

OTA Passive Antenna Pattern Test Report

Date of Report	10/12/2025	Test Period:	21-22.10.2025
Number of pages:	17	Customer's Contact person:	Jouni Lifländer
		Responsible Test engineer:	Veli-Matti Niemitalo
Testing laboratory:	Verkotan Oy Elektroniikkatie 17 90590 Oulu Finland	Client:	Haltian Oy Yrttipellontie 1 D3 90230 Oulu Finland
Tested Devices:	Clip BT, Clip WLAN		
Testing has been carried out in accordance with:	Passive measurements per customer request		
Documentation:	The test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory.		

Date and signature:



Jani Kallankari 10.12.2025
Chief scientist



- 1 TEST EQUIPMENT 3
 - 1.1 ANTENNA PATTERN MEASUREMENT SETUP..... 3
- 2 SUMMARY 4
 - 2.1 EQUIPMENT UNDER TEST 4
 - 2.2 TESTING INFORMATION 6
- 3 UNCERTAINTY ESTIMATES (ANTENNA PATTERN MEASUREMENT)..... 7
- 4 TEST SETUP AND MEASUREMENTS 8
- 5 TEST RESULTS 10
 - 5.1 PASSIVE OTA MEASUREMENT..... 10
 - 5.1.1 Maximum Gain, BT, Free Space 10
 - 5.1.2 Maximum Gain, WLAN, Free Space 11
 - 5.1.3 Efficiency, BT, Free Space 13
 - 5.1.4 Efficiency, WLAN, Free Space 14
 - 5.1.5 Maximum Gain (graph) 16
 - 5.1.6 Efficiency (graph) 17

1 TEST EQUIPMENT

Main used test equipment is listed below. For full equipment list and calibration intervals, please contact the testing laboratory. Equipment that is essential for the test but does not require a calibration or is calibrated as a part of part of the laboratory path loss measurement, the calibration information is marked as n/a i.e. not applicable.

1.1 Antenna pattern measurement setup

Type of Equipment	Type	Manufacturer	Calibration date	Calibration period	Calibration due	Purpose
Diagonal Dual Polarized Horn Measurement Antenna	3164-06	ETS	Included in range calibration	Included in range calibration	Included in range calibration	Probe antenna
Positioning Controller	2090	EMCO	n/a	n/a	n/a	DUT alignment
3D Positioner	Custom made	ETS-Lindgren	n/a	n/a	n/a	DUT alignment
Anechoic Chamber	1	ETS-Lindgren	04.11.2024	1 year	04.11.2025	Test range
Switching System	SW6AD-A61	Pulsar	Included in range calibration	Included in range calibration	Included in range calibration	Probe selection
Amplifier	ZX60-83LN12+	Mini-Circuits	Included in range calibration	Included in range calibration	Included in range calibration	Amplifier
Power supply	E3631A	Agilent	n/a	n/a	n/a	Power supply
Network Analyzer	E5071C	Agilent	21.05.2025	1 year	21.05.2026	Measurement transmitter / receiver
Dual-Ridge Horn Antenna	SH600	MVG	20.08.2020	n/a	n/a	Calibration antenna 1-9 GHz

Table 1. Antenna pattern measurement equipment

2 SUMMARY

2.1 Equipment under test

Product:	Clip
Description:	Description Hamina Clip is a device to scan and analyze WIFI networks. Results are sent using BLE connection or USB cable to survey application running on mobile device, iPad or computer.
Note	Clip sample for BT antenna test. Pluto is a project nickname for Hamina clip device.
Manufacturer info:	Hamina Wireless Oy Mannerheimintie 4 00100 Helsinki, Finland
HW info:	PTO_02, HWID 0203
SW Info:	0251110160312
DUT number:	51
Tested Frequencies [MHz]	2300-2600 in 20 MHz steps

Table 2 Equipment under test



Figure 1 Pluto BT Front



Figure 2 Pluto BT Back

Product:	Clip
Description:	Hamina Clip is a device to scan and analyze WIFI networks. Results are sent using BLE connection or USB cable to survey application running on mobile device, iPad or computer.
Note	Clip sample for WIFI antenna test, 4 antennas tested. Pluto is a project nickname for Hamina clip device.
Manufacturer info:	Hamina Wireless Oy Mannerheimintie 4 00100 Helsinki, Finland
HW info:	PTO_02, HWID 0203
SW Info:	0251110160312
DUT number:	52
Tested Frequencies [MHz]	2300-2600 in 20 MHz steps 4800-7200 in 20 MHz steps

Table 3 Equipment under test

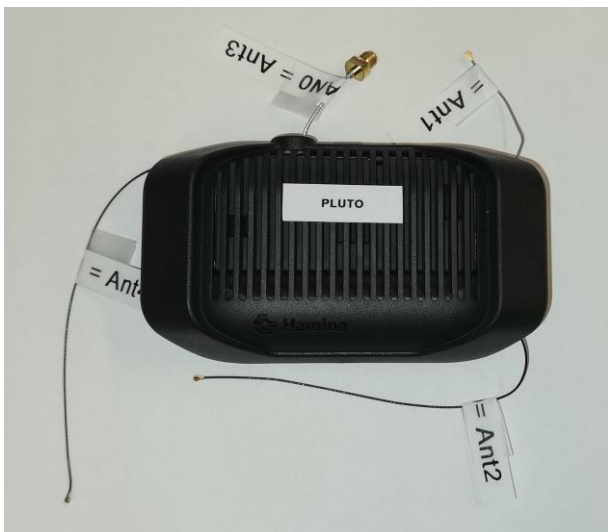


Figure 3 Pluto WLAN Front

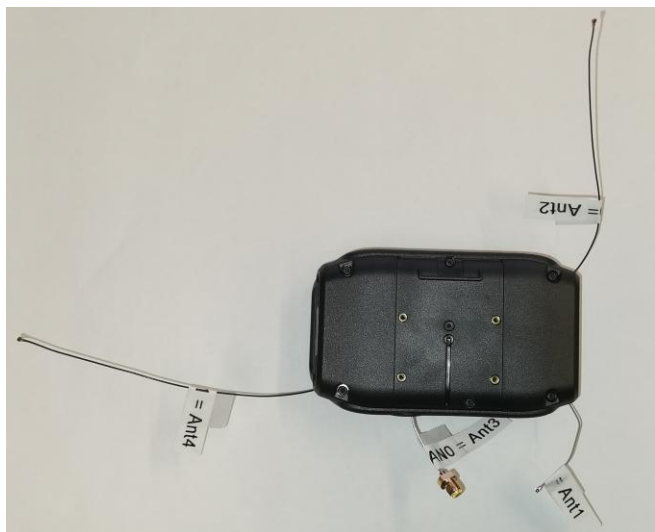


Figure 4 Pluto WLAN Back

2.2 Testing information

Testing performed:	21-22.10.2025
Temperature °C / Humidity RH%	22±2/40±20
Notes:	BT and WLAN results measured with separate samples
Document name	Passive_OTA_test_report_ID5993_Clip_27102025.docx
Version History:	10.12.2025 Non draft version, Equipment under test tables information updated, DUT name changed from Pluto to Clip 27.10.2025 Initial draft

3 UNCERTAINTY ESTIMATES (ANTENNA PATTERN MEASUREMENT)

Parameter	Expanded uncertainty (k=2)
Efficiency	± 1.61 dB
Maximum Gain	± 2.44 dB
Gain repeatability	± 0.2 dB

Table 4 Uncertainty estimates

4 TEST SETUP AND MEASUREMENTS

The test system uses 6 dual polarized probes in a full anechoic conical-cut chamber to measure 3D antenna pattern. Chamber dimensions are 6 meters x 6 meters x 7 meters. Measurement distance is ~3 meters. Data collection is performed using a vector network analyzer. Schematic of the test system is shown in Figure 5.

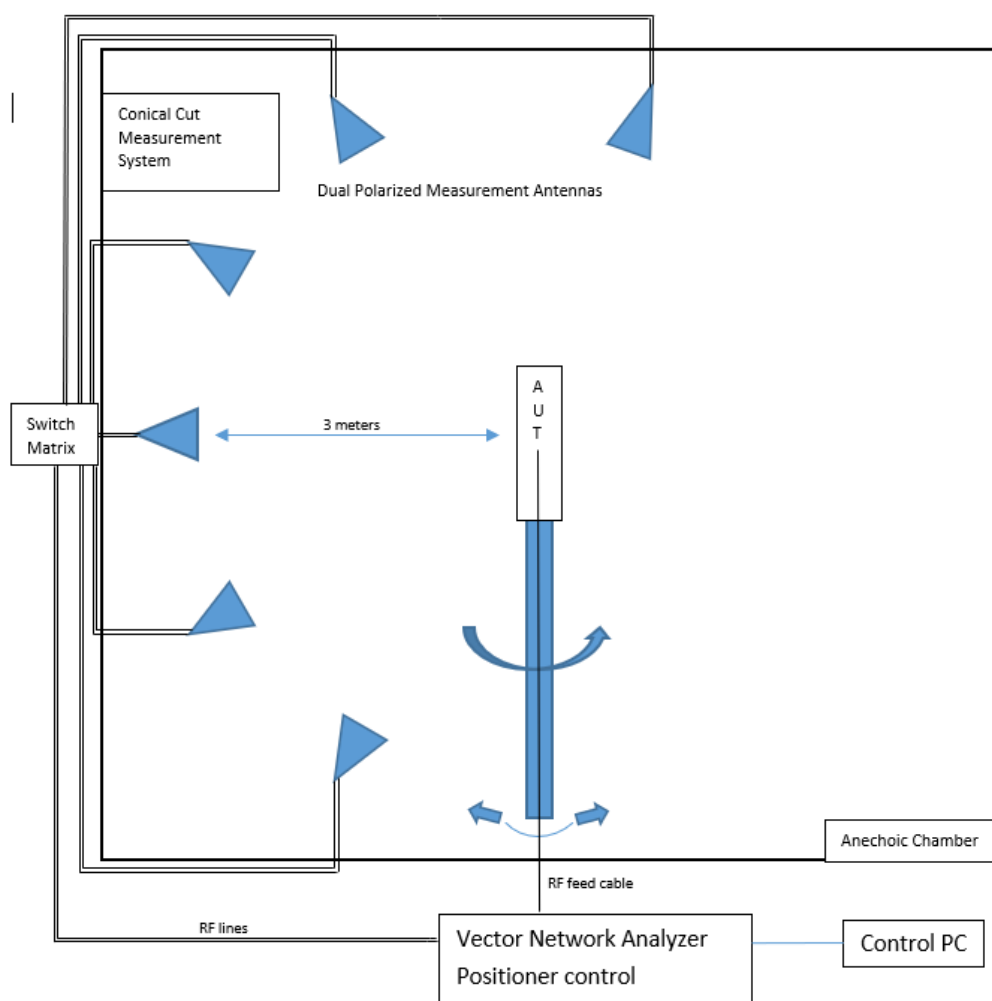


Figure 5. OTA laboratory schematic

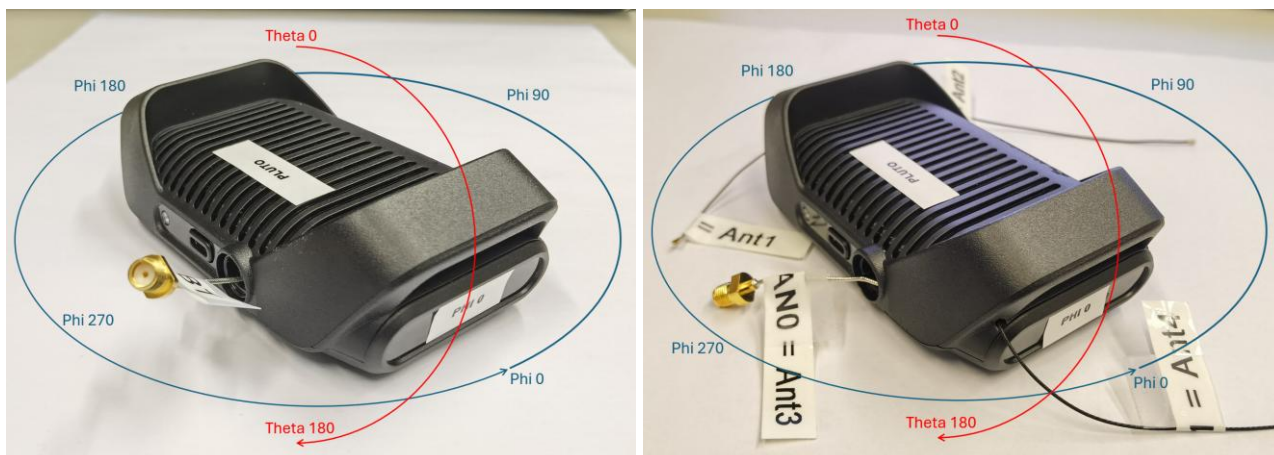


Figure 6 Coordinate system, Pluto BT and Pluto WLAN

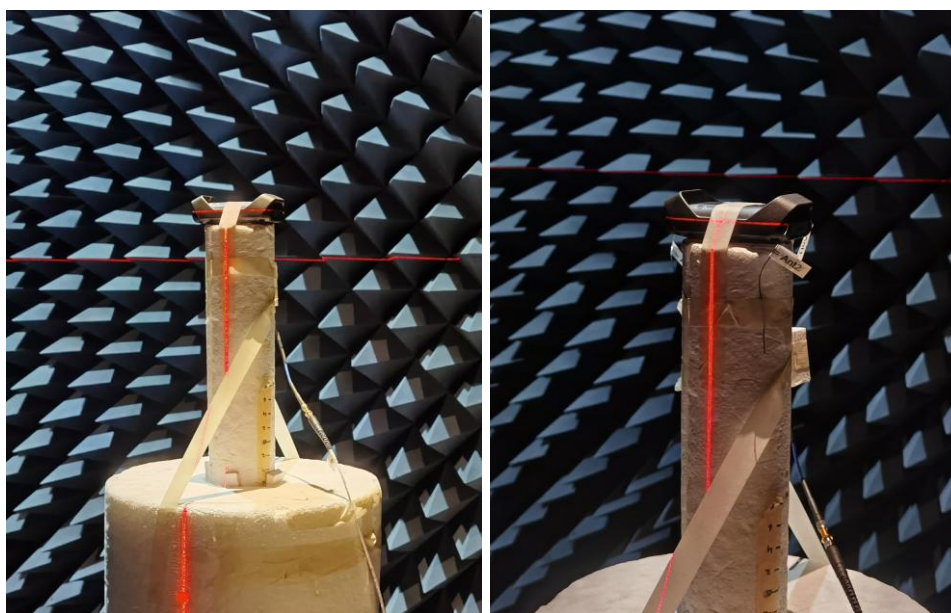


Figure 7 Free Space setup picture, Pluto BT and Pluto WLAN

5 TEST RESULTS

5.1 Passive OTA measurement

5.1.1 Maximum Gain, BT, Free Space

	Max Gain [dBi]
Frequency [MHz]	BT
2300	-3.4
2320	-2.1
2340	-0.2
2360	0.2
2380	0.0
2400	-0.4
2420	-0.7
2440	-1.8
2460	-2.4
2480	-2.7
2500	-3.5
2520	-3.6
2540	-3.9
2560	-3.7
2580	-3.3
2600	-3.2

Table 5. Maximum Gain, BT, Free Space

5.1.2 Maximum Gain, WLAN, Free Space

Max Gain [dBi]					Max Gain [dBi]				
Frequency [MHz]	Ant1	Ant2	Ant3	Ant4	Frequency [MHz]	Ant1	Ant2	Ant3	Ant4
2300	3.7	1.1	-1.0	2.5	5160	3.4	2.3	1.0	3.2
2320	3.7	1.4	-0.2	3.1	5180	3.7	2.6	1.3	3.4
2340	3.7	2.4	-0.1	3.9	5200	3.8	2.8	1.7	3.3
2360	3.8	2.4	-0.1	4.6	5220	4.1	2.7	2.3	3.4
2380	2.6	2.4	-0.2	4.7	5240	4.4	3.0	2.2	3.5
2400	2.3	2.6	-1.2	5.1	5260	4.4	2.9	2.6	3.4
2420	1.7	2.3	-1.9	5.4	5280	4.5	3.0	2.4	3.4
2440	0.7	2.4	-2.5	5.5	5300	4.6	3.2	2.8	3.4
2460	0.4	2.6	-3.7	5.6	5320	4.4	2.8	2.5	3.3
2480	-0.5	2.8	-4.3	5.7	5340	4.4	3.4	2.5	3.6
2500	-0.6	2.8	-5.2	5.8	5360	4.4	3.1	2.4	3.5
2520	-1.8	2.6	-5.8	5.5	5380	4.8	3.4	2.3	3.8
2540	-2.6	2.5	-6.1	5.6	5400	4.6	3.3	2.0	3.7
2560	-3.2	2.2	-6.7	5.2	5420	4.9	3.5	1.9	4.1
2580	-4.3	2.0	-7.1	4.8	5440	5.1	3.4	1.7	4.2
2600	-5.2	1.4	-7.5	4.4	5460	5.1	3.5	1.5	4.2
4800	2.6	-2.4	-3.9	0.8	5480	5.0	3.7	1.2	4.3
4820	2.8	-2.3	-4.3	1.0	5500	5.1	3.5	1.0	4.2
4840	2.7	-1.7	-3.6	1.4	5520	5.1	3.6	1.0	4.4
4860	2.1	-1.8	-3.6	1.1	5540	4.7	3.3	0.7	4.0
4880	2.4	-1.4	-3.6	1.8	5560	4.9	3.7	0.9	4.4
4900	2.1	-1.1	-2.6	1.2	5580	4.6	3.4	1.0	4.2
4920	2.5	-0.6	-3.4	1.5	5600	4.8	3.6	0.9	4.2
4940	2.5	0.0	-2.5	1.6	5620	4.7	3.6	1.1	4.5
4960	2.6	0.5	-2.4	1.7	5640	4.3	3.2	1.5	3.7
4980	3.1	1.0	-2.2	2.3	5660	4.7	3.3	1.5	4.2
5000	2.9	1.4	-1.3	2.3	5680	4.5	3.4	2.1	4.1
5020	3.1	1.6	-1.9	2.5	5700	4.4	3.1	1.7	3.8
5040	3.3	2.0	-1.0	2.9	5720	4.5	3.2	2.4	4.1
5060	3.3	1.9	-0.8	2.9	5740	4.2	3.3	2.0	3.7
5080	3.5	2.2	-0.7	3.2	5760	4.5	3.1	2.4	4.0
5100	3.3	2.2	-0.3	3.2	5780	3.9	2.9	2.6	3.7
5120	3.3	2.1	0.1	3.2	5800	4.0	2.9	2.3	3.6
5140	3.6	2.5	0.6	3.4	5820	3.9	2.8	2.7	3.5

Max Gain [dBi]					Max Gain [dBi]				
Frequency [MHz]	Ant1	Ant2	Ant3	Ant4	Frequency [MHz]	Ant1	Ant2	Ant3	Ant4
5840	3.4	2.4	2.6	2.9	6540	0.4	0.4	-2.8	1.2
5860	3.4	2.8	2.8	3.3	6560	0.7	0.8	-3.2	1.3
5880	2.9	2.4	3.0	3.0	6580	0.6	0.4	-2.5	1.2
5900	3.0	2.5	3.1	3.2	6600	0.6	1.3	-2.7	1.6
5920	2.6	2.5	3.1	3.3	6620	0.3	1.1	-2.5	1.3
5940	2.2	2.1	3.2	3.0	6640	0.1	1.0	-2.1	1.2
5960	2.5	2.2	3.1	3.3	6660	0.1	1.8	-1.9	1.6
5980	2.4	2.3	3.3	3.3	6680	-0.4	1.5	-1.9	0.8
6000	2.4	1.8	2.8	3.0	6700	-0.6	1.7	-1.5	0.9
6020	2.4	2.2	3.1	3.5	6720	-0.5	1.8	-1.1	1.2
6040	2.2	2.2	2.6	3.4	6740	-0.5	1.5	-0.3	0.8
6060	2.5	2.1	2.3	3.3	6760	-0.9	1.2	-0.7	0.9
6080	1.9	2.3	2.0	3.7	6780	-0.9	1.5	-0.2	0.7
6100	2.0	2.0	1.0	3.3	6800	-1.3	0.8	-0.2	0.8
6120	2.2	2.5	1.4	3.6	6820	-1.1	0.7	-0.5	0.9
6140	1.9	2.5	0.4	3.7	6840	-1.5	0.9	-0.2	1.0
6160	2.2	2.5	0.2	3.6	6860	-1.3	0.1	0.0	0.6
6180	1.7	2.7	0.1	3.8	6880	-1.3	0.5	0.0	0.9
6200	2.0	2.6	-0.4	3.7	6900	-1.5	-0.1	-0.6	0.0
6220	1.6	2.3	-0.4	3.6	6920	-1.4	0.2	-0.8	0.0
6240	1.5	2.2	-1.3	3.5	6940	-1.7	-0.3	-1.2	-0.2
6260	1.6	2.1	-1.4	3.4	6960	-1.4	-0.5	-1.9	-0.6
6280	1.2	1.9	-1.7	3.6	6980	-1.7	0.0	-2.3	-0.3
6300	1.3	1.8	-2.3	3.3	7000	-1.9	-0.6	-3.4	-1.1
6320	1.1	1.4	-2.4	3.3	7020	-1.5	-0.2	-3.5	-0.8
6340	0.7	1.5	-2.8	3.3	7040	-2.2	-0.7	-4.2	-1.1
6360	1.0	1.0	-3.1	3.0	7060	-1.9	-0.8	-4.6	-1.2
6380	0.6	0.9	-3.4	2.9	7080	-1.9	-0.6	-4.7	-1.4
6400	0.7	0.9	-3.8	2.6	7100	-2.0	-1.2	-5.4	-1.5
6420	0.3	0.5	-3.4	2.3	7120	-1.7	-1.1	-5.9	-1.4
6440	0.3	0.7	-3.5	2.1	7140	-2.2	-1.0	-5.6	-1.4
6460	0.4	0.6	-3.4	1.7	7160	-1.9	-1.4	-6.7	-1.5
6480	0.3	0.1	-3.0	1.5	7180	-2.2	-1.1	-6.8	-1.2
6500	0.5	0.8	-3.3	1.5	7200	-2.3	-1.1	-6.7	-1.1
6520	0.6	0.0	-2.8	1.2					

Table 6. Maximum Gain, WLAN, Free Space

5.1.3 Efficiency, BT, Free Space

	Efficiency [dB]
Frequency [MHz]	BT
2300	-7.5
2320	-5.5
2340	-3.9
2360	-3.2
2380	-3.2
2400	-3.8
2420	-4.4
2440	-5.4
2460	-6.4
2480	-6.9
2500	-7.8
2520	-8.0
2540	-8.1
2560	-8.0
2580	-7.6
2600	-7.2

Table 7. Efficiency, BT, Free Space

5.1.4 Efficiency, WLAN, Free Space

Efficiency [dB]					Efficiency [dB]				
Frequency [MHz]	Ant1	Ant2	Ant3	Ant4	Frequency [MHz]	Ant1	Ant2	Ant3	Ant4
2300	-3.9	-5.2	-5.3	-4.9	5160	-2.3	-3.4	-4.4	-2.8
2320	-3.6	-4.8	-4.6	-4.5	5180	-2.1	-3.3	-4.2	-2.6
2340	-3.5	-4.3	-4.6	-4.2	5200	-2.1	-3.2	-3.8	-2.7
2360	-3.7	-4.0	-4.8	-4.0	5220	-1.9	-3.3	-3.6	-2.6
2380	-4.3	-3.8	-5.1	-4.0	5240	-1.8	-3.0	-3.5	-2.5
2400	-4.8	-3.6	-5.9	-3.8	5260	-1.9	-3.2	-3.2	-2.7
2420	-5.3	-3.5	-6.6	-3.8	5280	-1.8	-3.0	-3.4	-2.5
2440	-6.1	-3.3	-7.4	-3.6	5300	-1.8	-3.0	-3.0	-2.5
2460	-6.3	-3.1	-8.5	-3.5	5320	-2.0	-3.2	-3.4	-2.7
2480	-7.3	-3.0	-9.2	-3.5	5340	-1.9	-2.8	-3.2	-2.3
2500	-7.3	-2.7	-10.1	-3.5	5360	-2.0	-3.1	-3.2	-2.6
2520	-8.3	-2.9	-10.7	-3.9	5380	-2.0	-2.7	-3.4	-2.4
2540	-9.1	-2.9	-11.0	-3.9	5400	-2.3	-3.0	-3.4	-2.5
2560	-9.7	-3.1	-11.6	-4.3	5420	-2.1	-2.7	-3.5	-2.4
2580	-10.7	-3.3	-11.9	-4.5	5440	-2.3	-2.7	-3.6	-2.4
2600	-11.6	-3.7	-12.3	-4.9	5460	-2.3	-2.7	-3.7	-2.5
4800	-3.9	-7.3	-9.3	-4.5	5480	-2.3	-2.5	-3.9	-2.4
4820	-3.8	-7.3	-9.8	-4.2	5500	-2.4	-2.6	-4.0	-2.4
4840	-3.5	-7.1	-9.1	-4.1	5520	-2.3	-2.4	-4.0	-2.3
4860	-3.9	-7.0	-9.1	-4.4	5540	-2.6	-2.5	-4.3	-2.4
4880	-3.2	-6.7	-9.1	-3.8	5560	-2.5	-2.5	-4.3	-2.4
4900	-3.6	-6.4	-8.1	-4.2	5580	-2.5	-2.4	-4.2	-2.3
4920	-3.1	-6.0	-8.8	-3.7	5600	-2.6	-2.3	-4.3	-2.2
4940	-3.2	-5.5	-8.0	-3.5	5620	-2.5	-2.4	-4.2	-2.1
4960	-3.2	-5.3	-7.8	-3.6	5640	-2.7	-2.3	-4.3	-2.1
4980	-2.7	-4.6	-7.7	-3.0	5660	-2.6	-2.3	-4.2	-2.0
5000	-2.9	-4.4	-6.9	-3.1	5680	-2.5	-2.2	-3.9	-1.9
5020	-2.8	-4.3	-7.2	-3.1	5700	-2.8	-2.4	-4.3	-2.2
5040	-2.6	-3.8	-6.4	-2.8	5720	-2.5	-2.3	-3.9	-2.1
5060	-2.7	-3.9	-6.0	-2.9	5740	-2.8	-2.4	-4.2	-2.2
5080	-2.4	-3.6	-5.9	-2.7	5760	-2.5	-2.4	-4.1	-2.2
5100	-2.6	-3.6	-5.4	-2.8	5780	-3.0	-2.7	-4.1	-2.5
5120	-2.4	-3.6	-5.1	-2.7	5800	-2.8	-2.8	-4.3	-2.6
5140	-2.2	-3.3	-4.7	-2.6	5820	-2.7	-2.7	-4.0	-2.6

Efficiency [dB]					Efficiency [dB]				
Frequency [MHz]	Ant1	Ant2	Ant3	Ant4	Frequency [MHz]	Ant1	Ant2	Ant3	Ant4
5840	-3.0	-3.1	-4.2	-2.8	6540	-4.7	-5.1	-8.9	-5.1
5860	-2.8	-3.0	-4.0	-2.7	6560	-4.4	-5.0	-8.9	-5.0
5880	-3.0	-3.2	-3.9	-2.9	6580	-4.4	-5.2	-8.2	-4.9
5900	-2.8	-3.2	-3.9	-2.8	6600	-4.3	-4.8	-8.3	-4.6
5920	-2.9	-3.3	-3.8	-2.9	6620	-4.5	-4.9	-8.0	-4.7
5940	-3.2	-3.6	-3.7	-3.1	6640	-4.8	-5.1	-7.6	-4.8
5960	-2.9	-3.6	-3.7	-2.9	6660	-4.5	-4.6	-7.4	-4.4
5980	-3.0	-3.6	-3.5	-2.9	6680	-4.9	-5.1	-7.1	-4.9
6000	-3.2	-4.0	-3.9	-3.2	6700	-5.0	-5.0	-6.5	-4.8
6020	-3.0	-3.7	-3.6	-2.9	6720	-4.9	-5.0	-6.4	-4.8
6040	-3.4	-4.0	-4.0	-3.0	6740	-5.0	-5.1	-5.6	-5.0
6060	-3.0	-3.9	-4.2	-3.0	6760	-5.2	-5.1	-5.7	-5.0
6080	-3.5	-3.8	-4.5	-2.9	6780	-5.2	-5.3	-5.3	-5.2
6100	-3.5	-4.2	-5.4	-3.1	6800	-5.5	-5.4	-5.0	-5.3
6120	-3.3	-3.6	-5.0	-2.8	6820	-5.4	-5.4	-5.2	-5.5
6140	-3.7	-3.8	-6.0	-2.9	6840	-5.6	-5.5	-4.8	-5.5
6160	-3.4	-3.8	-6.2	-3.0	6860	-5.4	-5.6	-5.1	-5.7
6180	-3.9	-3.6	-6.5	-2.9	6880	-5.5	-5.5	-5.1	-5.6
6200	-3.5	-3.7	-7.1	-3.0	6900	-5.8	-6.0	-5.7	-6.2
6220	-3.8	-3.7	-7.0	-3.1	6920	-5.5	-5.8	-6.0	-6.0
6240	-4.0	-3.9	-8.0	-3.3	6940	-6.0	-6.2	-6.5	-6.5
6260	-3.8	-4.0	-8.1	-3.5	6960	-5.7	-6.4	-7.4	-6.6
6280	-4.0	-3.8	-8.3	-3.4	6980	-5.9	-6.2	-7.6	-6.5
6300	-3.9	-4.1	-8.9	-3.7	7000	-6.1	-6.9	-8.8	-7.1
6320	-4.2	-4.2	-9.0	-3.9	7020	-6.0	-6.6	-9.0	-6.7
6340	-4.2	-4.2	-9.4	-3.9	7040	-6.6	-7.0	-9.7	-7.0
6360	-4.1	-4.4	-9.6	-4.2	7060	-6.1	-7.1	-10.5	-7.0
6380	-4.5	-4.4	-9.7	-4.2	7080	-6.5	-7.1	-10.7	-7.0
6400	-4.3	-4.4	-10.0	-4.4	7100	-6.6	-7.3	-11.5	-7.2
6420	-4.5	-4.8	-9.7	-4.7	7120	-6.3	-7.2	-11.9	-7.0
6440	-4.6	-4.7	-9.8	-4.6	7140	-6.6	-7.3	-12.3	-7.0
6460	-4.5	-4.9	-9.8	-4.9	7160	-6.5	-7.6	-13.1	-7.1
6480	-4.7	-5.1	-9.3	-5.1	7180	-6.6	-7.5	-13.2	-7.0
6500	-4.5	-4.9	-9.5	-4.9	7200	-6.8	-7.4	-13.5	-6.8
6520	-4.5	-5.3	-9.0	-5.3					

Table 8. Efficiency, WLAN, Free Space

5.1.5 Maximum Gain (graph)

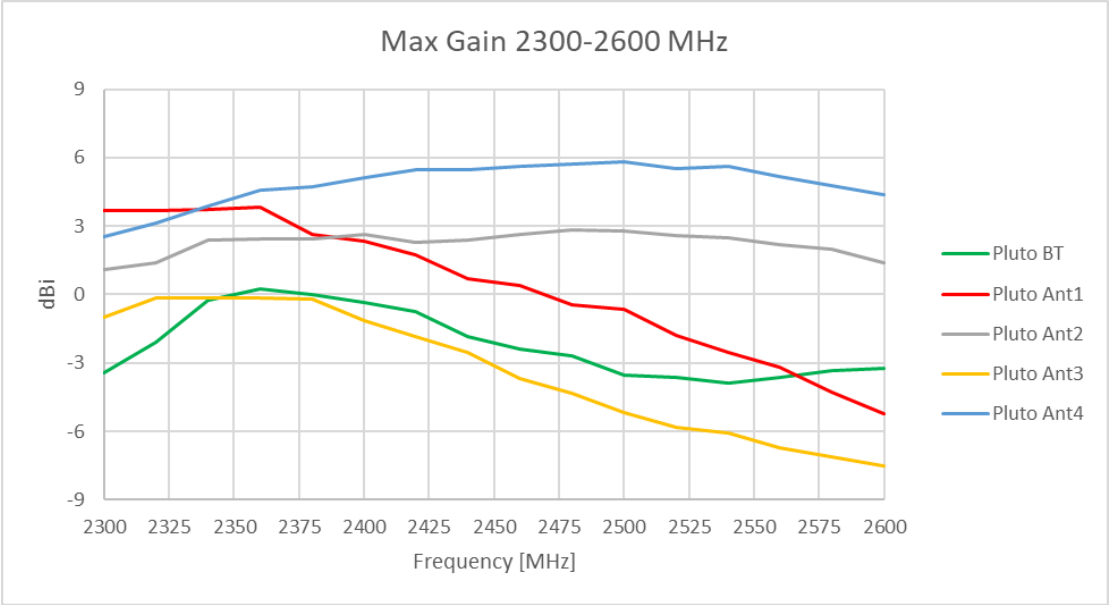


Figure 8 Maximum Gain, 2300-2600 MHz

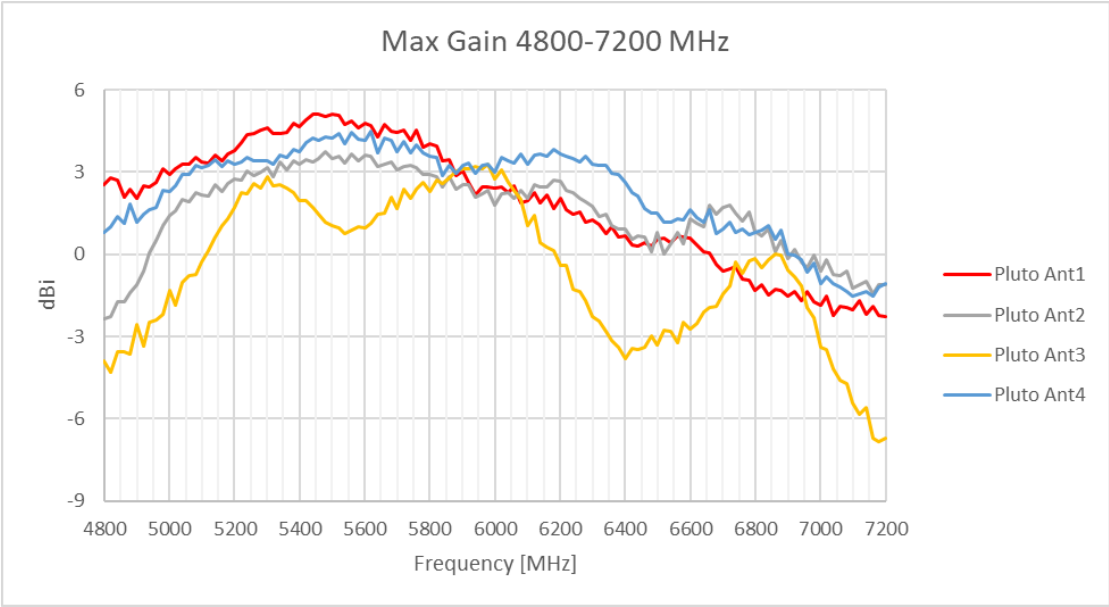


Figure 9 Maximum Gain, 4800-7200 MHz

5.1.6 Efficiency (graph)

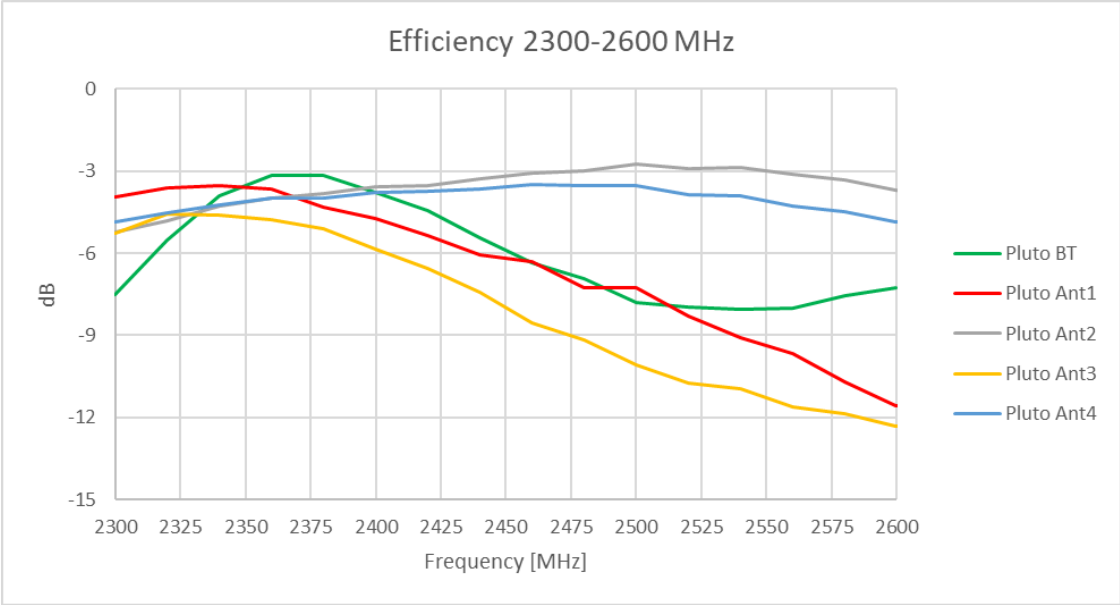


Figure 10 Efficiency, 2300-2600 MHz

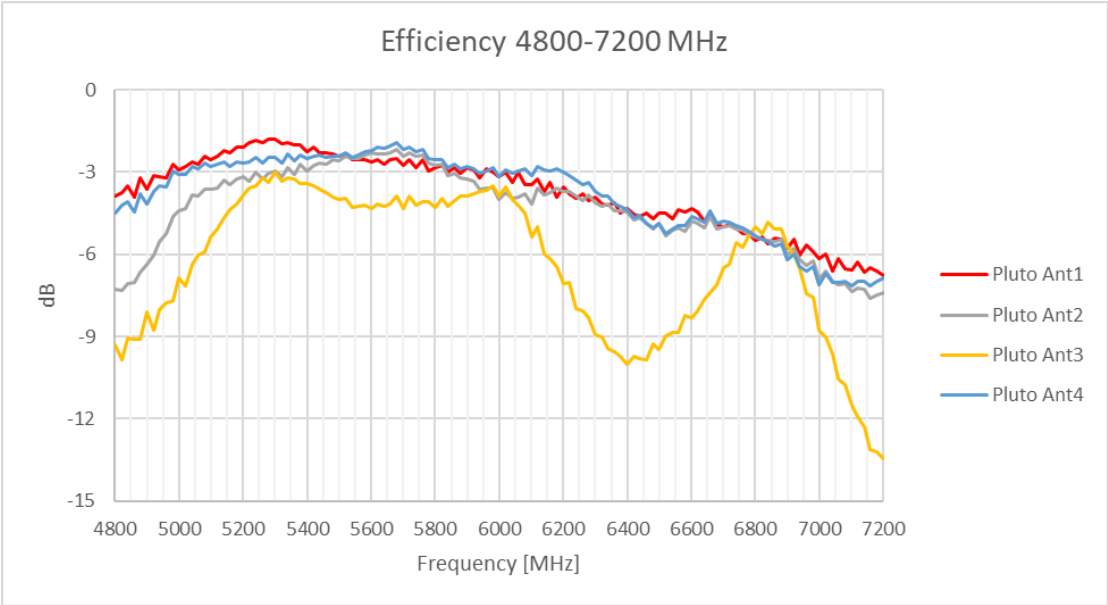


Figure 11 Efficiency, 4800-7200 MHz