

# Antenna Tuning & Optimization

## Test Report

**Version: 1.0**

**Report No: SER0001-003**

**Document Classification: External**

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# Antenna Tuning & Optimization Report

## 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.

## Privacy Information

This Report shall not be reproduced except in full without the written approval of the Avartanam Test Labs LLP.

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                  |

## 1.1.1 DUT Photograph



Figure 1: DUT Photograph

## 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.

## 2 Antenna Tuning & Optimization

### 2.1 Introduction

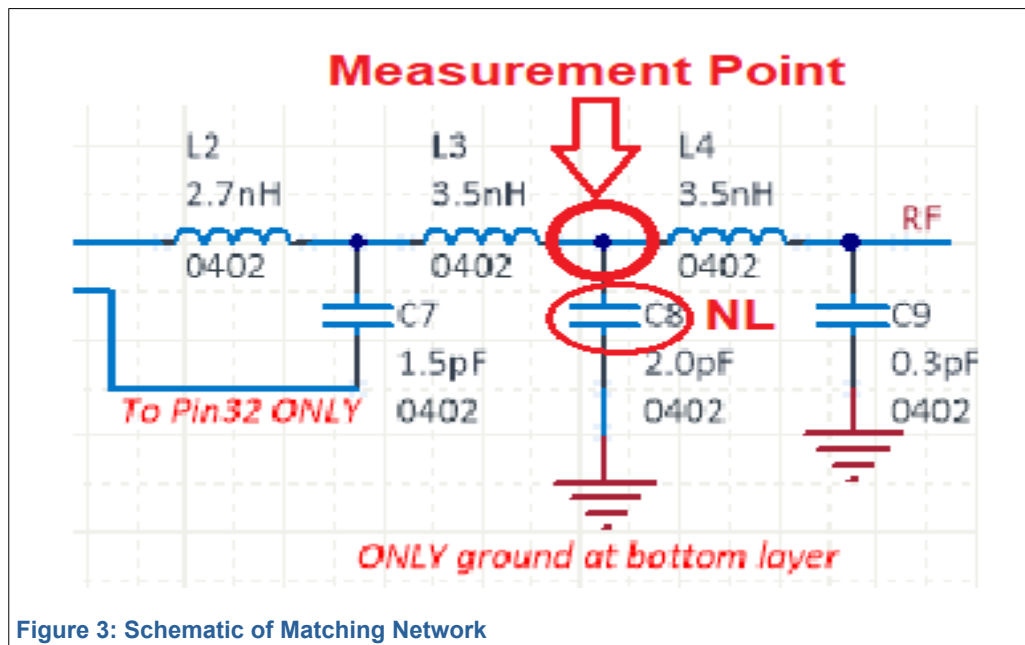
- Antenna Tuning & Optimization will optimize the antenna performance that is degraded/off tuned by the several factors considering the product form factors.
- The antenna must be placed in its final environment and impedance matched so that it operates in the desired frequency band.
- A poorly matched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

### 2.2 Test Setup Image



Figure 2: Test Setup Image

### 2.2.1 Measurement Point on DUT for Optimization



2.3 Test Conditions

| DUT Operating Condition        |                                                         |
|--------------------------------|---------------------------------------------------------|
| Temperature                    | Relative Humidity                                       |
| 23 <sup>0</sup> 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

## 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.

2.5.3 Test Plot

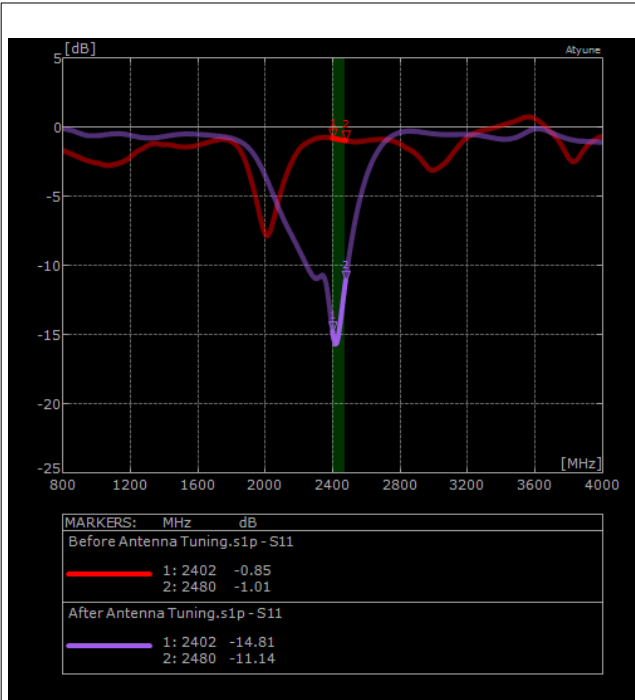


Figure 5: S11 Plot

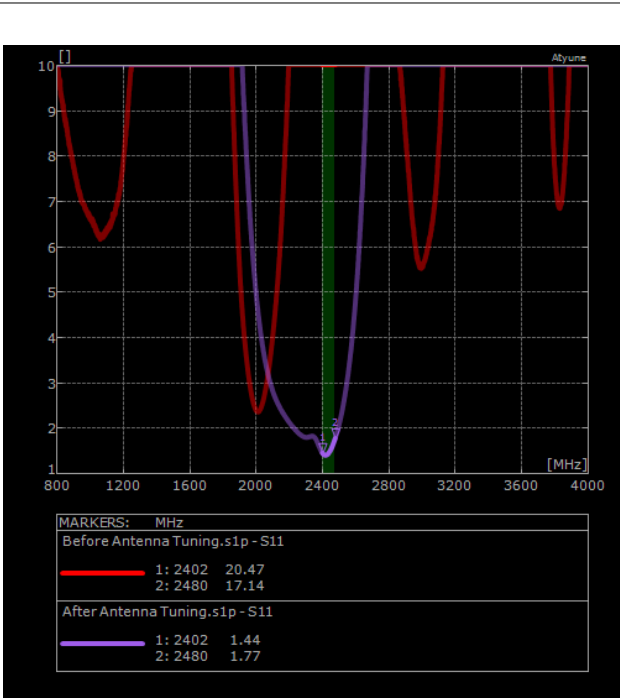


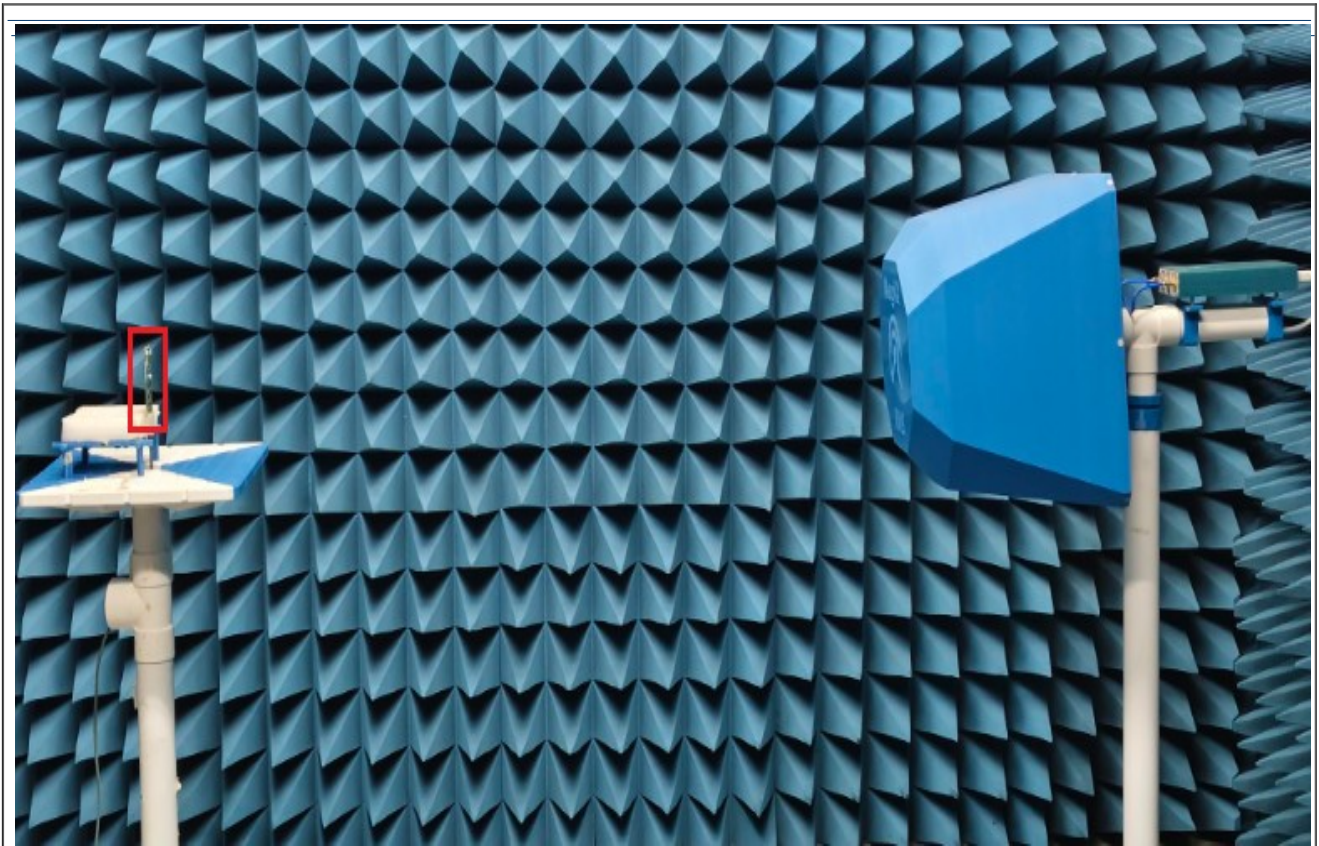
Figure 6: VSWR Plot

## 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*

3.3 Test Conditions

| DUT Operating Condition        |                                                        |
|--------------------------------|--------------------------------------------------------|
| Temperature                    |                                                        |
| 23 <sup>0</sup> 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

### 3.5 DUT Orientation in Three Planes

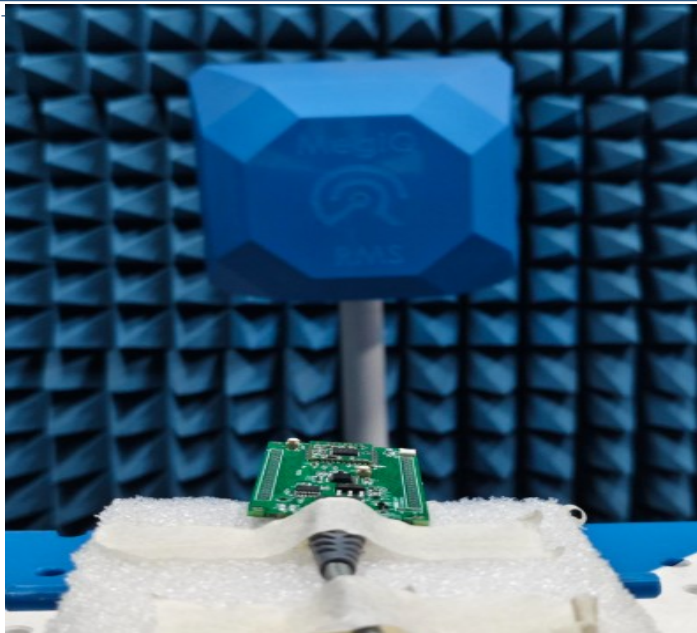


Figure 8: YZ Plane ( $\phi=90^\circ$ )

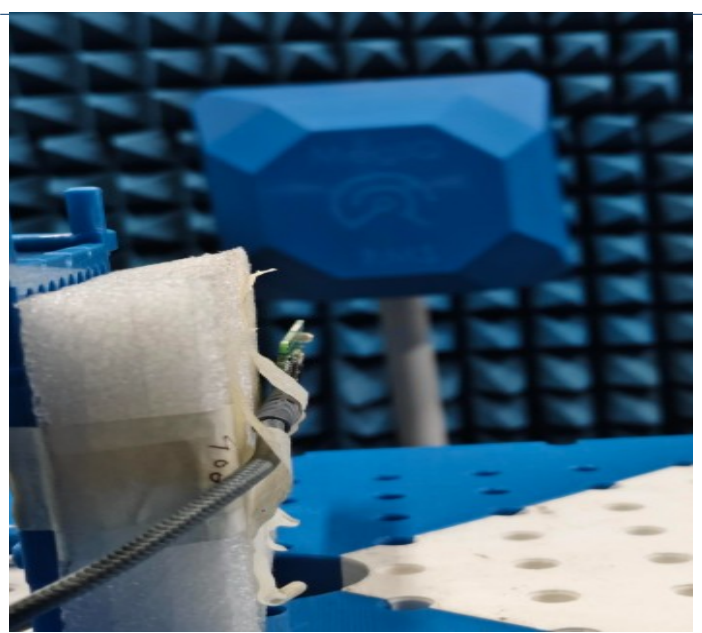


Figure 9: ZX Plane ( $\phi=0^\circ$ )

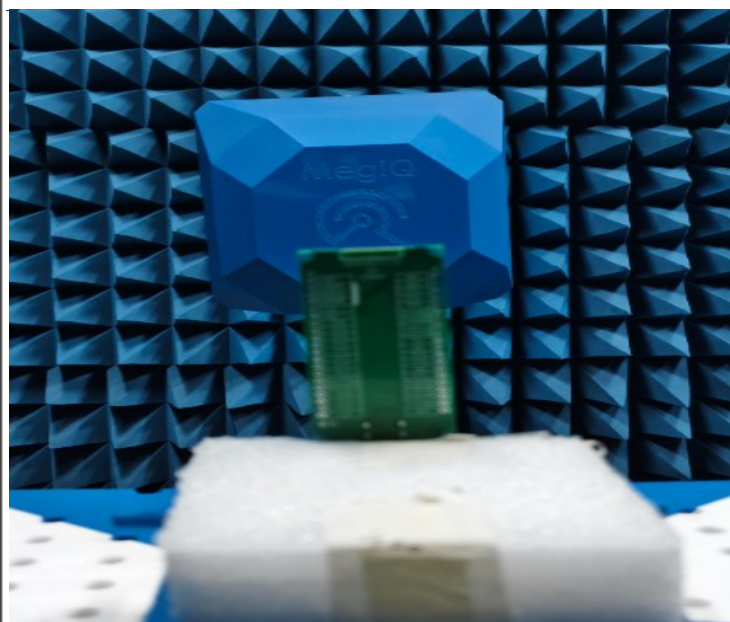
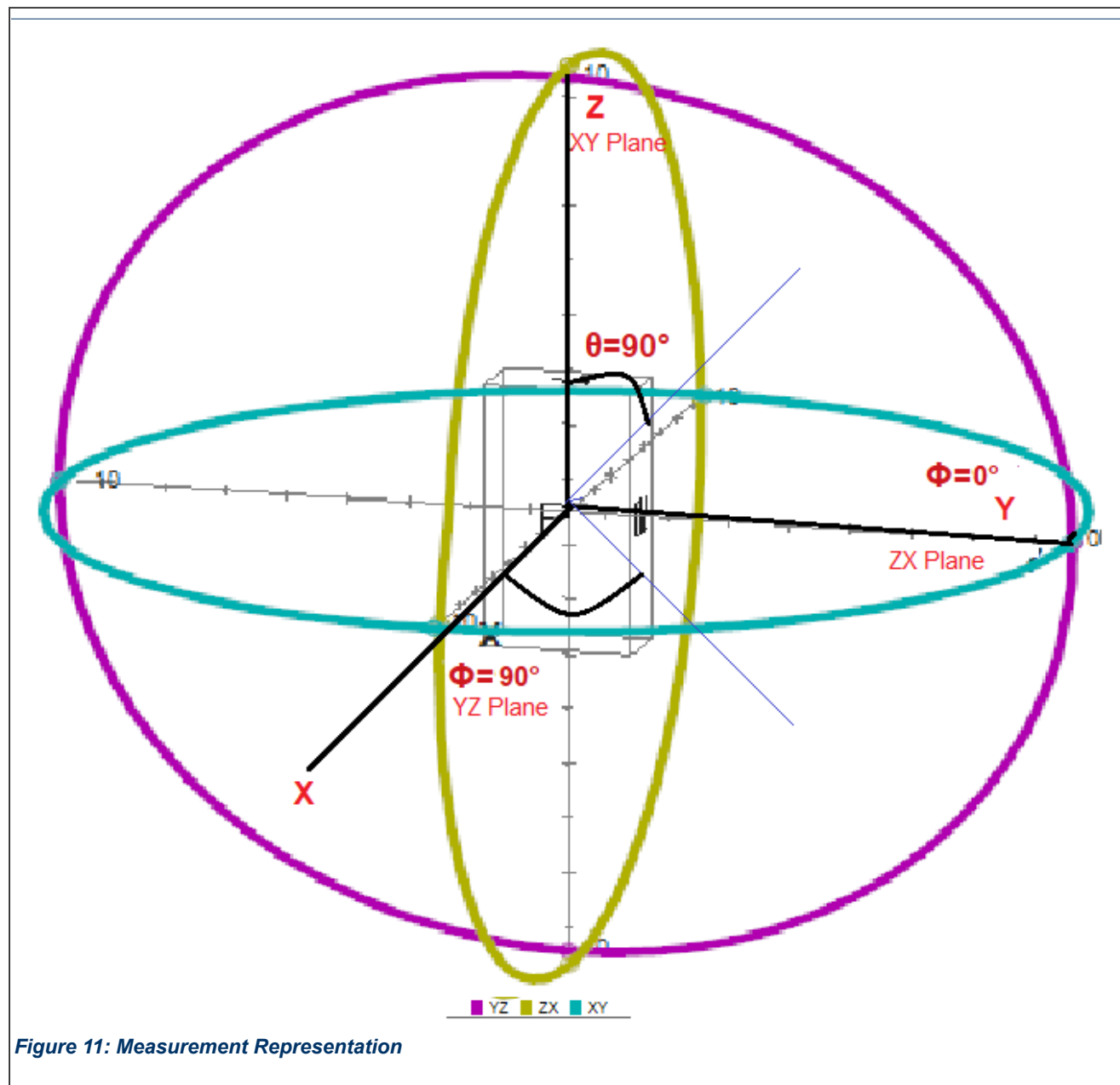


Figure 10: XY Plane ( $\theta=90^\circ$ )

### 3.6 Measurement Representation



## 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.

3.7.2 Gain Graphical Plots

3.7.2.1 Gain for First Channel: 2402 MHz

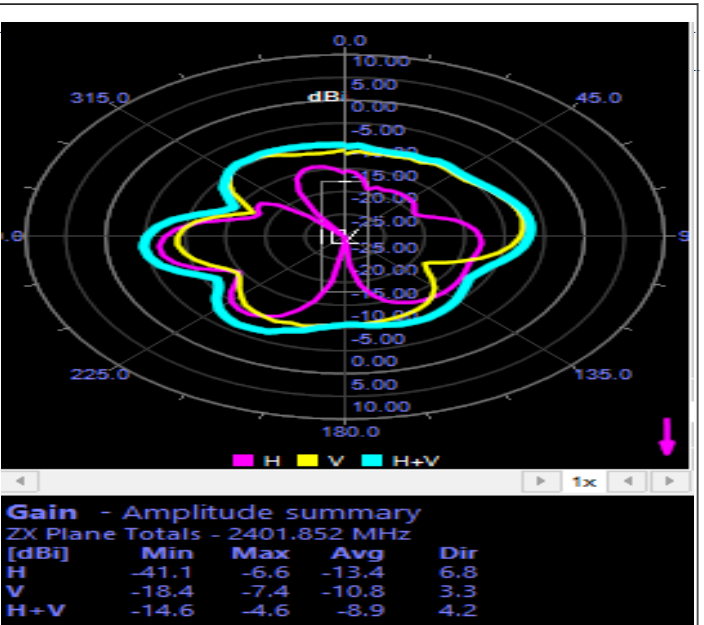
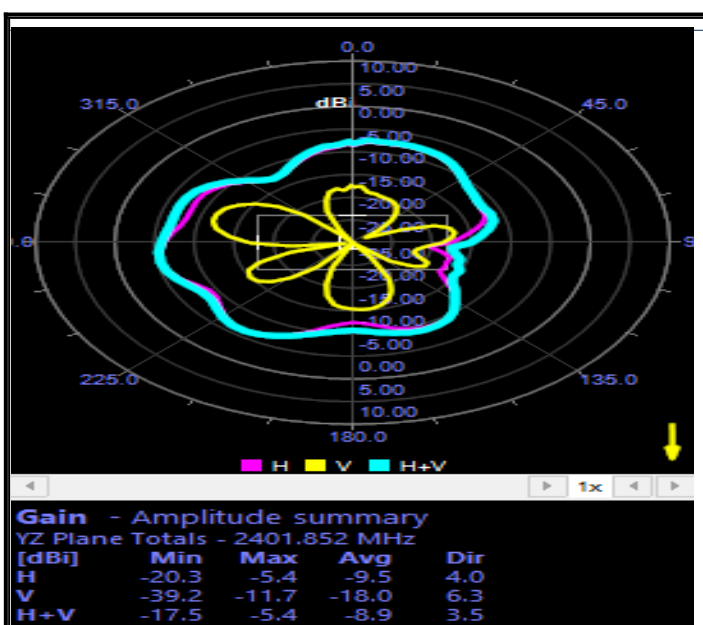


Figure 12: YZ Plane

Figure 13: ZX Plane

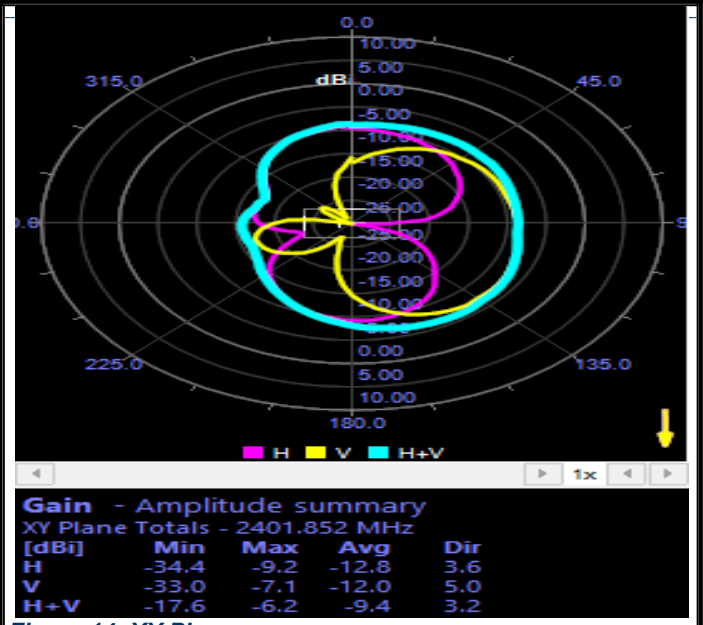


Figure 14: XY Plane

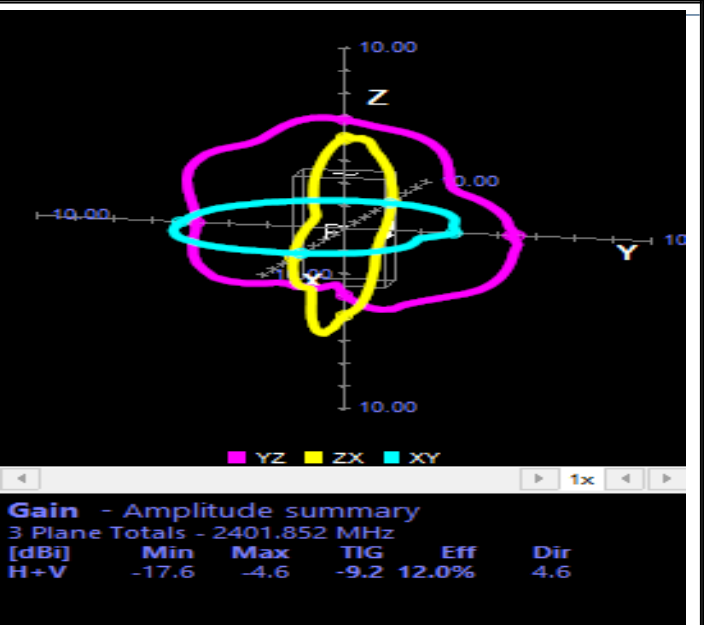
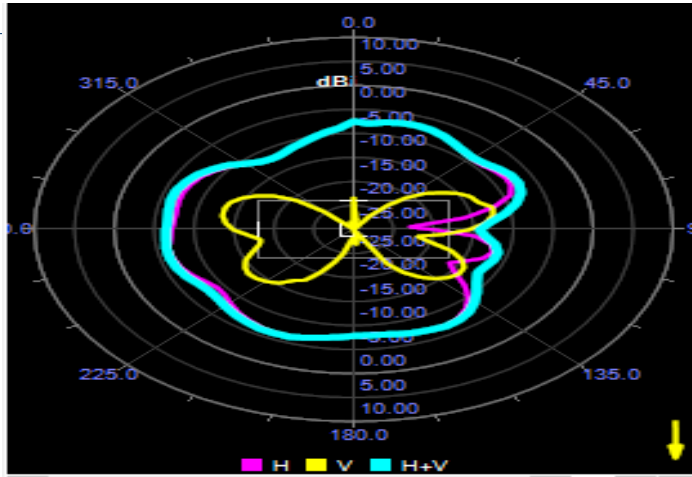


Figure 15: 3-Plane Cut Radiation Pattern

## Antenna Tuning & Optimization Report

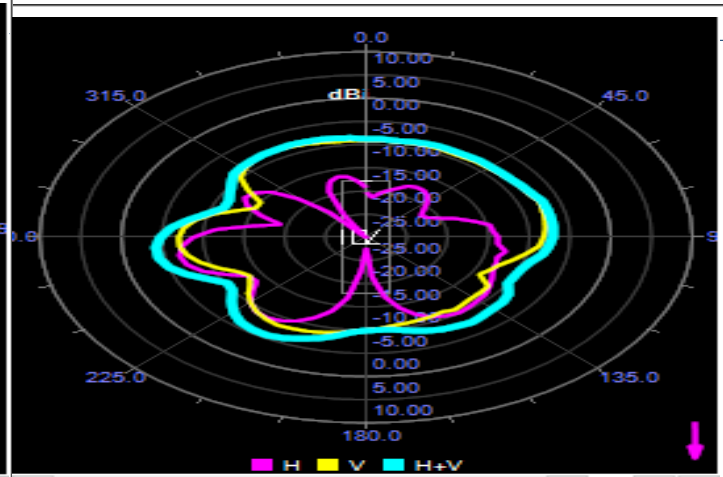
### 3.7.2.2 Gain for Middle Channel: 2440 MHz



**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 |

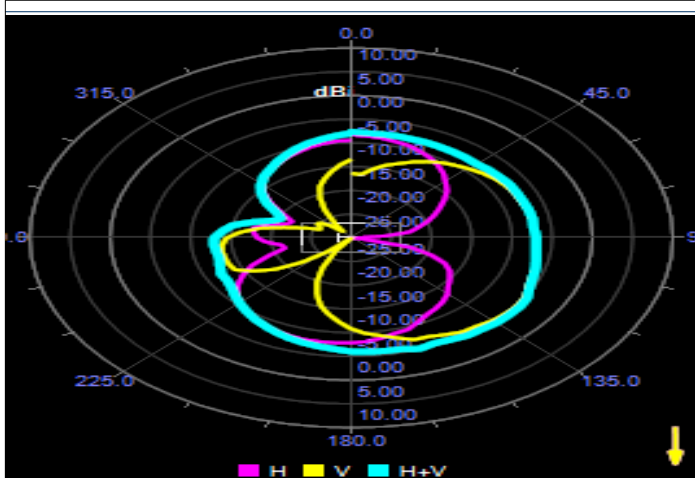
Figure 16: YZ Plane



**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 |

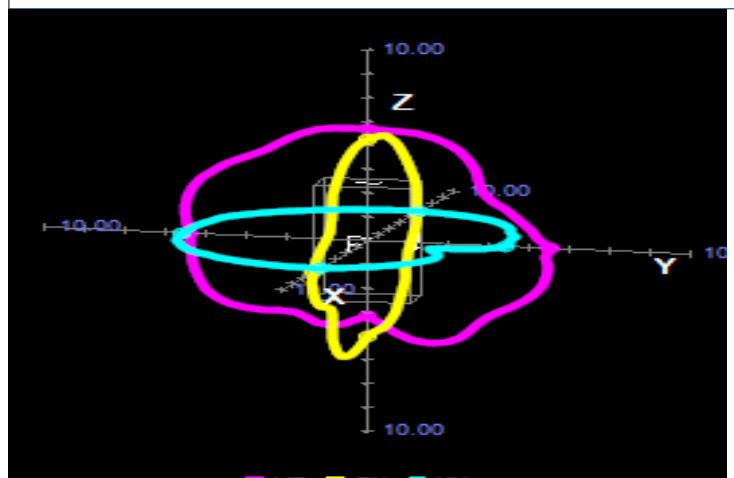
Figure 17: ZX Plane



**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

3.7.2.3 Gain for Last Channel: 2480 MHz

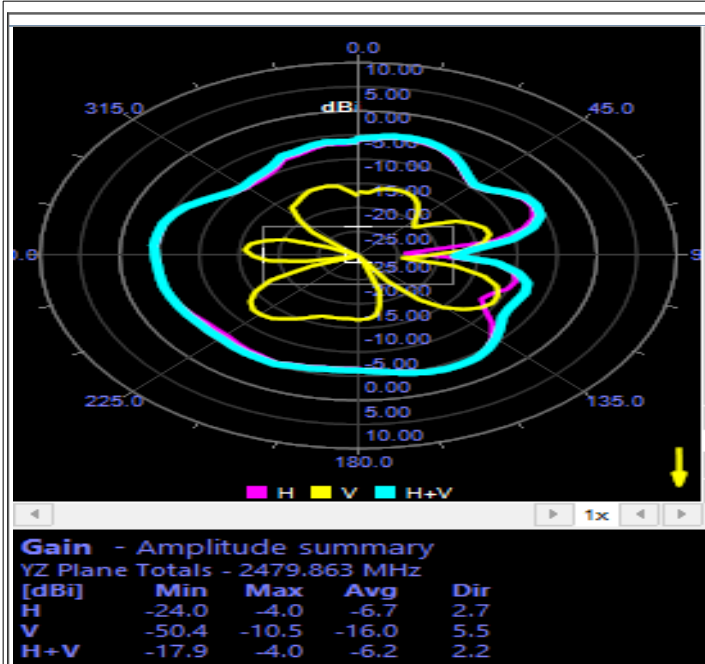


Figure 20: YZ Plane

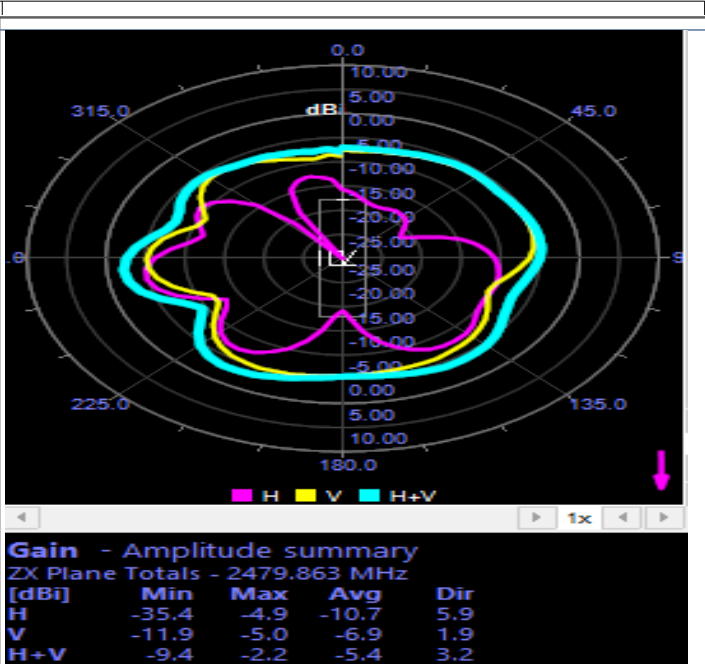


Figure 21: ZX Plane

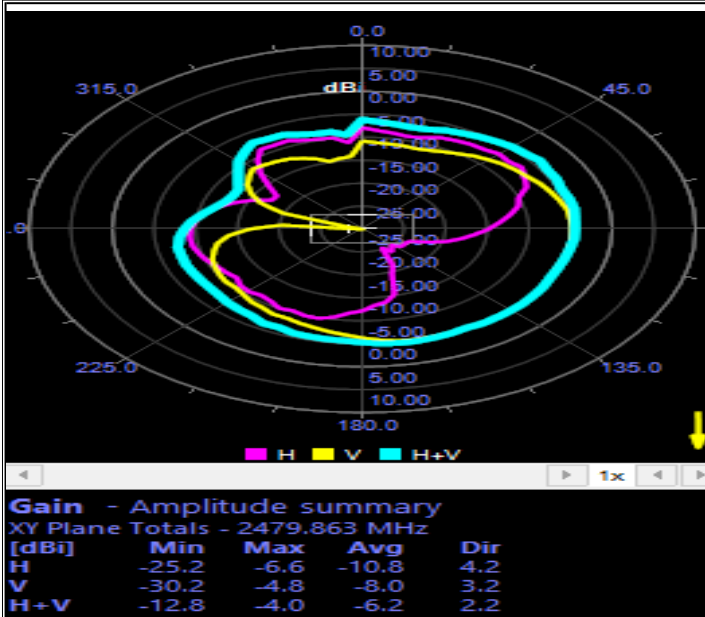


Figure 22: XY Plane

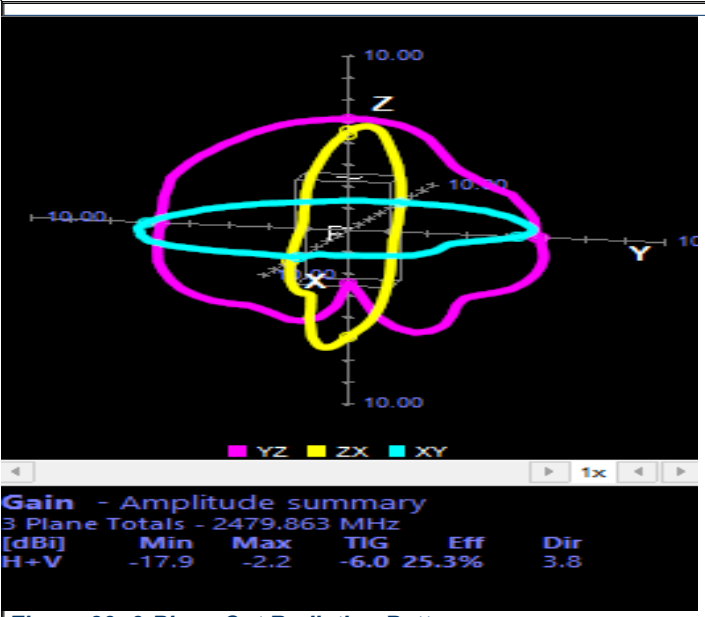


Figure 23: 3-Plane Cut Radiation Pattern

### 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