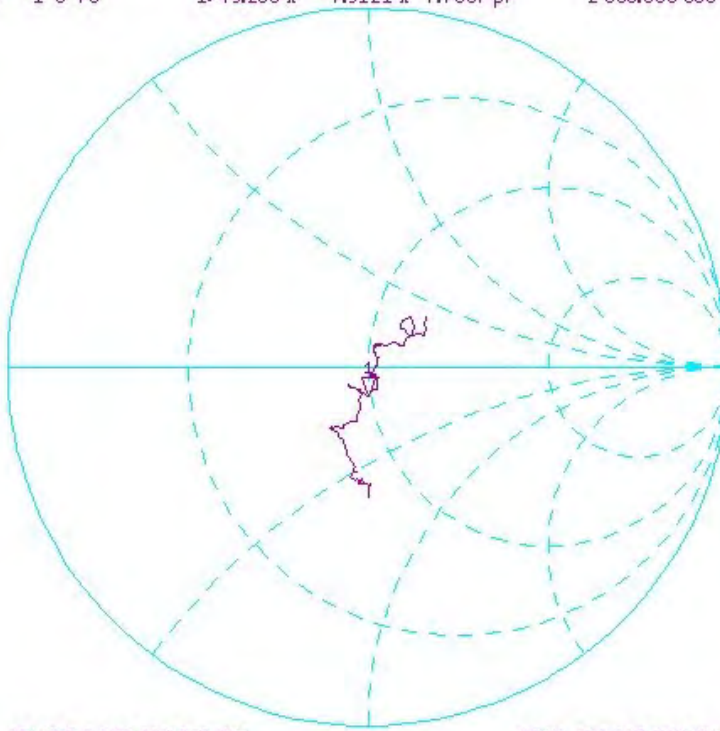
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
6/19/2018	6/19/2019	1.153	5.58	5.87	5.20%	2.51	2.61	3.99%	49.8	49.3	0.5	-5	-7.9	2.9	-26	-23.2	10.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/19/2018	6/19/2019	1.153	5.55	5.39	-2.88%	2.5	2.39	-4.40%	44.3	46.7	2.3	-4.8	-5.3	0.5	-22.1	-24.1	-8.90%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL

CH1 S11 1 U FS 1: 49.258 Ω -7.9121 Ω 7.7367 pF 2 600.000 000 MHz

*
De1
Cor
Avg
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↑

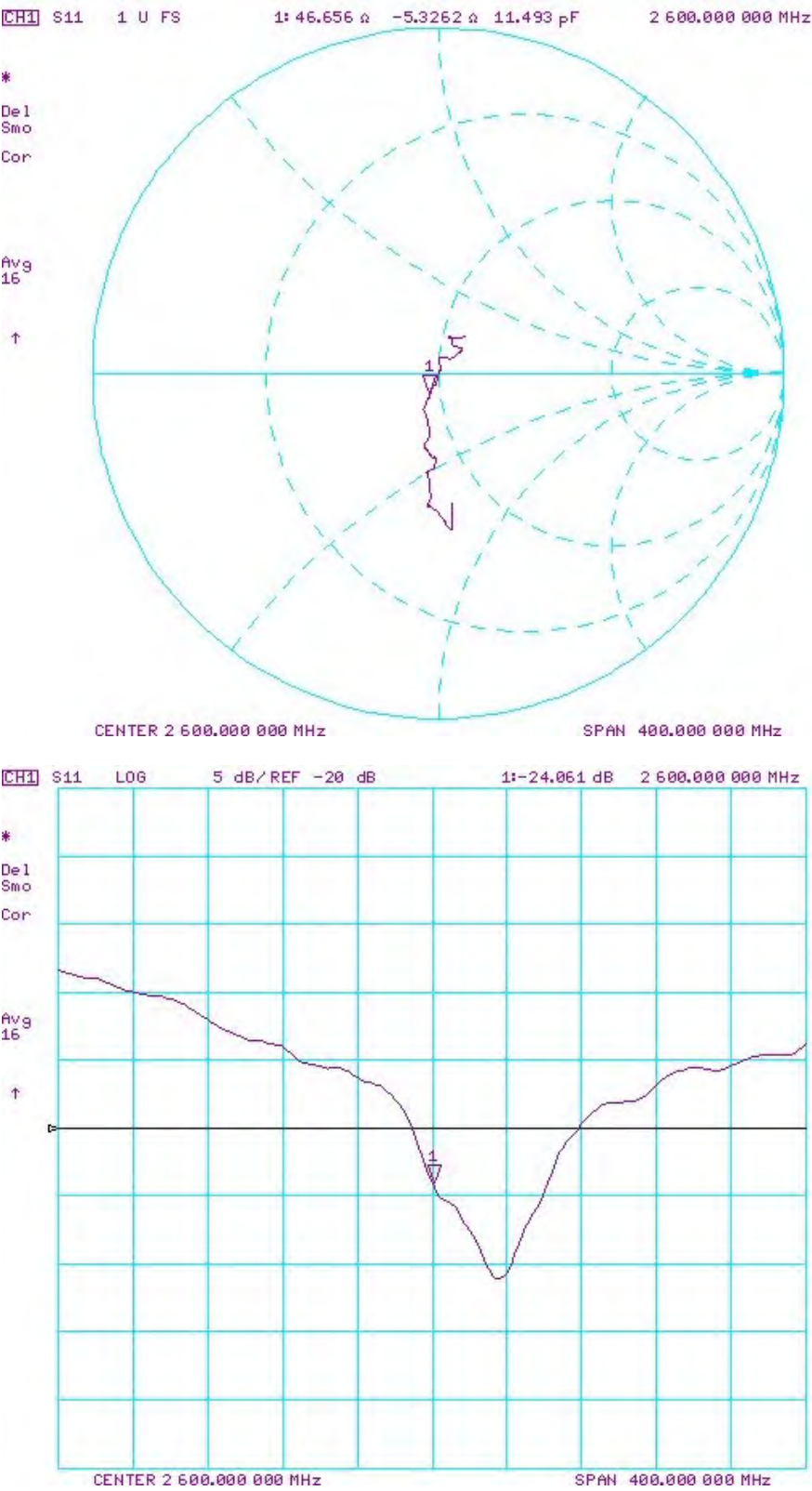


CH1 S11 LOG 5 dB/REF -20 dB 1: -23.218 dB 2 600.000 000 MHz

*
De1
Smo
Cor
Avg
12
↑



Impedance & Return-Loss 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

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2600V2-1069_Sep17**

CALIBRATION CERTIFICATE

Object **D2600V2 - SN:1069**

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

SCV
10/03/2017

Calibration date: **September 11, 2017**

SCV
9/10/2018

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.

BNV
10/10/2019

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 / 06927	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	28-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: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

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

Signature

M. Weber

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

K. Pokovic

Issued: September 11, 2017

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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	2600 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.2 $\pm$ 6 %	2.03 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	14.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	56.9 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	6.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.4 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	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.4 $\pm$ 6 %	2.23 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	14.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	55.3 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	6.26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.8 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	49.1 Ω - 6.1 j Ω
Return Loss	- 24.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.2 Ω - 4.7 j Ω
Return Loss	- 24.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.152 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	July 17, 2013

DASY5 Validation Report for Head TSL

Date: 11.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1069

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 37.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- 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:

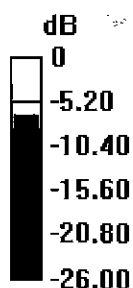
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 115.4 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 31.2 W/kg

SAR(1 g) = 14.6 W/kg; SAR(10 g) = 6.45 W/kg

Maximum value of SAR (measured) = 24.5 W/kg



0 dB = 24.5 W/kg = 13.89 dBW/kg

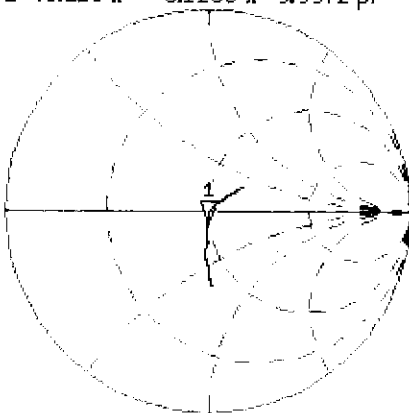
Impedance Measurement Plot for Head TSL

11 Sep 2017 12:04:09
 [CH1] S11 1 U FS 1: 49.115 Ω -6.1230 Ω 9.9972 pF 2 600.000 000 MHz

*
 Del
 CA

Avg
 16

H1d

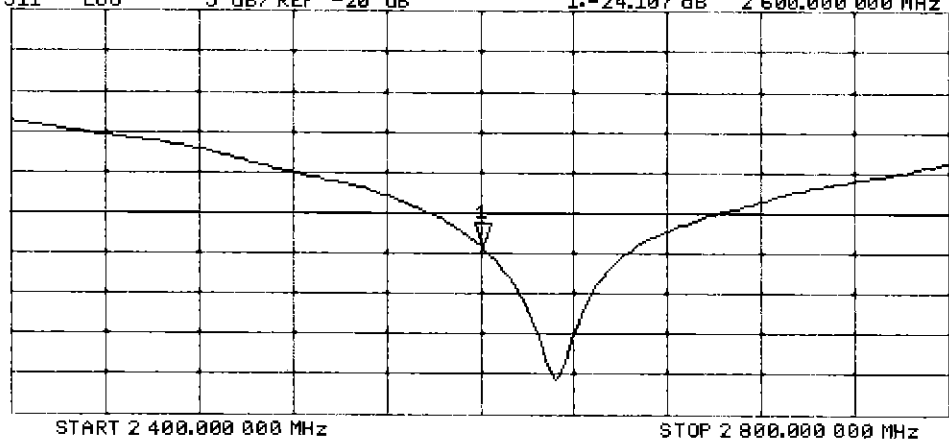


CH2 S11 LOG 5 dB/REF -20 dB 1:-24.107 dB 2 600.000 000 MHz

CA

Avg
 16

H1d



START 2 400.000 000 MHz

STOP 2 800.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 11.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1069

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.23$ 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(7.94, 7.94, 7.94); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- 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:

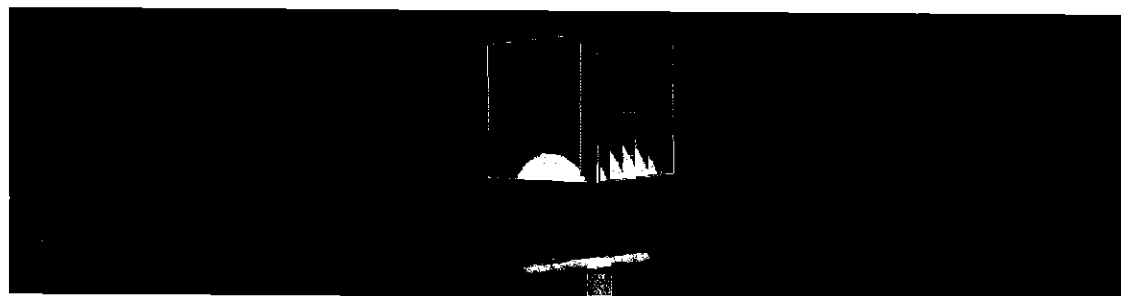
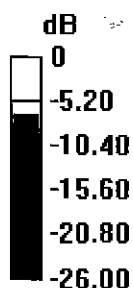
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.7 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.26 W/kg

Maximum value of SAR (measured) = 22.9 W/kg

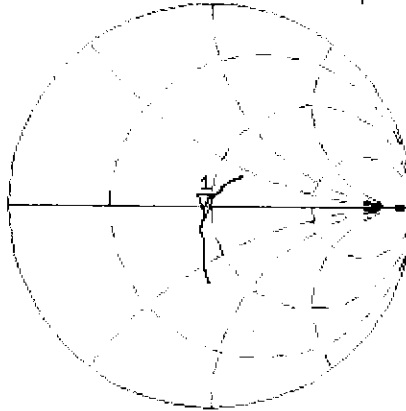


0 dB = 22.9 W/kg = 13.60 dBW/kg

Impedance Measurement Plot for Body TSL

11 Sep 2017 12:03:28
 CH1 S11 1 U FS 1: 46.244 Ω -4.7051 Ω 13.010 pF 2 600.000 000 MHz

*
 Del
 CA



Avg
 16

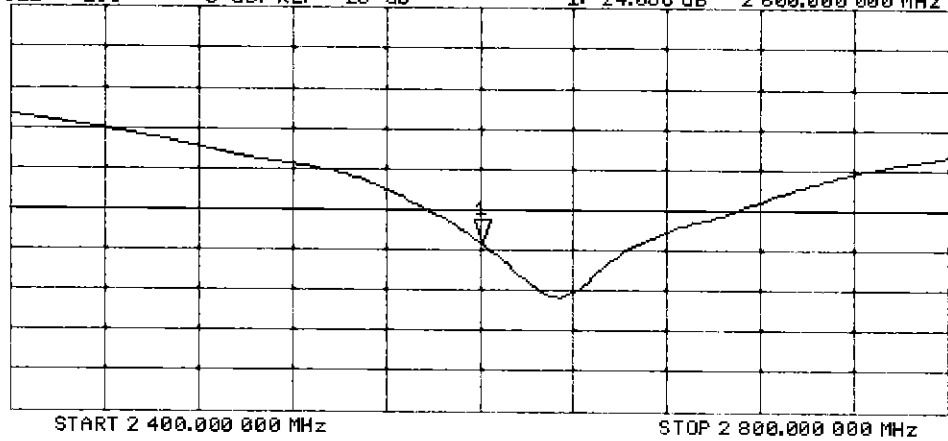
H1d

CH2 S11 L06 5 dB/REF -20 dB 1:-24.086 dB 2 600.000 000 MHz

CA

Avg
 16

H1d



Certification of Calibration

Object D2600V2 – SN: 1069

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

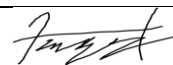
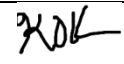
Extended Calibration date: September 10, 2018

Description: SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	9/14/2017	Annual	9/14/2018	US39170118
Agilent	N5182A	MXG Vector Signal Generator	3/19/2018	Annual	3/19/2019	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2496A	Power Meter	10/9/2017	Annual	10/9/2018	1138001
Anritsu	MA2411B	Pulse Power Sensor	11/15/2017	Annual	11/15/2018	1339007
Anritsu	MA2411B	Pulse Power Sensor	11/22/2017	Annual	11/22/2018	1339008
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/14/2017	Biennial	2/14/2019	170112507
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	PE5011-1	Torque Wrench	7/19/2017	Biennial	7/19/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/15/2018	Annual	5/15/2019	1070
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287
SPEAG	DAE4	Data Acquisition Electronics	1/26/2018	Annual	1/26/2019	1533
SPEAG	ES3DV3	SAR Probe	4/12/2018	Annual	4/12/2019	3275
SPEAG	DAE4	Dasy Data Acquisition Electronics	4/12/2018	Annual	4/12/2019	501

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Sangmin Cha	Team Lead Engineer	
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	

DIPOLE CALIBRATION EXTENSION

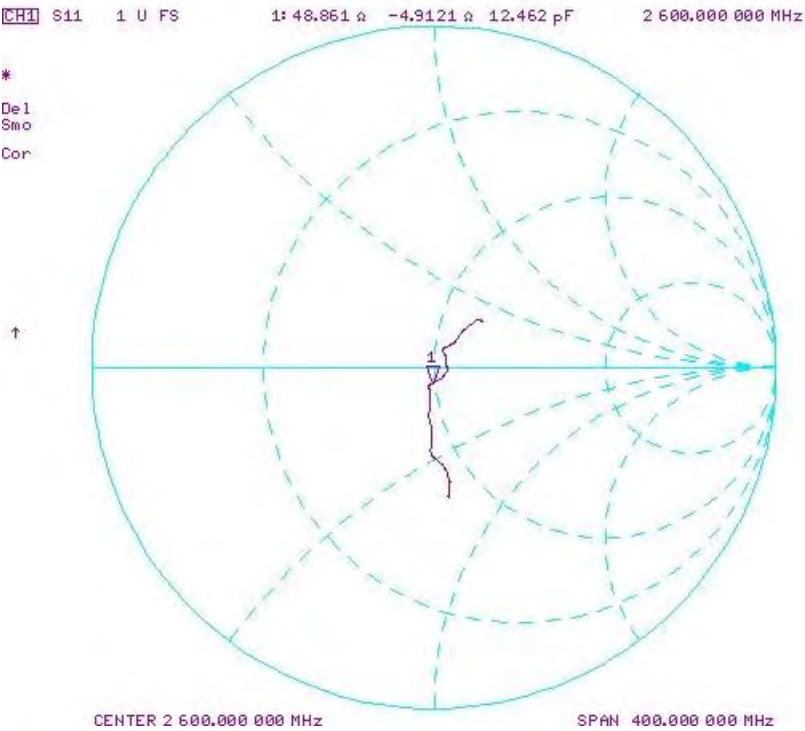
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

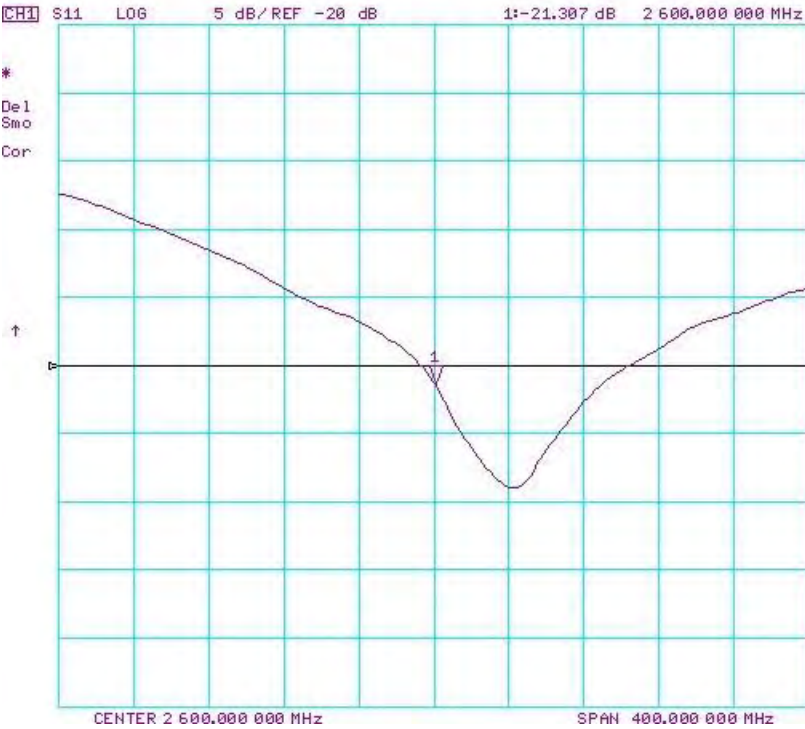
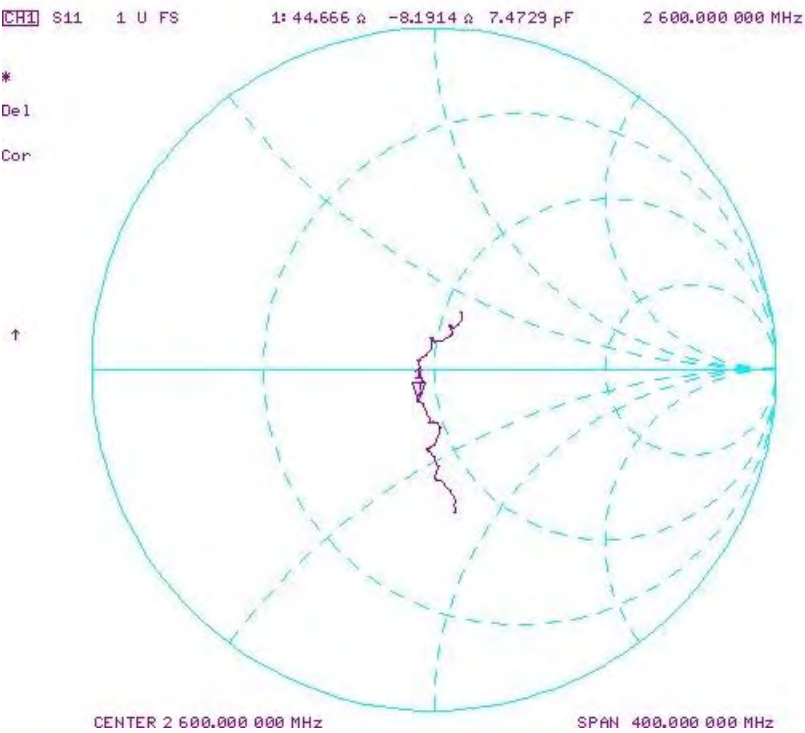
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/11/2017	9/10/2018	1.152	5.69	5.52	-2.99%	2.54	2.51	-1.18%	49.1	48.9	0.2	-6.1	-4.9	1.2	-24.1	-25.8	-7.10%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/11/2017	9/10/2018	1.152	5.53	5.28	-4.52%	2.48	2.35	-5.24%	46.2	44.7	1.5	-4.7	-8.2	3.5	-24.1	-21.3	11.60%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL



Certification of Calibration

Object D2600V2 – SN: 1069

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 9, 2019

Description: SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	1/24/2019	Annual	1/24/2020	7490
SPEAG	DAE4	Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	1532

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

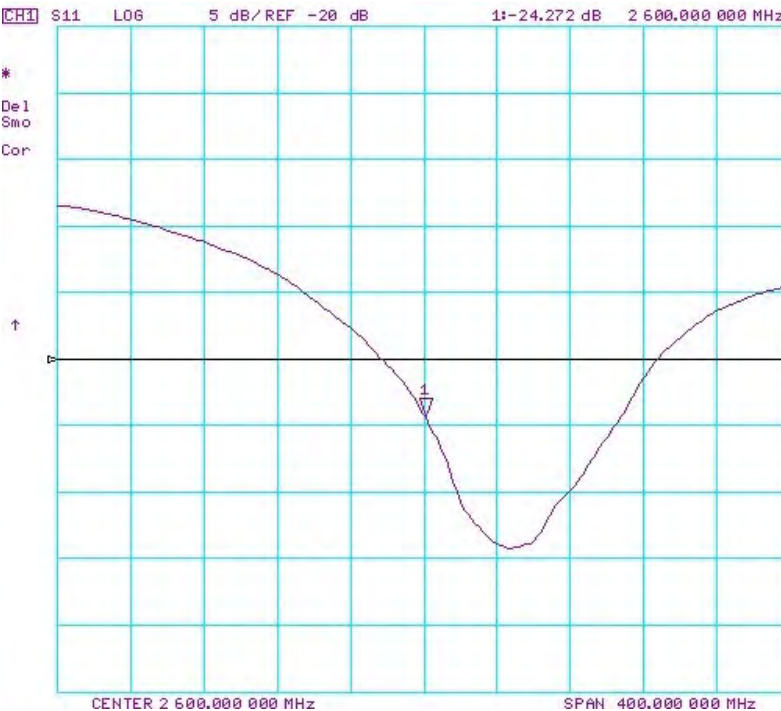
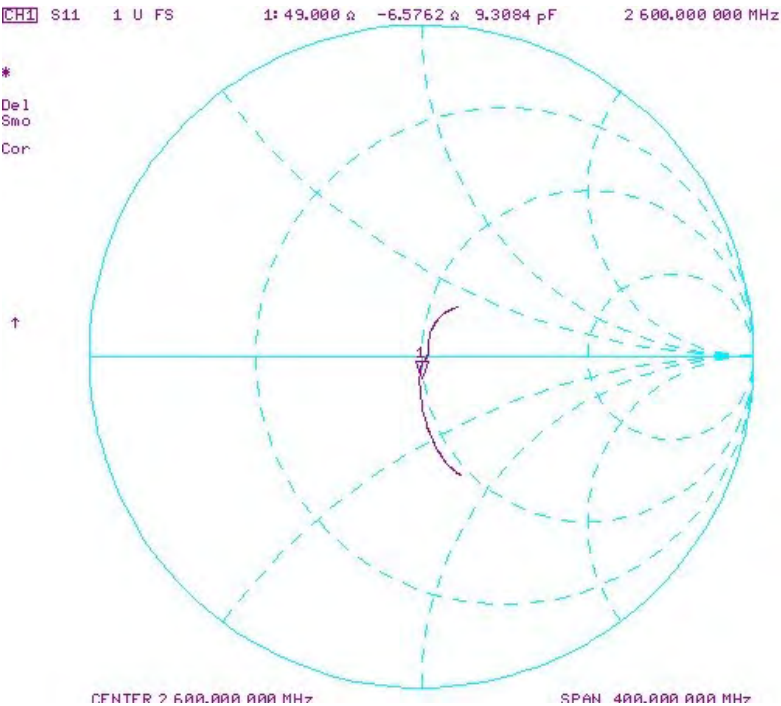
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

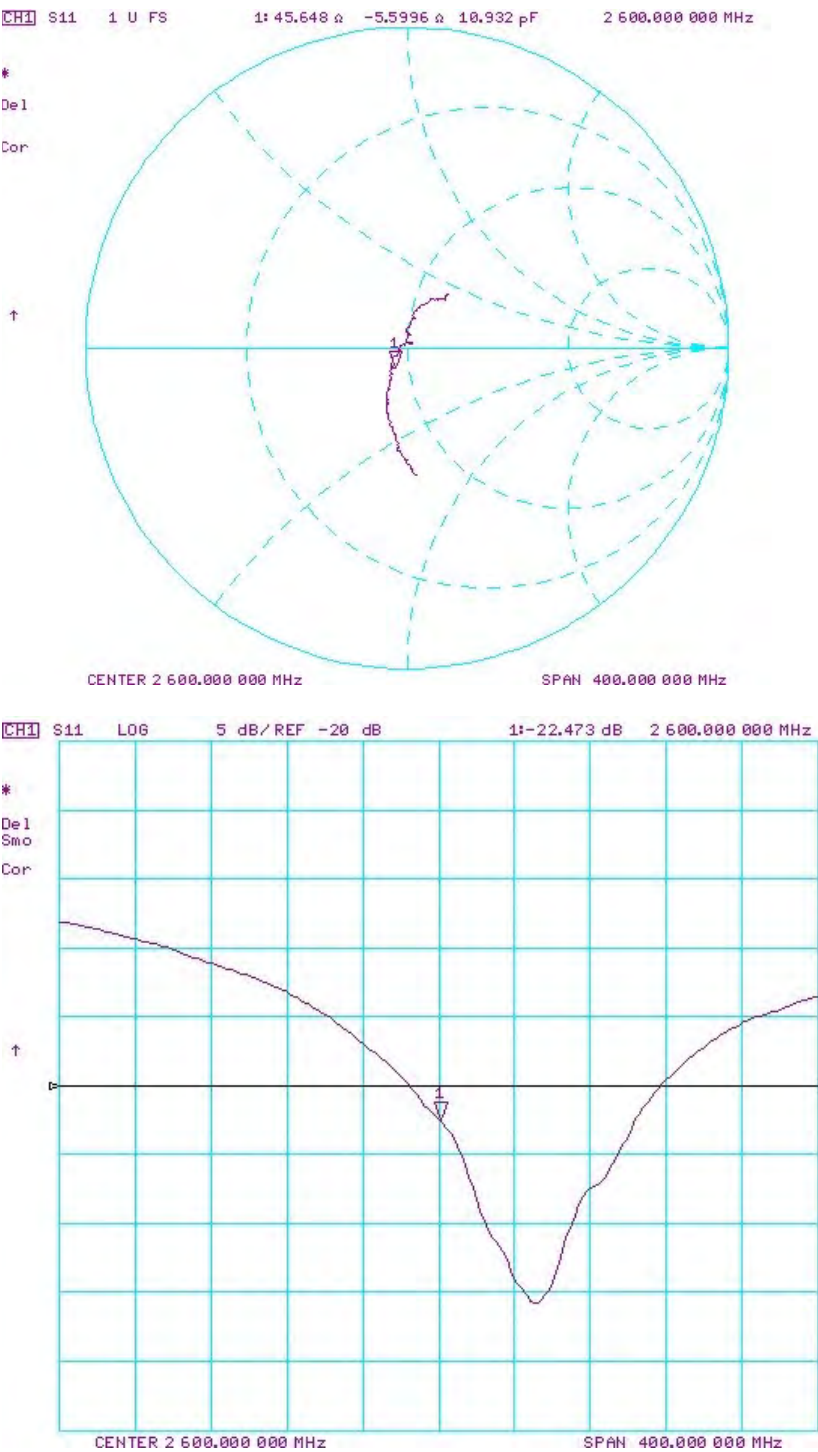
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/11/2017	9/9/2019	1.152	5.69	5.29	-7.03%	2.54	2.37	-6.69%	49.1	49	0.1	-6.1	-6.6	0.5	-24.1	-24.3	-0.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/11/2017	9/9/2019	1.152	5.53	6.73	3.62%	2.48	2.56	2.82%	46.2	45.6	0.6	-4.7	-5.6	0.9	-24.1	-22.5	6.60%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **D3500V2-1068_Dec19**

CALIBRATION CERTIFICATE

Object **D3500V2 - SN:1068**

Calibration procedure(s) **QA CAL-22.v4**
Calibration Procedure for SAR Validation Sources between 3-6 GHz

Calibration date: **December 04, 2019**

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	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 3503	25-Mar-19 (No. EX3-3503_Mar19)	Mar-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

Calibrated by: **Leif Klysner** Function: **Laboratory Technician** Signature: *Leif Klysner*

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

Issued: December 6, 2019

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



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	V52.10.3
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3500 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.9	2.91 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.0 $\pm$ 6 %	2.89 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.71 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	66.9 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.1 W/kg $\pm$ 19.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	51.3	3.31 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	50.0 $\pm$ 6 %	3.34 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	6.58 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	65.3 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.45 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.3 W/kg $\pm$ 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.5 Ω - 4.6 j Ω
Return Loss	- 25.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.5 Ω - 3.5 j Ω
Return Loss	- 27.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.132 ns
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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
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DASY5 Validation Report for Head TSL

Date: 04.12.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 3500 MHz; Type: D3500V2; Serial: D3500V2 - SN:1068

Communication System: UID 0 - CW; Frequency: 3500 MHz

Medium parameters used: $f = 3500$ MHz; $\sigma = 2.89$ S/m; $\epsilon_r = 37$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.75, 7.75, 7.75) @ 3500 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3500MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 70.28 V/m; Power Drift = 0.11 dB

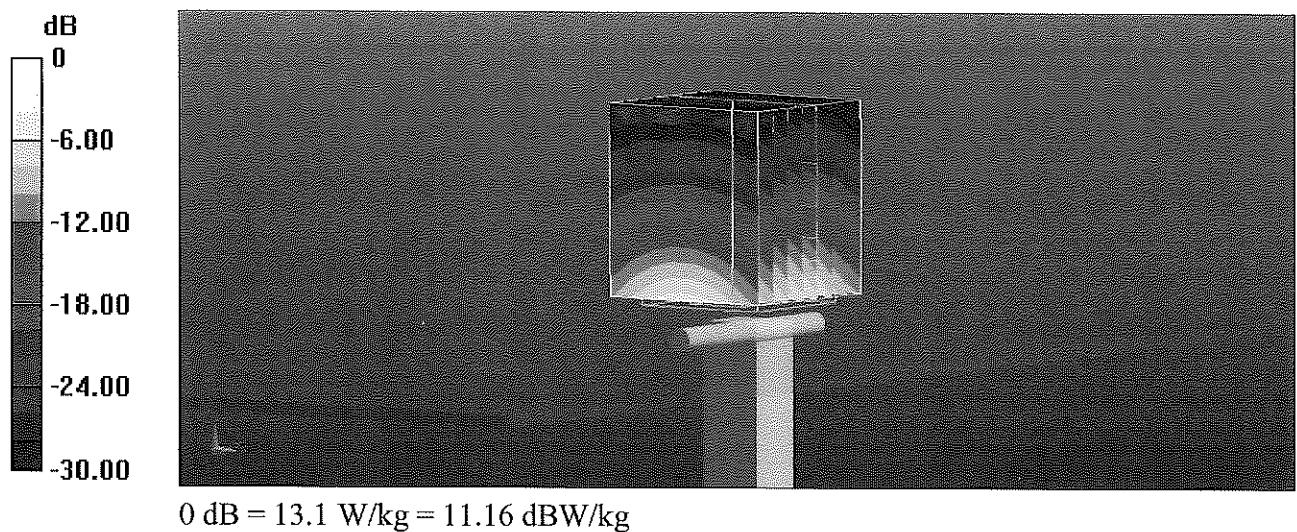
Peak SAR (extrapolated) = 18.6 W/kg

SAR(1 g) = 6.71 W/kg; SAR(10 g) = 2.52 W/kg

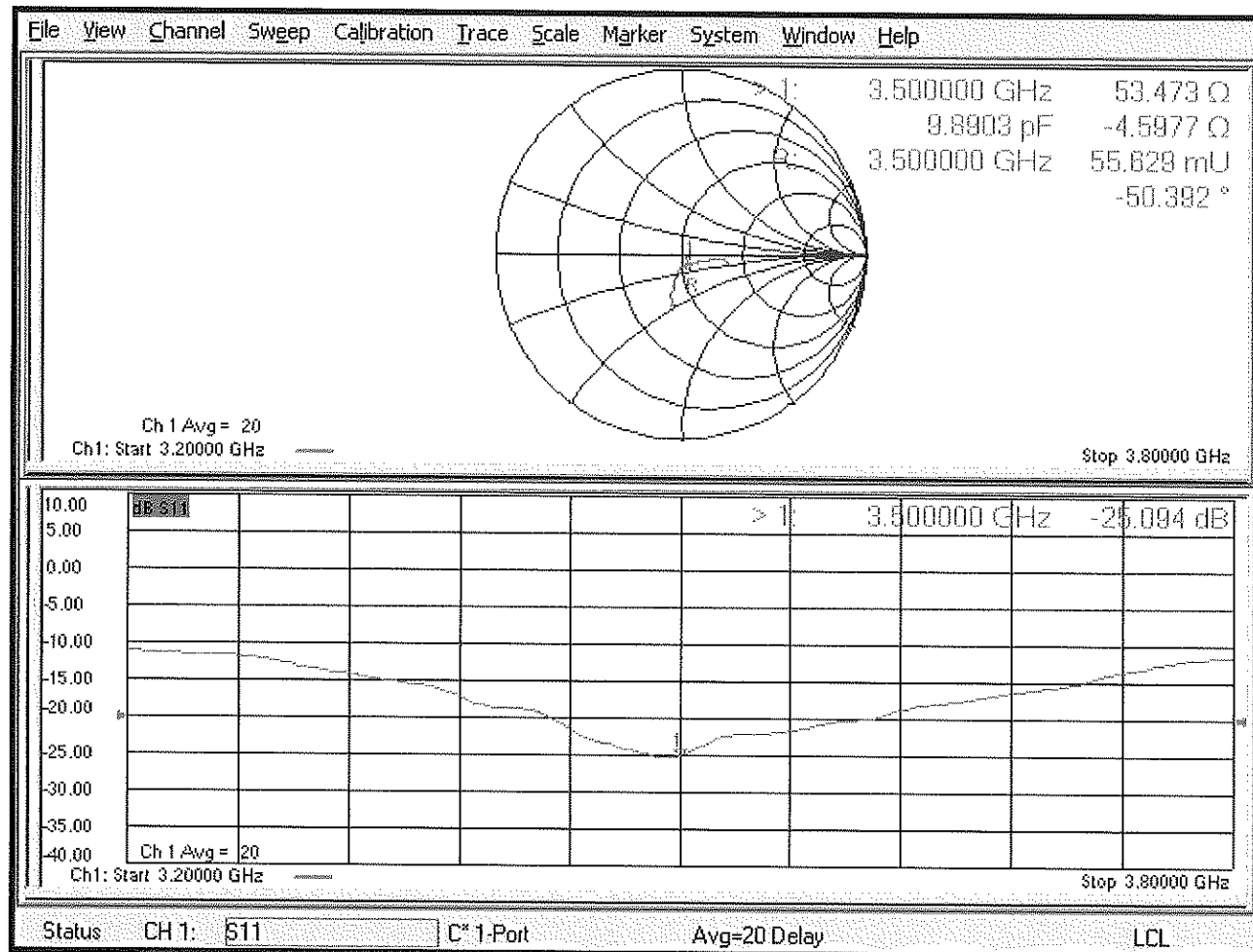
Smallest distance from peaks to all points 3 dB below = 8.4 mm

Ratio of SAR at M2 to SAR at M1 = 73.7%

Maximum value of SAR (measured) = 13.1 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 04.12.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 3500 MHz; Type: D3500V2; Serial: D3500V2 - SN:1068

Communication System: UID 0 - CW; Frequency: 3500 MHz

Medium parameters used: $f = 3500$ MHz; $\sigma = 3.34$ S/m; $\epsilon_r = 50$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.35, 7.35, 7.35) @ 3500 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm, f=3500MHz/Zoom Scan , dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.74 V/m; Power Drift = -0.04 dB

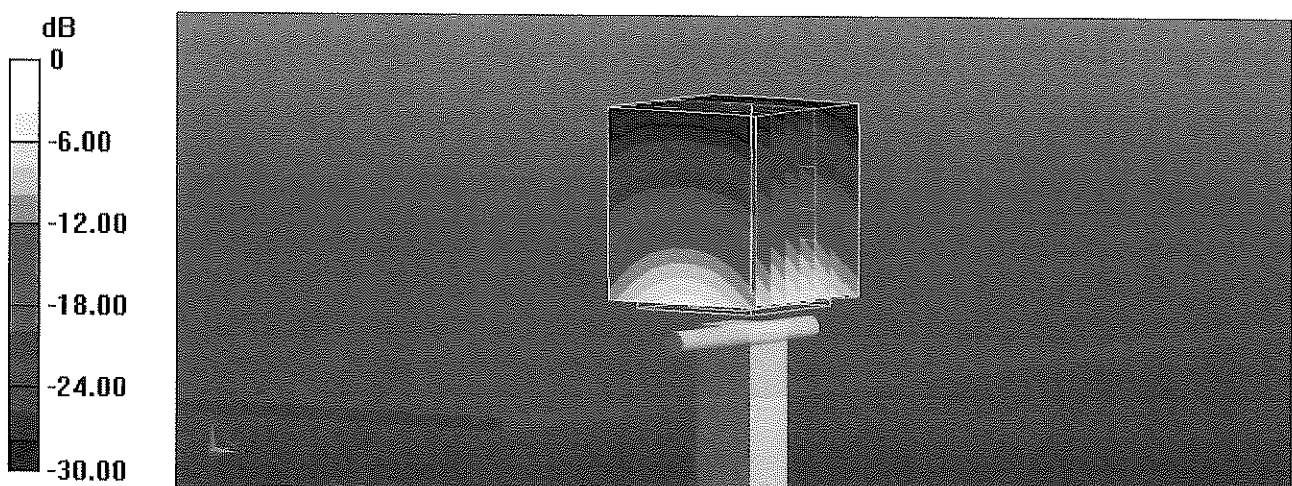
Peak SAR (extrapolated) = 17.7 W/kg

SAR(1 g) = 6.58 W/kg; SAR(10 g) = 2.45 W/kg

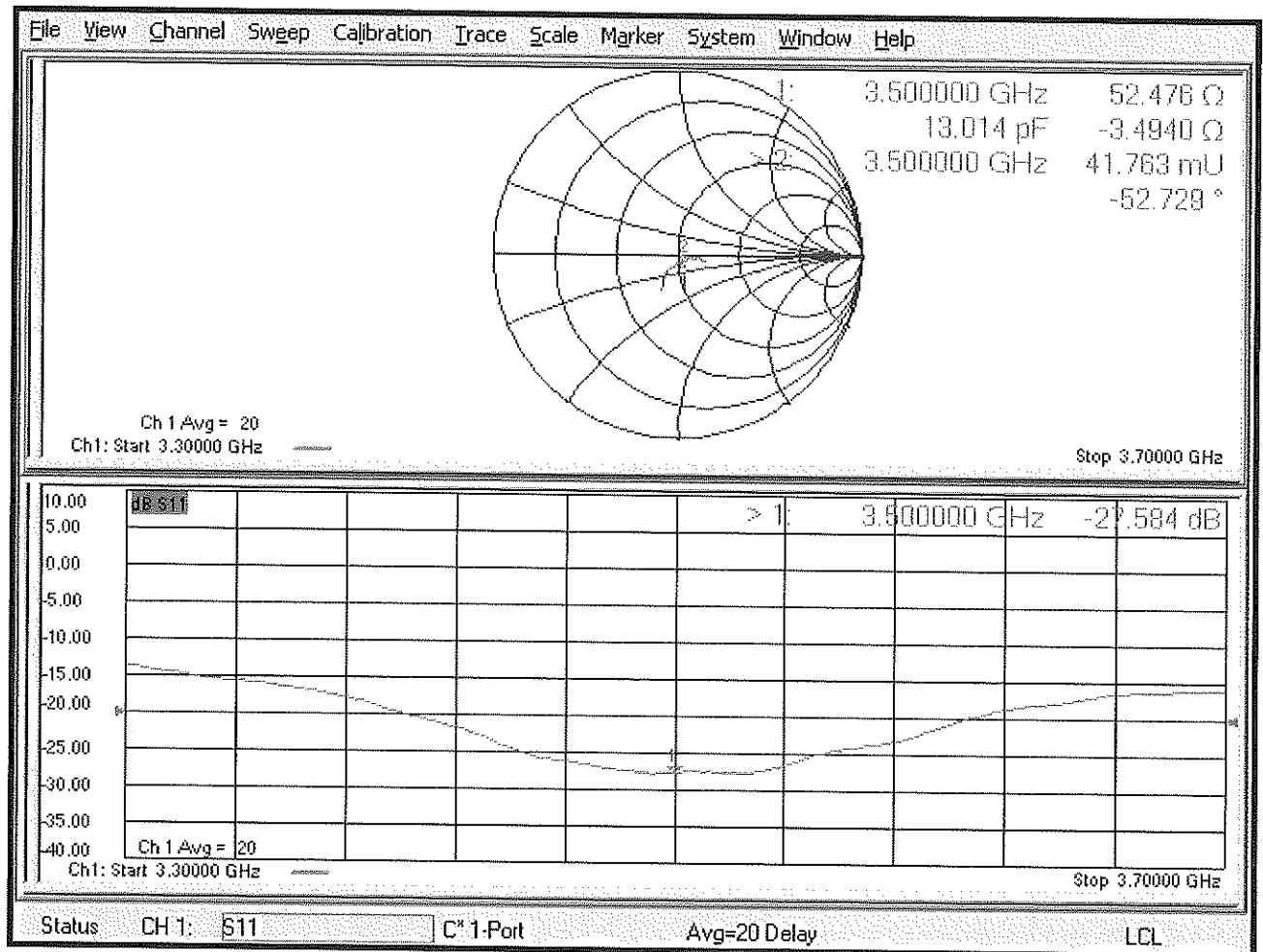
Smallest distance from peaks to all points 3 dB below = 8 mm

Ratio of SAR at M2 to SAR at M1 = 75%

Maximum value of SAR (measured) = 12.4 W/kg



Impedance Measurement Plot for Body TSL





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D3700V2-1029_Dec19**

CALIBRATION CERTIFICATE

Object **D3700V2 - SN:1029**

Calibration procedure(s) **QA CAL 22.v4
 Calibration Procedure for SAR Validation Sources between 3-6 GHz**

Calibration date: **December 04, 2019**

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	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 3503	25-Mar-19 (No. EX3-3503_Mar19)	Mar-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

Calibrated by: **Leif Klysner** **Laboratory Technician** **Signature**

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

Issued: December 6, 2019

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



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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	V52.10.3
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3700 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.7	3.12 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	36.8 $\pm$ 6 %	3.05 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.87 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	68.6 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.48 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.7 W/kg $\pm$ 19.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	51.0	3.55 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	49.7 $\pm$ 6 %	3.55 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	6.53 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	64.9 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.2 W/kg $\pm$ 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$45.1 \Omega - 1.9 j\Omega$
Return Loss	- 25.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$43.9 \Omega + 0.5 j\Omega$
Return Loss	- 23.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.139 ns
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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
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DASY5 Validation Report for Head TSL

Date: 04.12.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1029

Communication System: UID 0 - CW; Frequency: 3700 MHz

Medium parameters used: $f = 3700$ MHz; $\sigma = 3.05$ S/m; $\epsilon_r = 36.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.5, 7.5, 7.5) @ 3700 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.30 V/m; Power Drift = -0.02 dB

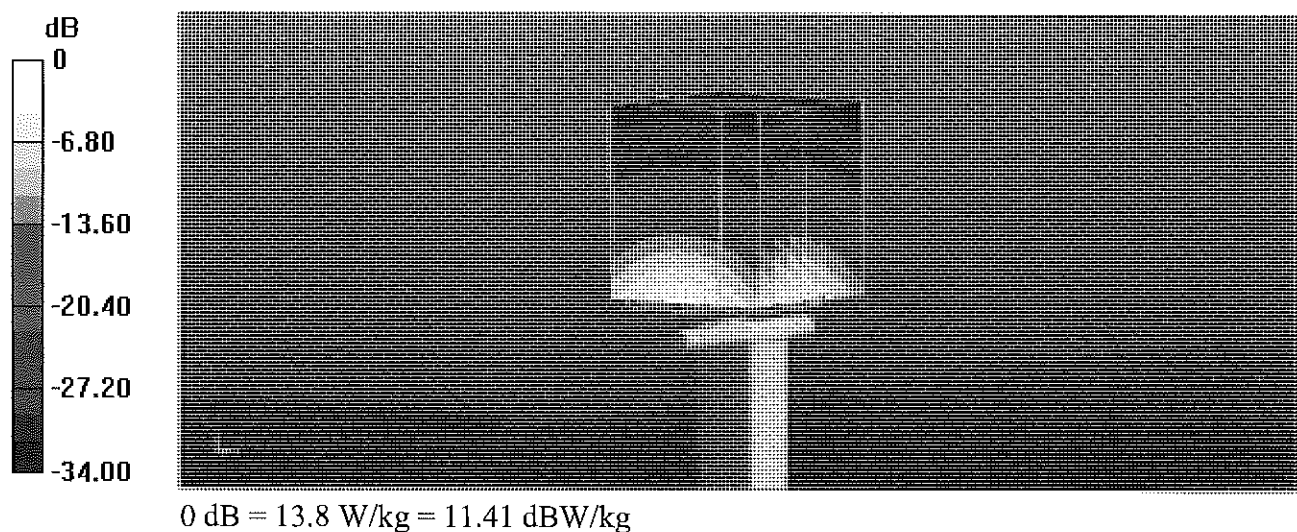
Peak SAR (extrapolated) = 19.8 W/kg

SAR(1 g) = 6.87 W/kg; SAR(10 g) = 2.48 W/kg

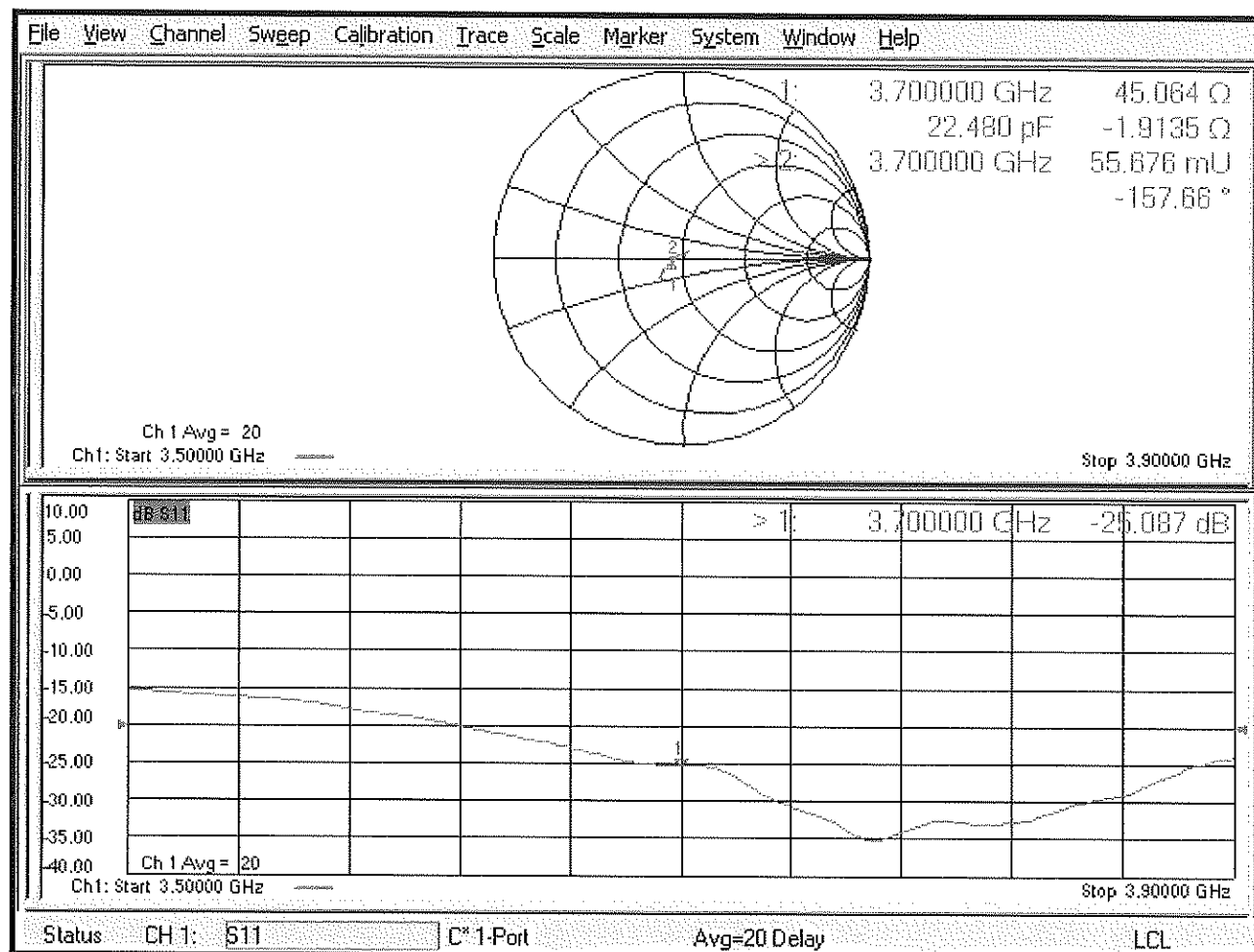
Smallest distance from peaks to all points 3 dB below = 8 mm

Ratio of SAR at M2 to SAR at M1 = 72.7%

Maximum value of SAR (measured) = 13.8 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 04.12.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1029

Communication System: UID 0 - CW; Frequency: 3700 MHz

Medium parameters used: $f = 3700$ MHz; $\sigma = 3.55$ S/m; $\epsilon_r = 49.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.1, 7.1, 7.1) @ 3700 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm/Zoom Scan , dist=1.4mm

(8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.42 V/m; Power Drift = -0.05 dB

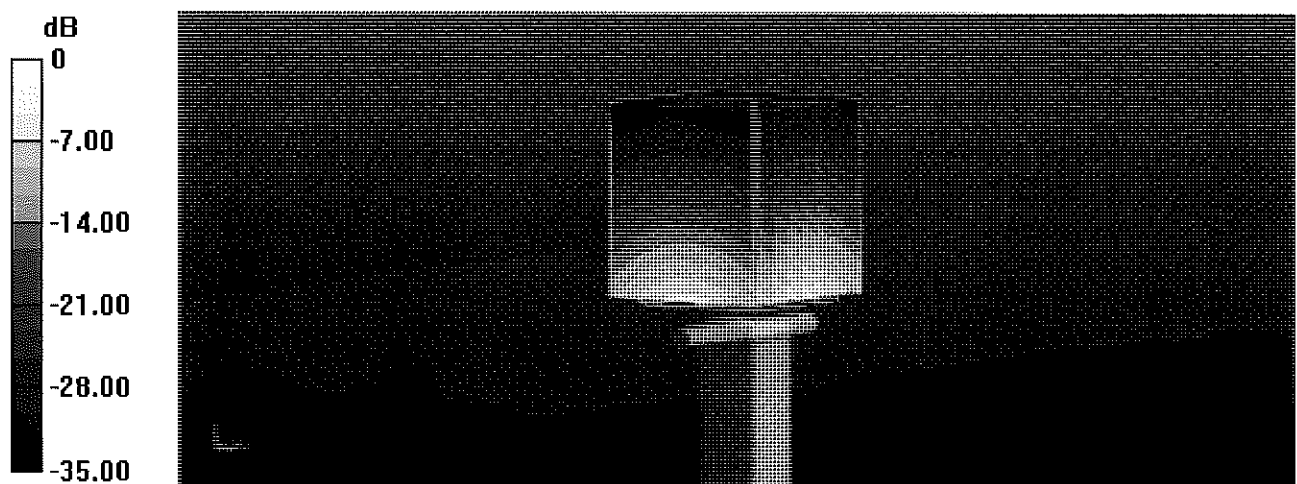
Peak SAR (extrapolated) = 18.3 W/kg

SAR(1 g) = 6.53 W/kg; SAR(10 g) = 2.33 W/kg

Smallest distance from peaks to all points 3 dB below = 8 mm

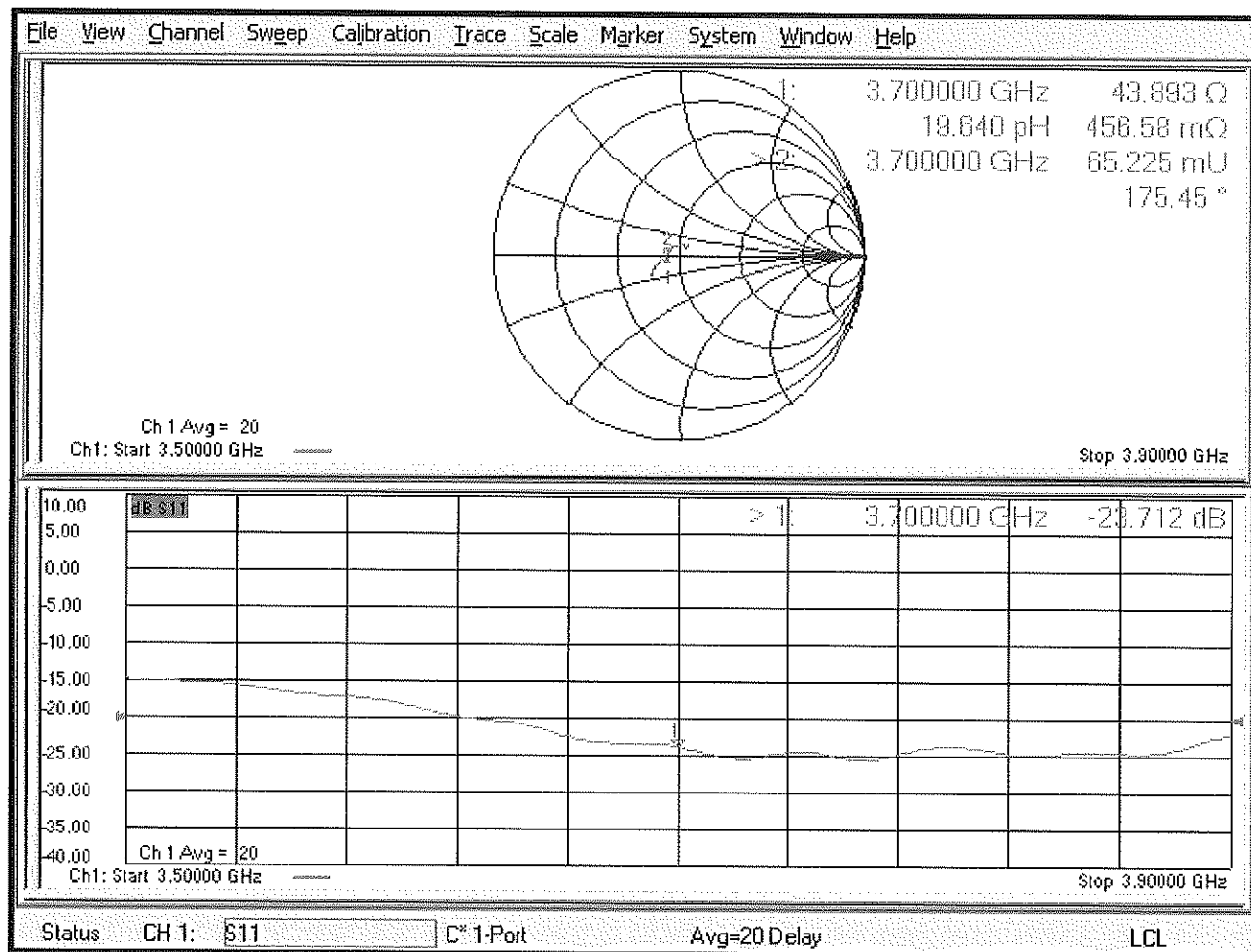
Ratio of SAR at M2 to SAR at M1 = 74.2%

Maximum value of SAR (measured) = 12.9 W/kg



0 dB = 12.9 W/kg = 11.11 dBW/kg

Impedance Measurement Plot for Body TSL





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D5GHzV2-1163_Sep18**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1163**

Calibration procedure(s) **QA CAL-22.v3**
Calibration procedure for dipole validation kits between 3-6 GHz

Calibration date: **September 13, 2018**

SC ✓
9/21/2018
BNW
10/10/2019

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-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 3503	30-Dec-17 (No. EX3-3503_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: 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 Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Manu Seitz	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 19, 2018

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Accredited by the Swiss Accreditation Service (SAS)

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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	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5750 MHz $\pm$ 1 MHz	

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	35.3 $\pm$ 6 %	4.52 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.6 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg $\pm$ 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.8 ± 6 %	4.87 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.8 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.0 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	5.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.9 ± 6 %	5.46 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.83 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.3 ± 6 %	5.93 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	80.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.3 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.0 ± 6 %	6.14 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	48.0 Ω - 2.0 j Ω
Return Loss	- 30.9 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	49.0 Ω + 4.4 j Ω
Return Loss	- 26.8 dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	50.9 Ω + 4.3 j Ω
Return Loss	- 27.2 dB

Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	46.4 Ω - 0.4 j Ω
Return Loss	- 28.5 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	50.2 Ω + 4.1 j Ω
Return Loss	- 27.8 dB

Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	51.8 Ω + 5.9 j Ω
Return Loss	- 24.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns
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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	June 06, 2013

DASY5 Validation Report for Head TSL

Date: 13.09.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1163

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz

Medium parameters used: $f = 5250$ MHz; $\sigma = 4.52$ S/m; $\epsilon_r = 35.3$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5600$ MHz; $\sigma = 4.87$ S/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5750$ MHz; $\sigma = 5.03$ S/m; $\epsilon_r = 34.6$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.51, 5.51, 5.51) @ 5250 MHz, ConvF(5.05, 5.05, 5.05) @ 5600 MHz, ConvF(4.98, 4.98, 4.98) @ 5750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601 (5GHz); Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 77.54 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 26.6 W/kg

SAR(1 g) = 8.1 W/kg; SAR(10 g) = 2.33 W/kg

Maximum value of SAR (measured) = 17.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 77.29 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 30.6 W/kg

SAR(1 g) = 8.43 W/kg; SAR(10 g) = 2.42 W/kg

Maximum value of SAR (measured) = 19.3 W/kg

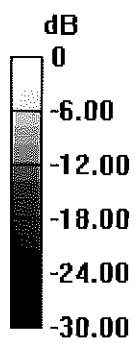
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.35 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 30.3 W/kg

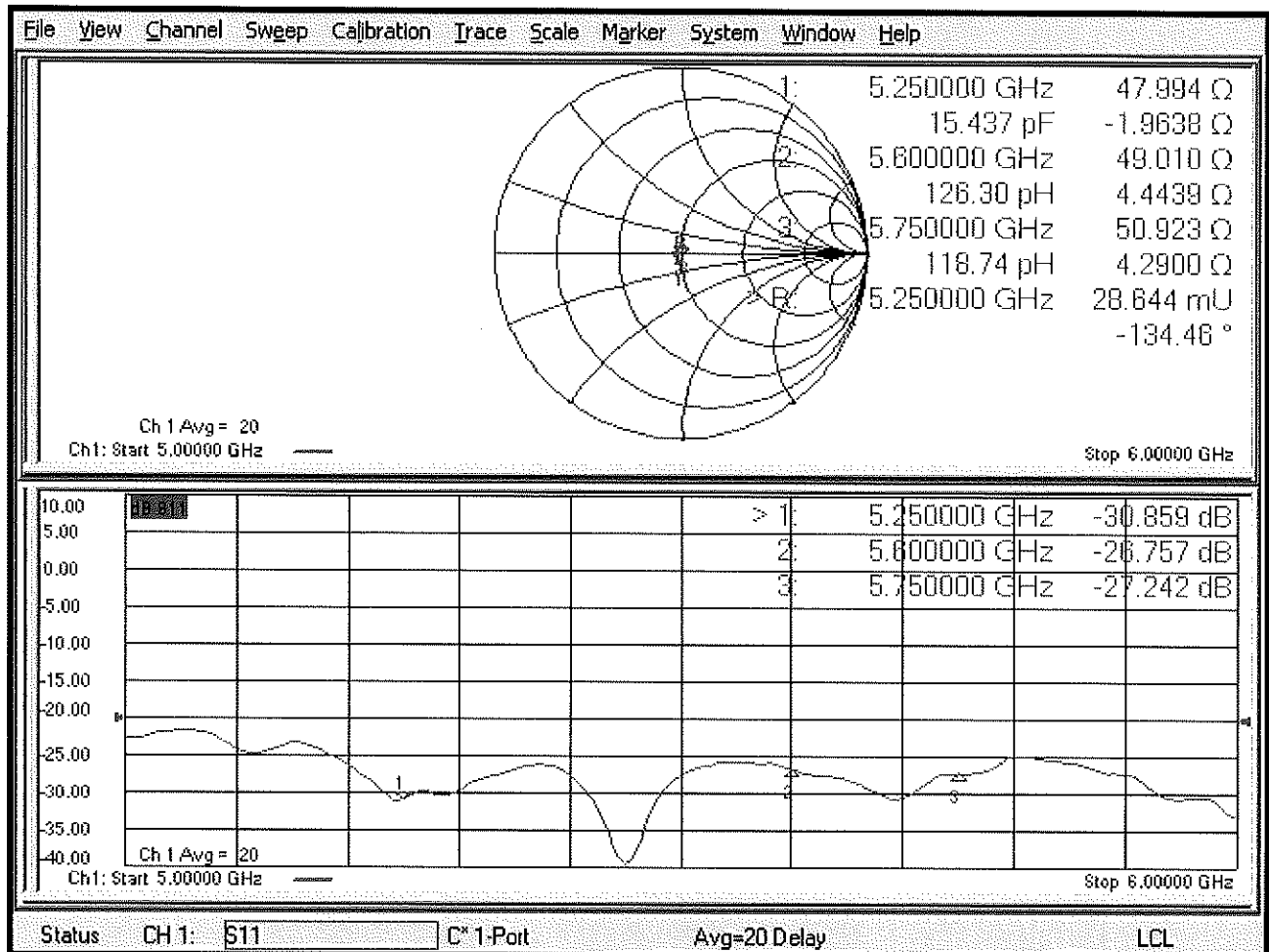
SAR(1 g) = 8.16 W/kg; SAR(10 g) = 2.32 W/kg

Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 17.9 W/kg = 12.53 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 12.09.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1163

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz

Medium parameters used: $f = 5250$ MHz; $\sigma = 5.46$ S/m; $\epsilon_r = 46.9$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5600$ MHz; $\sigma = 5.93$ S/m; $\epsilon_r = 46.3$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5750$ MHz; $\sigma = 6.14$ S/m; $\epsilon_r = 46$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.65, 4.65, 4.65) @ 5600 MHz, ConvF(4.57, 4.57, 4.57) @ 5750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601 (5GHz); Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 69.57 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.17 W/kg

Maximum value of SAR (measured) = 17.8 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.75 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 33.7 W/kg

SAR(1 g) = 8.08 W/kg; SAR(10 g) = 2.25 W/kg

Maximum value of SAR (measured) = 19.2 W/kg

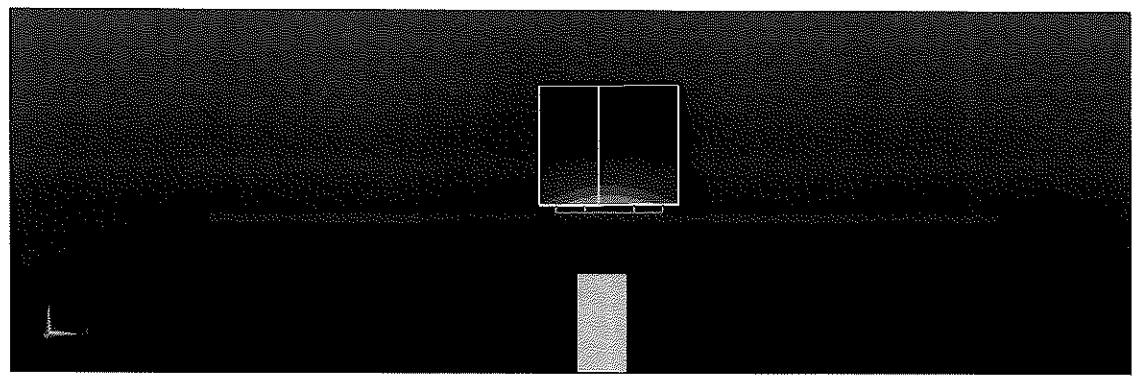
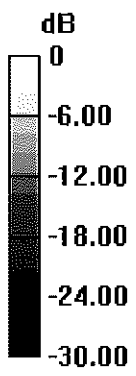
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 67.61 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 33.2 W/kg

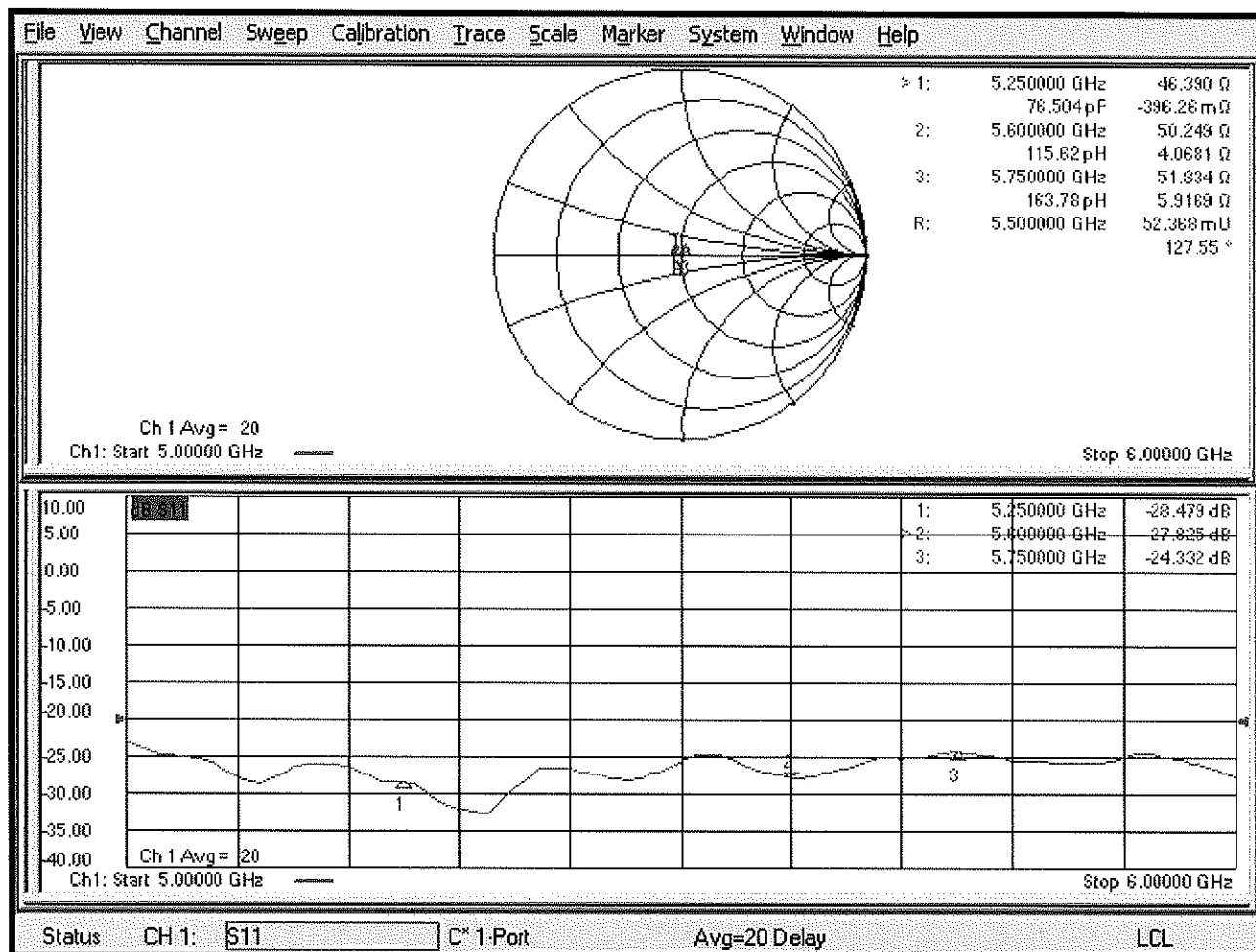
SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.18 W/kg

Maximum value of SAR (measured) = 18.6 W/kg



0 dB = 17.8 W/kg = 12.50 dBW/kg

Impedance Measurement Plot for Body TSL



Certification of Calibration

Object D5GHzV2 – SN: 1163

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: September 11, 2019

Description: SAR Validation Dipole at 5250, 5600, and 5750 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	E4438C	ESG Vector Signal Generator	6/27/2019	Annual	6/27/2020	MY45093852
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	11/1/2017	Biennial	11/1/2019	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/7/2019	Annual	5/7/2020	1070
SPEAG	EX3DV4	SAR Probe	7/16/2019	Annual	7/16/2020	7491
SPEAG	EX3DV4	SAR Probe	1/28/2019	Annual	1/28/2020	3837
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/10/2019	Annual	7/10/2020	1402
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/15/2019	Annual	1/15/2020	793

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	<i>Parker Jones</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

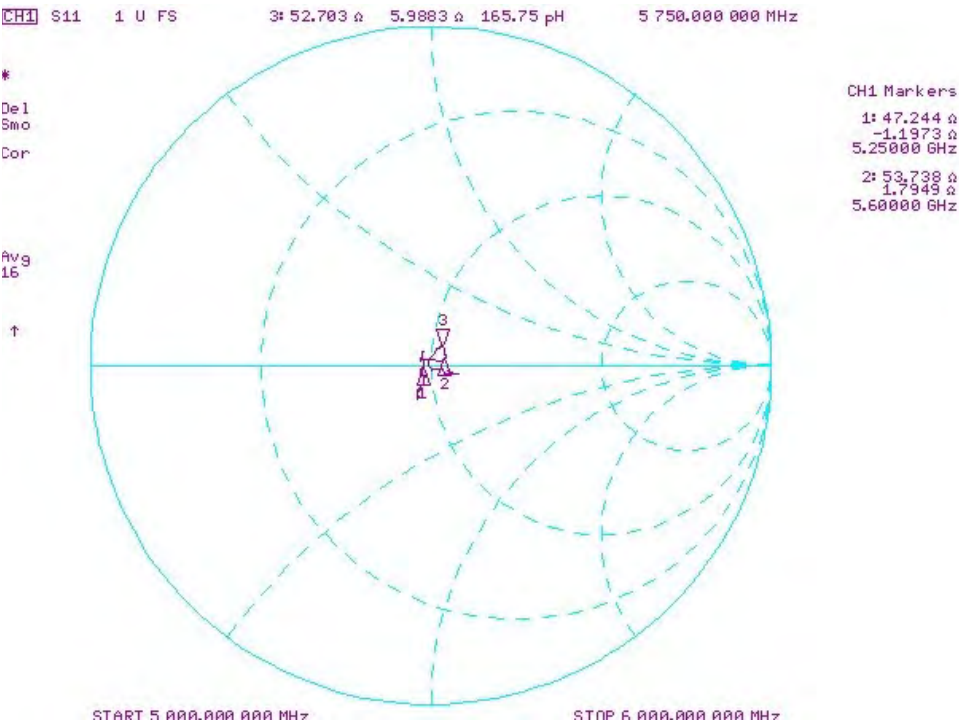
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

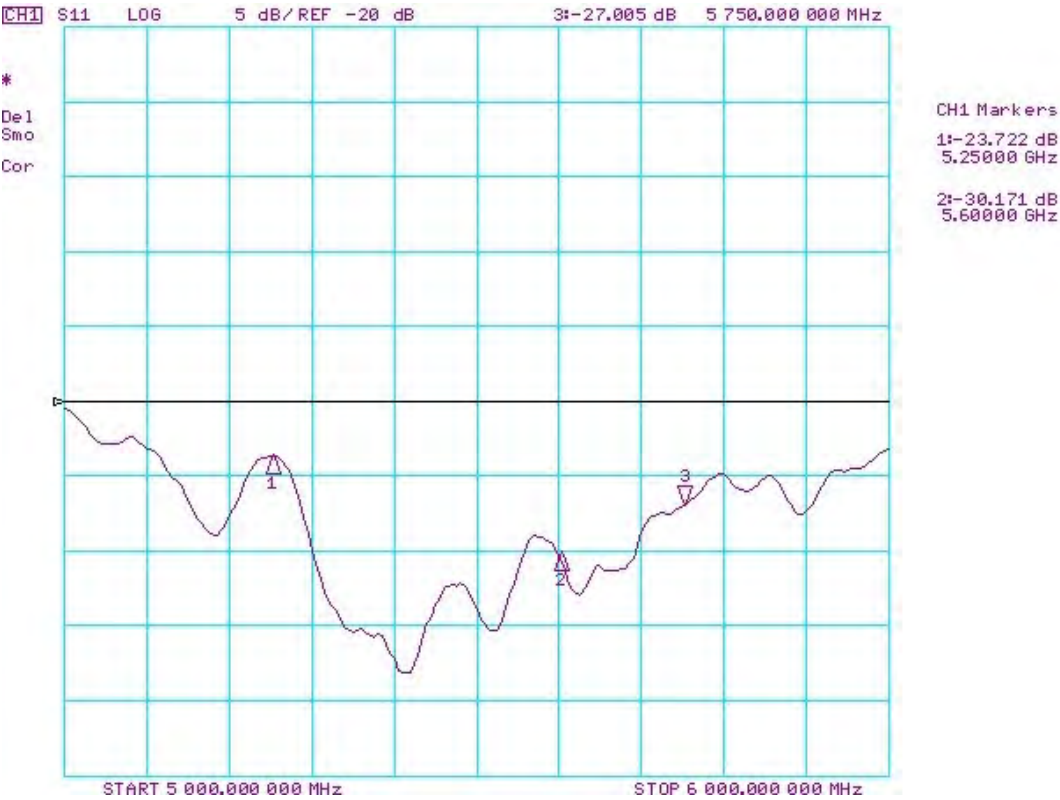
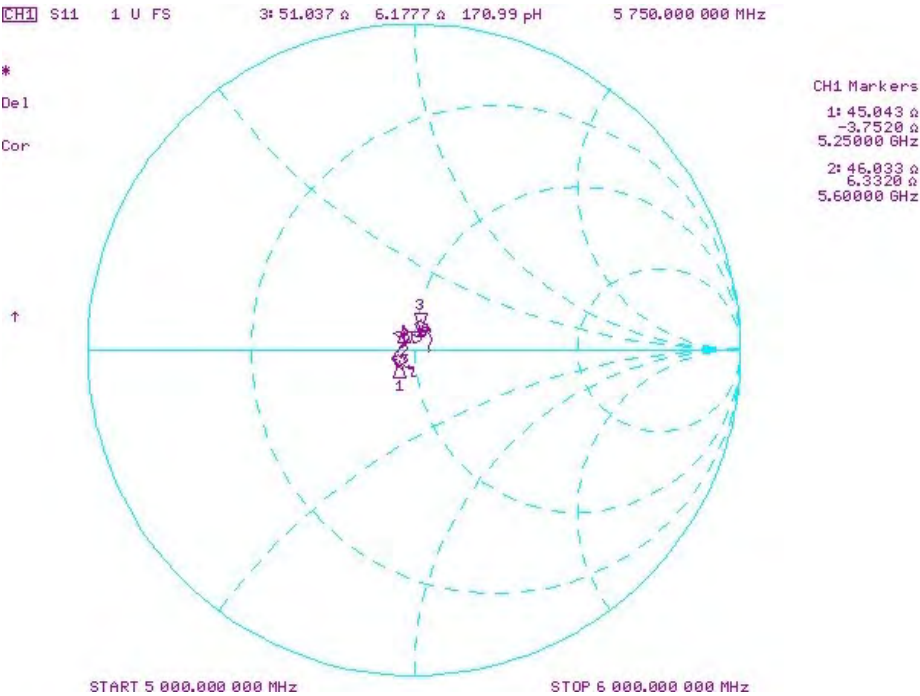
Frequency (MHz)	Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 17.0 dBm	Measured Head SAR (1g) W/kg @ 17.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 17.0 dBm	Measured Head SAR (10g) W/kg @ 17.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5250	9/13/2018	9/11/2019	1.202	4.03	3.89	-3.47%	1.15	1.14	-1.30%	48	47.2	0.8	-2	-1.2	0.8	-30.9	-29.9	3.20%	PASS
5600	9/13/2018	9/11/2019	1.202	4.19	3.92	-6.44%	1.2	1.13	-5.83%	49	53.7	4.7	4.4	1.8	2.6	-26.8	-26.1	-4.90%	PASS
5750	9/13/2018	9/11/2019	1.202	4.06	3.88	-4.32%	1.15	1.12	-2.61%	50.9	52.7	1.8	4.3	6	1.7	-27.2	-23.9	12.10%	PASS

Frequency (MHz)	Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 17.0 dBm	Measured Body SAR (1g) W/kg @ 17.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 17.0 dBm	Measured Body SAR (10g) W/kg @ 17.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5250	9/13/2018	9/11/2019	1.202	3.89	3.72	-4.29%	1.08	1.04	-3.59%	46.4	45	-1.4	-0.4	-3.8	3.4	-28.5	-23.7	16.80%	PASS
5600	9/13/2018	9/11/2019	1.202	4.01	3.72	-7.12%	1.12	1.03	-7.62%	50.2	46	-4.2	4.1	6.3	2.2	-27.8	-30.2	-8.60%	PASS
5750	9/13/2018	9/11/2019	1.202	3.89	3.62	-6.90%	1.08	1.01	-6.05%	51.8	51	-0.8	5.9	6.2	0.3	-24.3	-27	-11.10%	PASS

Impedance & Return-Loss Measurement Plot for Head TSL



Impedance & Return-Loss Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **EX3-3949_Aug19**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3949**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v5, QA CAL-23.v5,
QA CAL-25.v7
Calibration procedure for dosimetric E-field probes**

Calibration date: **August 29, 2019**

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	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-19 (No. 217-02894)	Apr-20
DAE4	SN: 660	19-Dec-18 (No. DAE4-660_Dec18)	Dec-19
Reference Probe ES3DV2	SN: 3013	31-Dec-18 (No. ES3-3013_Dec18)	Dec-19
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-18)	In house check: Jun-20
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature
Approved by:	Katja Pokovic	Technical Manager	
			Issued: August 31, 2019
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			