Antenna Characterization Test Report

Test Report Reference: MUS_HARMAN_192211#FCAINT

Date: 2025-02-12

Test Laboratory:
Bureau Veritas CPS Inc.
1293 Anvilwood Ave
Sunnyvale, CA 94089
USA

Note: The following test results relate only to the devices specified in this document. This report shal not be reproduced in parts without the written approval of the test laboratory.

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Cert# 3699.02

ctia Authorized™ Test Lab
Lab Code: 20011202-00
20131001-00

RELEASE CONTROL RECORD

REPORT NO.	REASON FOR CHANGE	DATE ISSUED
MUS_HARMAN_192211	Initial release	10.28.2019
MUS_HARMAN_192211_REV1	Updated missing antenna description in section 2.1	05/16/2022
MUS_HARMAN_192211_REV2	Updated Model Number and Antenna Manufacturer in section 2.1	02/12/2025

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1 Administrative Data

1.1 Project Data

Responsible for testing and report:	Alberto Saldivar
Receipt of OUT:	2019-10-15
Date of first test:	2019-10-17
Date of last test:	2019-10-18
Date of Report:	2025-02-12

1.2 Applicant Data

Company Name:	Harman International Industries, Inc.
Address:	30001 Cabot Drive Novi, MI 48377 USA
Contact Person:	Mark Bowman Phone: +1 (248) 633 5481 email: mark.bowman@harman.com

1.3 Testing Laboratory

Company Name:	Bureau Veritas CPS Inc.
Street:	1293 Anvilwood Ave
City:	Sunnyvale, CA 94089
Country:	USA
Contact Person:	Jenil Nathwani
Phone:	+1-949-716-6512
Email:	Jenil.nathwani@us.bureauveritas.com

Laboratory Details

Identification:	OTA 3 Chamber
Responsible:	Felix Huang

*Details of the laboratory equipment available upon request.

1.4 Signature of responsible for testing

Jenil Nathwani

Jenil Nathwani

1.5 Signature of responsible for accreditation scope

Eddie Parsons

Eddie Parsons

2 Object Under Test Data

2.1 General SocketGate Description

Manufacturer	Harman
Model	FCA R1 INT
Serial Number/IMEI	P68306857AA
Hardware Version	N/A
Software Version	N/A

Antenna Manufacturer	Antenna Type	Connector	Brand	Model Number
Harman	PCB Trace	PCB Trace	Integral	4010 MAIN, 9090 FRONT

2.2 Test Equipment List

Type of Equipment	Model Number	Serial Number	Calibration Due Date
Vector Network Anaylzer	Keysight E5071C	MY46525119	05/06/2020

2.3 Description of Testing

7layers has been tasked to perform passive antenna characterization for Harman antennas to evaluate the performance (efficiency, Return Loss, Peak Gain, 2D-3D Radiation Patterns).

3 Introduction

This package is for customers who want to identify the most suitable off-the-self antenna for their device in terms of performance. This testing should provide key metrics to indicate if the selected antenna would meet the required performance when paired with the device. The test will be performed in an accredited OTA chamber, producing reliable results to be analysed by our Sr. RF Engineer. This package is also included in the *"Product Review Package"* and does not include antenna matching services.

The services performed will include:

- Testing each antenna in an accredited test environment, providing the characteristics of the antenna.

Deliverables:

- Report detailing the results of each antenna includes radiation pattern, efficiency, return loss and peak gain of each antenna.

Requirements:

- Sample prototype to be tested (if applicable)
- sample of each antenna to be tested

4 Objectives and Summary of Tests to be Performed

- Measure the Return Loss and VSWR of the antennas.
- Measure the efficiency, radiation patterns and peak gain of the antenna.

5 Passive testing

5.1 Test set up

Figure 1 shows the Return Loss test set up with the VNA, the antenna is connected to the VNA using a low loss coaxial cable, the reference plane of the VNA was move it until the end of the low loss coaxial cable in order to measure accurately the Return Loss the antenna.

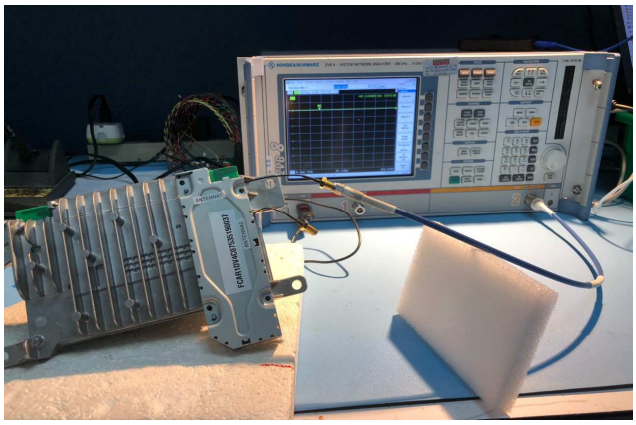

Figure 1. *Return Loss and VSWR test set up*

Figure 2 shows the OTA test set up for Efficiency and Peak Gain testing, an RF signal is injected to the antenna, and most of this RF signal is radiated by the antenna and measured.

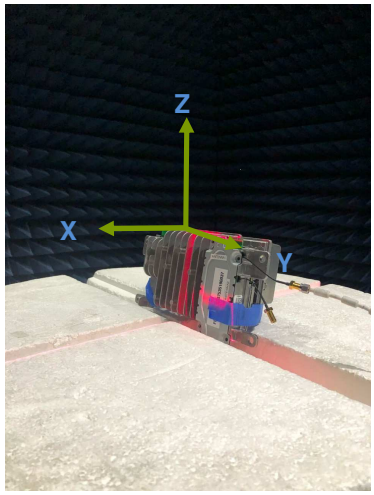

Figure 2. *OTA test set up.*

5.2 Antenna Return Loss

The following figure shows the antenna Return Loss.

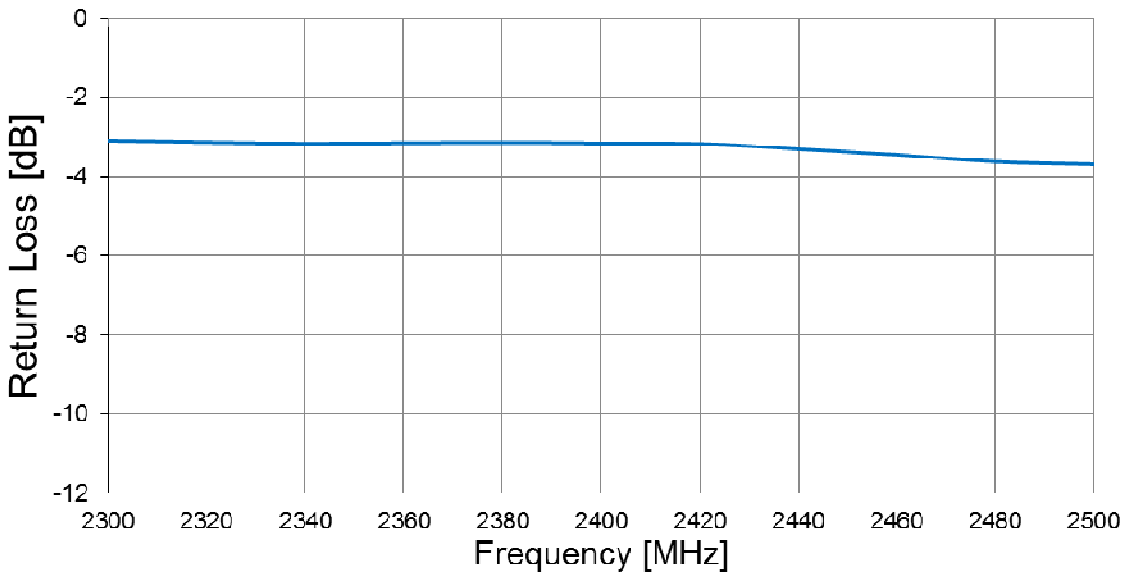

Figure 3. *Antenna Return Loss at 2.4GHz Port1.*

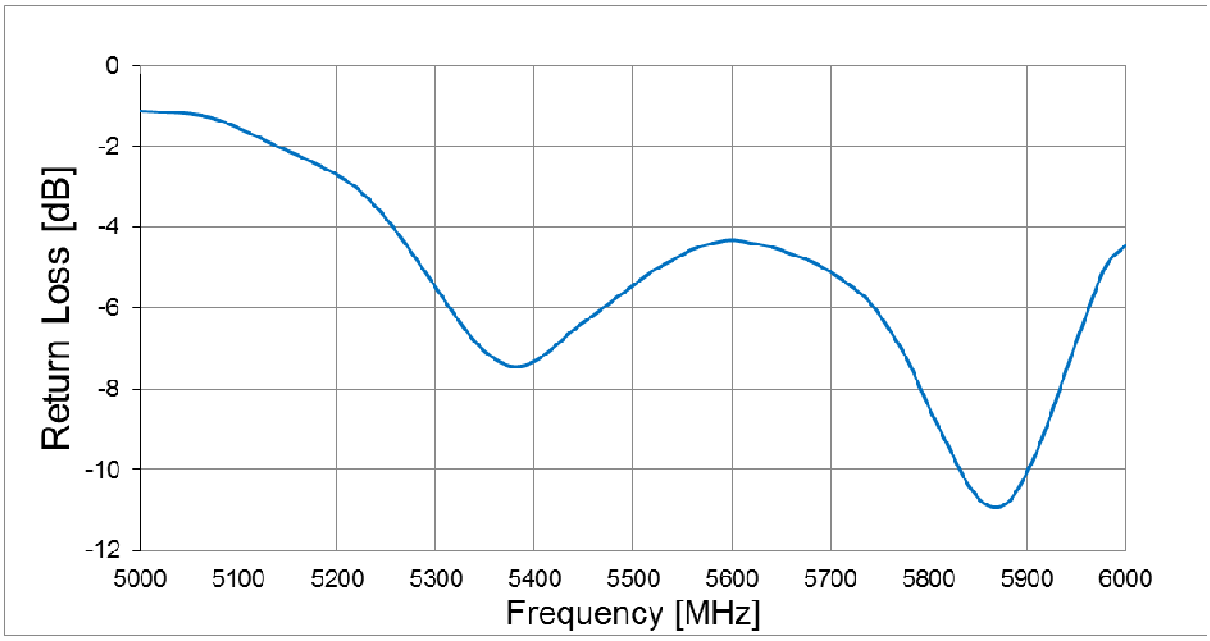

Figure 4. *Antenna Return Loss at 5.0GHz Port1.*

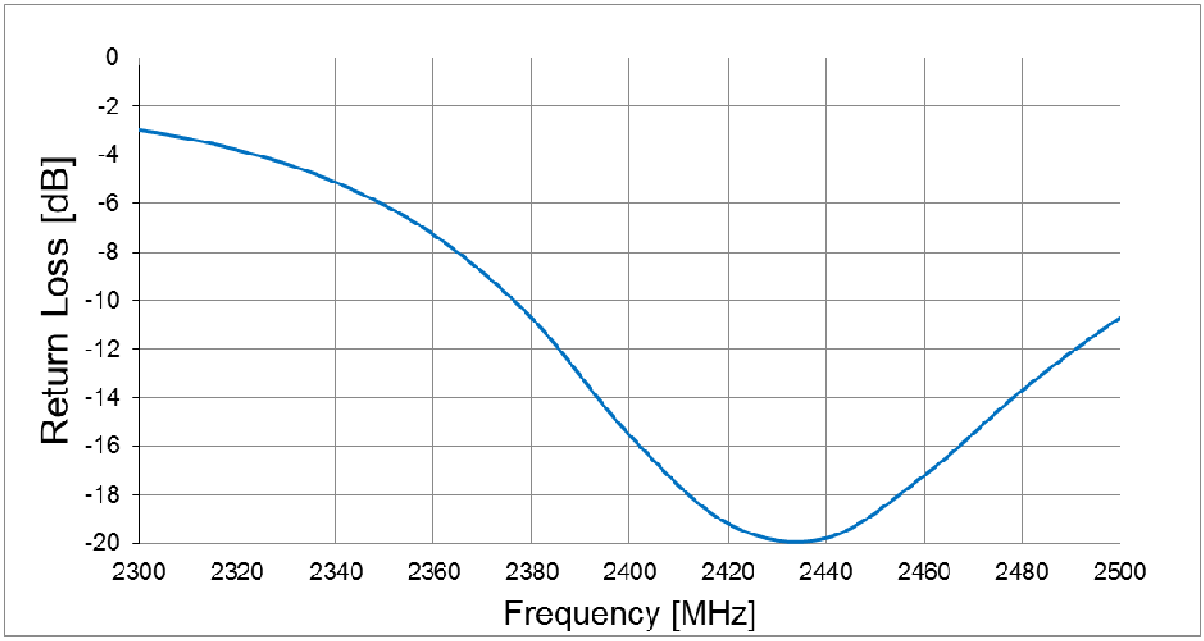

Figure 5. *Antenna Return Loss at 2.4GHz Port2.*

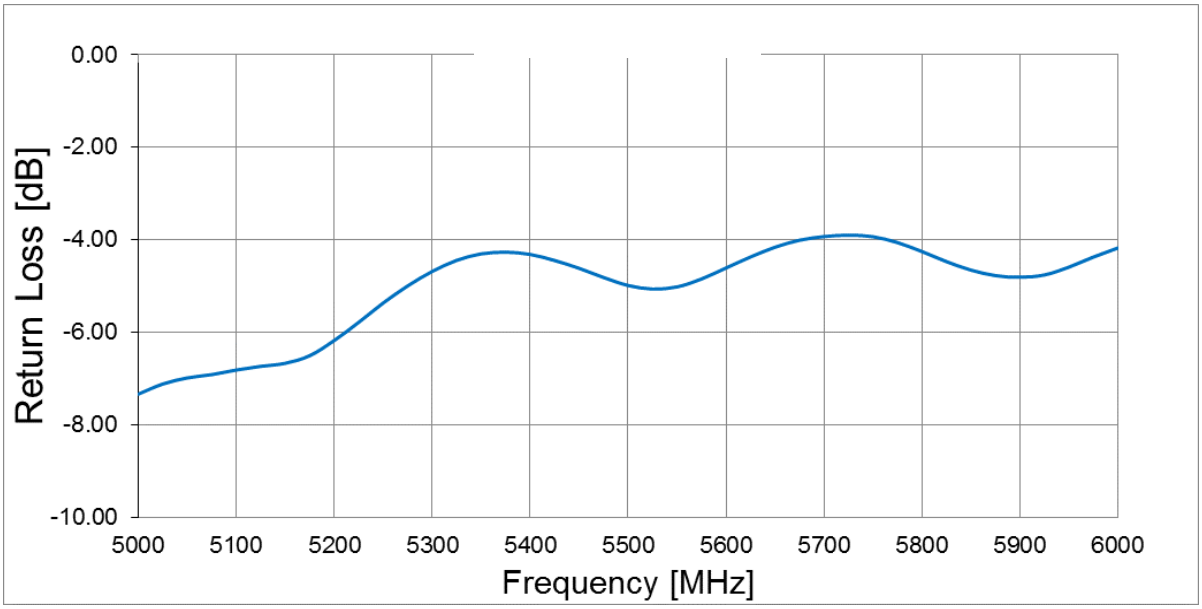

Figure 6. *Antenna Return Loss at 5.0GHz Port2.*

5.3 Antenna VSWR

The following figure shows the Antenna VSWR.

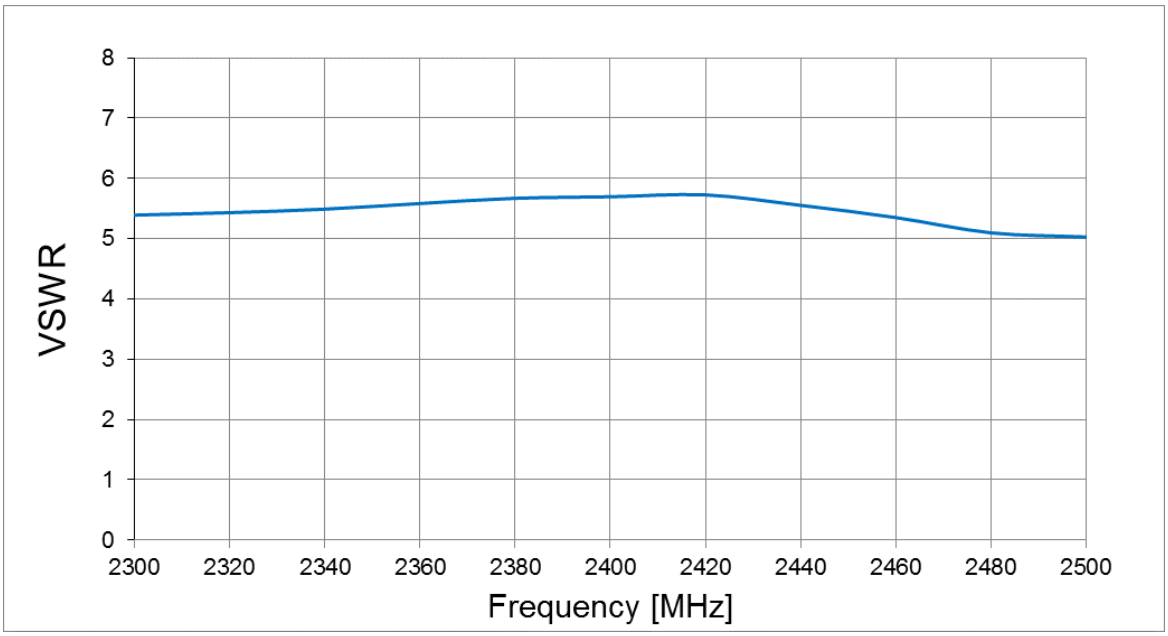

Figure 7. *Antenna VSWR at 2.4GHz PORT1.*

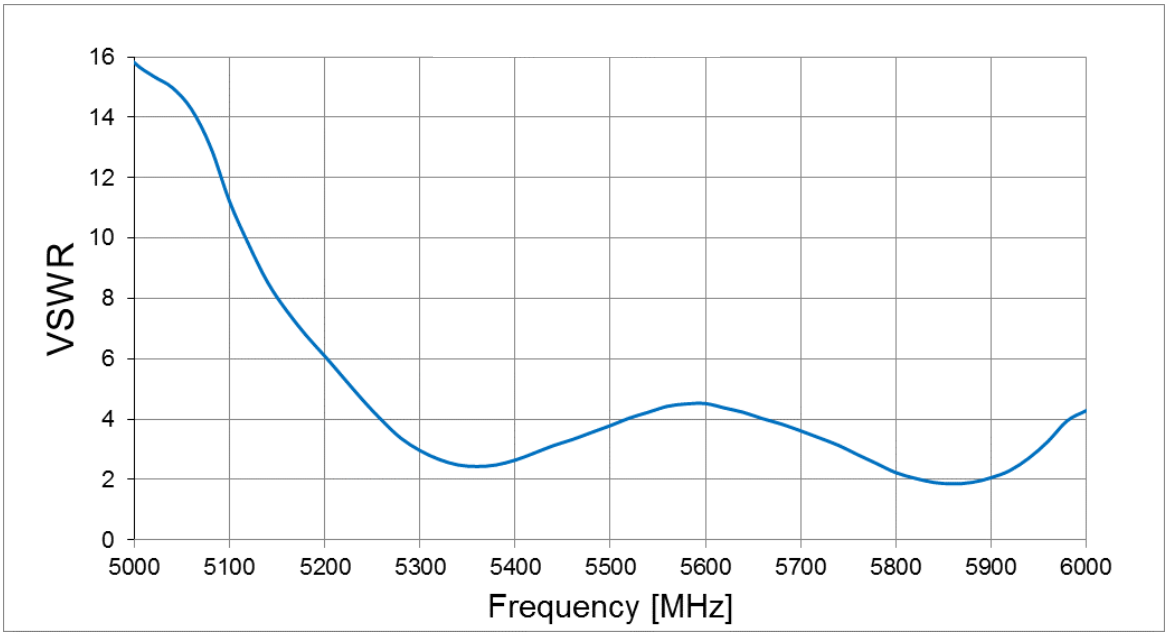

Figure 8. *Antenna VSWR at 5.0GHz PORT1.*

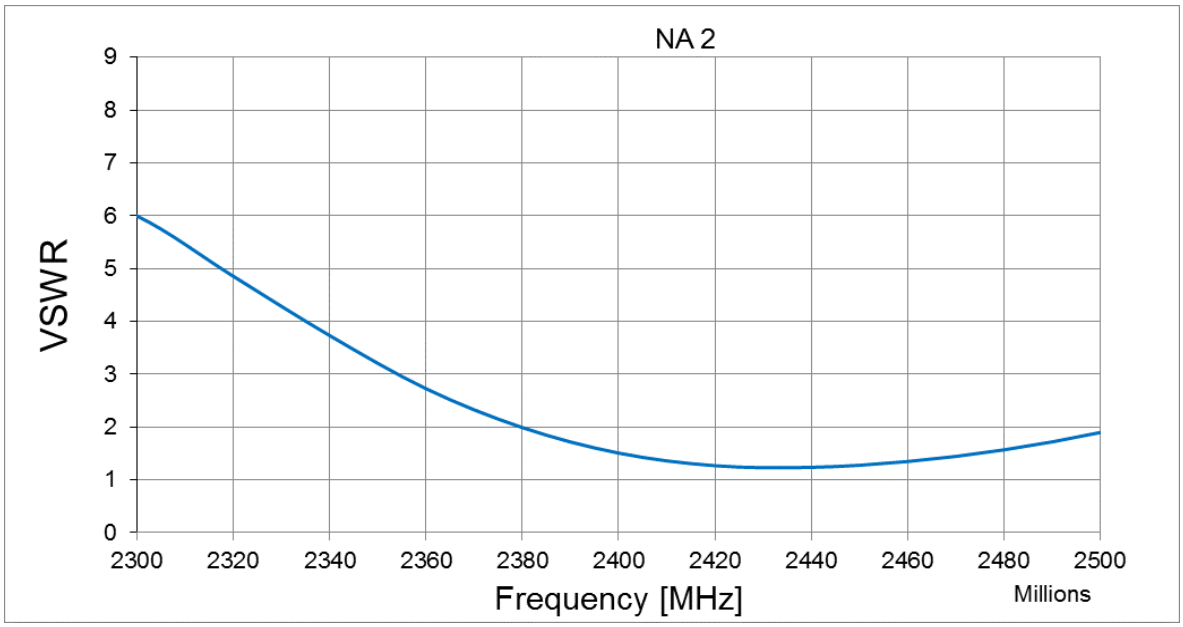

Figure 9. *Antenna VSWR at 2.4GHz Port2.*

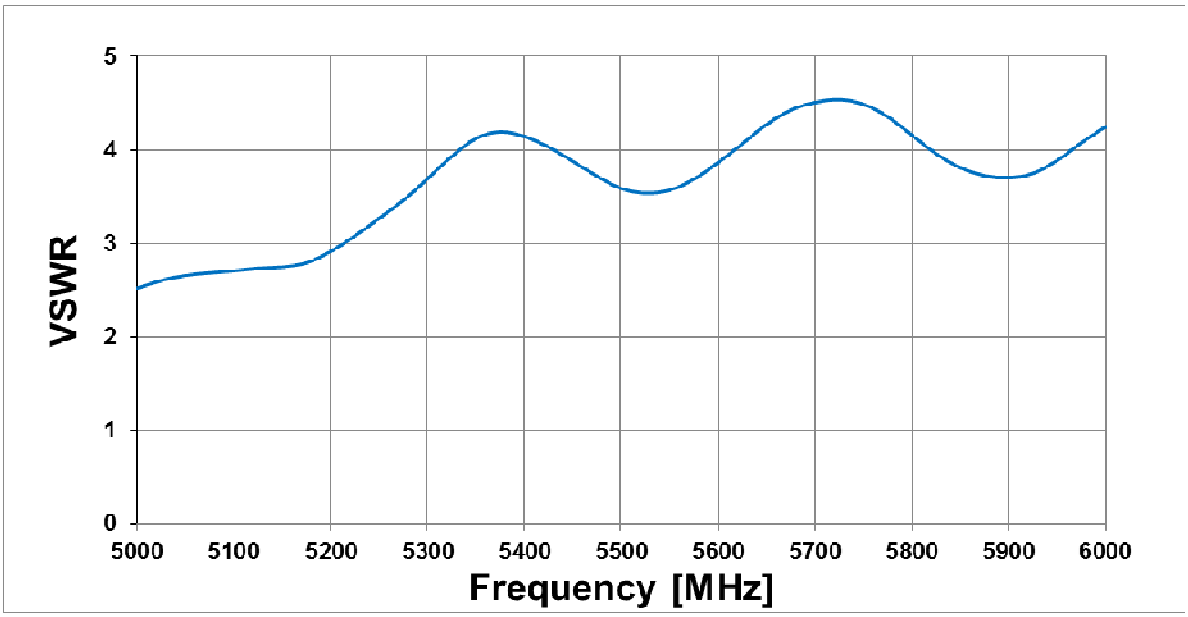

Figure 10. *Antenna VSWR at 5.0GHz Port2.*

5.4 Antenna Efficiency

The following figure shows the efficiency of the device.

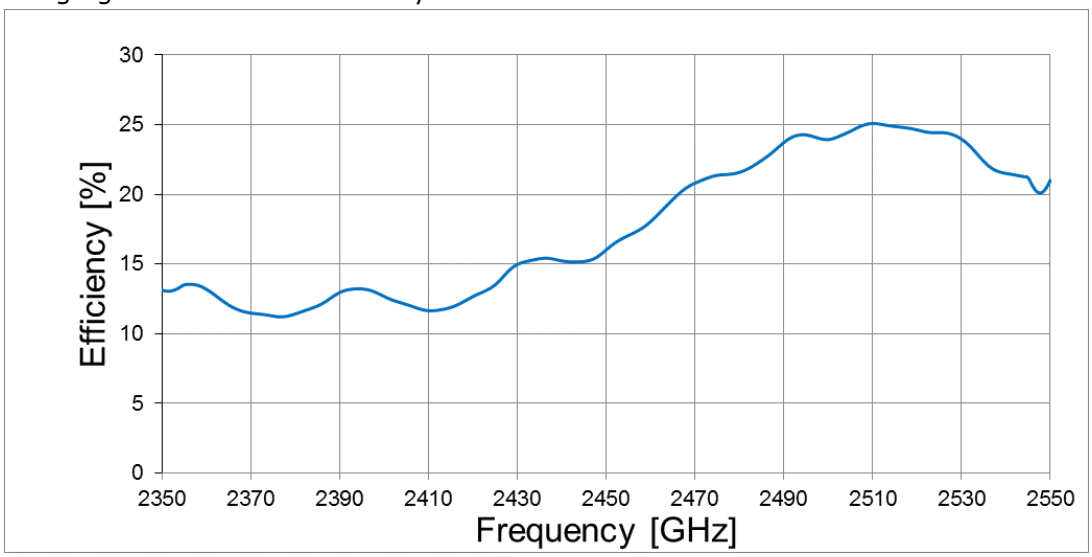

Figure 11. *Antenna Efficiency at 2.4GHz Port1.*

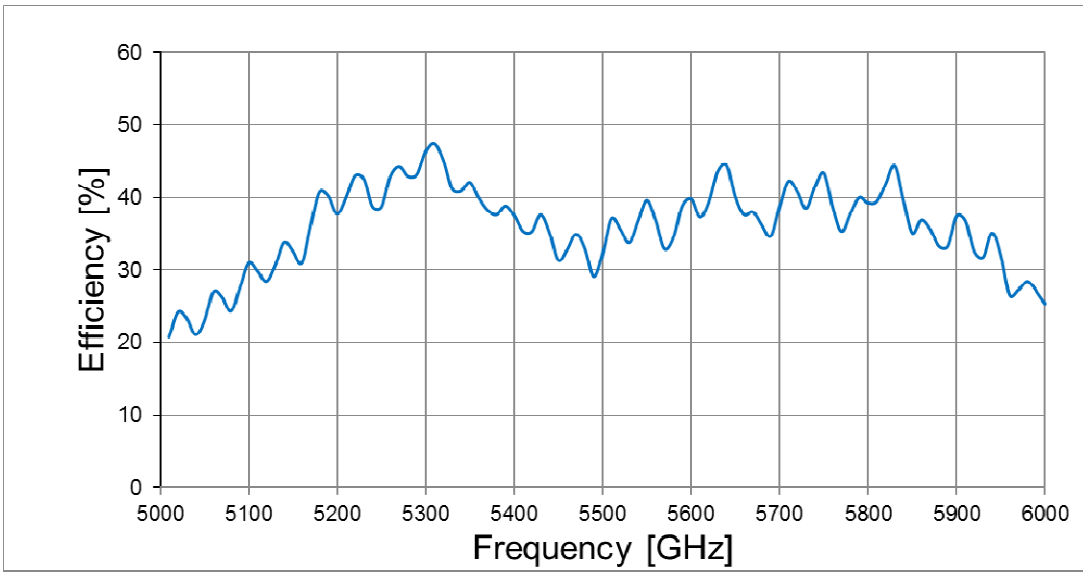

Figure 12. *Antenna Efficiency at 5.0GHz Port1.*

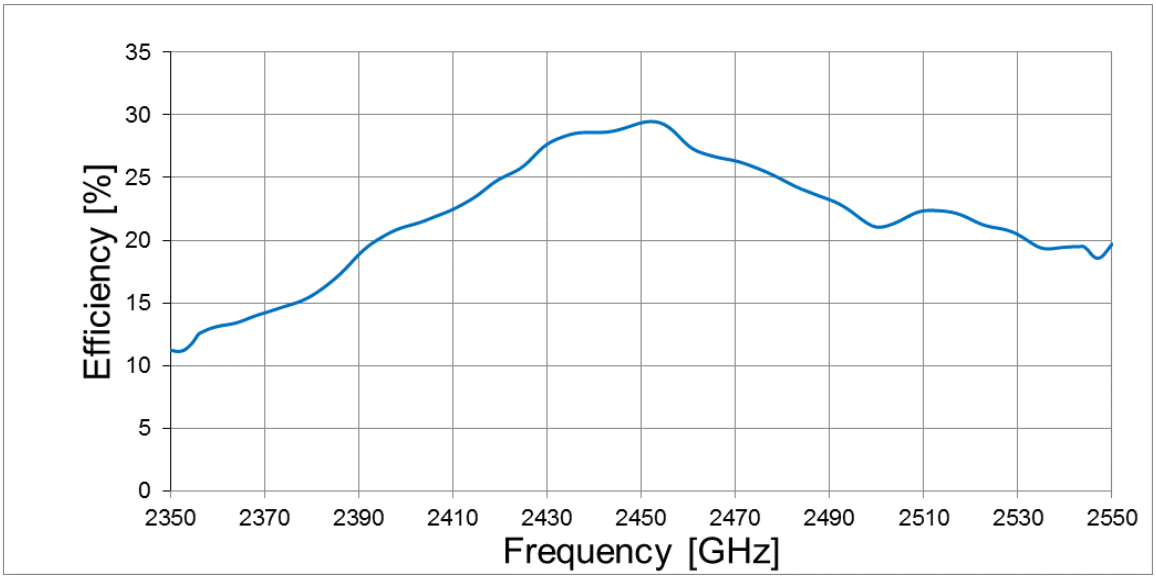

Figure 13. *Antenna Efficiency at 2.4GHz Port2.*

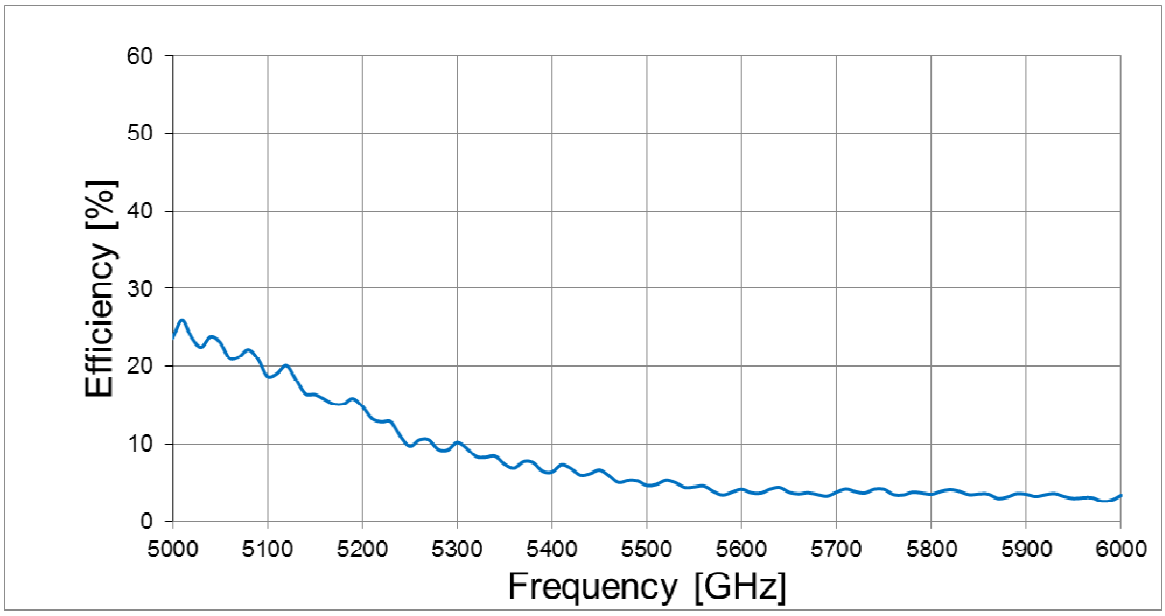

Figure 14. *Antenna Efficiency at 5.0GHz Port2.*

5.5 Antenna Peak Gain

The following figure shows the peak gain of the device.

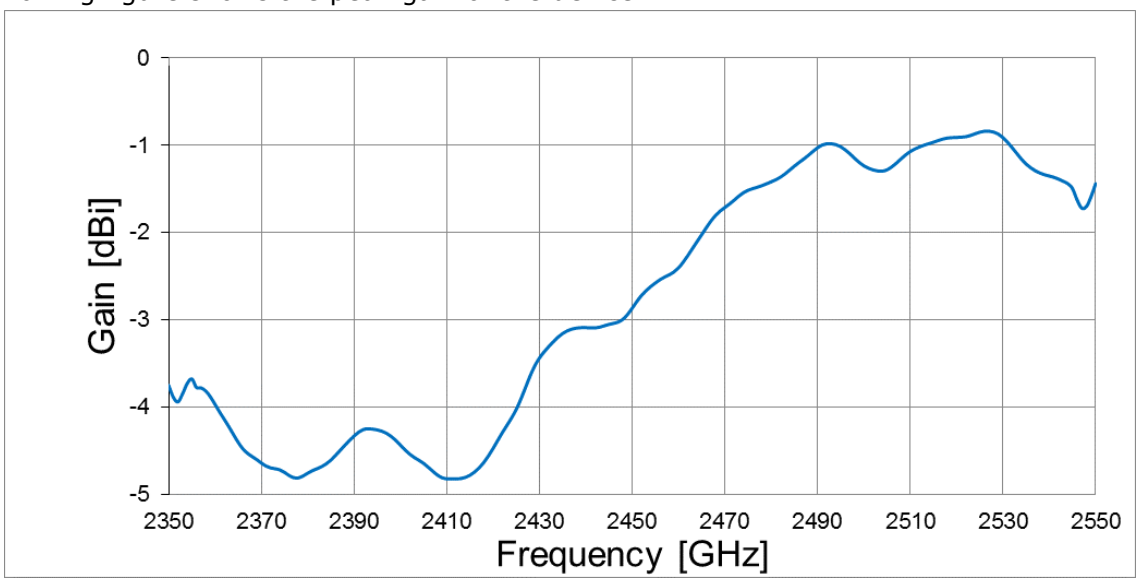

Figure 15. *Antenna Peak Gain at 2.4GHz Port1.*

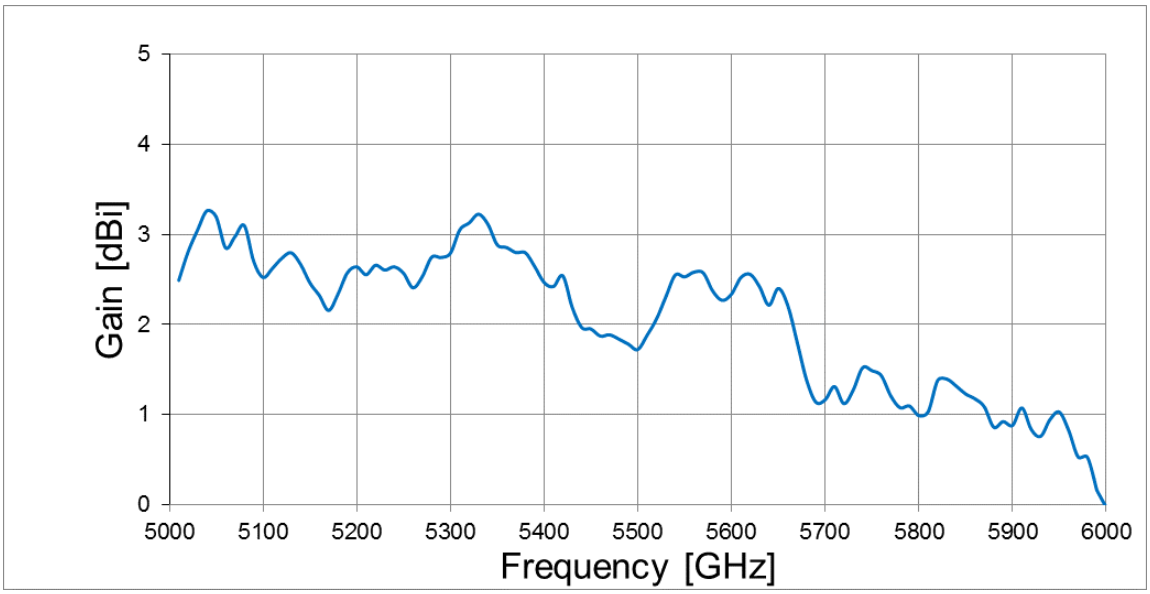

Figure 16. *Antenna Peak Gain at 5.0GHz Port1.*

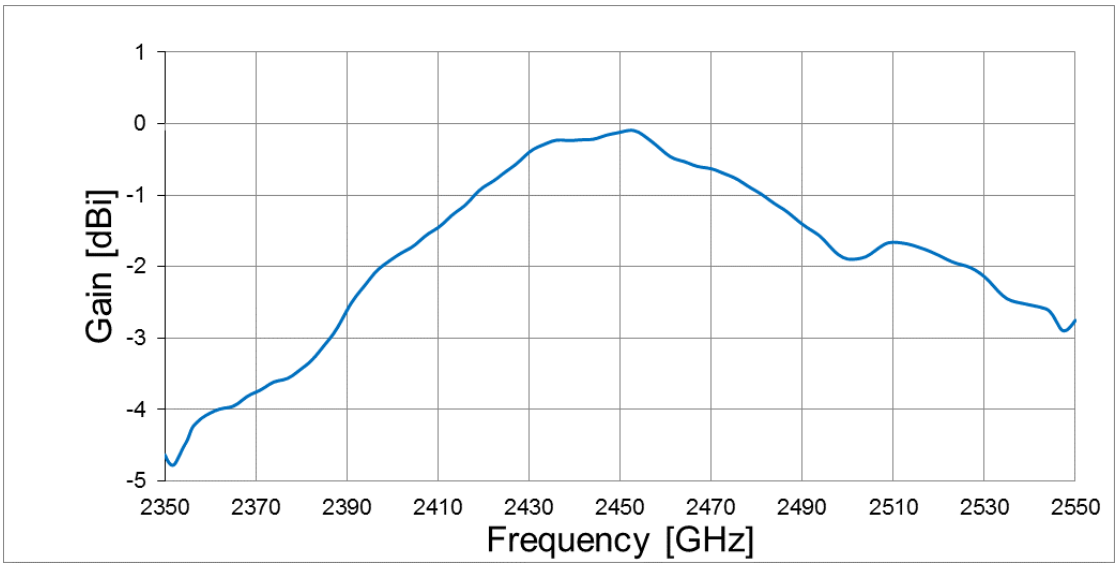

Figure 17. *Antenna Peak Gain at 2.4GHz Port2.*

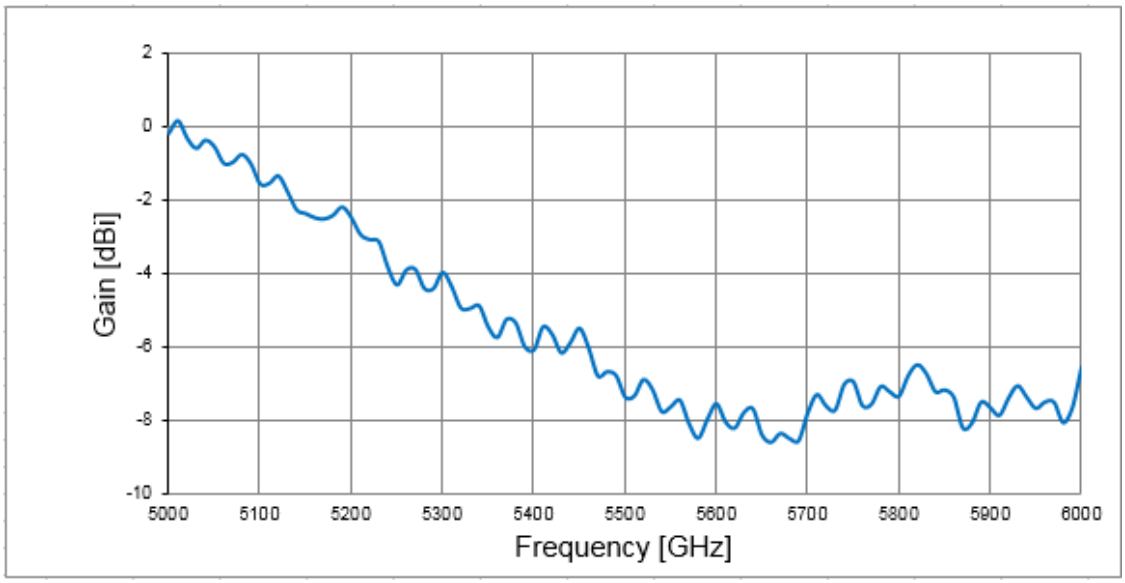

Figure 18. *Antenna Peak Gain at 5.0GHz Port2.*

5.6 Antenna Average Gain

The following figure shows the peak gain of the device.

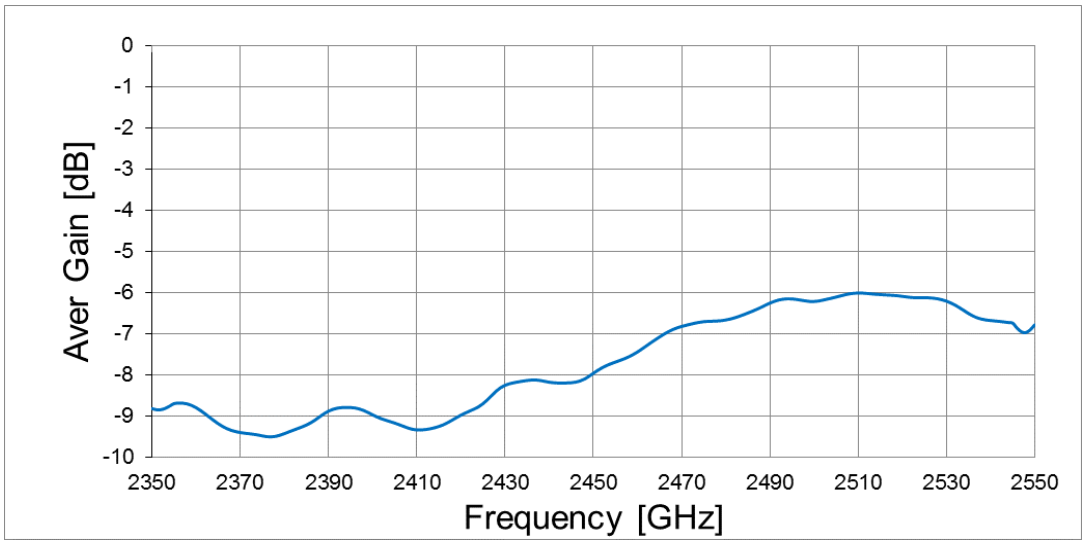

Figure 19. *Antenna Average Gain at 2.4GHz Port1.*

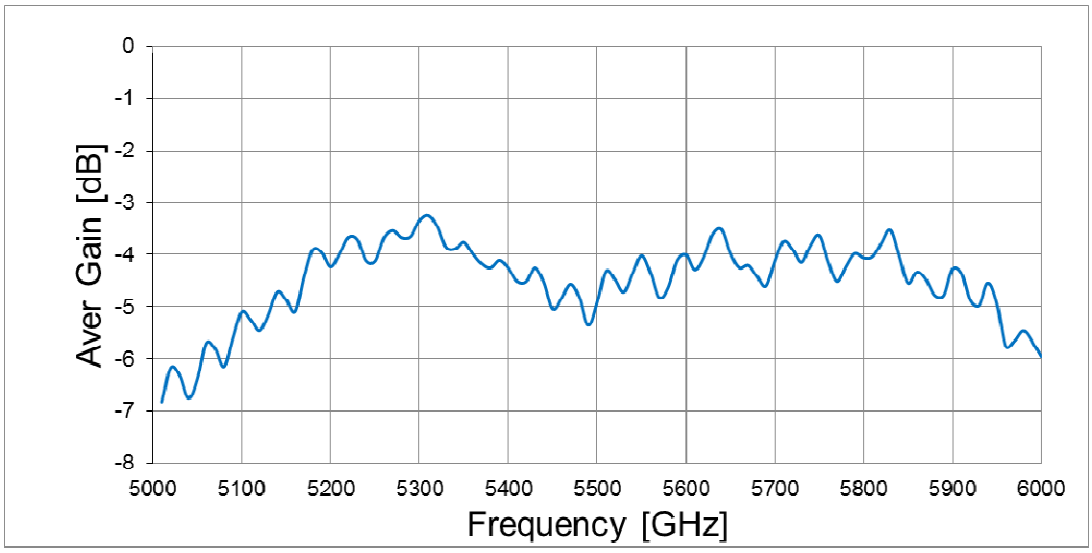

Figure 20. *Antenna Average Gain at 5.0GHz Port1.*

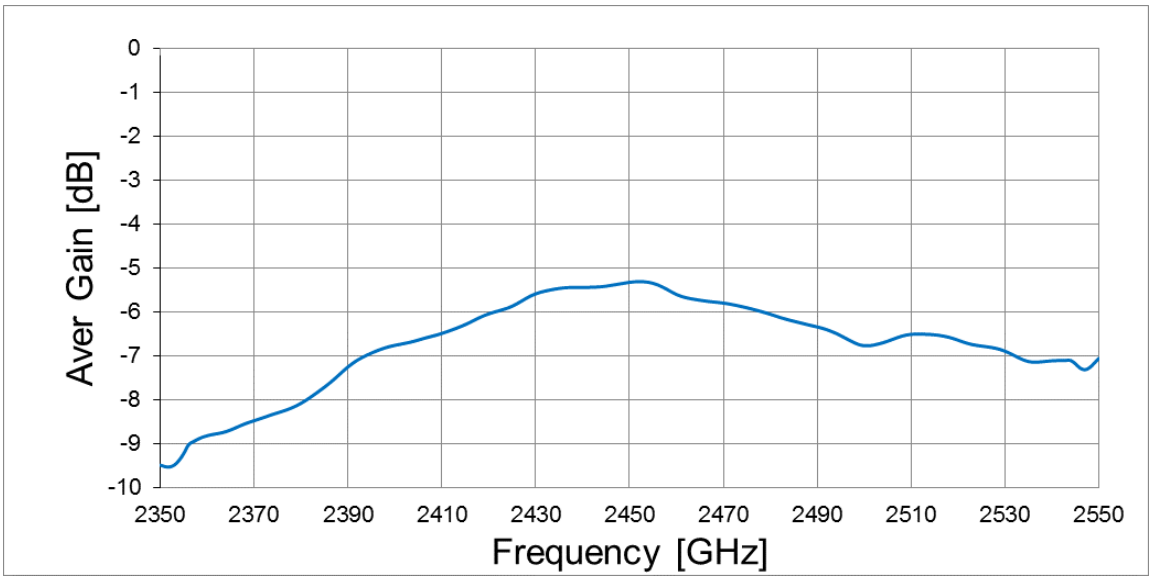

Figure 21. *Antenna Average Gain at 2.4GHz Port2.*

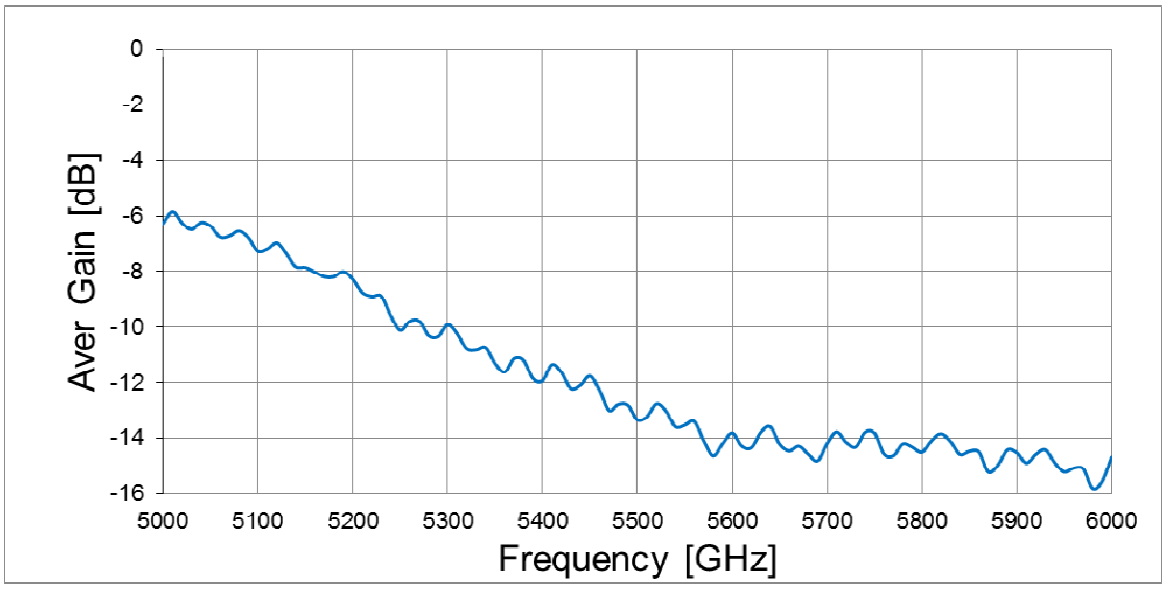

Figure 22. *Antenna Average Gain at 5.0GHz Port2.*

Table 1, shows the antenna characteristics at 2.4GHz Port1.

Frequency	*Efficiency [%]*	*Peak Gain [dBi]*	*Efficiency [dB]*
2400	12.6841	-4.43203	-8.967403427
2402	12.4096	-4.53494	-9.062422169
2405	12.1109	-4.64141	-9.168235818
2410	11.6569	-4.81843	-9.334169292
2415	11.8819	-4.77751	-9.25114107
2420	12.6639	-4.47042	-8.974325275
2425	13.5019	-4.02226	-8.696051129
2430	14.9688	-3.435	-8.248130142
2435	15.3794	-3.15485	-8.130606074
2440	15.2305	-3.08777	-8.17285839
2441	15.1834	-3.09085	-8.186309665

2445	15.1864	-3.05052	-8.185451653
2450	16.0073	-2.8661	-7.956819157
2455	17.0455	-2.576	-7.68390255
2460	18.0375	-2.40371	-7.438236559
2462	18.6565	-2.2638	-7.291698275
2465	19.6169	-2.02481	-7.073696218
2470	20.8015	-1.71184	-6.819053469
2475	21.3634	-1.51466	-6.703296279
2480	21.5712	-1.41827	-6.661256945
2485	22.4293	-1.23837	-6.491842802
2490	23.7074	-1.02826	-6.251160727
2495	24.267	-1.01639	-6.149839099
2500	23.9213	-1.23558	-6.212152224

Table 2, shows the antenna characteristics at 5.0 GHz Port1.

Frequency	*Efficiency [%]*	*Peak Gain [dBi]*	*Efficiency [dB]*
5000	20.7396	2.49	-6.83199624
5020	24.1644	2.80735	-6.168239839
5040	21.0863	3.26252	-6.75999619
5060	26.9571	2.85167	-5.693268303
5080	24.2839	3.0976	-6.146815642
5100	30.928	2.52252	-5.096481633
5120	28.4627	2.73464	-5.457239047
5140	33.8008	2.6683	-4.710730207
5160	30.963	2.32271	-5.091569672
5180	40.7305	2.33849	-3.900802586
5200	37.7684	2.63976	-4.22871413