

This document summarizes the conducted Hub and SB TX power measurements and antenna performance calculations
The conducted measurements were at the GE RF laboratory (Helsinki, Finland)
The radiated measurements were made at Verkotan laboratory (Oulu, Finland)
Antenna parameters calculated based on radiated and conducted measurement result are: maximum antenna gain and total antenna efficiency
Maximum antenna gain is used as in put in radio standard testing to define the EIRP power from SGS measured conducted power
Total antenna efficiency is used as SB and Hub RF unit test evidence

The devices used to define antenna parameters are (from antenna point of view the both DUTs are mass production equivalent):

Sensor Battery

HLA SN AXLD041
PWA SN 4R41
SW MBAN test mode 1.0.0.0.1.0-1.2.86b05b8
proto name ANT SB C2
modifications preMVP4 PWA with TX and antenna RF matchings to MVP equivalent

Hub

HLA SN SRW20030023SP
PWA SN 2YMB
SW ge-swu-image-beat3-imx7d-0.0.0.20.1.9217 (MBAN test mode 20.1)
proto name ANT Hub A1
modifications preMVP4 no modifications

Change history

18 Dec 20 v1 Timo Hakala Initial version released in MWS

Tables to AMS v1 hub and SB antenna test report

Sensor Battery

Sensor Battery Maximum antenna gain	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dBi								
max PA	1.8			2.6	1.7	2.4			-4.8
max RFIC	2.3			2.1	0.5	-2.4			-4.3
MCAL 0	2.4	3.4	2.0	1.8	2.2	-1.3	-3.2	-4.9	
MCAL 1				1.5	2.3	-0.5			-2.8
ETSI EN300328 and EN300203	N/A						2.3		-3.2
FCC part15 and part95	3.4	2.0		2.6			N/A		

Sensor Battery Total antenna efficiency	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dB								
max PA	-7.5			-6.0	-7.0	-9.8			-11.1
max RFIC	-6.6			-6.3	-8.4	-9.9			-10.7
MCAL 0	-6.6	-5.7	-6.8	-6.8	-6.8	-8.8	-10.1	-10.8	
MCAL 1				-7.0	-6.8	-7.8			-9.1
Body normal max PA	-11.5			-10.2	-12.0	-13.7			-14.5
Body flipped max PA	-10.4			-9.1	-10.3	-12.2			-13.1

Hub

Hub - MBAN bottom antenna Maximum antenna gain	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dBi								
max PA	2.4			2.7	2.9	3.1			2.2
max RFIC	2.1			2.3	2.6	2.6			1.8
MCAL 0	2.2	2.5	2.2	2.3	2.7	2.8	2.9		1.9
MCAL 1				2.4	2.6	3.0			2.2
ETSI EN300328 and EN300203	N/A						3.0		2.9
FCC part15 and part95	2.5	2.2		2.9			N/A		

Hub - MBAN bottom antenna Total antenna efficiency	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dB								
max PA	-1.8			-1.3	-1.5	-1.5			-2.0
max RFIC	-1.7			-1.6	-1.8	-1.9			-2.4
MCAL 0	-1.6	-1.4	-1.6	-1.6	-1.8	-1.7	-1.8	-2.2	
MCAL 1				-1.6	-1.9	-1.7			-1.9
Body normal max PA	-5.5			-5.6	-5.5	-6.0			-6.4
Body flipped max PA	-4.5			-4.6	-4.9	-5.2			-5.6

Hub - MBAN top antenna Maximum antenna gain	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dBi								
max PA	4.8			5.2	5.6	5.2			5.5
max RFIC	4.2			4.6	5.1	4.9			5.4
MCAL 0	4.1	4.3	4.3	4.4	5.0	5.0	5.2	5.1	
MCAL 1				4.5	5.0	5.1			5.4
ETSI EN300328 and EN300203	N/A						5.1		5.4
FCC part15 and part95	4.3	4.3		5.6			N/A		

Hub - MBAN top antenna Total antenna efficiency	US MBAN			ISM			EU MBAN		unit
	indoor		anywhere	low	mid	high	low	high	
	low	high	mid						
channel	0	11	13	15	31	46	47	52	MHz
frequency	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	MHz
Free space	dB								
max PA	-1.6			-1.1	-1.1	-1.2			-1.3
max RFIC	-2.0			-1.6	-1.6	-1.5			-1.4
MCAL 0	-2.3	-2.0	-1.8	-1.7	-1.7	-1.2	-1.3	-1.4	
MCAL 1				-1.6	-1.7	-1.2			-1.2
Body normal max PA	-6.2			-5.3	-5.1	-5.3			-6.2
Body flipped max PA	-5.6			-5.3	-4.9	-4.8			-4.6

WLAN 2.4 GHz Top

Hub - WLAN 2.4 GHz top antenna Maximum antenna gain	ETSI				unit
	FCC		FCC N/A		
	channel	1	6	11	
frequency	2412	2437	2462	2472	MHz
Free space	dBi				
max power	5.2	4.4	6.0	4.2	dBm

Hub - WLAN 2.4 GHz top antenna Total antenna efficiency	ETSI				unit
	FCC		FCC N/A		
	channel	1	6	11	
frequency	2412	2437	2462	2472	MHz
Free space	dBi				
max pow	0.4	-2.0	0.1	-1.8	dBm
Body normal max power	-3.2			-4.9	dBm
Body flipped max power	-3.0			-4.8	dBm

WLAN 5GHz Top

Hub - WLAN 5 GHz top antenna Maximum antenna gain	ETSI								ETSI N/A		unit	
	FCC				FCC N/A				FCC			
	channel	36	48	64	100	108	116	128	140	153		165
frequency	5180	5240	5320	5500	5540	5580	5640	5700	5765	5825	5875	MHz
Free space	dBi											
max power	1.3	2.4	3.7	6.8	6.2	6.0	6.2	5.6	6.0	5.9	5.9	dBm

Hub - WLAN 5 GHz top antenna Total antenna efficiency	ETSI								ETSI N/A		unit	
	FCC				FCC N/A				FCC			
	channel	36	48	64	100	108	116	128	140	153		165
frequency	5180	5240	5320	5500	5540	5580	5640	5700	5765	5825	5875	MHz
Free space	dBi											
max power	-4.4	-3.8	-3.0	-0.9	-1.7	-2.2	-1.8	-2.6	-2.3	-2.1	-2.1	dBm
Body normal max power	-6.5			-3.0								-4.3
Body flipped max power	-6.5			-2.7								-4.3

WLAN 5GHz Bottom

Hub - WLAN 5 GHz bottom antenna Maximum antenna gain	ETSI								ETSI N/A		unit	
	FCC				FCC N/A				FCC			
	channel	36	48	64	100	108	116	128	140	153		165
frequency	5180	5240	5320	5500	5540	5580	5640	5700	5765	5825	5875	MHz
Free space	dBi											
max power	1.2	1.0	2.0	3.4	3.1	2.6	3.2	2.5	4.0	3.6	3.6	dBm

Hub - WLAN 5 GHz bottom antenna Total antenna efficiency	ETSI								ETSI N/A		unit	
	FCC				FCC N/A				FCC			
	channel	36	48	64	100	108	116	128	140	153		165
frequency	5180	5240	5320	5500	5540	5580	5640	5700	5765	5825	5875	MHz
Free space	dBi											
max power	-4.1	-3.6	-2.9	-1.8	-1.5	-2.0	-1.7	-2.3	-2.2	-2.1	-2.1	dBm
Body normal max power	-5.7			-4.3								-4.0
Body flipped max power	-6.2			-3.5								-4.0

Summary all

use case	DUT	radio	antenna	max gain (dBi)		total efficiency (dB)	
				min	max	min	max
free space	Hub	WLAN 2.4GHz	SB MBAN bottom	3.4	-11.1	-5.7	
			MBAN top	3.0	-2.4	-1.3	
			WLAN 2.4GHz top	5.6	-2.3	-1.1	
			WLAN 5GHz bottom	6.0	-2.0	0.4*	
			WLAN 5GHz top	4.0	-4.1	-1.5	
on body	Hub	WLAN 2.4GHz	SB MBAN bottom	6.8	-4.4	-0.9	
			MBAN top	N/A	-14.5	-9.1	
			WLAN 2.4GHz top	N/A	-6.4	-4.5	
			WLAN 5GHz bottom	N/A	-6.2	-4.6	
			WLAN 5GHz top	N/A	-4.9	-3.0	

* positive is due to antenna input (non 50 ohm) vs. power meter (50 ohm) RF matching

ANT Hub A1 top -orig		2 GHz				5 GHz																channels 104-136 power back off 2dB															
		ETSI				ETSI								ETSI DFS								ETSI N/A (SRD)															
		FCC	FCC N/A	FCC	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS																				
channel	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165									
frequency	2412	2437	2462	2472	5180	5200	5220	5240	5260	5280	5300	5320	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5745	5765	5785	5805	5825									
DC 94% cond TX power	9.4	14.1	9.5	14	11.4	11.7	11.6	11.6	9.4	9.5	9.4	9.3	9.9	12.6	12.7	12.8	12.8	12.4	11.8	11.9	12.1	12.2	9.4	9.6	14.5	14.5	14.5	10.5									
TRP	9.66	11.89	9.44	11.99	6.77	7.59						6.1	8.81	10.8	10.8	10.46	9.96	6.63	11.97																		
ERP sum	14.45	18.79	15.27	18.03	12.48	13.8						12.77	16.5	18.76	18.64	17.9	14.78	16.4	17.9																		
ERP vertical	14	17.72	15.16	17.95	11.05							11	14.81	17.05	16.83	16	12.72	16	17.22																		
ERP horizontal	13.14	16.41	11.49	14.75	9.2							8.72	12.28	14.46	14.5	13.96	11.68	18.22																			
TRP	9.8	12.1	9.6	12.2	7.0							6.3	9.0	11.0	10.6	10.1	6.8	12.2																			
ERP sum	14.6	18.5	15.5	18.2	12.7							13.0	16.7	18.9	18.8	18.1	15.0	16.4	17.9																		
ERP vertical	14.2	17.9	15.3	18.1	11.2							11.2	15.0	17.2	17.0	16.2	12.5	17.9	19.1																		
ERP horizontal	13.3	16.6	11.7	14.9	9.4							8.9	12.5	14.6	14.7	14.1	11.9	18.4																			
DC corrected	0.4	-2.0	0.1	-1.8	-4.4							-3.0	-0.9	-1.7	-2.2	-2.2	-1.8	-2.6	-2.3																		
95.8% total efficiency	4.8	6.4	5.8	6.0	5.7							6.7	7.7	8.0	8.2	7.9	8.2	8.4	8.0																		
antenna directivity	5.2	4.4	6.0	4.2	1.3							3.7	6.8	6.2	6.0	6.2	5.6	6.0	5.9																		
max antenna gain	9.4	14.1	9.5	14	11.4	11.7	11.6	11.6	9.4	9.5	9.4	9.3	9.9	12.6	12.7	12.8	12.8	12.4	11.8	11.9	12.1	12.2	9.4	9.6	14.5	14.5	14.5	10.5									

ANT Hub A1 bottom -orig		2 GHz				5 GHz																channels 104-136 power back off 2dB															
		ETSI				ETSI								ETSI DFS								ETSI N/A (SRD)															
		FCC	FCC N/A	FCC	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS																				
channel	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165									
frequency	2412	2437	2462	2472	5180	5200	5220	5240	5260	5280	5300	5320	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5745	5765	5785	5805	5825									
DC 94% cond TX power	N/A	N/A	N/A	N/A	12.9	12.8	12.8	12.8	9.8	9.6	9.6	9.5	10.6	12.5	12.4	12.3	12.3	12.3	12.2	12.1	12	12	8.3	8.7	13.5	13.5	13.5	9.9									
TRP					13.87							11.36	13.83	15.33	14.71	15.16	10.63	17.3																			
ERP sum					12.68							9.01	11.24	14.02	13.39	15.05	9.63	17.22																			
ERP vertical					11.87							11	13.66	14.9	14.56	14.46	10.34	15.18																			
ERP horizontal					11.44							6.41	8.8	10.7	10.16	11.14	5.86	11.84																			
TRP					14.1							11.5	14.0	15.5	14.9	10.8	15.3																				
ERP sum					12.9							9.2	11.4	14.2	13.6	15.2	9.8	17.4																			
ERP vertical					12.1							11.3	13.8	15.1	14.7	15.6	10.5	15.1																			
ERP horizontal					11.63							6.6	8.8	10.9	10.4	6.0	11.3																				
DC corrected					-1.1							-2.9	-1.8	-1.5	-2.0	-1.7	-2.3	-2.2																			
95.8% total efficiency					5.2							5.0	5.2	4.6	4.6	5.0	4.8	6.2																			
antenna directivity					5.2							2.0	8.4	8.1	2.6	3.2	2.5	4.0																			
max antenna gain					12.9	12.8	12.8	12.8	9.8	9.6	9.6	9.5	10.6	12.5	12.4	12.3	12.3	12.3	12.2	12.1	12	12	8.3	8.7	13.5	13.5	13.5	9.9									

ANT Hub A2 top -orig		2 GHz				5 GHz																channels 104-136 power back off 2dB															
		ETSI				ETSI								ETSI DFS								ETSI N/A (SRD)															
		FCC	FCC N/A	FCC	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS																				
channel	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165									
frequency	2412	2437	2462	2472	5180	5200	5220	5240	5260	5280	5300	5320	5500	5520	5540	5560	5580	5600	5620	5640	5660	5680	5700	5745	5765	5785	5805	5825									
DC 94% cond TX power	8.3	12.8	8.2	12.5	10.8	11.3	11.5	11.7	9	9	9	8.9	10.1	12.4	12.4	12.6	12.7	11.8	11.9	12	12.1	12.2	9	9	14.1	14.1	14.1	11.3									
TRP	4.1	0	0	0	8.66	6.27	8.66	9.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
ERP sum	11.93				15.59	12.03																															
ERP vertical	11.03				15.56	11.22																															
ERP horizontal	10.31				12.54	8.76																															
DC corrected	-4.2				-3.84	-4.59																															
95.8% total efficiency	7.83				6.93	5.76																															
antenna directivity	3.63				3.09	1.23																															
max antenna gain	9.4	14.1	9.5	14	11.4	11.7	11.6	11.6	9.4	9.5	9.4	9.3	9.9	12.6	12.7	12.8	12.8	12.4	11.8	11.9	12.1	12.2	9.4	9.6	14.5	14.5	14.5	10.5									
cond TX power	0				0							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TRP																																					
ERP sum																																					
ERP vertical																																					
ERP horizontal																																					
DC corrected																																					
95.8% total efficiency																																					
antenna directivity																																					
max antenna gain	N/A	N/A	N/A	N/A	12.9	12.8	12.8	12.8	9.8	9.6	9.6	9.5	10.6	12.5	12.4	12.3	12.3	12.3	12.2	12.1	12	12	8.3	8.7	13.5	13.5	13.5	9.9									

ANT Hub A2 bottom -orig		2 GHz				5 GHz																channels 104-136 power back off 2dB															
		ETSI				ETSI								ETSI DFS								ETSI N/A (SRD)															
		FCC	FCC N/A	FCC	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS	FCC	FCC DFS	FCC N/A	FCC DFS																				
channel	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	14													

Test environment:

date 14 Oct 2020 18 Oct 2020
 tester 212487387 - Timo Hakala 212487387 - Timo Hakala
 place GE Vallila RF lab GE Vallila RF lab
 temp 21.1 C 21.1 C
 RH 43.60% 39.70%

Duty-cycle compensation:
 Pulse duration 5.75 ms
 Pulse on time 5.39 ms
 TX duty-cycle 94 %

Hub SW ge-swu-image-beat3-1mx7d-0.0.0.20.1.9217

Measurement equipment:
 Environment meter: Vaisala HUMICAP, ML 642.6810, calibration valid Jun-2021
 RF power meter: R&S NRP18SN, ML 804.6708, calibration valid until 30-Apr-2022
 ant cable B

WLAN TX power measurement:
 Measured in 802.11g (2GHz) and 802.11 (5) at 6Mbps datarate, 94% duty-cycle (measured) is compensated by R&S NRP18SN
 94% duty-cycle (measured) compensated by R&S NRP18SN

Antenna parameter DUT

DUT PWA 2YMB - original -> ANT Hub A1
 measured: 16-Oct-2020

	2 GHz				5 GHz				ETSI DFS																ETSI N/A (SDR)			
	ETSI		FCC N/A		ETSI		FCC		FCC DFS		FCC N/A		FCC DFS		FCC N/A		FCC DFS		FCC		FCC		FCC		FCC			
frequency (MHz)	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165
TX power (dBm) - top antenna	9.4	14.1	9.5	14	11.4	11.7	11.6	11.6	9.4	9.5	9.4	9.3	9.9	12.6	12.7	12.8	12.8	12.4	11.8	11.9	12.1	12.2	9.4	9.6	14.5	14.5	14.5	10.5
TX power (dBm) - bottom antenna	N/A	N/A	N/A	N/A	12.9	12.8	12.8	12.8	9.8	9.6	9.6	9.5	10.6	12.5	12.4	12.3	12.3	12.3	12.2	12.1	12	12	8.3	8.7	13.5	13.5	13.5	9.9

DUT PWA 3WDD - original -> ANT Hub A2
 measured: 14-Oct-2020

	2 GHz				5 GHz				ETSI DFS																ETSI N/A (SDR)			
	ETSI		FCC N/A		ETSI		FCC		FCC DFS		FCC N/A		FCC DFS		FCC N/A		FCC DFS		FCC		FCC		FCC		FCC		FCC	
frequency (MHz)	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165
TX power (dBm) - top antenna	8.3	12.8	8.2	12.5	10.8	11.3	11.5	11.7	9	9	9	8.9	10.1	12.4	12.4	12.6	12.7	11.8	11.9	12	12.1	12.2	9	9	14.1	14.1	14.1	11.3
TX power (dBm) - bottom antenna	N/A	N/A	N/A	N/A	12.6	12.6	12.6	12.5	9.3	9.2	9	8.9	9.8	11.6	11.5	11.4	11.4	11.4	11.3	11.2	11.2	11.1	7.3	7.5	12.3	12.3	12.3	9

Comments:
 ch1 power varies +0.3dB from measurement to measurement -> this DUT is not preferred in 2GHz WLAN radiated measurement

DUT PWA 3VYK - modified MBAN antenna lines -> ANT Hub B1
 measured: 14-Oct-2020

	2 GHz				5 GHz				ETSI DFS																ETSI N/A (SDR)			
	ETSI		FCC N/A		ETSI		FCC		FCC DFS		FCC N/A		FCC DFS		FCC N/A		FCC DFS		FCC		FCC		FCC		FCC		FCC	
channel	1	6	11	13	36	40	44	48	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140	149	153	157	161	165
TX power (dBm) - top antenna	9.7	13.9	8.8	13.3	11.1	11.4	11.5	11.4	9.2	9.3	9.1	9.1	9.9	12.3	12.4	12.5	12.6	11.7	11.7	11.9	12.1	9.2	9.5	14.5	14.5	14.5	11.5	
TX power (dBm) - bottom antenna	N/A	N/A	N/A	N/A	12.4	12.5	12.4	12.4	9.3	9.3	9.1	9	10	11.9	11.8	11.8	11.7	11.9	11.7	11.6	11.6	11.5	7.6	8.3	13.1	13.1	13	9.4



Test environment:

date	14 Oct 2020	date	16 Oct 2020	date	17 Oct 2020
tester	212487387 - Timo Hakala	tester	212487387 - Timo Hakala	tester	212487387 - Timo Hakala
place	GE Vallila RF lab	place	GE Vallila RF lab	place	GE Vallila RF lab
temp	21.1 C	temp	21.1 C	temp	21.9 C
RH	43.60%	RH	39.70%	RH	31.70%

Hub SW ge-swu-image-beat3-imx7d-0.0.0.20.1.9217 (MBAN test mode 20.1)

Measurement equipment:

Environment meter: Vaisala HUMICAP, ML 642.6810, calibration valid Jun-2021
 RF power meter: R&S NRP18SN, ML 804.6708, calibration valid until 30-Apr-2022
 ant cable B

MBAN TX power measurement:

Continuous MBAN signal used in measurement

Antenna parameter DUT

DUT PWA 2YMB - original --> ANT Hub A1

measured: 17-Oct-2020		US MBAN indoor			US MBAN anywhere	ISM			EU MBAN	
		low	high	mid	low	mid	high	low	high	
		channel	0	11	13	15	31	46	47	52
	frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	
Max TX power with PA	top antenna (dBm)	10.6	10.5	10.5	10.5	10.2	9.9	9.9	9.7	
	bottom antenna (dBm)	11.1	10.9	10.8	10.7	10.1	9.3	9.3	9	
Max TX no PA	top antenna (dBm)	2.1	2.2	2.2	2.2	2	1.6	1.5	1.3	
	bottom antenna (dBm)	2.2	2.2	2.2	2.2	1.7	0.8	0.7	0.4	
MCAL vector 0	top antenna (dBm)	-5.4	-5.2	7.7	7.7	7.7	7.7	-5.3	-5.5	
	bottom antenna (dBm)	-4.6	-4.3	8.7	8.7	8.7	8.6	-4.1	-4.4	
MCAL vector 1	top antenna (dBm)	N/A	N/A	N/A	4.6	4.7	4.5	4.8	4.7	
	bottom antenna (dBm)	N/A	N/A	N/A	5.6	5.6	5.7	5.8	5.7	

DUT PWA 3WOD - original --> ANT Hub A2

measured: 14-Oct-2020		US MBAN indoor			US MBAN anywhere	ISM			EU MBAN	
		low	high	mid	low	mid	high	low	high	
		channel	0	11	13	15	31	46	47	52
	frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	
Max TX power with PA	top antenna (dBm)	10.9	10.8	10.8	10.7	10.4	10.1	10	9.8	
	bottom antenna (dBm)	11.4	11.1	11	10.9	10.1	9.1	9	8.7	
Max TX no PA	top antenna (dBm)	2.3	2.3	2.2	2.2	1.9	1.3	1.2	1	
	bottom antenna (dBm)	2.1	2	1.9	1.8	1.1	0.1	-0.1	-0.4	
MCAL vector 0	top antenna (dBm)	-5.4	-5.3	7.6	7.7	7.7	7.6	-5.2	-5.4	
	bottom antenna (dBm)	-4.4	-4.3	8.6	8.6	8.6	8.4	-4.1	-4.5	
MCAL vector 1	top antenna (dBm)	N/A	N/A	N/A	4.7	4.5	4.6	4.6	4.4	
	bottom antenna (dBm)	N/A	N/A	N/A	5.7	5.8	5.5	5.9	5.7	

DUT PWA 3VYK - modified MBAN antenna lines --> ANT Hub B1

measured: 17-Oct-2020		US MBAN indoor			US MBAN anywhere	ISM			EU MBAN	
		low	high	mid	low	mid	high	low	high	
		channel	0	11	13	15	31	46	47	52
	frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498	
Max TX power with PA	top antenna (dBm)	11.2	11.2	11.2	11.2	11	10.6	10.6	10.4	
	bottom antenna (dBm)	11.5	11.4	11.3	11.3	10.7	9.9	9.8	9.6	
Max TX no PA	top antenna (dBm)	2	2.3	2.3	2.3	2.3	1.8	1.7	1.5	
	bottom antenna (dBm)	1.9	2.1	2.1	2.1	1.7	1	0.9	0.6	
MCAL vector 0	top antenna (dBm)	-5.5	-5.4	7.5	7.5	7.6	7.5	-5.4	-5.7	
	bottom antenna (dBm)	-4.6	-4.4	8.5	8.5	8.6	8.6	-4.3	-4.6	
MCAL vector 1	top antenna (dBm)	N/A	N/A	N/A	4.4	4.6	4.7	4.7	4.6	
	bottom antenna (dBm)	N/A	N/A	N/A	5.7	5.3	5.7	5.7	5.6	

Measurement data:

date	14 Oct 20	date	18 Oct 20
tester	212487387 - Timo Hakala	tester	212487387 - Timo Hakala
place	GE Vallila RF lab	place	GE Vallila RF lab
temp	21.1 C	temp	21.7 C
RH	43.60%	RH	27.70%

SB SW MBAN test mode 1.0.0.0.1.0-1.2.86b05b8

Measurement equipment:
 Environment meter: Vaisala HUMICAP, ML 642.6810, calibration valid Jun-2021
 RF power meter: R&S NRP185N, ML 804.6708, calibration valid until 30-Apr-2022
 ant cable B (compensated off from the TX power results)

MBAN TX power measurement:
 Continuous MBAN signal used in measurement
 MAX TX power with PA: MBAN test mode command --pa_ic 63 --pa_ext 1
 MAX TX power with PA: MBAN test mode command --pa_ic 63 --pa_ext 1
 MCAL vector 0 (or 1): MBAN test command --pa_mcal 0 (or 1)

14 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.5	11.3	11.2	11.2	10.9	10.6	10.6	10.5
Max TX no PA	2.8	3	3.1	3.1	3.3	3.3	3.3	3.2
MCAL vector 0	-3	-3	10.2	10.1	10.1	10	-2.8	-2.8
MCAL vector 1	N/A	N/A	N/A	7.2	7	7	7.2	7.1

14 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.5	11.3	11.3	11.3	11	10.9	10.8	10.8
Max TX no PA	2.7	2.9	3	3	3.2	3.2	3.2	3.1
MCAL vector 0	-3	-3	10.2	10.1	10.1	10.1	-2.8	-2.8
MCAL vector 1	N/A	N/A	N/A	7	7.1	7	7.2	7.1

14 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.8	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Max TX no PA	3	3.1	3.1	3.1	3.1	3	3	2.9
MCAL vector 0	-2.9	-2.8	10.1	10	10.1	10.1	-3	-3.1
MCAL vector 1	N/A	N/A	N/A	6.9	7	7	7.3	7.2

14 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
Max TX no PA	3.1	3.2	3.2	3.2	3.2	3.1	3.1	3
MCAL vector 0	-2.9	-2.8	10	10.1	10.1	10	-3	-3.1
MCAL vector 1	N/A	N/A	N/A	7.1	7.2	7	7.3	7.1

14 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.6	11.7	11.7	11.7	11.8	11.8	11.8	11.7
Max TX no PA	2.8	2.9	2.9	2.9	3	2.9	2.9	2.8
MCAL vector 0	-2.8	-3	10	10.1	10.2	10	-2.9	-3
MCAL vector 1	N/A	N/A	N/A	7.1	7.2	7.1	7.1	6.9

18 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.7	11.8	11.8	11.8	11.8	11.9	11.9	11.8
Max TX no PA	3.2	3.3	3.3	3.3	3.3	3.2	3.2	3.1
MCAL vector 0	-2.9	-2.8	10.1	10	10.2	10.1	-3.1	-3.1
MCAL vector 1	N/A	N/A	N/A	7.1	7.2	7.2	7.2	7.1

Antenna parameter DUT								
	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.6	11.6	11.6	11.6	11.7	11.7	11.6	11.6
Max TX no PA	3.3	3.3	3.3	3.3	3.3	3.2	3.2	3.1
MCAL vector 0	-3	-2.9	10.1	10	10.1	10.1	-2.9	-2.9
MCAL vector 1	N/A	N/A	N/A	7.1	7	6.9	7.2	7.1

18 Oct 20

	US MBAN indoor		US MBAN anywhere			EU MBAN		
	low	high	mid	low	mid	high	low	high
channel	0	11	13	15	31	46	47	52
frequency (MHz)	2362	2390.2	2395.4	2402	2443	2481.5	2485.5	2498
Max TX with PA	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Max TX no PA	2.8	2.9	2.9	2.9	3	2.9	2.9	2.9
MCAL vector 0	-2.9	-2.7	10.1	10.1	10.1	10.1	-3.1	-3.2
MCAL vector 1	N/A	N/A	N/A	7	7	6.9	7.2	7.1

Measurement equipment:
 RF power meter: R&S NRP185N, ML804.6708, calibration valid until 30-Apr-2022

ant cable B

freq[Hz]	re:Trc4_S21	im:Trc4_S21	comp S21
2.00E+09	3.58E-01	8.75E-01	-0.48
2.02E+09	4.55E-01	8.29E-01	-0.49
2.04E+09	5.46E-01	7.72E-01	-0.49
2.06E+09	6.30E-01	7.05E-01	-0.49
2.08E+09	7.06E-01	6.29E-01	-0.49
2.10E+09	7.73E-01	5.45E-01	-0.49
2.12E+09	8.29E-01	4.54E-01	-0.49
2.14E+09	8.75E-01	3.57E-01	-0.49
2.16E+09	9.10E-01	2.55E-01	-0.49
2.18E+09	9.33E-01	1.49E-01	-0.49
2.20E+09	9.44E-01	4.28E-02	-0.49
2.22E+09	9.43E-01	-6.46E-02	-0.49
2.24E+09	9.29E-01	-1.71E-01	-0.49
2.26E+09	9.04E-01	-2.75E-01	-0.49
2.28E+09	8.66E-01	-3.76E-01	-0.50
2.30E+09	8.18E-01	-4.70E-01	-0.50
2.32E+09	7.60E-01	-5.62E-01	-0.50
2.34E+09	6.92E-01	-6.41E-01	-0.51
2.36E+09	6.14E-01	-7.15E-01	-0.51
2.38E+09	5.30E-01	-7.79E-01	-0.52
2.40E+09	4.39E-01	-8.34E-01	-0.51
2.42E+09	3.41E-01	-8.78E-01	-0.52
2.44E+09	2.39E-01	-9.11E-01	-0.52
2.46E+09	1.34E-01	-9.31E-01	-0.53
2.48E+09	2.82E-02	-9.41E-01	-0.53
2.50E+09	-7.77E-02	-9.38E-01	-0.53
2.52E+09	-1.83E-01	-9.23E-01	-0.53
2.54E+09	-2.86E-01	-8.96E-01	-0.53
2.56E+09	-3.85E-01	-8.58E-01	-0.53
2.58E+09	-4.80E-01	-8.09E-01	-0.53
2.60E+09	-5.68E-01	-7.50E-01	-0.53
2.62E+09	-6.50E-01	-6.80E-01	-0.53
2.64E+09	-7.23E-01	-6.02E-01	-0.53
2.66E+09	-7.87E-01	-5.15E-01	-0.53
2.68E+09	-8.41E-01	-4.21E-01	-0.53
2.70E+09	-8.83E-01	-3.22E-01	-0.54
2.72E+09	-9.14E-01	-2.20E-01	-0.54
2.74E+09	-9.33E-01	-1.14E-01	-0.54
2.76E+09	-9.40E-01	-7.43E-02	-0.54
2.78E+09	-9.34E-01	8.85E-02	-0.54
2.80E+09	-9.17E-01	2.05E-01	-0.54
2.82E+09	-8.87E-01	3.07E-01	-0.55
2.84E+09	-8.47E-01	4.05E-01	-0.55
2.86E+09	-7.95E-01	4.99E-01	-0.55
2.88E+09	-7.33E-01	5.85E-01	-0.56
2.90E+09	-6.62E-01	6.64E-01	-0.56
2.92E+09	-5.82E-01	7.34E-01	-0.56
2.94E+09	-4.96E-01	7.95E-01	-0.57
2.96E+09	-4.02E-01	8.46E-01	-0.57
2.98E+09	-3.03E-01	8.85E-01	-0.58
3.00E+09	-2.01E-01	9.13E-01	-0.58
3.02E+09	-9.64E-02	9.30E-01	-0.58
3.04E+09	9.98E-02	9.35E-01	-0.58
3.06E+09	1.16E-01	9.27E-01	-0.59
3.08E+09	2.21E-01	9.08E-01	-0.59
3.10E+09	3.23E-01	8.77E-01	-0.59
3.12E+09	4.20E-01	8.34E-01	-0.59
3.14E+09	5.12E-01	7.81E-01	-0.60
3.16E+09	5.97E-01	7.18E-01	-0.60
3.18E+09	6.74E-01	6.45E-01	-0.60
3.20E+09	7.43E-01	5.64E-01	-0.60
3.22E+09	8.03E-01	4.76E-01	-0.60
3.24E+09	8.51E-01	3.82E-01	-0.60
3.26E+09	8.89E-01	2.83E-01	-0.60
3.28E+09	9.16E-01	1.80E-01	-0.60
3.30E+09	9.30E-01	7.52E-02	-0.60
3.32E+09	9.33E-01	-3.05E-02	-0.60
3.34E+09	9.23E-01	-1.36E-01	-0.60
3.36E+09	9.02E-01	-2.40E-01	-0.60
3.38E+09	8.69E-01	-3.40E-01	-0.60
3.40E+09	8.25E-01	-4.36E-01	-0.60
3.42E+09	7.70E-01	-5.27E-01	-0.60
3.44E+09	7.05E-01	-6.10E-01	-0.61
3.46E+09	6.31E-01	-6.86E-01	-0.61
3.48E+09	5.49E-01	-7.53E-01	-0.61
3.50E+09	4.59E-01	-8.10E-01	-0.62
3.52E+09	3.64E-01	-8.57E-01	-0.62
3.54E+09	2.65E-01	-8.92E-01	-0.63
3.56E+09	1.62E-01	-9.16E-01	-0.63
3.58E+09	5.73E-02	-9.28E-01	-0.63
3.60E+09	-4.84E-02	-9.28E-01	-0.64
3.62E+09	-1.53E-01	-9.16E-01	-0.64
3.64E+09	-2.56E-01	-8.93E-01	-0.64
3.66E+09	-3.55E-01	-8.58E-01	-0.64
3.68E+09	-4.50E-01	-8.12E-01	-0.65
3.70E+09	-5.39E-01	-7.55E-01	-0.65
3.72E+09	-6.21E-01	-6.90E-01	-0.65
3.74E+09	-6.95E-01	-6.15E-01	-0.64
3.76E+09	-7.60E-01	-5.32E-01	-0.65
3.78E+09	-8.16E-01	-4.43E-01	-0.64
3.80E+09	-8.61E-01	-3.48E-01	-0.65
3.82E+09	-8.95E-01	-2.48E-01	-0.64
3.84E+09	-9.17E-01	-1.45E-01	-0.64
3.86E+09	-9.28E-01	-3.92E-02	-0.64
3.88E+09	-9.26E-01	6.68E-02	-0.64
3.90E+09	-9.13E-01	1.72E-01	-0.64
3.92E+09	-8.87E-01	2.74E-01	-0.64
3.94E+09	-8.50E-01	3.74E-01	-0.64
3.96E+09	-8.02E-01	4.68E-01	-0.65
3.98E+09	-7.43E-01	5.56E-01	-0.65
4.00E+09	-6.74E-01	6.37E-01	-0.65
4.02E+09	-5.97E-01	7.10E-01	-0.65
4.04E+09	-5.12E-01	7.72E-01	-0.66
4.06E+09	-4.21E-01	8.25E-01	-0.66
4.08E+09	-3.24E-01	8.67E-01	-0.67
4.10E+09	-2.23E-01	8.97E-01	-0.68
4.12E+09	-1.20E-01	9.16E-01	-0.68
4.14E+09	-1.55E-02	9.23E-01	-0.69
4.16E+09	8.87E-02	9.19E-01	-0.70
4.18E+09	1.93E-01	9.02E-01	-0.71
4.20E+09	2.92E-01	8.73E-01	-0.72
4.22E+09	3.89E-01	8.34E-01	-0.72
4.24E+09	4.80E-01	7.85E-01	-0.73
4.26E+09	5.65E-01	7.26E-01	-0.73
4.28E+09	6.43E-01	6.57E-01	-0.73
4.30E+09	7.13E-01	5.80E-01	-0.73
4.32E+09	7.74E-01	4.96E-01	-0.74
4.34E+09	8.25E-01	4.05E-01	-0.73
4.36E+09	8.65E-01	3.10E-01	-0.73
4.38E+09	8.95E-01	2.09E-01	-0.73
4.40E+09	9.13E-01	1.07E-01	-0.73
4.42E+09	9.19E-01	2.51E-03	-0.73
4.44E+09	9.14E-01	-1.01E-01	-0.73
4.46E+09	8.98E-01	-2.04E-01	-0.72
4.48E+09	8.69E-01	-3.04E-01	-0.72
4.50E+09	8.28E-01	-4.01E-01	-0.72
4.52E+09	7.77E-01	-4.93E-01	-0.72
4.54E+09	7.16E-01	-5.79E-01	-0.71
4.56E+09	6.46E-01	-6.57E-01	-0.71
4.58E+09	5.66E-01	-7.26E-01	-0.72
4.60E+09	4.79E-01	-7.86E-01	-0.72
4.62E+09	3.86E-01	-8.35E-01	-0.72
4.64E+09	2.88E-01	-8.74E-01	-0.73
4.66E+09	1.86E-01	-9.00E-01	-0.73
4.68E+09	8.30E-02	-9.15E-01	-0.74
4.70E+09	-2.17E-02	-9.17E-01	-0.75
4.72E+09	-1.27E-01	-9.08E-01	-0.76
4.74E+09	-2.30E-01	-8.86E-01	-0.77
4.76E+09	-3.29E-01	-8.53E-01	-0.78
4.78E+09	-4.23E-01	-8.09E-01	-0.79
4.80E+09	-5.11E-01	-7.55E-01	-0.80
4.82E+09	-5.92E-01	-6.91E-01	-0.82
4.84E+09	-6.66E-01	-6.18E-01	-0.83
4.86E+09	-7.31E-01	-5.38E-01	-0.84
4.88E+09	-7.86E-01	-4.52E-01	-0.85
4.90E+09	-8.31E-01	-3.60E-01	-0.87
4.92E+09	-8.65E-01	-2.63E-01	-0.88
4.94E+09	-8.88E-01	-1.64E-01	-0.89
4.96E+09	-9.00E-01	-6.26E-02	-0.89
4.98E+09	-9.01E-01	3.86E-02	-0.89
5.00E+09	-8.91E-01	1.40E-01	-0.90
5.02E+09	-8.69E-01	2.39E-01	-0.90
5.04E+09	-8.36E-01	3.35E-01	-0.90
5.06E+09	-7.93E-01	4.28E-01	-0.90
5.08E+09	-7.41E-01	5.15E-01	-0.89
5.10E+09	-6.78E-01	5.96E-01	-0.89
5.12E+09	-6.07E-01	6.68E-01	-0.89
5.14E+09	-5.27E-01	7.33E-01	-0.89
5.16E+09	-4.41E-01	7.89E-01	-0.88
5.18E+09	-3.49E-01	8.35E-01	-0.87
5.20E+09	-2.52E-01	8.70E-01	-0.86
5.22E+09	-1.51E-01	8.93E-01	-0.86
5.24E+09	-4.83E-02	9.05E-01	-0.85
5.26E+09	5.60E-02	9.05E-01	-0.85
5.28E+09	1.59E-01	8.93E-01	-0.85
5.30E+09	2.60E-01	8.68E-01	-0.85
5.32E+09	3.58E-01	8.33E-01	-0.85
5.34E+09	4.51E-01	7.86E-01	-0.86
5.36E+09	5.38E-01	7.28E-01	-0.86
5.38E+09	6.17E-01	6.61E-01	-0.87
5.40E+09	6.88E-01	5.85E-01	-0.89
5.42E+09	7.49E-01	5.02E-01	-0.90
5.44E+09	8.00E-01	4.13E-01	-0.91
5.46E+09	8.41E-01	3.18E-01	-0.93
5.48E+09	8.70E-01	2.20E-01	-0.94
5.50E+09	8.88E-01	1.20E-01	-0.96
5.52E+09	8.94E-01	1.90E-02	-0.98
5.54E+09	8.88E-01	-8.22E-02	-0.99
5.56E+09	8.71E-01	-1.82E-01	-1.01
5.58E+09	8.44E-01	-2.78E-01	-1.03
5.60E+09	8.06E-01	-3.70E-01	-1.04
5.62E+09	7.58E-01	-4.57E-01	-1.05
5.64E+09	7.01E-01	-5.38E-01	-1.07
5.66E+09	6.35E-01	-6.13E-01	-1.09
5.68E+09	5.62E-01	-6.80E-01	-1.09
5.70E+09	4.83E-01	-7.38E-01	-1.09
5.72E+09	3.98E-01	-7.87E-01	-1.09
5.74E+09	3.07E-01	-8.26E-01	-1.10
5.76E+09	2.12E-01	-8.55E-01	-1.10
5.78E+09	1.15E-01	-8.74E-01	-1.10
5.80E+09	1.60E-02	-8.83E-01	-1.08
5.82E+09	-8.31E-02	-8.80E-01	-1.07
5.84E+09	-1.81E-01	-8.66E-01	-1.07
5.86E+09	-2.78E-01	-8.40E-01	-1.07
5.88E+09	-3.72E-01	-8.04E-01	-1.05
5.90E+09	-4.62E-01	-7.57E-01	-1.04
5.92E+09	-5.46E-01	-7.01E-01	-1.03
5.94E+09	-6.23E-01	-6.35E-01	-1.02
5.96E+09	-6.92E-01	-5.59E-01	-1.02
5.98E+09	-7.52E-01	-4.75E-01	-1.02
6.00E+09	-8.02E-01	-3.86E-01	-1.02

ant cable A

freq[Hz]	re:Trc4_S1	im:Trc4_S1	comp S1
2.00E+09	3.87E-01	8.60E-01	-0.51
2.02E+09	4.82E-01	8.10E-01	-0.51
2.04E+09	5.71E-01	7.50E-01	-0.52
2.06E+09	6.53E-01	6.80E-01	-0.52
2.08E+09	7.26E-01	6.01E-01	-0.52
2.10E+09	7.89E-01	5.15E-01	-0.52
2.12E+09	8.42E-01	4.23E-01	-0.52
2.14E+09	8.85E-01	3.24E-01	-0.52
2.16E+09	9.16E-01	2.21E-01	-0.52
2.18E+09	9.35E-01	1.15E-01	-0.52
2.20E+09	9.42E-01	7.83E-03	-0.52
2.22E+09	9.37E-01	-9.94E-02	-0.52
2.24E+09	9.19E-01	-2.05E-01	-0.52
2.26E+09	8.90E-01	-3.08E-01	-0.52
2.28E+09	8.49E-01	-4.07E-01	-0.53
2.30E+09	7.97E-01	-5.00E-01	-0.53
2.32E+09	7.35E-01	-5.87E-01	-0.53
2.34E+09	6.64E-01	-6.66E-01	-0.54
2.36E+09	5.84E-01	-7.36E-01	-0.54
2.38E+09	4.97E-01	-7.97E-01	-0.54
2.40E+09	4.05E-01	-8.48E-01	-0.54
2.42E+09	3.05E-01	-8.88E-01	-0.55
2.44E+09	2.01E-01	-9.16E-01	-0.55
2.46E+09	9.54E-02	-9.33E-01	-0.56
2.48E+09	-1.09E-02	-9.38E-01	-0.56
2.50E+09	-1.16E-01	-9.31E-01	-0.56