Avartanam
PRODUCT TESTING THE RIGHT WAY

Antenna Tuning & Optimization

Test Report

Version: 1.0

Report No:SER0001-003

Document Classification: External

Preface

This measurement report includes Antenna return loss, matching circuits and radiation pattern data information with best performance achieved using antenna optimization as per the requirement from the customer.

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Only the test(s) asked by the customer has been carried out and particular tests are performed on the DUT's only whose serial no is given by the customer for that test.

Any anomaly/discrepancy in this test report/certificate should be brought to our notice within 45 days from the date of issue.

Testing has been done in environmental conditions as specified by the standard.

Report Prepared by

Name	Position	Signature	Date
Varun Parmar	RF Engineer		17/06/2025

Report Verified by

Name	Position	Signature	Date
Sagar Mistry	Technical Manager		19/06/2025

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1 General Information

Service Request No.	RFSRV-ANTT-0625-003
Purchase Order No/Quotation No	PO-00014
DUT Inward No.	SEM0001
Name and Address of Customer	INDIESEMIC PRIVATE LIMITED A-1101, B-1101, The First, B/H Keshavbaug Party Plot, Vastrapur, Ahmedabad, Ahmedabad, Gujarat, 380015

1.1 DUT Description

Manufacturer	INDIESEMIC PRIVATE LIMITED
Number of Samples tested	2
Serial No.(s) of product(s) tested	24012615000010
Sample(s) Condition on receipt	OK
Product	ISC-nRF54L Series Module
Accessories	NA
Operating Frequency	2.402GHz, 2.440GHz, 2.480GHz
Received Date	05/06/2025
Test Start Date	09/06/2025
Test Completed Date	16/06/2025
DUT Size(mm)	15mmX20mmX2.5mm
DUT Weight (kg)	0.01
Antenna Type	PCB Antenna

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1.1.1 DUT Photograph

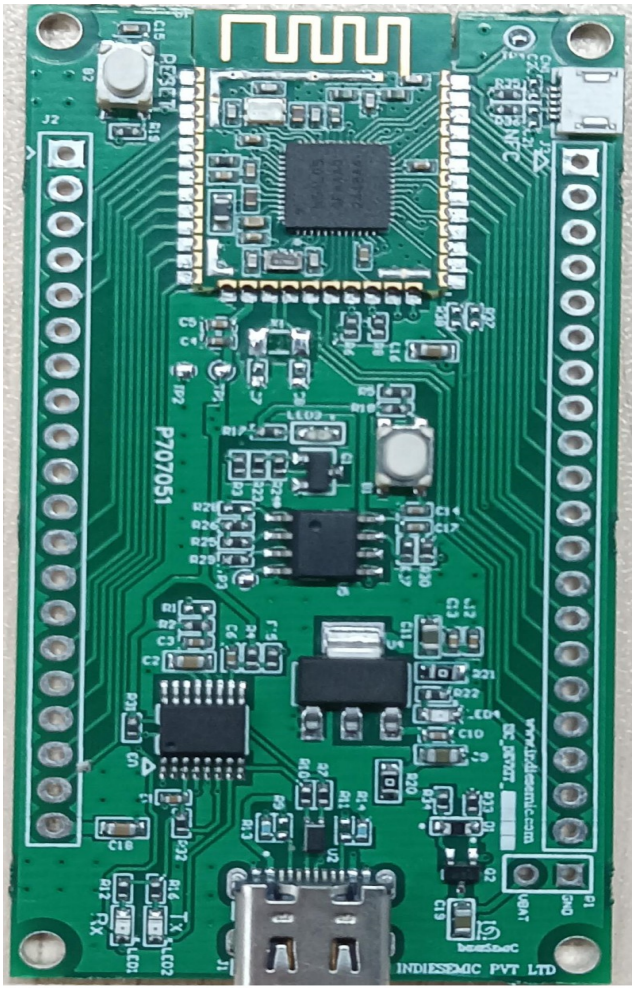

Figure 1: DUT Photograph

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1.2 Test Instrument Details

Instrument Name	Manufacturer	Model No
Radiation Measurement System	MegiQ	RMS-0460
RF Anechoic Chamber	Shenzhen Tojoin Technology Co. Ltd	3 Meter Semi Anechoic Chamber
Vector Network Analyzer	Keysight Technologies	N9918A
VNA Calibration Kit	Keysight Technologies	85521A
RF Cable/Adaptor Accessories	__	__

Table 1: Test instrument details

1.3 Testing Location

Avartanam Test Labs LLP.

Plot#32, Zone-D/4,

Phase-1,GIDC Estate,

V.U. Nagar, 388 121,

Anand, Gujarat,

India.

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2 Antenna Tuning & Optimization

2.1 Introduction

- Antenna Tuning & Optimization will optimize the antenna performance that is degraded/off tuned by the several factors considering the product form factors.
- The antenna must be placed in its final environment and impedance matched so that it operates in the desired frequency band.
- A poorly matched antenna can degrade your link budget by 10-30 dB and severely reduce range.

2.2 Test Setup Image

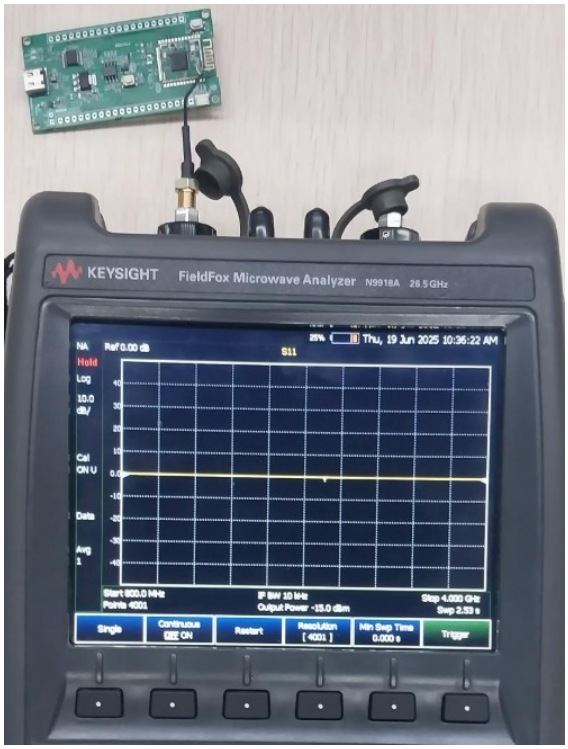

Figure 2: Test Setup Image

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2.2.1 Measurement Point on DUT for Optimization

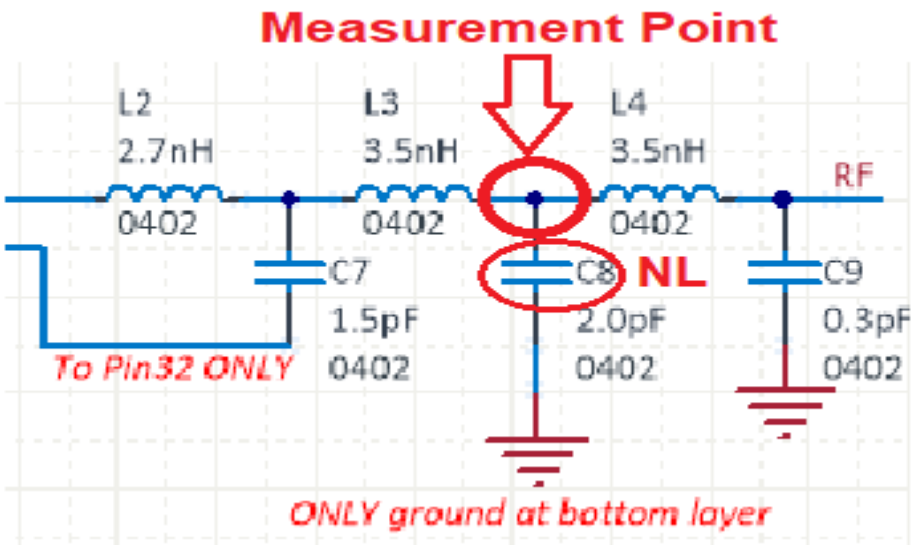

Figure 3: Schematic of Matching Network

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2.3 Test Conditions

DUT Operating Condition	
Temperature	**Relative Humidity**
23^0 C	54%
Measurement Standard Reference	As per IEEE Standards 149-2021 on Pre-Compliance basis.

Table 2: Test Conditions

2.4 Measurement Uncertainty

Measurement Type	As per Avartanam Test Lab
VSWR	± 0.3

Table 3: Measurement Uncertainty

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2.5 Test Results

2.5.1 Summary

Frequency(MHz)	Before Tuning (VSWR)	Before Tuning (S11) dB	After Tuning (VSWR)	After Tuning (S11) dB
2402	20.47	-0.89	1.44	-14.81
2480	17.14	-1.01	1.77	-11.14

Table 4: Summary

***Note:** VNA Calibration was performed at the end point of the instrument including the effect of the corresponding RF Cable/Adapter used during the test. Above test results are considering the comparison between before tuning and after tuning of PCB antenna. Finalize Matching components details are available in Table no.5 as mentioned below.

2.5.2 Antenna Matching Components List

Designator	Component Value	Mfg.	Mfg. Part no.
C9	2pF	Johanson Technology	500R07S2R0BV4T
L4	4.3nH	Johanson Technology	L-07C4N3SV6S

Table : 5 Antenna Matching Component List

Note*: Antenna matching performed on the **independent module** in free space scenario. By using the proposed L/C matching network on the PCB assembly described in this report, the client should expect the antenna performance to resemble the results shown here in a mass production phase.
The client must always corroborate the system performance by re-verifying the tuning/gain if any changes in PCB layout, encasement, vendor, supplier, materials, etc, as this may cause the current L/C values to no longer be valid.

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2.5.3 Test Plot

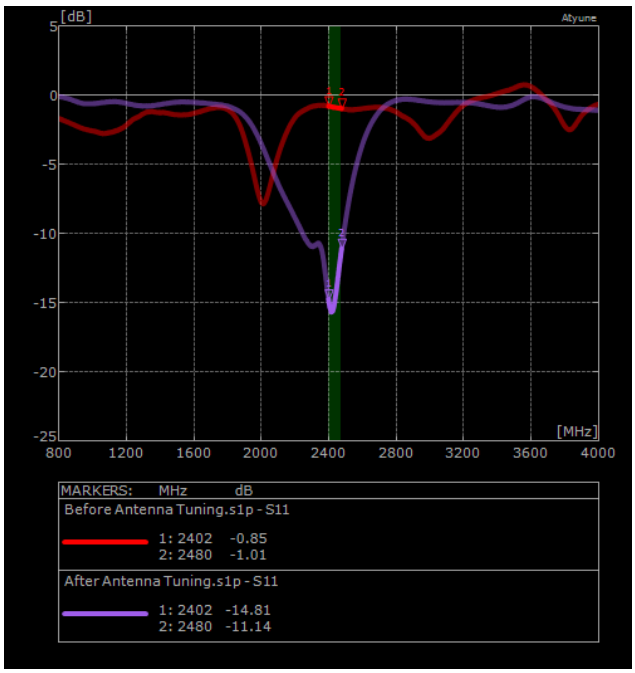

Figure 5: S11 Plot

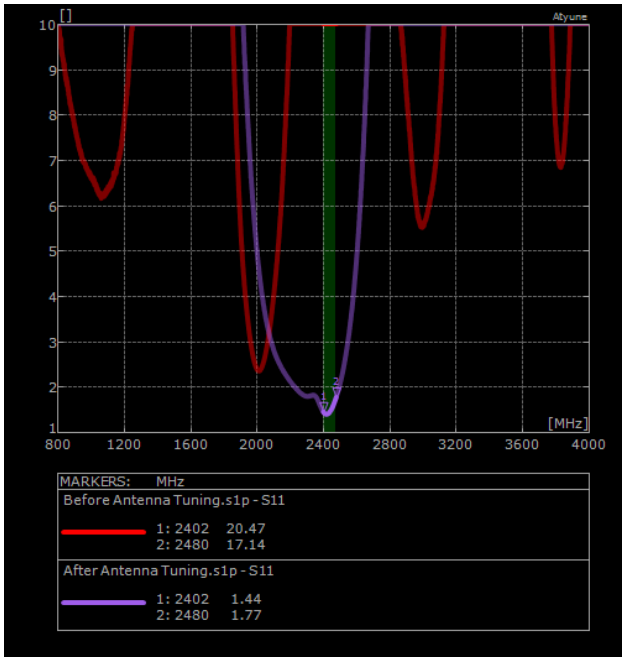

Figure 6: VSWR Plot

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3 Radiation Pattern & Gain Measurement

3.1 Introduction

- The energy radiated by an antenna is represented by the Radiation pattern of the antenna. Radiation Patterns are diagrammatical representations of the distribution of radiated energy into space, as a function of direction performed in RF Anechoic chamber.

3.2 Test Setup Image

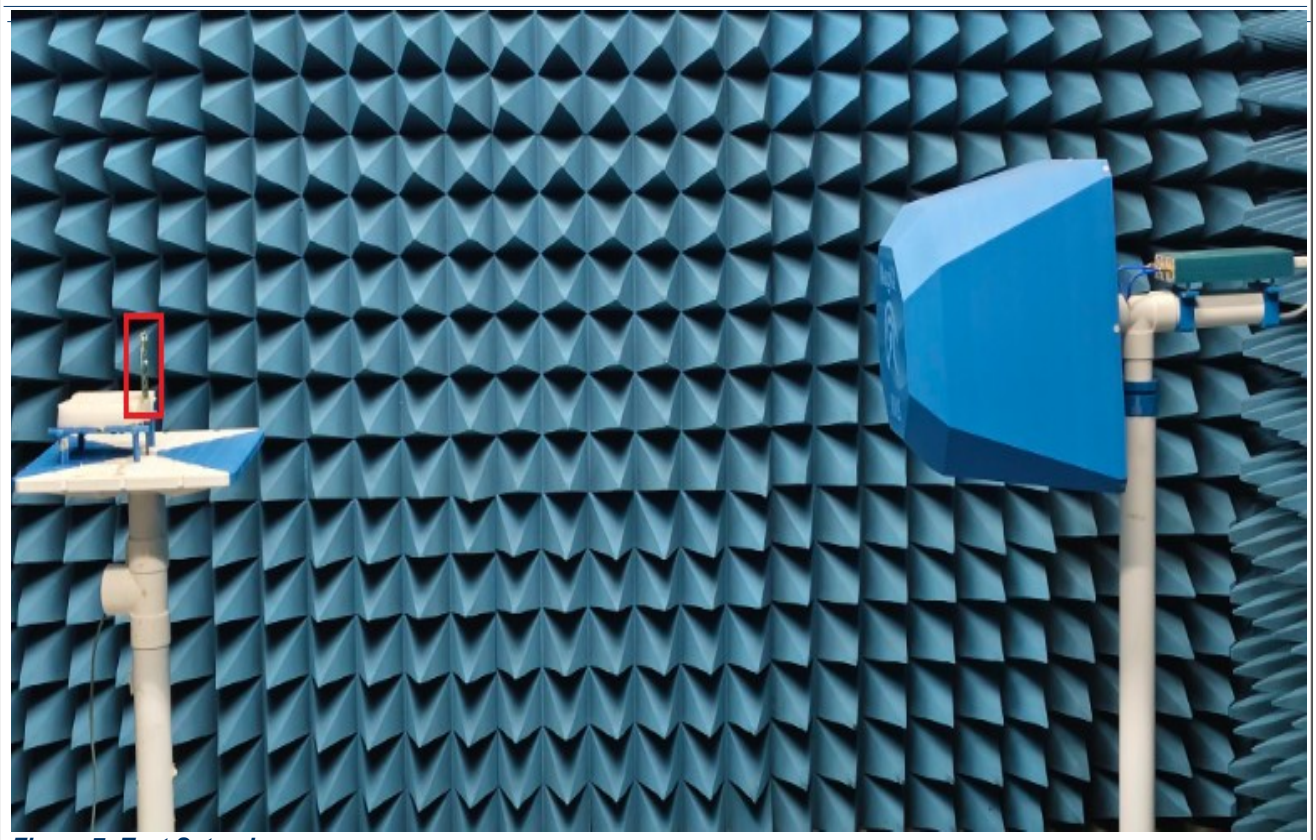

Figure 7: Test Setup Image

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3.3 Test Conditions

DUT Operating Condition	
Temperature	
23^0 C	
Measurement Standard Reference	As per IEEE Standard 149-2021 on Pre-Compliance basis.
DUT Configuration	Input CW signal generated from the DUT of 3 dBm

Table 5: Test Conditions

3.4 Measurement Uncertainty

Measurement Type	As per Avartanam Lab
Antenna Gain	± 1dB

Table 6: Measurement Uncertainty

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3.5 DUT Orientation in Three Planes

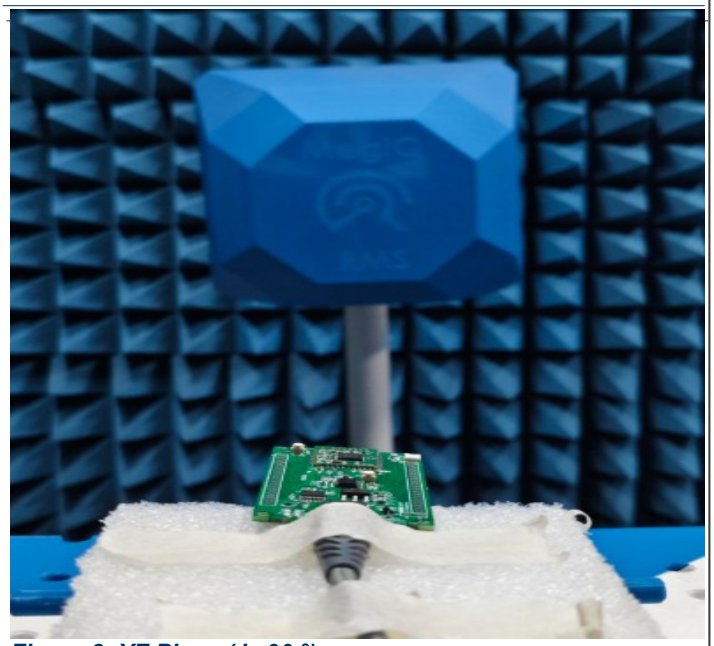

Figure 8: YZ Plane (ϕ=90 °)

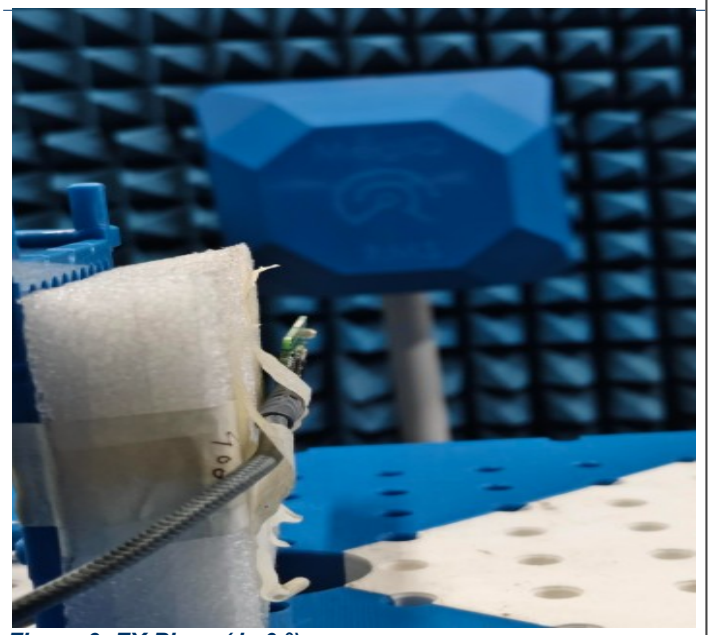

Figure 9: ZX Plane (ϕ=0 °)

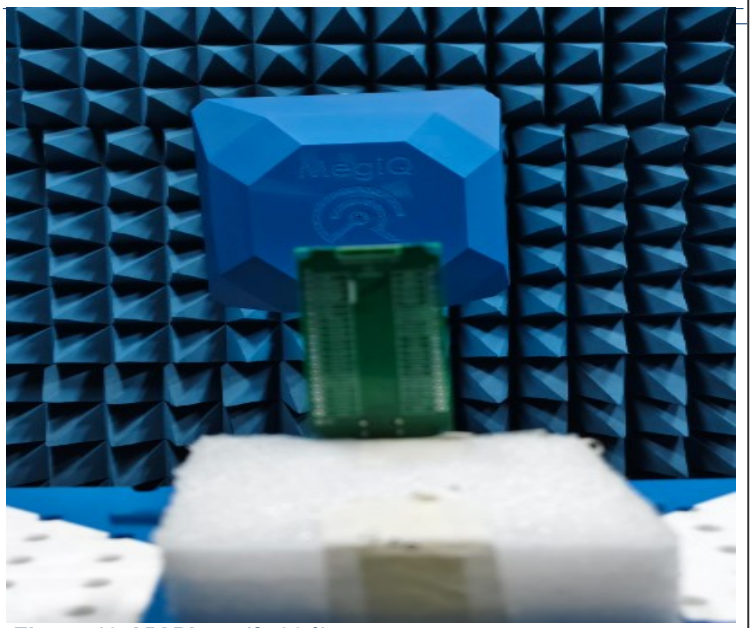

Figure 10: XY Plane (θ=90 °)

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3.6 Measurement Representation

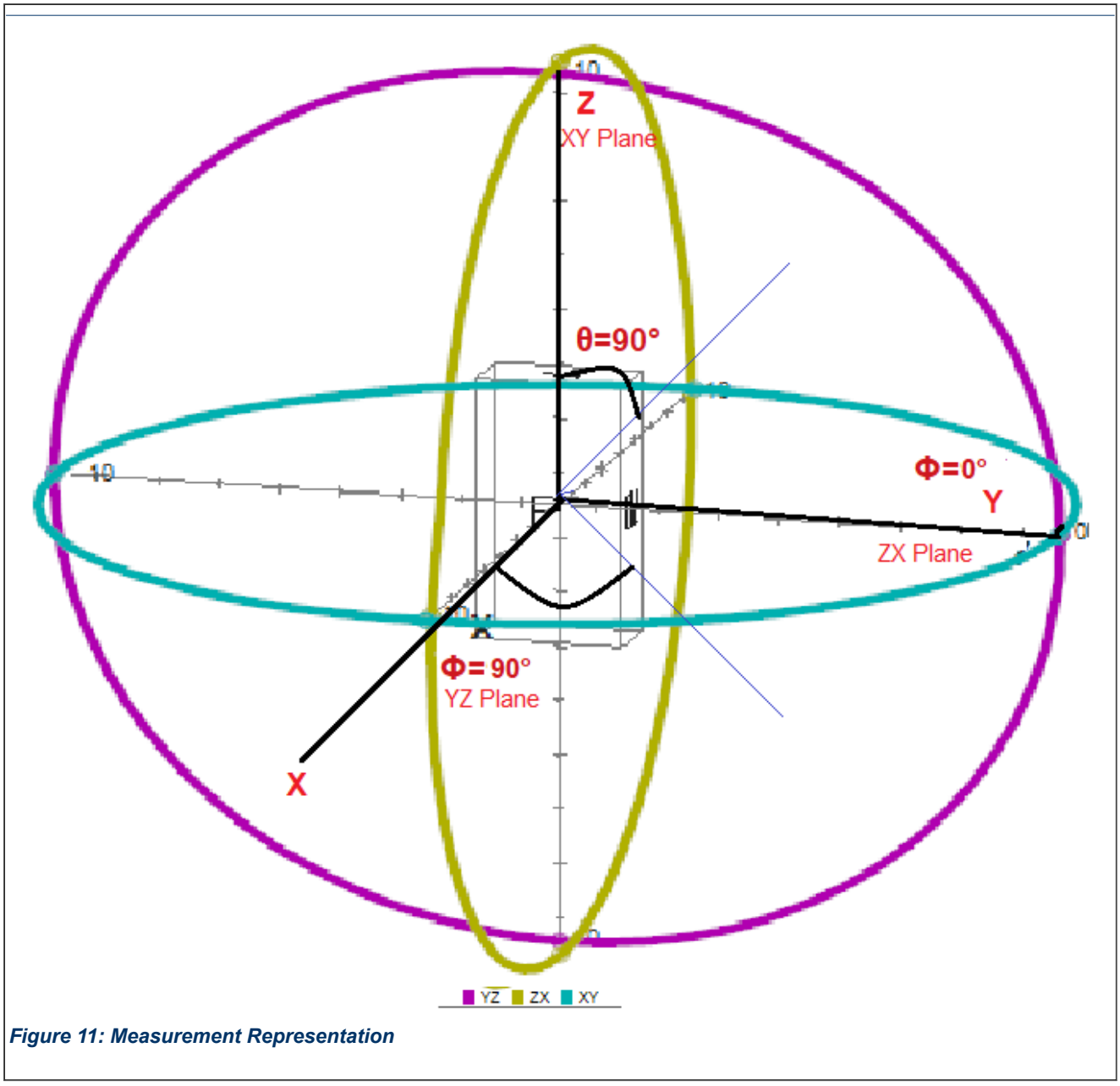

Figure 11: Measurement Representation

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3.7 Test Results

3.7.1 Summary

Sr. No	Frequency (MHz)	Plane	Gain		Peak Gain (dBi)	Average Gain TIG(dBi)
			Peak (dBi)	Average (dBi)		
1	2402	YZ	-5.4	-8.9	-4.6	-9.2
		ZX	-4.6	-8.9		
		XY	-6.2	-9.4		
2	2440	YZ	-6.2	-8.0	-4.2	-8.1
		ZX	-4.2	-7.9		
		XY	-4.5	-8.0		
3	2480	YZ	-4.0	-6.2	-2.2	-6.0
		ZX	-2.2	-5.4		
		XY	-4.0	-6.2		

Table 7: Summary

***Note**:

- Above test results are considering with the 3-plane cut measurement using Radiation Measurement System inside RF Anechoic Chamber along with matching components whose details are available in Table no.5.

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3.7.2 Gain Graphical Plots

3.7.2.1 Gain for First Channel: 2402 MHz

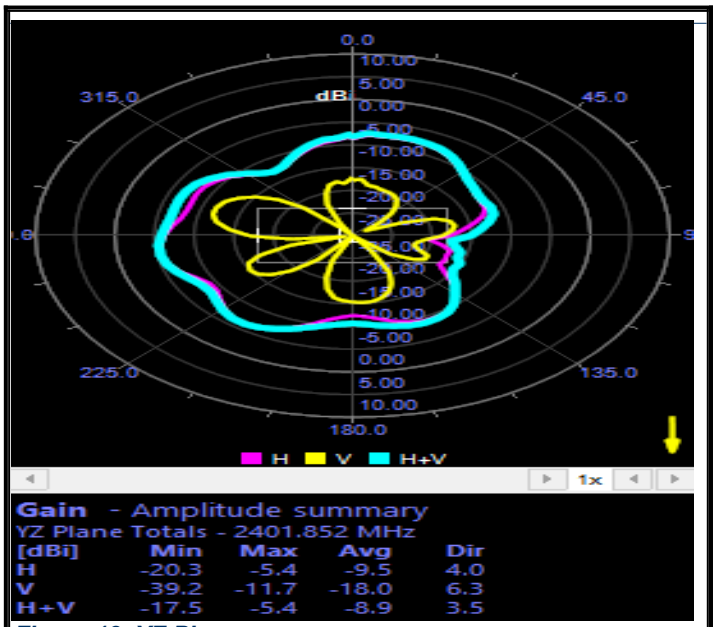

Figure 12: YZ Plane

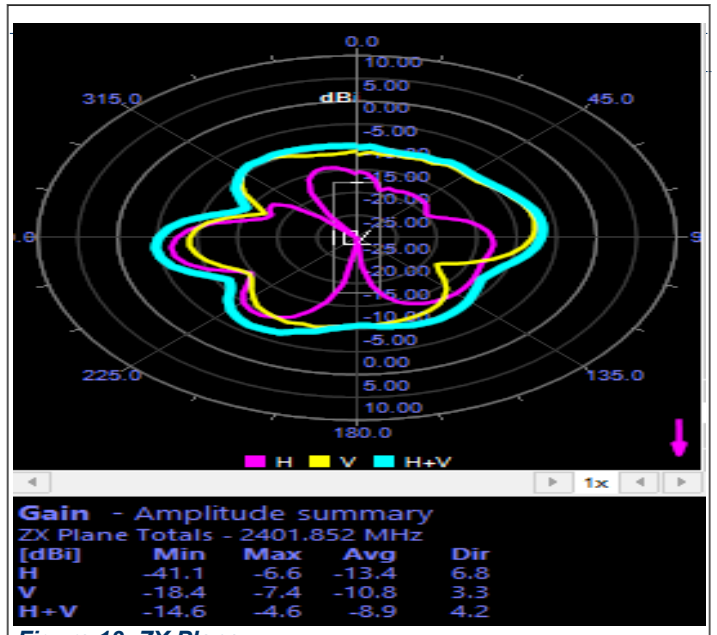

Figure 13: ZX Plane

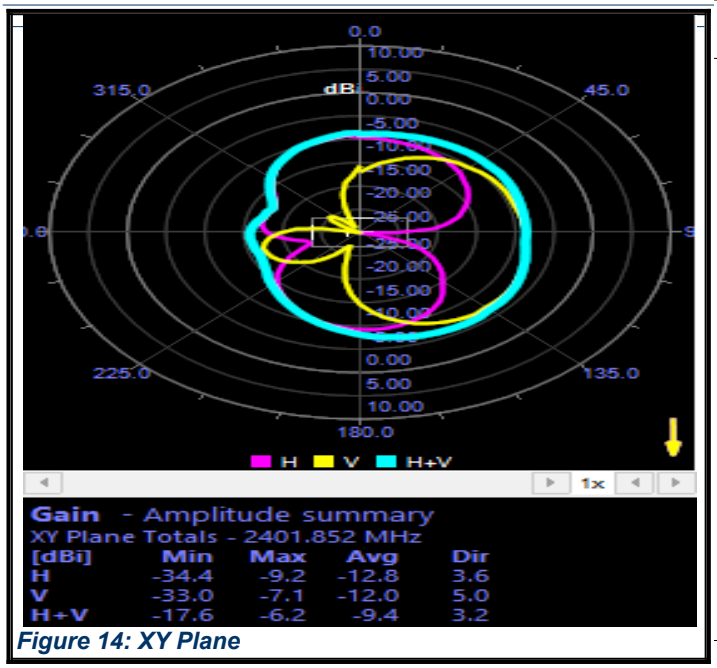

Figure 14: XY Plane

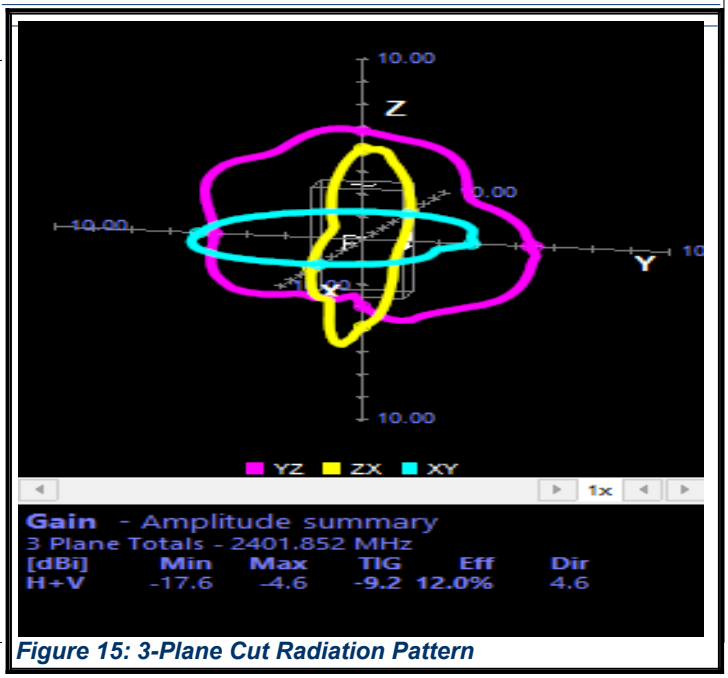

Figure 15: 3-Plane Cut Radiation Pattern

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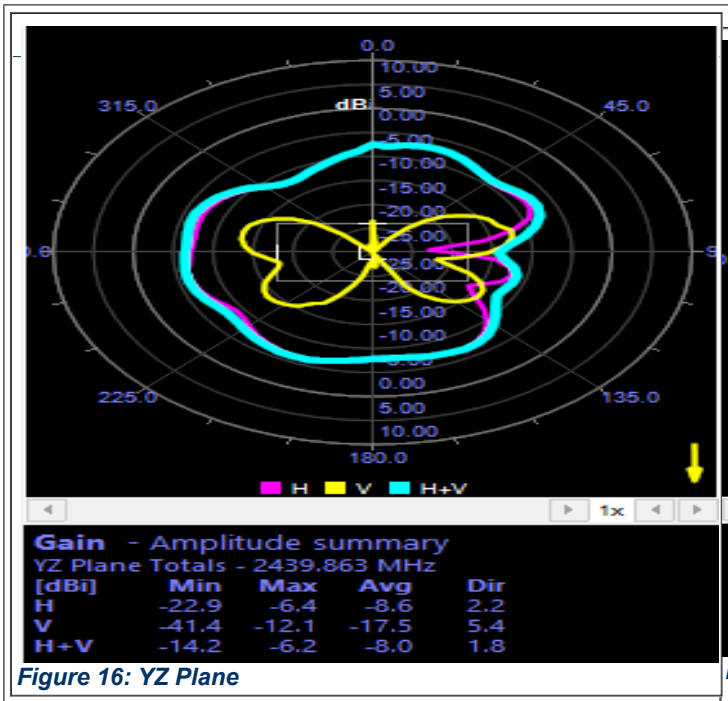
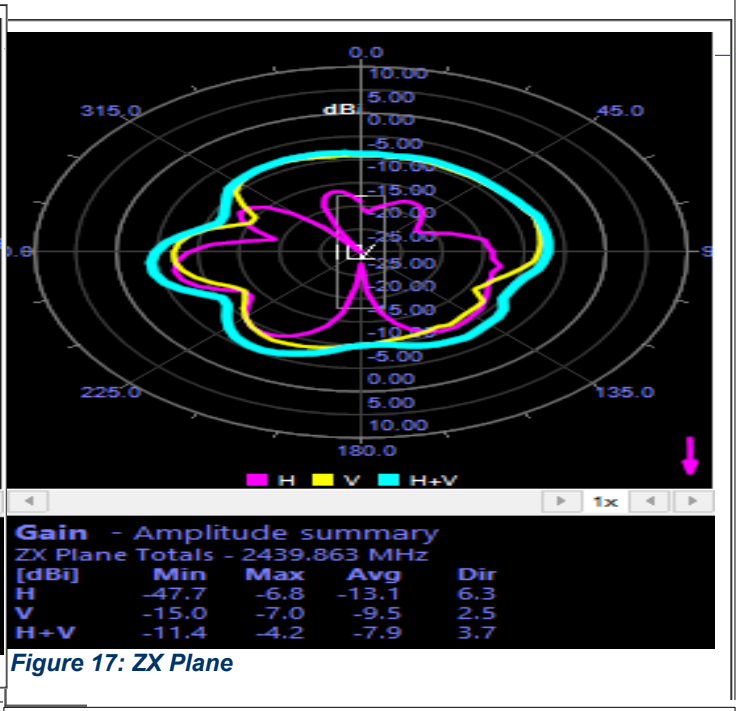
3.7.2.2 Gain for Middle Channel: 2440 MHz



Gain - Amplitude summary
YZ Plane Totals - 2439.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-22.9	-6.4	-8.6	2.2
V	-41.4	-12.1	-17.5	5.4
H+V	-14.2	-6.2	-8.0	1.8

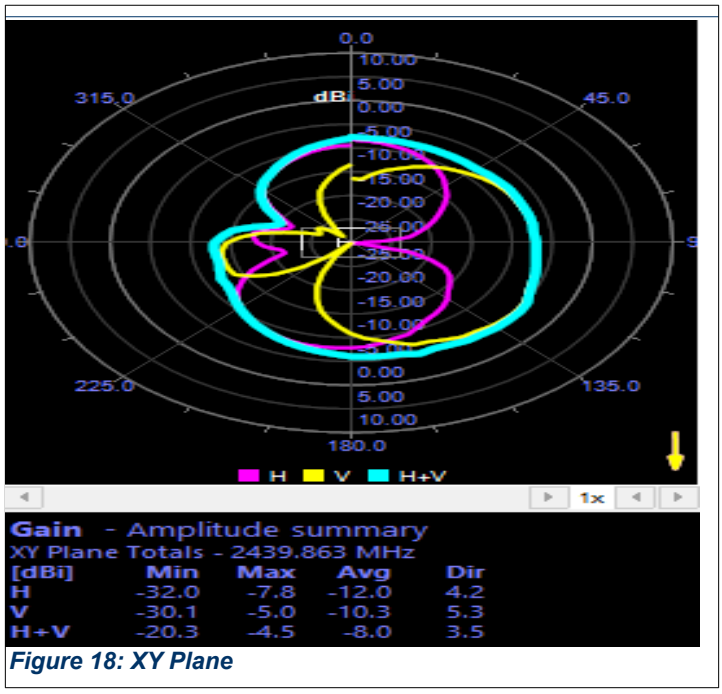
Figure 16: YZ Plane



Gain - Amplitude summary
ZX Plane Totals - 2439.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-47.7	-6.8	-13.1	6.3
V	-15.0	-7.0	-9.5	2.5
H+V	-11.4	-4.2	-7.9	3.7

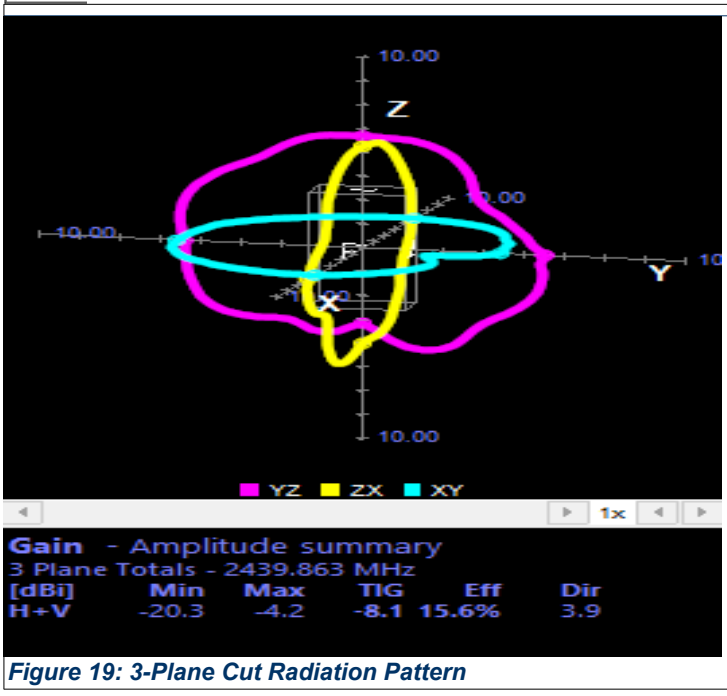
Figure 17: ZX Plane



Gain - Amplitude summary
XY Plane Totals - 2439.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-32.0	-7.8	-12.0	4.2
V	-30.1	-5.0	-10.3	5.3
H+V	-20.3	-4.5	-8.0	3.5

Figure 18: XY Plane



Gain - Amplitude summary
3 Plane Totals - 2439.863 MHz

[dBi]	Min	Max	TIG	Eff	Dir
H+V	-20.3	-4.2	-8.1	15.6%	3.9

Figure 19: 3-Plane Cut Radiation Pattern

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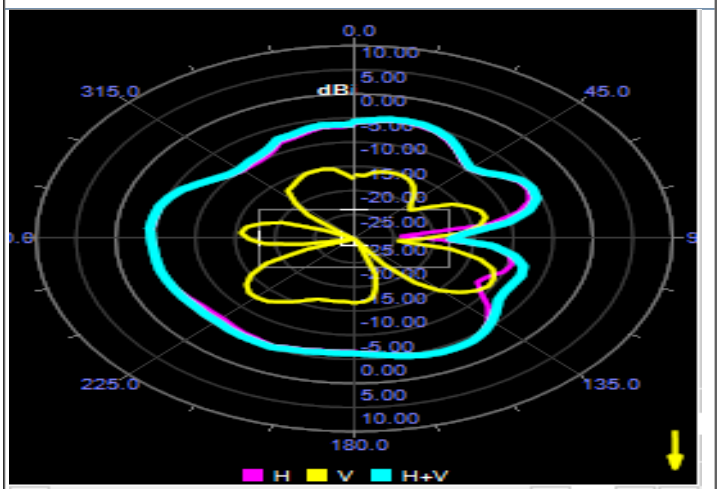
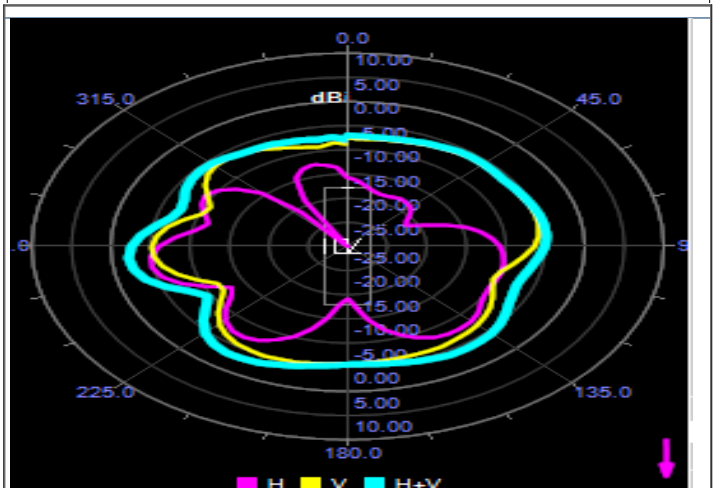
3.7.2.3 Gain for Last Channel: 2480 MHz



Gain - Amplitude summary
YZ Plane Totals - 2479.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-24.0	-4.0	-6.7	2.7
V	-50.4	-10.5	-16.0	5.5
H+V	-17.9	-4.0	-6.2	2.2

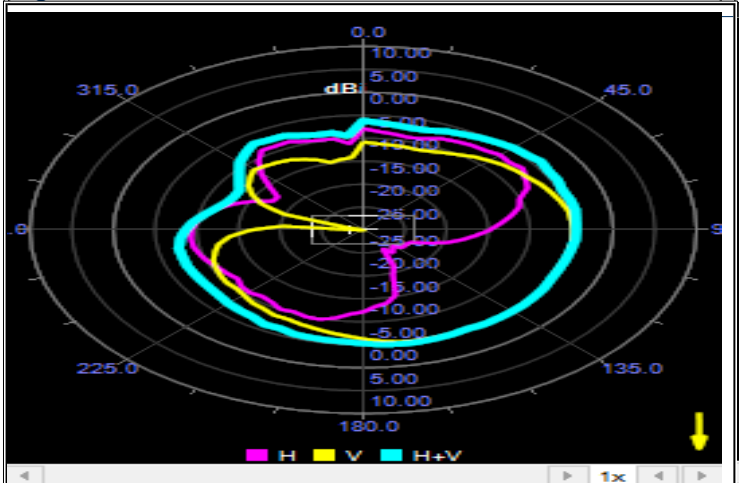
Figure 20: YZ Plane



Gain - Amplitude summary
ZX Plane Totals - 2479.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-35.4	-4.9	-10.7	5.9
V	-11.9	-5.0	-6.9	1.9
H+V	-9.4	-2.2	-5.4	3.2

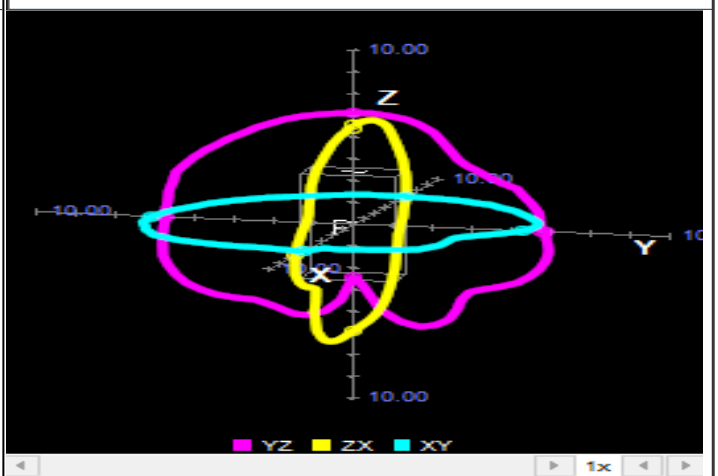
Figure 21: ZX Plane



Gain - Amplitude summary
XY Plane Totals - 2479.863 MHz

[dBi]	Min	Max	Avg	Dir
H	-25.2	-6.6	-10.8	4.2
V	-30.2	-4.8	-8.0	3.2
H+V	-12.8	-4.0	-6.2	2.2

Figure 22: XY Plane



Gain - Amplitude summary
3 Plane Totals - 2479.863 MHz

[dBi]	Min	Max	TIG	Eff	Dir
H+V	-17.9	-2.2	-6.0	25.3%	3.8

Figure 23: 3-Plane Cut Radiation Pattern

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Appendix A: Abbreviations

CW: Continuous Wave

RF: Radio Frequency

DUT: Device Under Test

TIG: Total Isotropic Gain

VNA: Vector Network Analyzer

VSWR: Voltage Standing Wave Ratio

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