New Kinpo Group

NVG578HLX/LX/LX1 Antenna Measurement Report
2 on-Board + 2 off-Board PCAs

Rex Chiang

2022-09-20

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Revision History

Version	Remark	Date
V1.0	Antenna Evaluation Report on current Jaguar 3D printing enclosure using 2 on-board and 2 off-board PCAs	2020-03-09
V1.1	Antenna Measurement Report on NVG578HLX mock-up ID and real PCBA.	2020-06-22
V1.2	Update antenna measurement report with heat spreader.	2020-07-13
V1.3	Sync the naming of antenna between all the RF reports	2020-07-30
V1.4	Antenna Measurement Report on NVG578HLX EPR2 ID and PCBA.	2020-09-25
V1.5	Add Antenna Vendor Info and Measurement Setup	2022-09-14
V1.6	Add 5450MHz 3D correlated radiation pattern	2022-09-20

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List Contents

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- Experiment Setup
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- 3D Radiation Pattern
- 2D Correlated Radiation Pattern
- 3D Correlated Radiation Pattern

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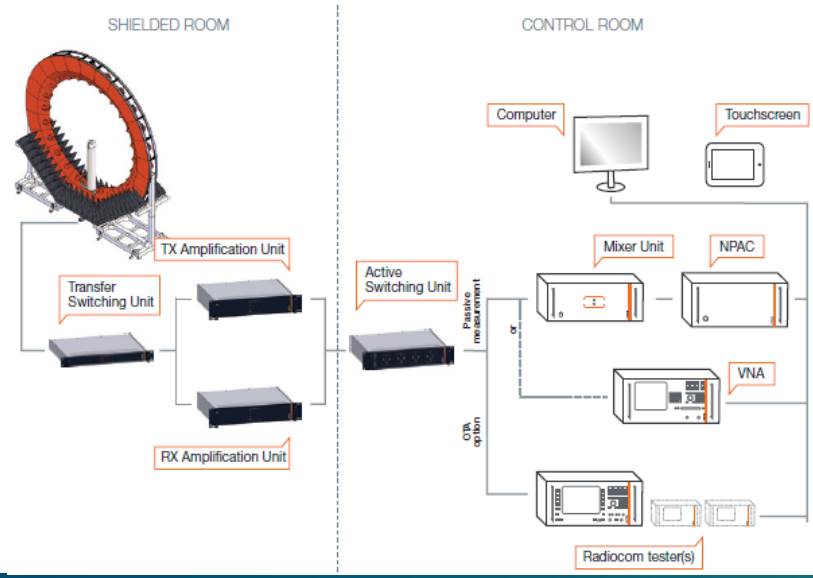
Antenna Vendor Info & Measurement Setup

- **Antenna Vendor: Walsin Technology (Inpaq)**
- **Test Date: 2020/9/21**
- **Test Engineer: Inpaq Jack Yeh**
- **Measurement Setup:**
  - **Reflection Coefficient Measurement:**
    - **Instrument: Network Analyzer (Keysight E5071A)**
    - **Setup:**
      - **Calibrate the Network Analyzer by one port calibration using O.S.L. calibration kits.**
      - **Connect the antenna under test to the Network Analyzer.**
      - **Measure the S11 (reflection coefficient), Return Loss …**
  - **Pattern Measurement**
    - **Chamber: Satimo SG 24**
    - **Satimo program: SPM1.5**
    - **System Overview:**



  - **Test Item**

    Antenna passive test 400MHz~6GHz

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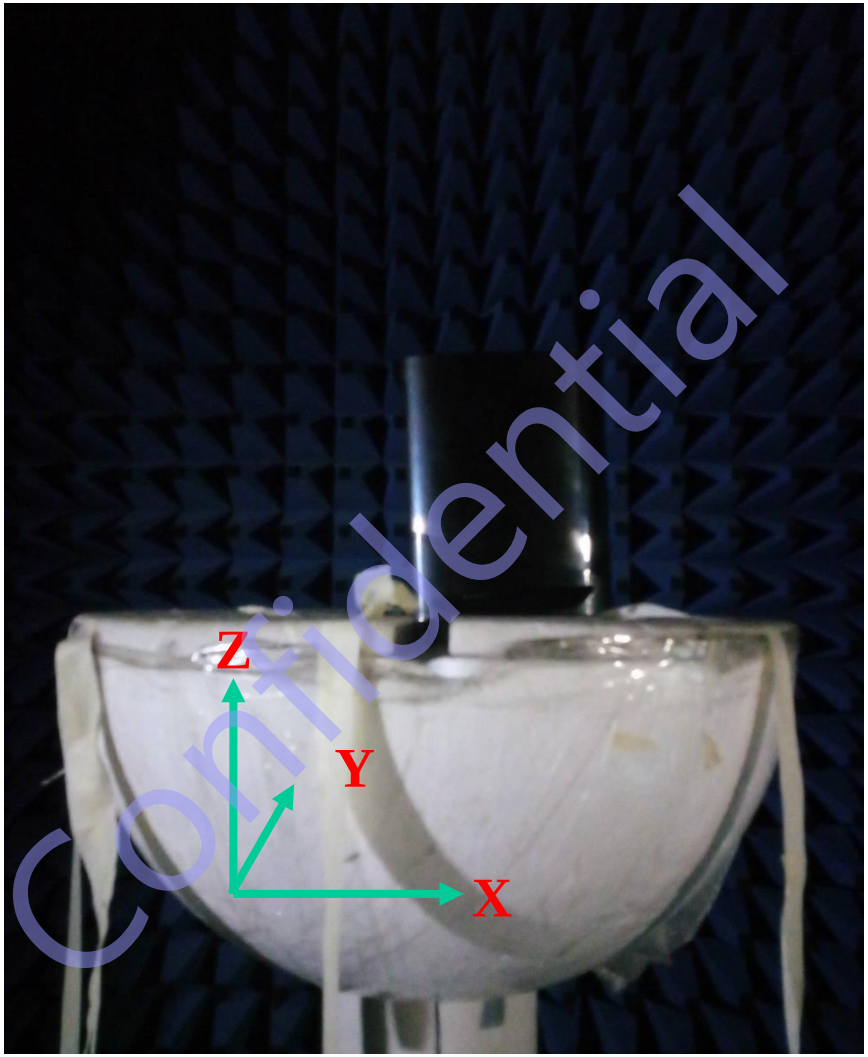
Experiment Setup



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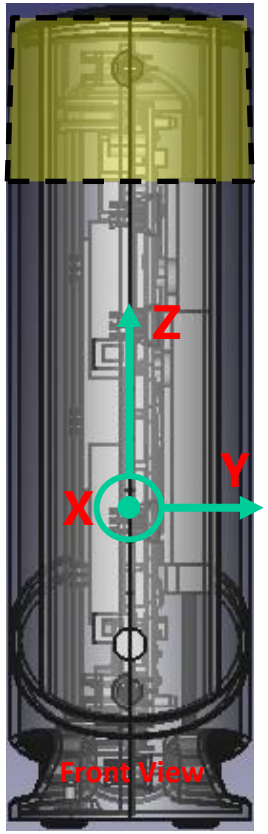
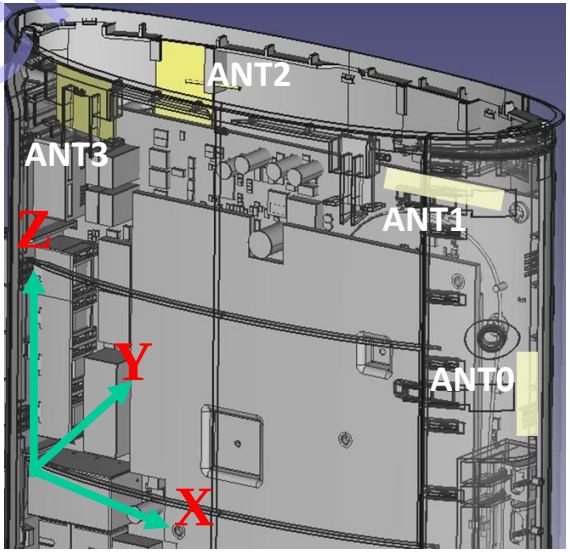
Antenna Placement

•Two 2.4G/5GHz dual band off-board PCAs are located on top of enclosure. One 2.4G/5GHz dual band on-board PCA and one 5GHz single band on-board PCA are on PCB.

• Under the ID dimension constraint (w70 x d190 x h238 mm) the free space for antennas is limited to around w63 x d184 x h30 mm.



ANT0: on-board (Single Band)
ANT1: on-board (Dual Band)
ANT2: 28 x 18 x 0.8 mm (Dual Band)
ANT3: 25 x 18 x 0.8 mm (Dual Band)



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Antenna Cable Routing on PCBA

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Antenna Cable Routing on Enclosure

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Evaluation Summary

	Spec 2.4/5GHz	Performance Evaluation
Technology	Dual-band & Single-band PCAs	Dual-band PCA x2 (off-board) Dual-band PCA x1 (on-board) Single-band PCA x1 (on-board)
Radiation	Omnidirectional	Omnidirectional
Efficiency	> 60%	2.4G: > 65.0% 5G: > 70.1%
Gain	Desirable 6 dBi*	2.4G: < 4.69 dBi 5G: < 4.54 dBi
Return Loss	< -10dB	< -12.0 dB
Isolation	> 25dB	> 25.04 dB

* This requirement is from NVG578LX Hardware Product Functional Specification (enb-19029 x3) but removed on the later version.

- The antenna performance measurement result was tested on EPR2 ID with heat spreader.

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Efficiency & Peak Gain Summary

ANT0 Single-Band on-board	
Frequency	**Efficiency**
5150MHz	70.27%
5250MHz	70.96%
5350MHz	70.66%
5725MHz	71.12%
5825MHz	70.55%

ANT1 Dual-Band on-board	
Frequency	**Efficiency**
2400MHz	66.9%
2450MHz	70.99%
2500MHz	65.01%
5150MHz	71.39%
5250MHz	71.21%
5350MHz	71.33%
5725MHz	71.41%
5825MHz	70.1%

ANT2 Dual-Band off-board	
Frequency	**Efficiency**
2400MHz	67.41%
2450MHz	72.2%
2500MHz	68.47%
5150MHz	72.35%
5250MHz	73.24%
5350MHz	74.26%
5725MHz	72.06%
5825MHz	71.04%

ANT3 Dual-Band off-board	
Frequency	**Efficiency**
2400MHz	65.07%
2450MHz	72.57%
2500MHz	70.45%
5150MHz	70.75%
5250MHz	71.34%
5350MHz	72.54%
5725MHz	71.19%
5825MHz	71.44%

The antenna gain is measured on each polarization and get its max value from H/V polarizations.

ANT# is the naming of antenna in this report.

Chain# is the naming of hardware RF trace, defined by Broadcom.

Antenna Gain (dBi)		ANT1 (Chain2)	ANT2 (Chain1)	ANT3 (Chain0)
2400 ~ 2483.5 MHz:		4.69	2.27	3.36
Antenna Gain (dBi)	**ANT0 (Chain 0)**	**ANT1 (Chain1)**	**ANT2 (Chain2)**	**ANT3 (Chain3)**
5150 ~ 5250 MHz:	3.93	2.77	2.65	2.83
5250 ~ 5350 MHz:	3.45	3.33	2.86	2.77
5470 ~ 5725 MHz:	4.15	4.33	3.12	2.65
5725 ~ 5850 MHz:	4.33	4.54	3.12	2.83

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Return Loss & Isolation Summary

Return Loss (dB)				
Frequency	**ANT0**	**ANT1**	**ANT2**	**ANT3**
2400MHz		-15.6	-12	-13.8
2450MHz		-14	-19.6	-27.9
2500MHz		-12.7	-21	-18.3
5150MHz	-12.1	-13.9	-20.3	-13.6
5500MHz	-13.3	-16.5	-19.7	-18.4
5850MHz	-13.1	-13.2	-16.2	-31.9

Isolation (dB)						
Ant No.	**Ant 0 (Dual Band)**			**Ant 1 (Dual Band)**		**Ant 2 (Dual Band)**
Frequency	1	2	3	2	3	3
2400MHz	46.8	55.4	54.4	26.7	28.3	29
2450MHz	48	53.8	57.8	25.1	27.8	32.9
2500MHz	48.1	52.7	60.7	25	29.2	41.8
5150MHz	29.7	54.8	42.5	46.7	37	36.4
5500MHz	29.5	45.8	43.8	40.4	41	35.3
5850MHz	25.7	40.7	63.2	44	45.3	36.2

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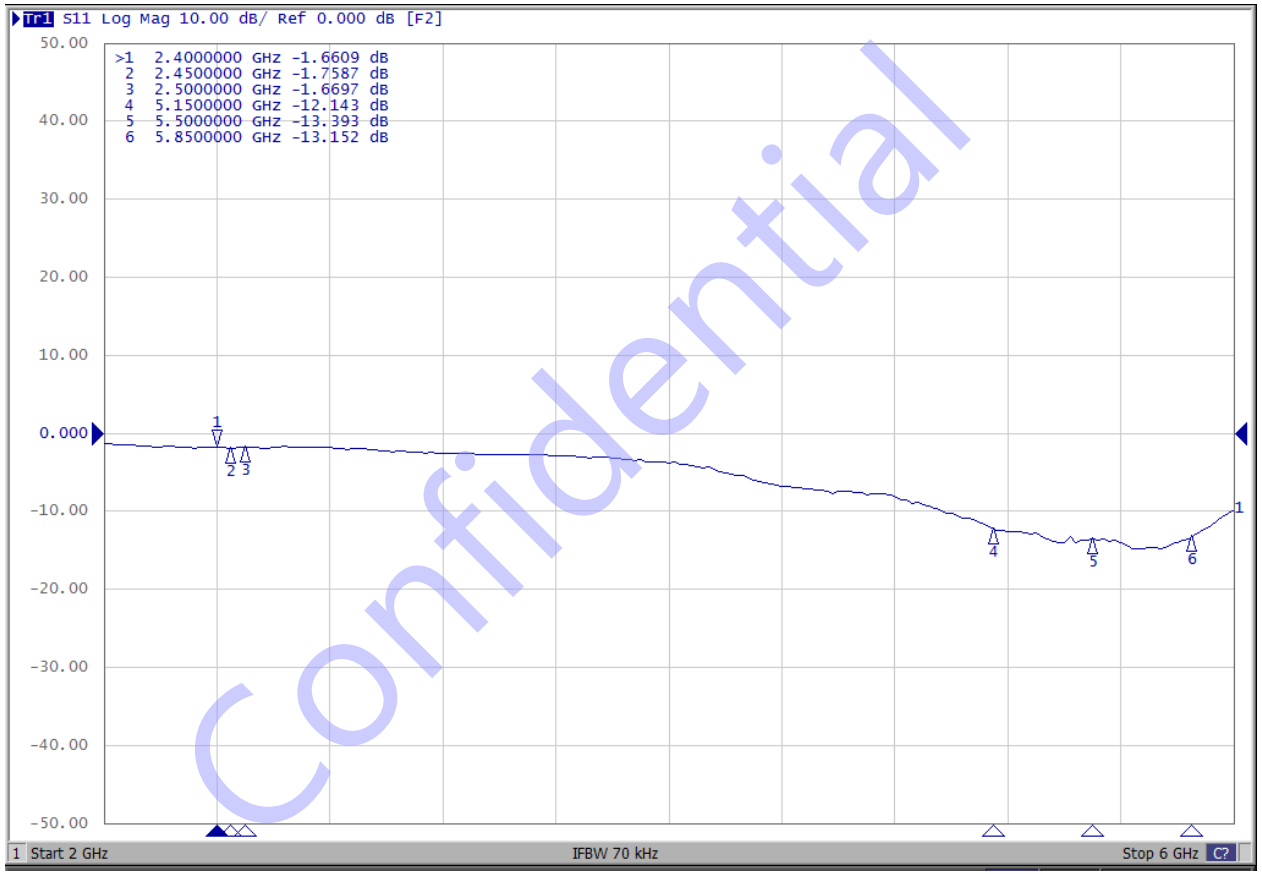
Return Loss: ANT-0



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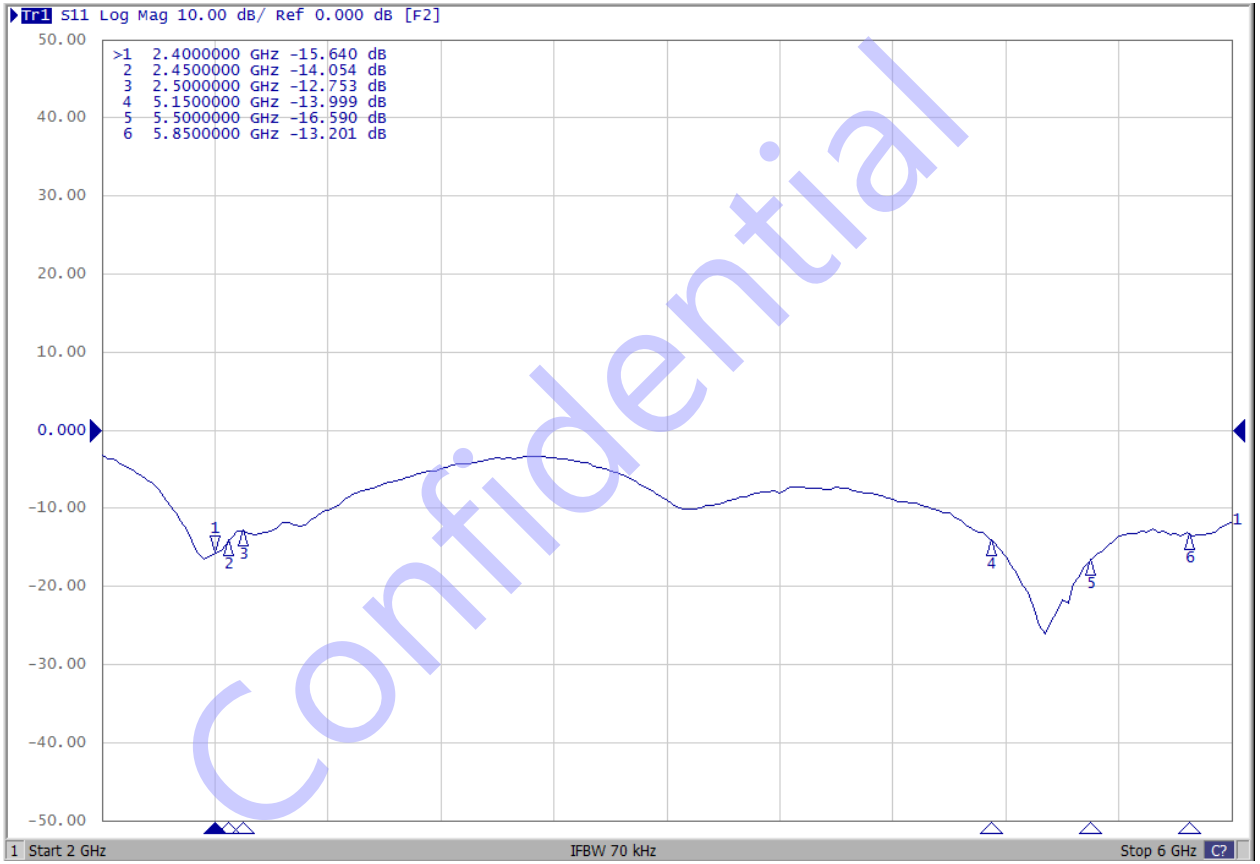
Return Loss: ANT-1



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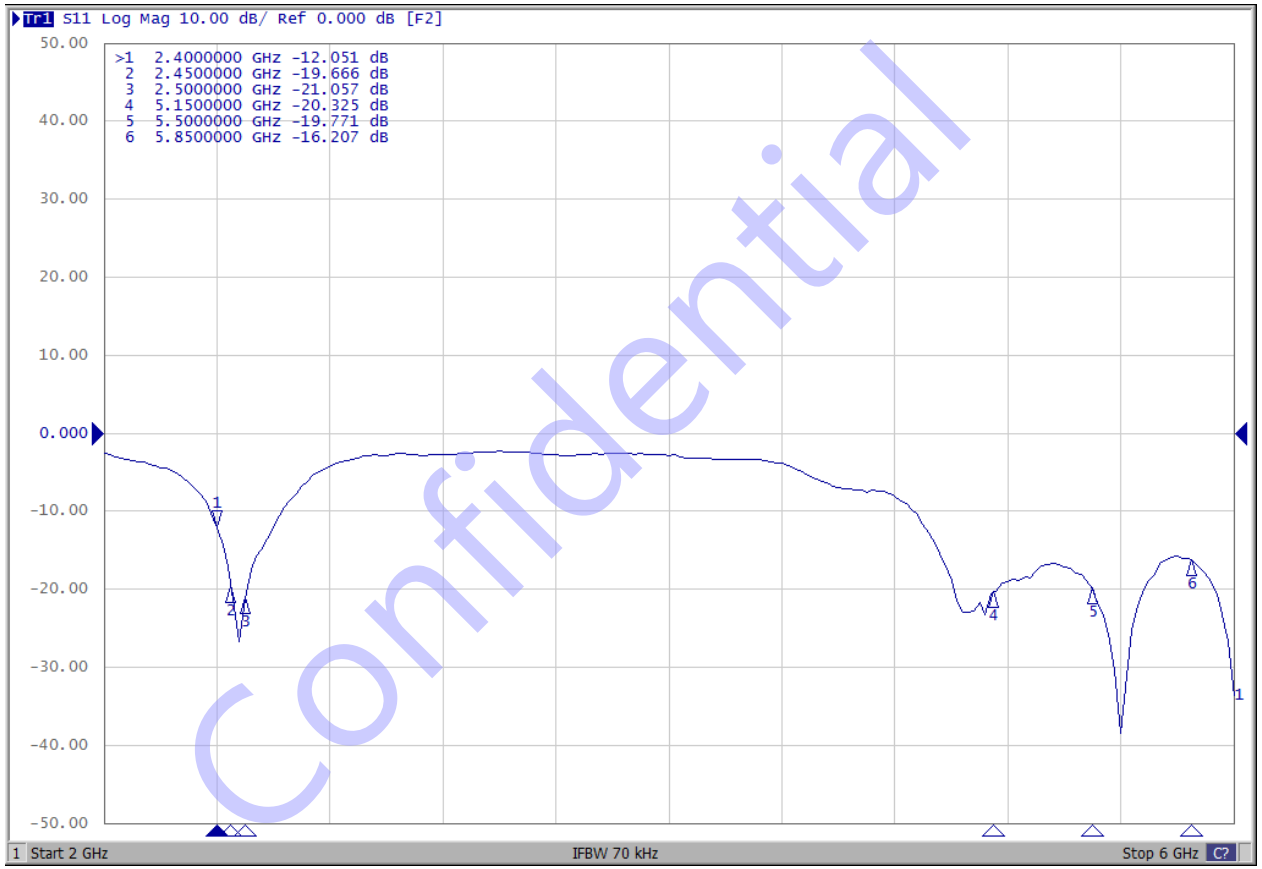
Return Loss: ANT-2



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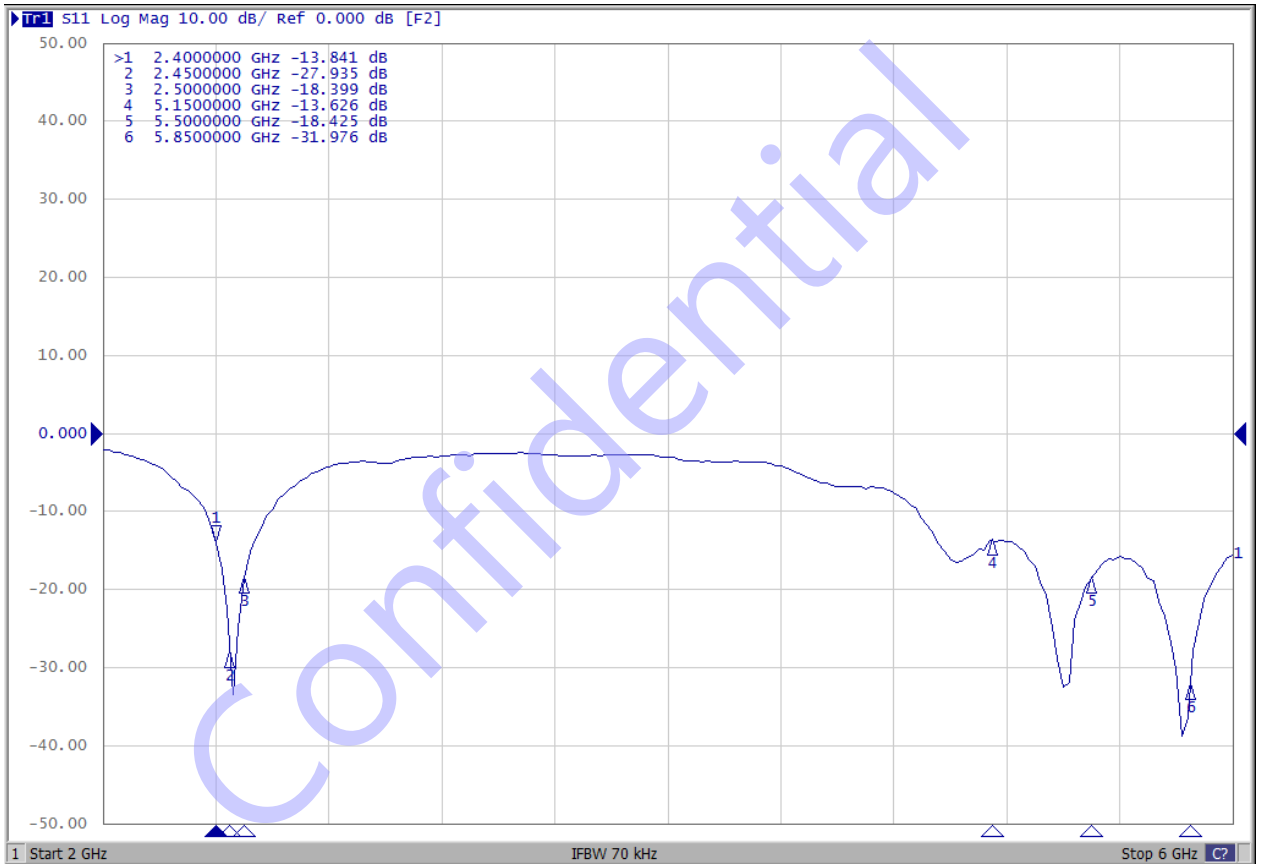
Return Loss: ANT-3



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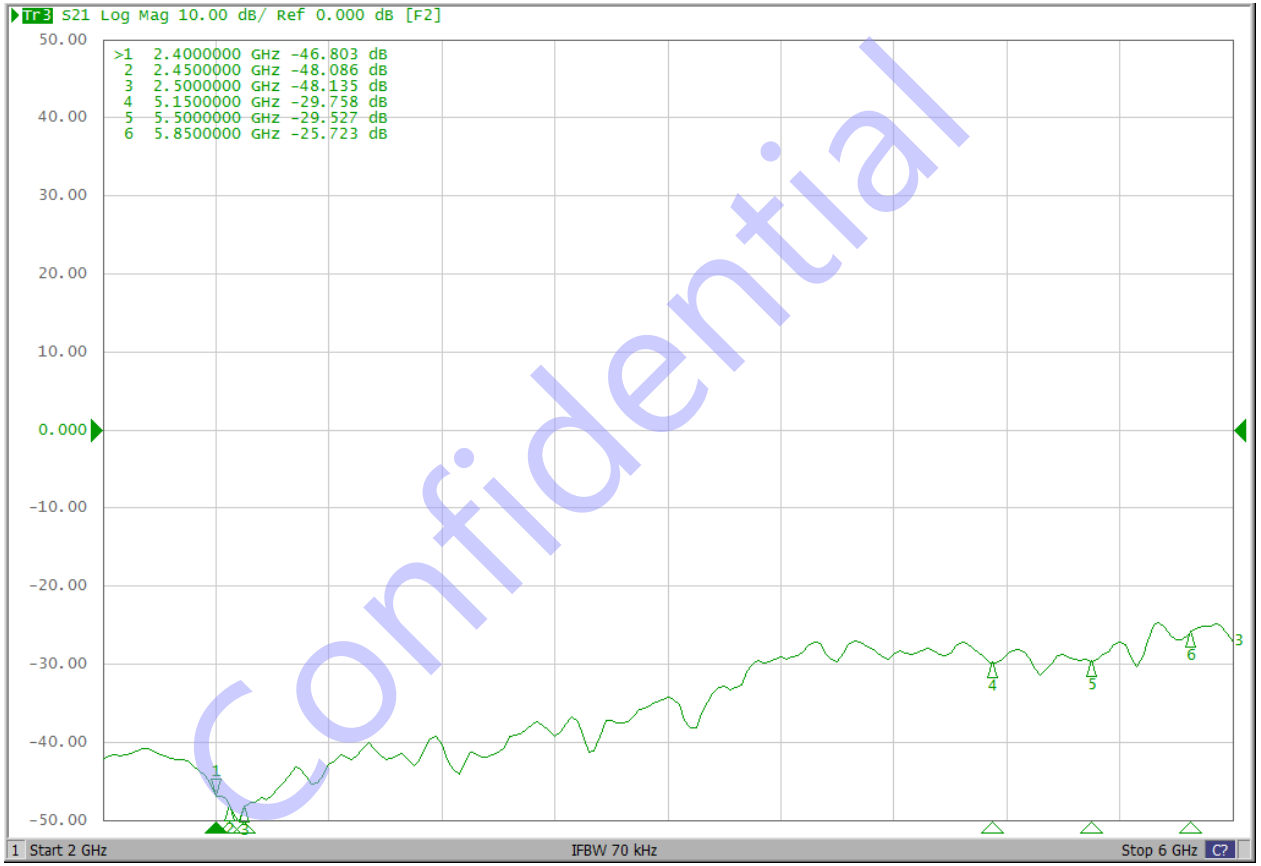
Isolation: ANT-0 & ANT-1



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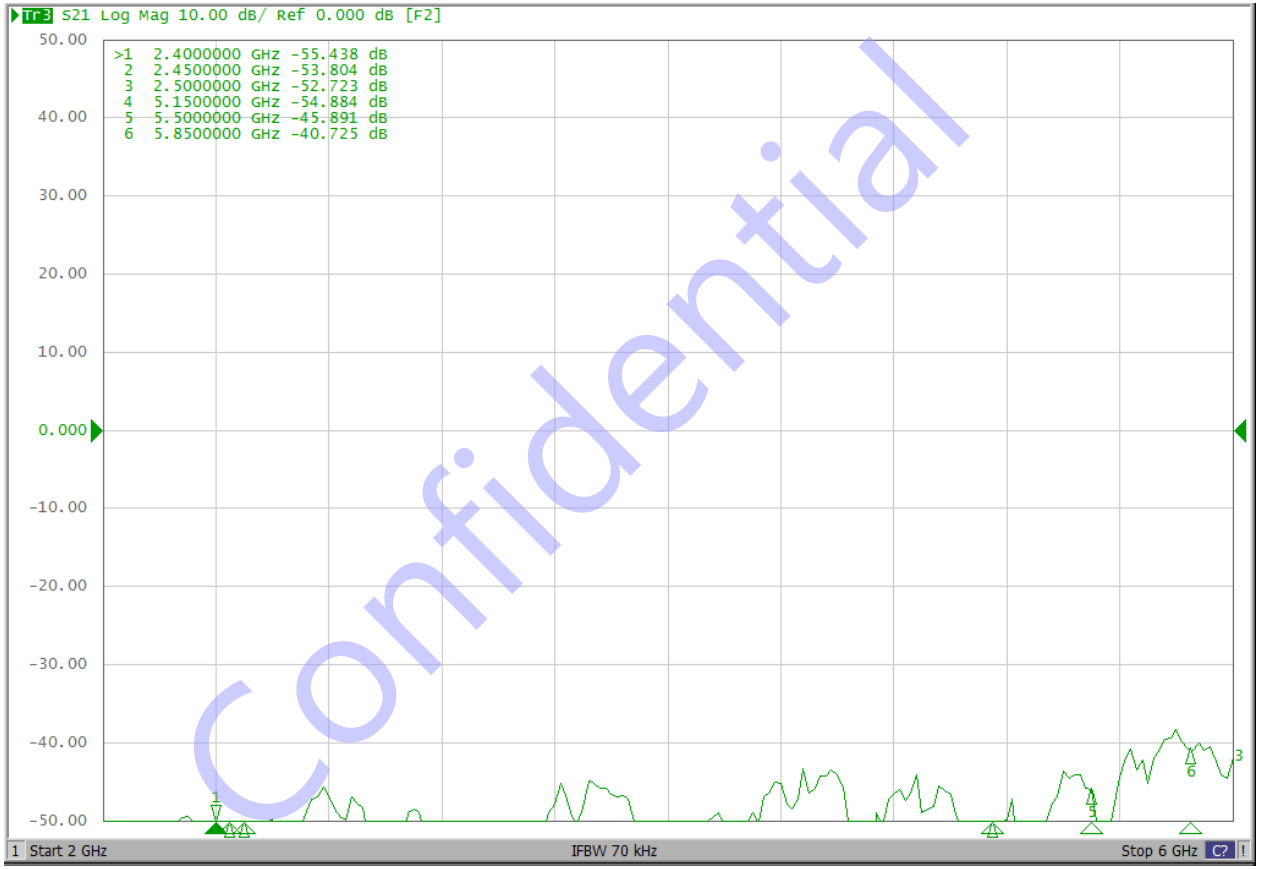
Isolation: ANT-0 & ANT-2



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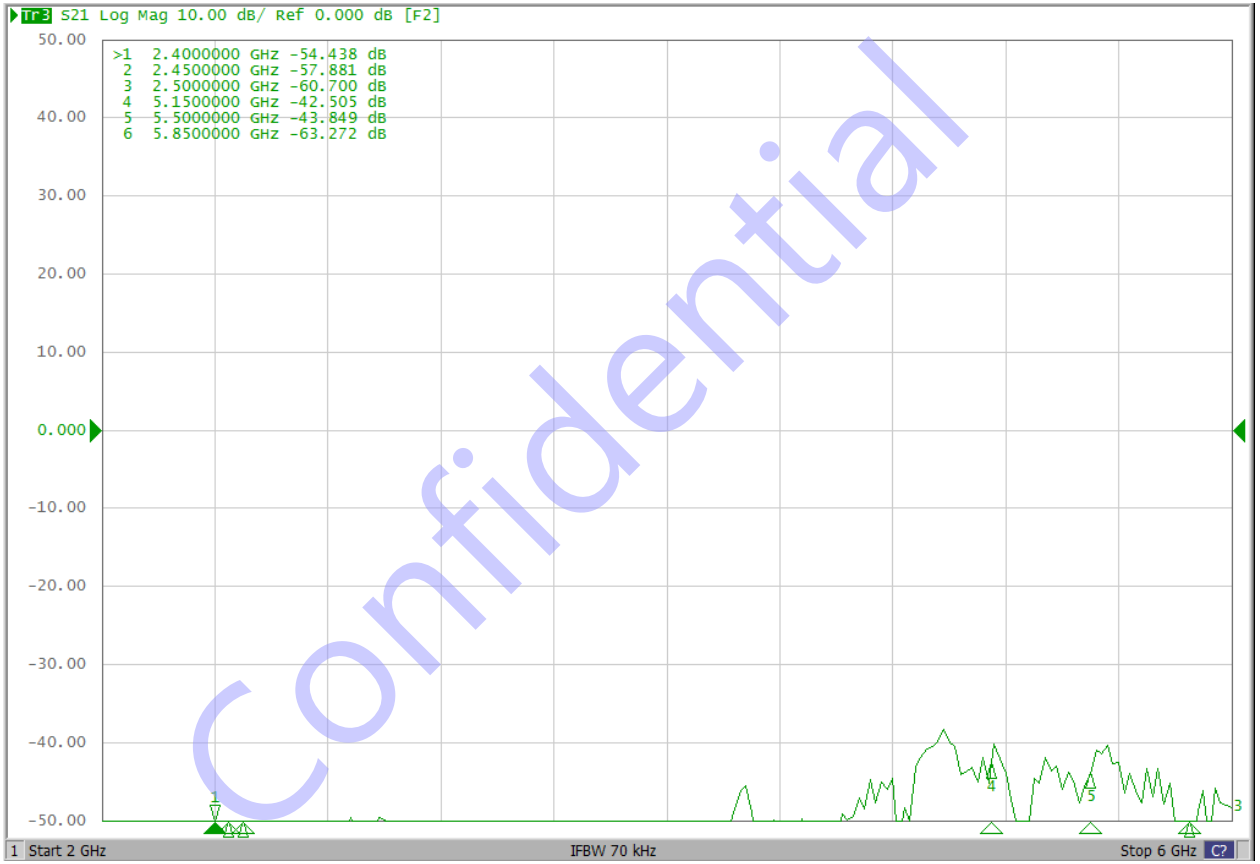
Isolation: ANT-0 & ANT-3



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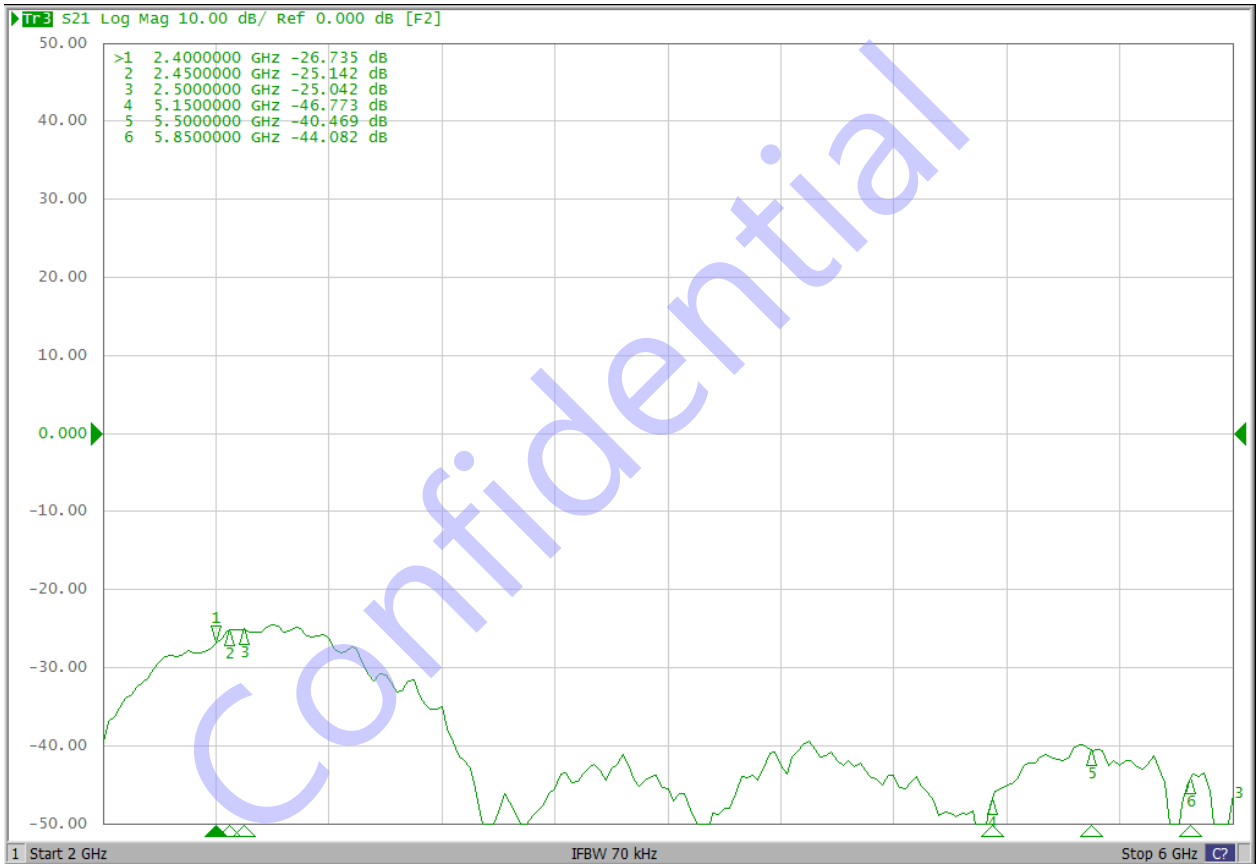
Isolation: ANT-1 & ANT-2



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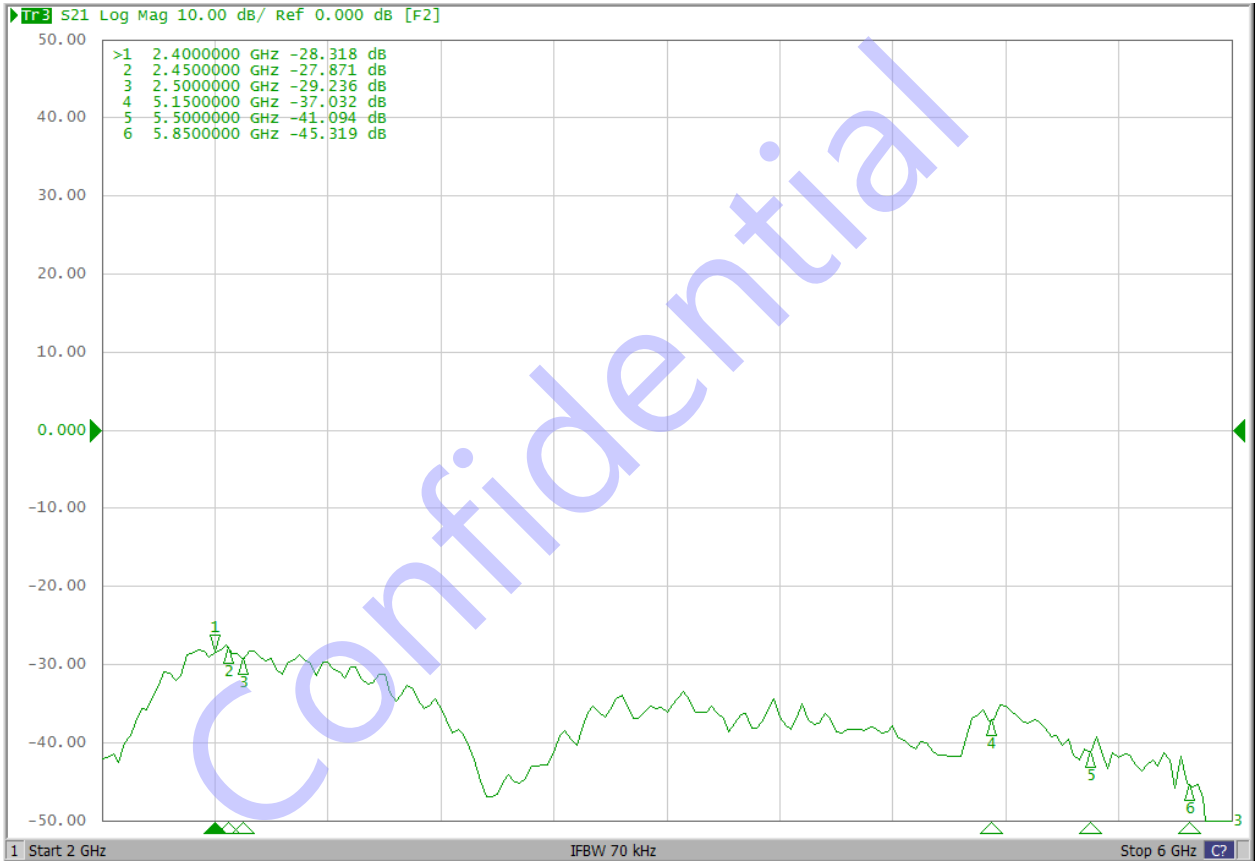
Isolation: ANT-1 & ANT-3



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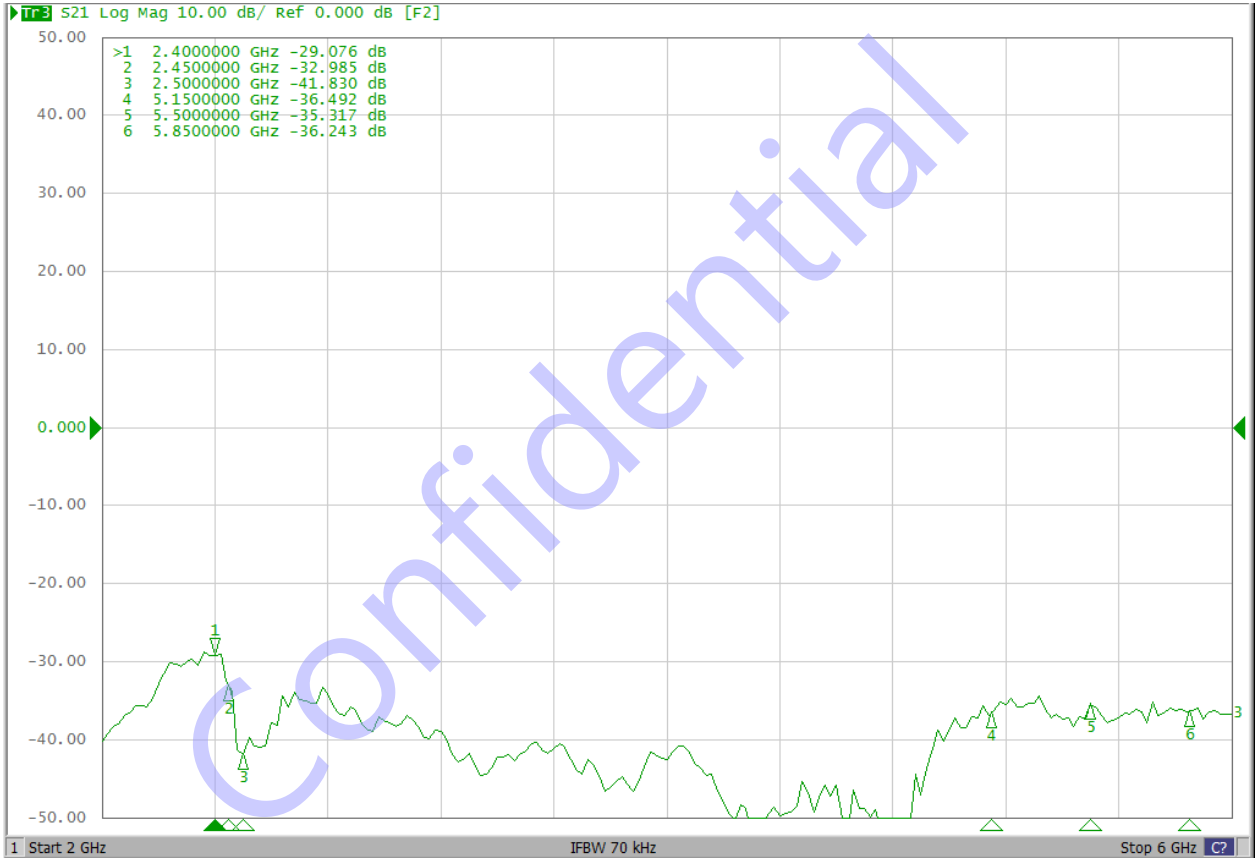
Isolation: ANT-2 & ANT-3



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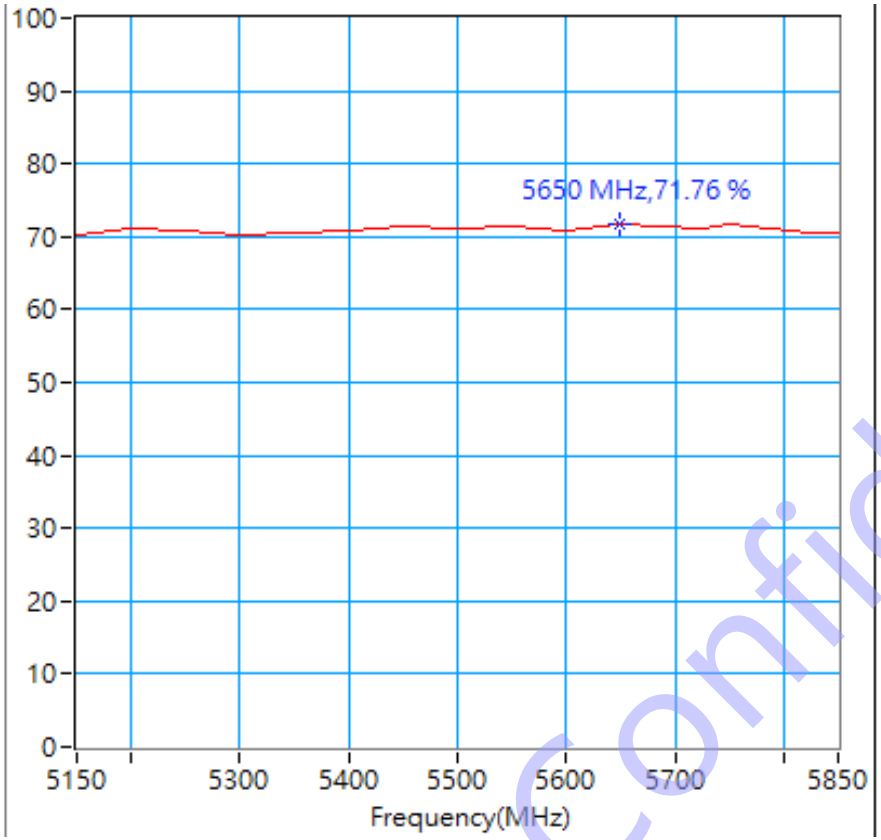
Efficiency: ANT-0 5GHz



Maximum Efficiency at 5650 MHz : 71.76 %

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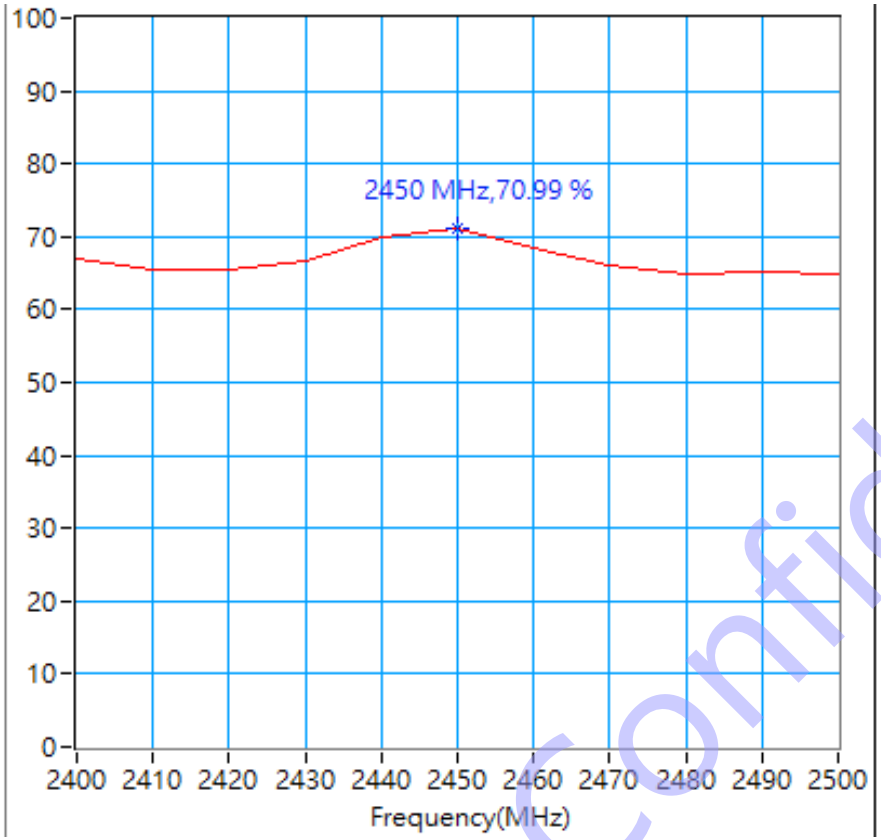
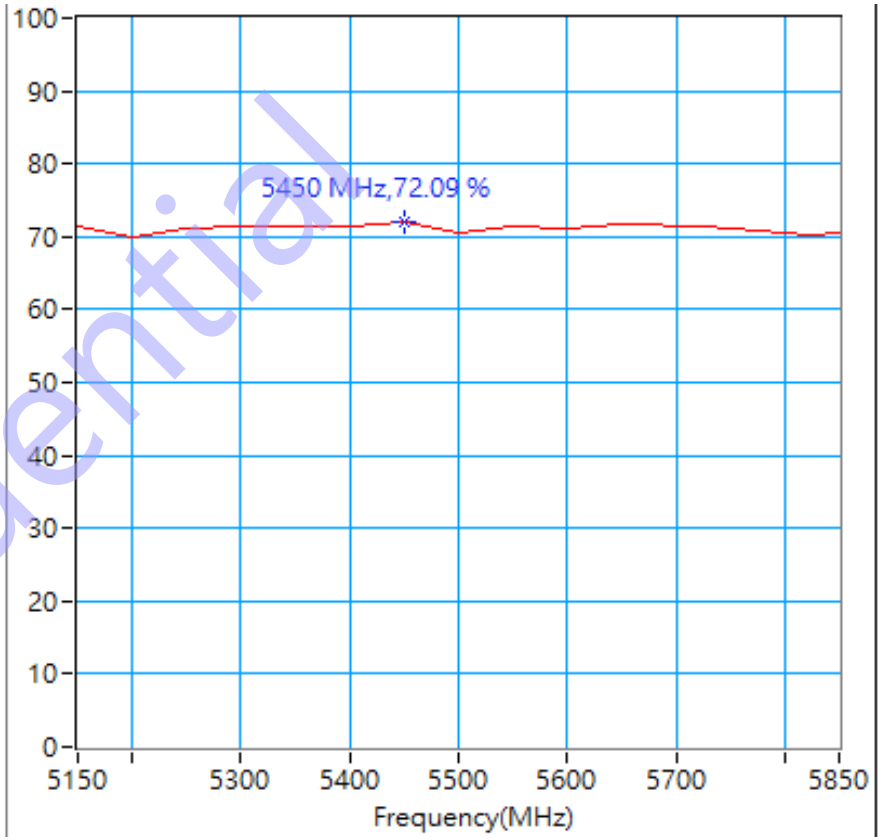
Efficiency: ANT-1 2.4GHz / 5GHz





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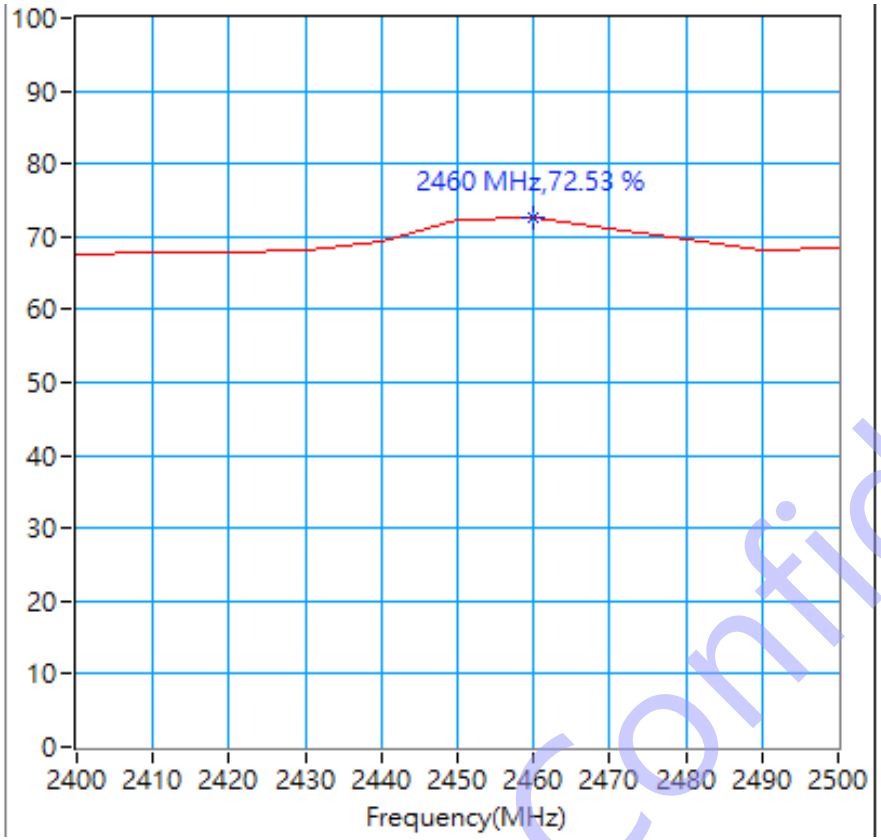
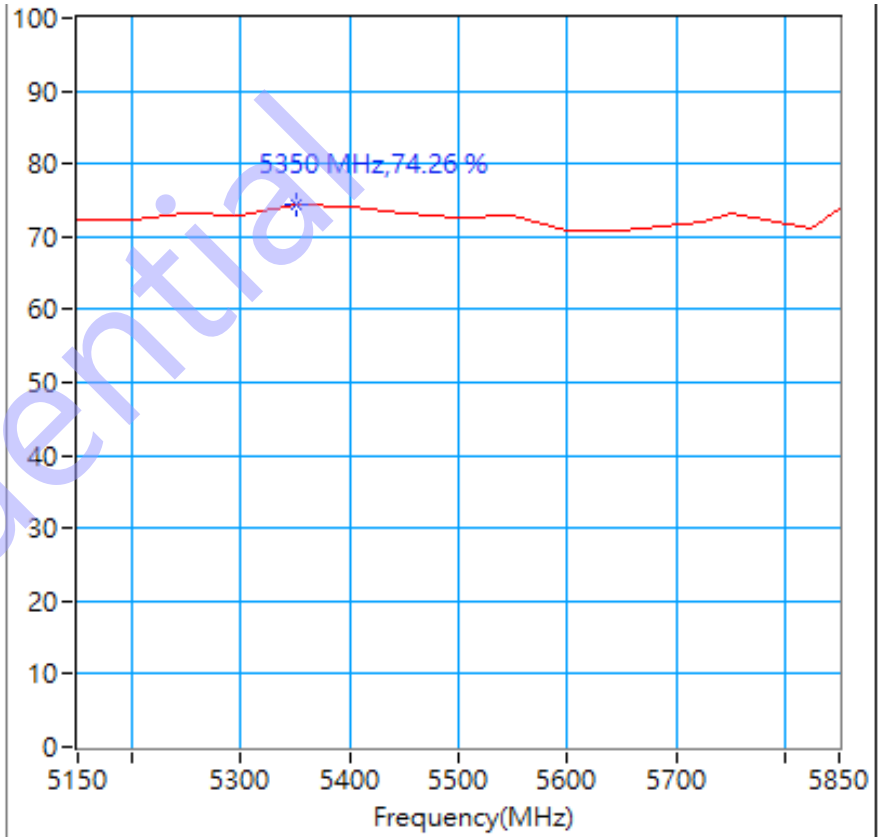
Maximum Efficiency at 2450 MHz : 70.99 %

Maximum Efficiency at 5450 MHz : 72.09 %

Efficiency: ANT-2 2.4GHz / 5GHz





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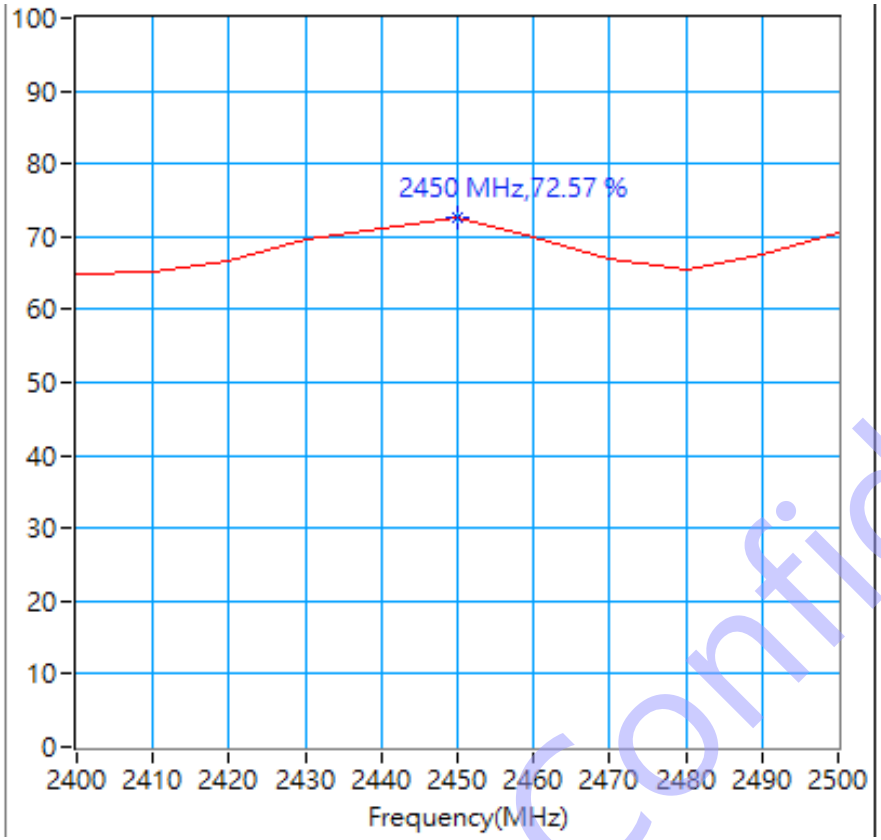
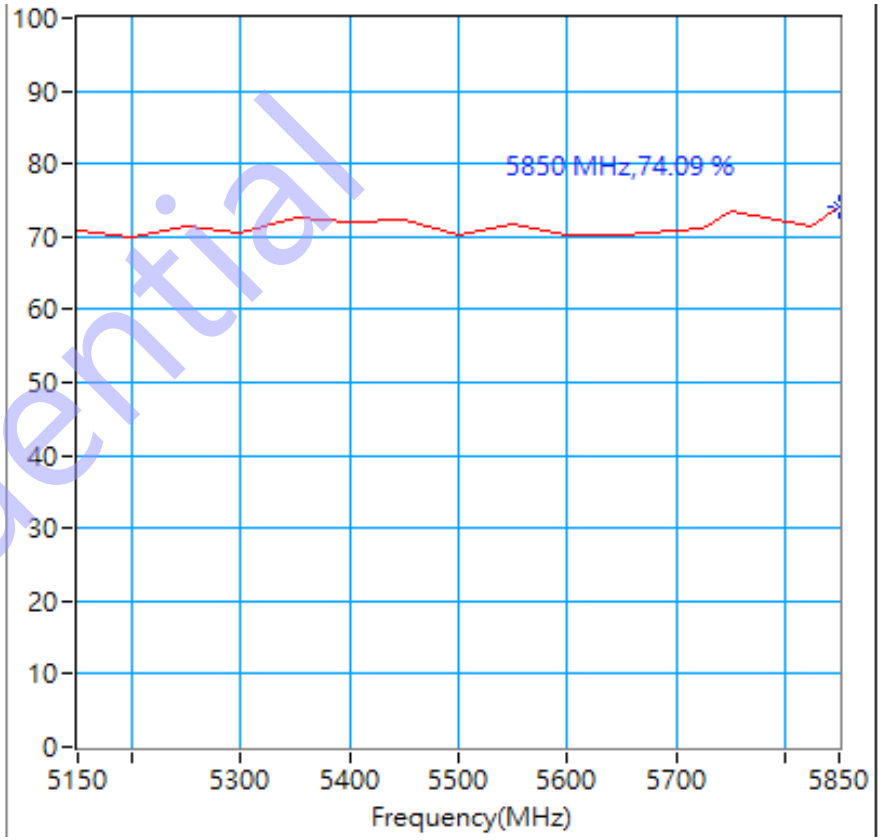
Maximum Efficiency at 2460 MHz : 72.53%

Maximum Efficiency at 5350 MHz : 74.26 %

Efficiency: ANT-3 2.4GHz / 5GHz





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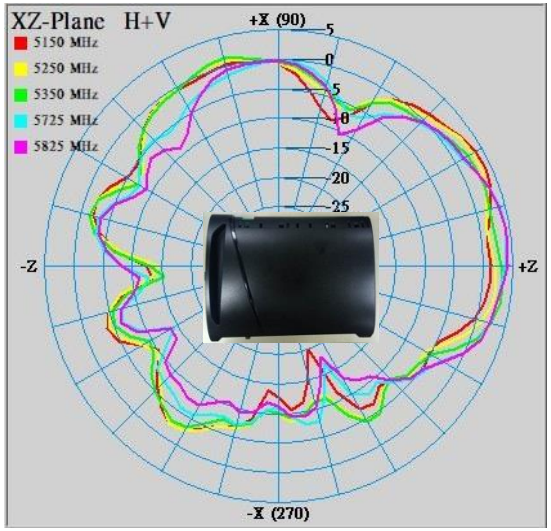
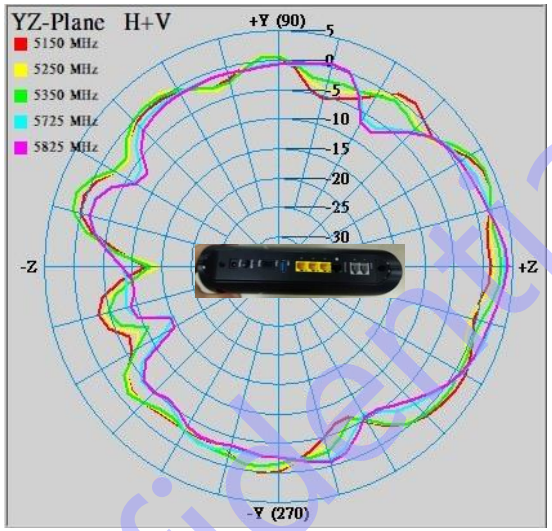
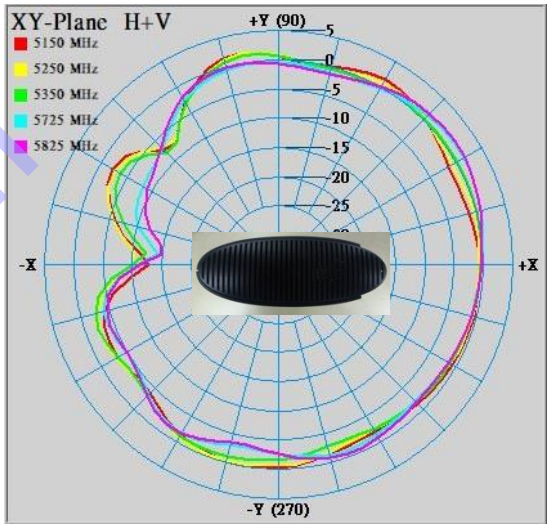
Maximum Efficiency at 2450 MHz : 72.57%

Maximum Efficiency at 5850 MHz : 74.09 %

2D Radiation Pattern: ANT-0 5GHz







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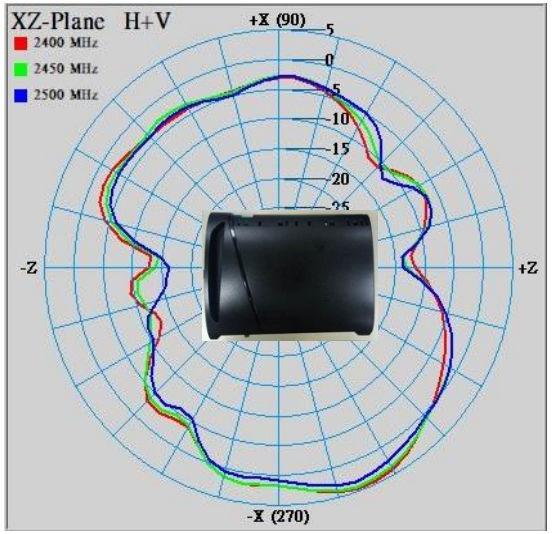
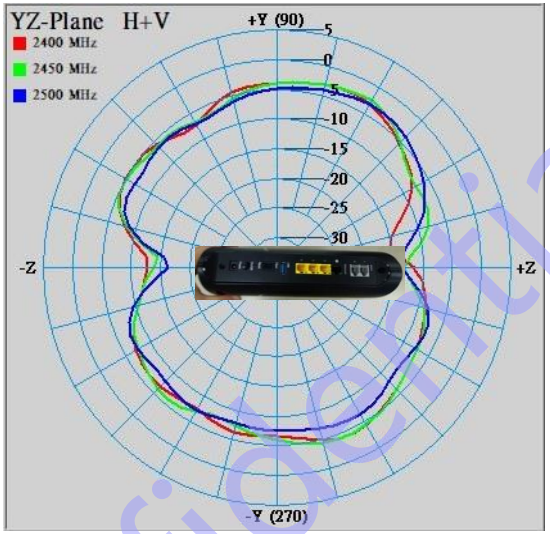
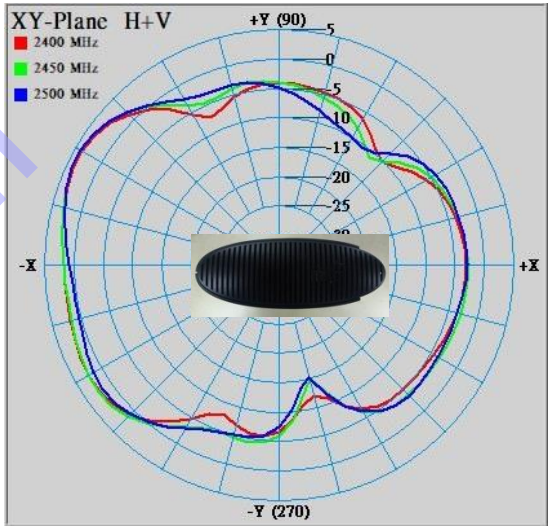
2D Radiation Pattern: ANT-1 2.4GHz







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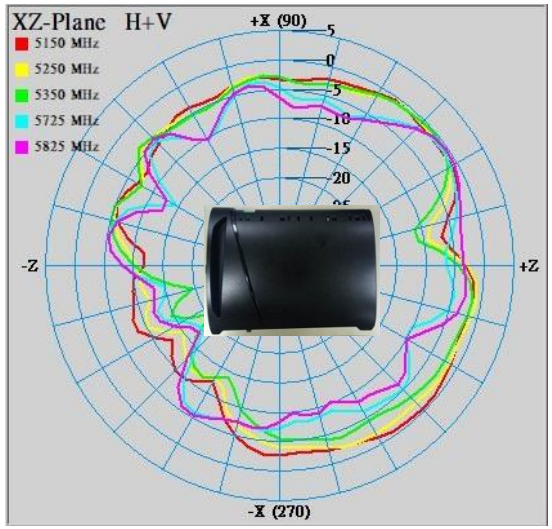
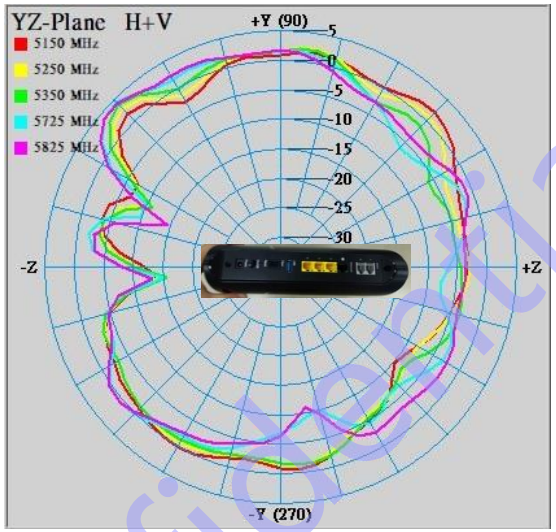
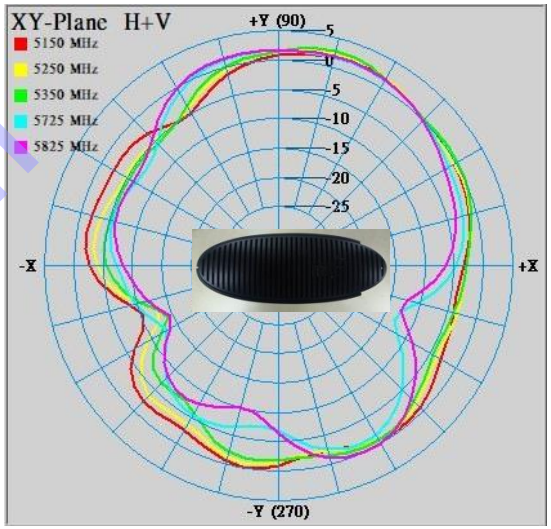
2D Radiation Pattern: ANT-1 5GHz







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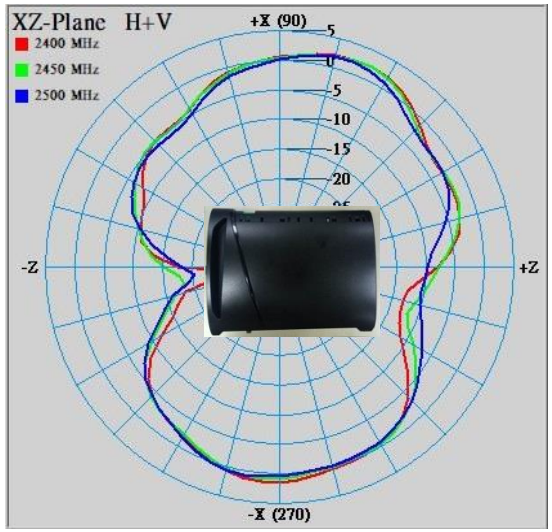
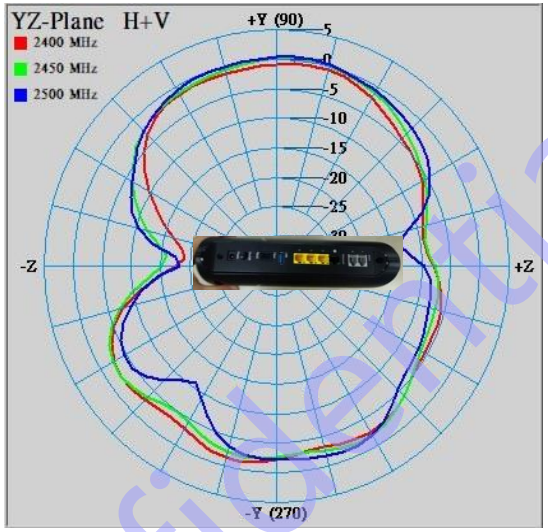
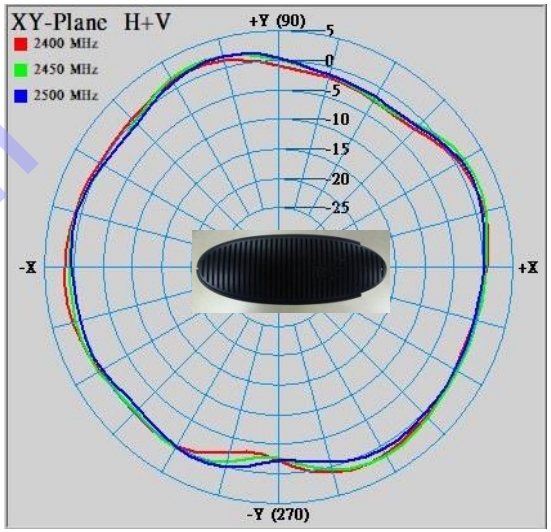
2D Radiation Pattern: ANT-2 2.4GHz







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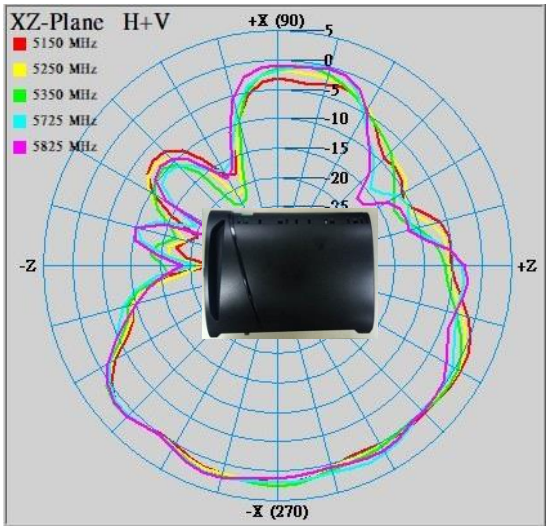
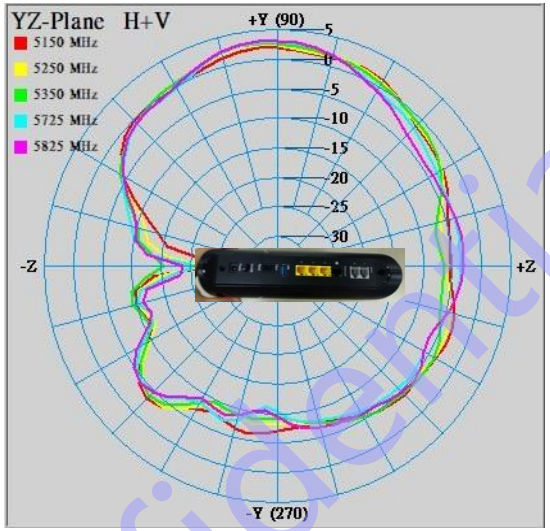
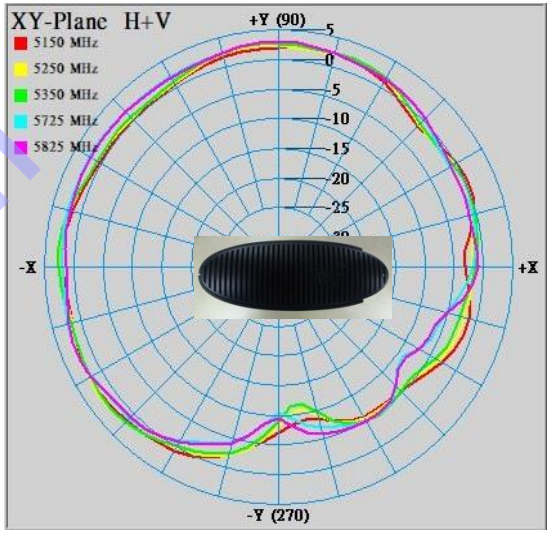
2D Radiation Pattern: ANT-2 5GHz







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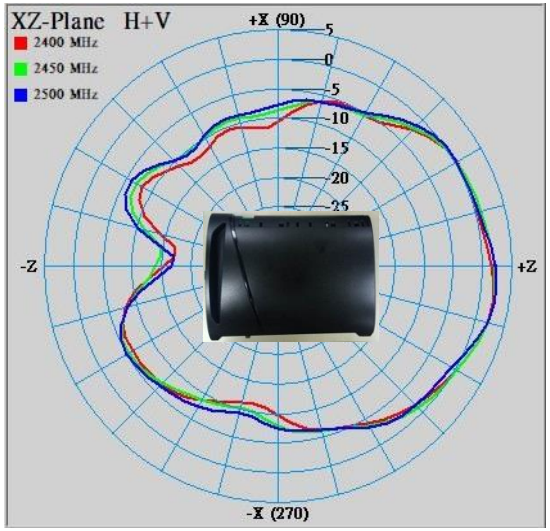
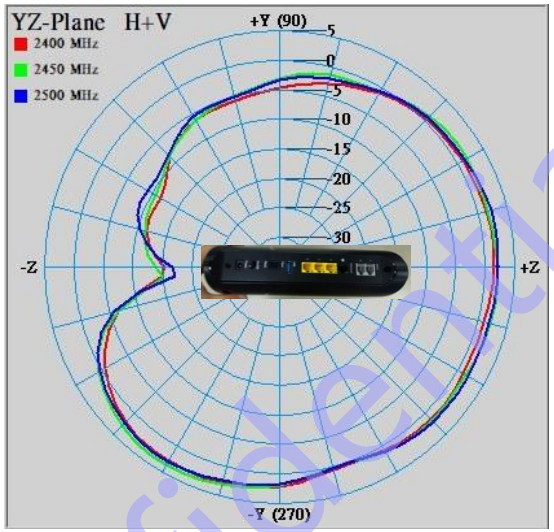
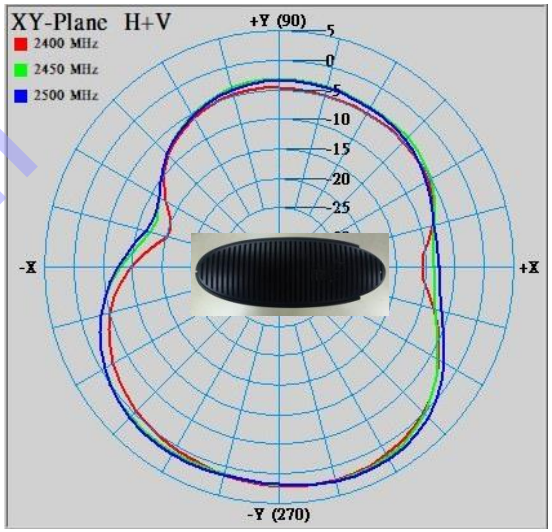
2D Radiation Pattern: ANT-3 2.4GHz







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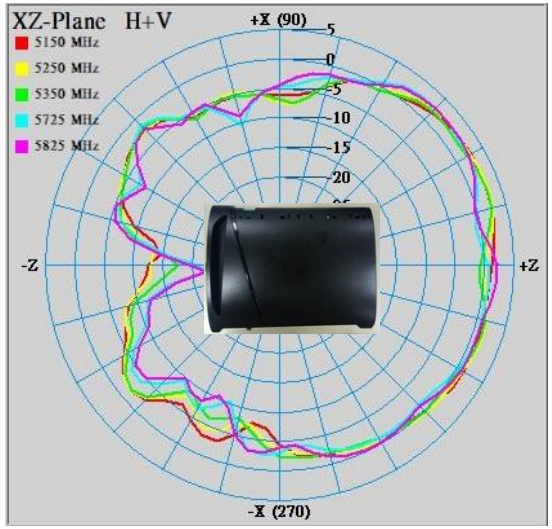
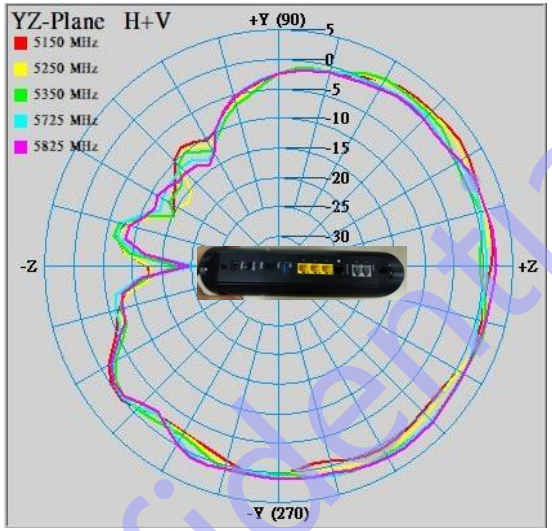
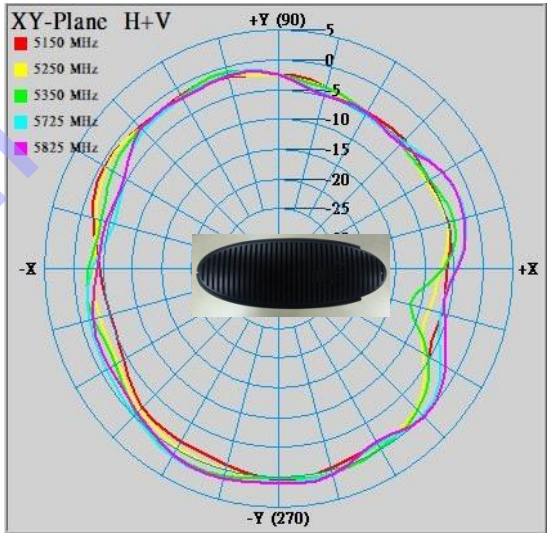
2D Radiation Pattern: ANT-3 5GHz







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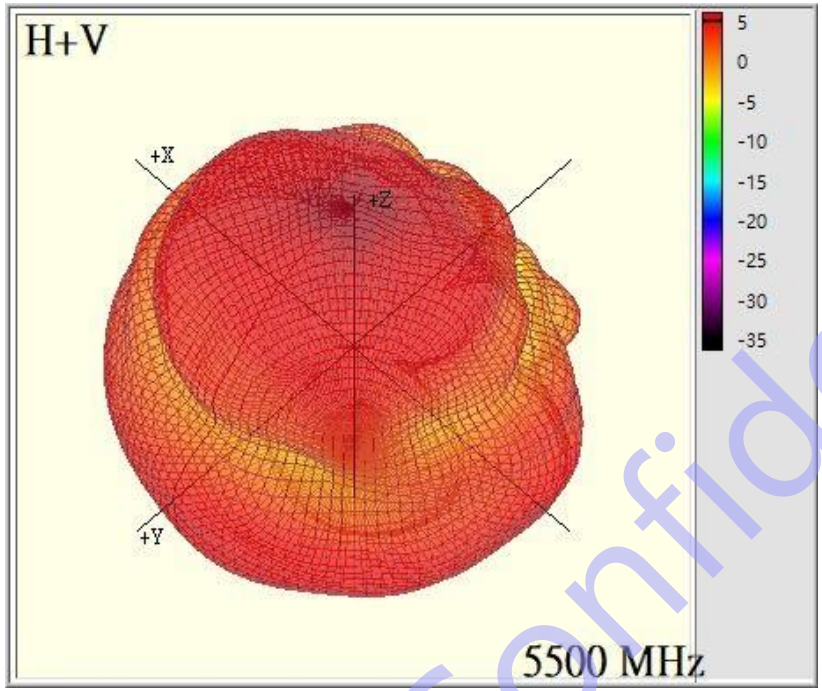
3D Radiation Pattern: ANT-0 5.5GHz



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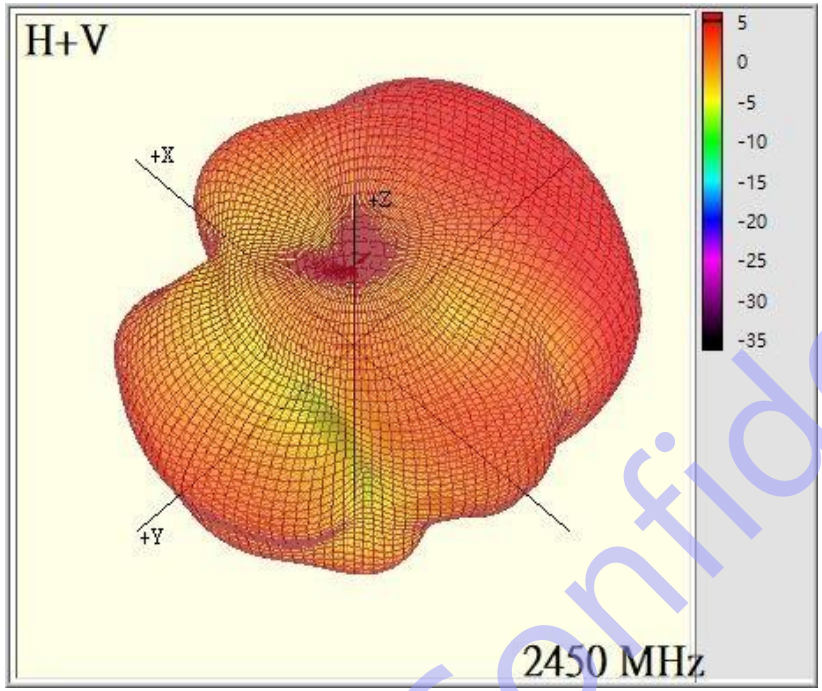
3D Radiation Pattern: ANT-1 2.45GHz



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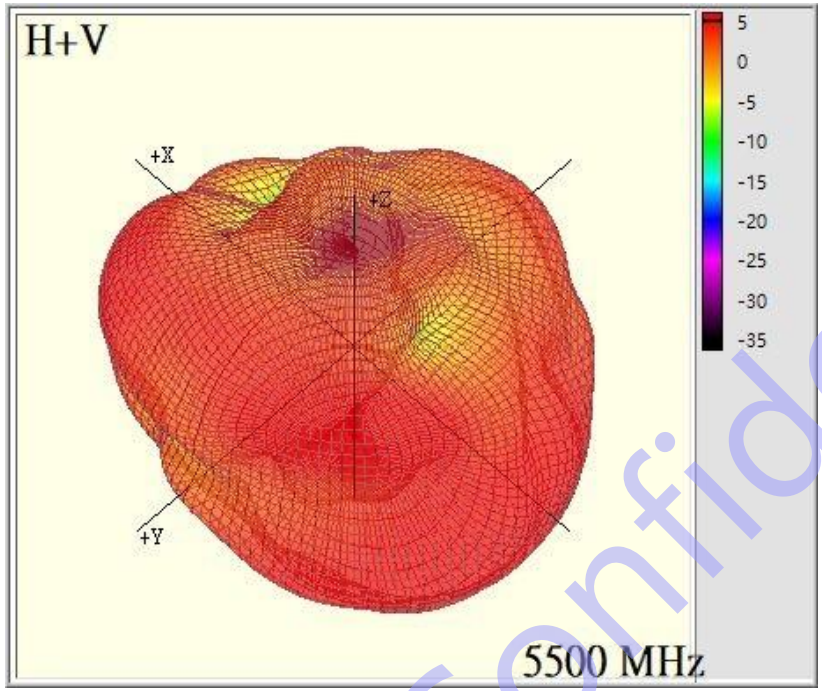
3D Radiation Pattern: ANT-1 5.5GHz



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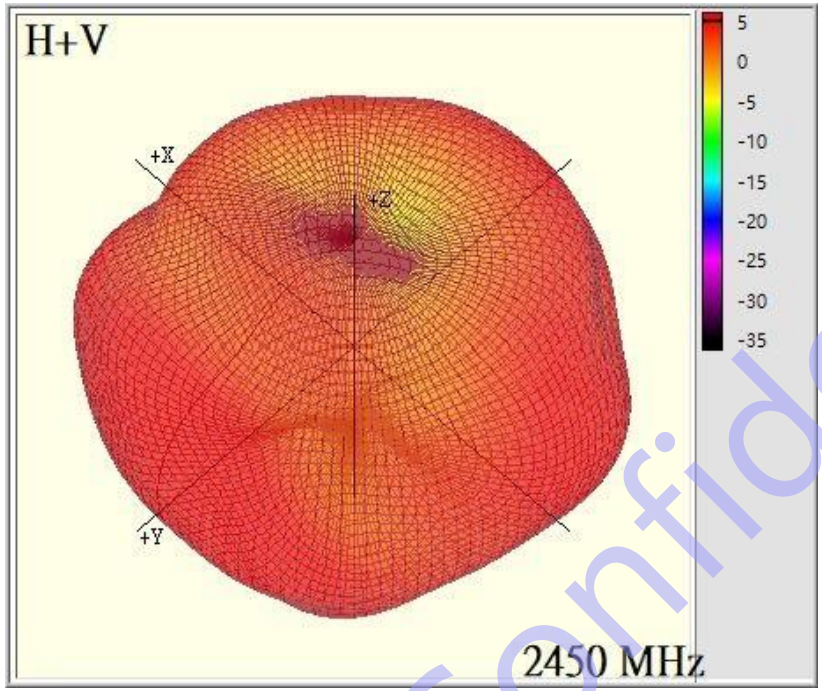
3D Radiation Pattern: ANT-2 2.45GHz



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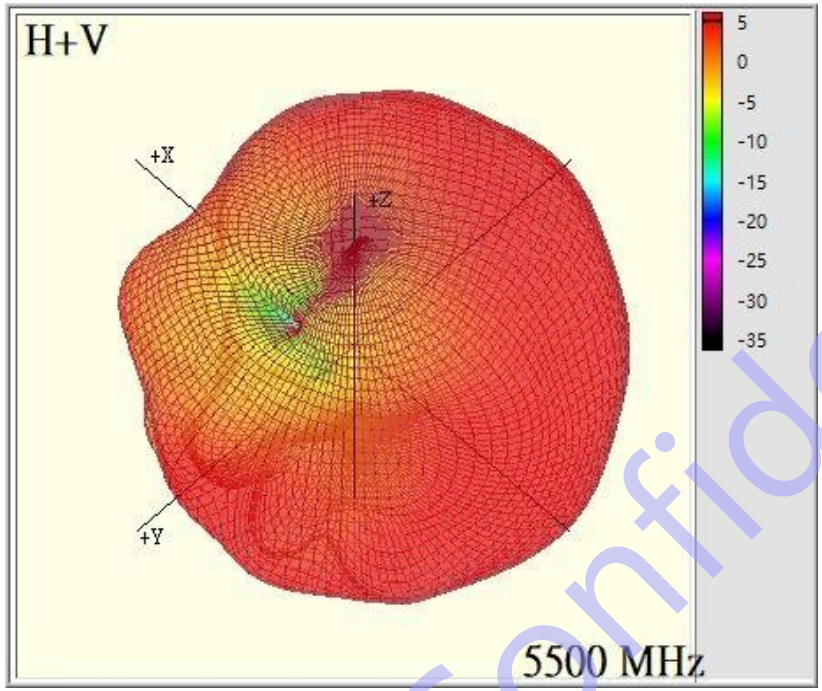
3D Radiation Pattern: ANT-2 5.5GHz



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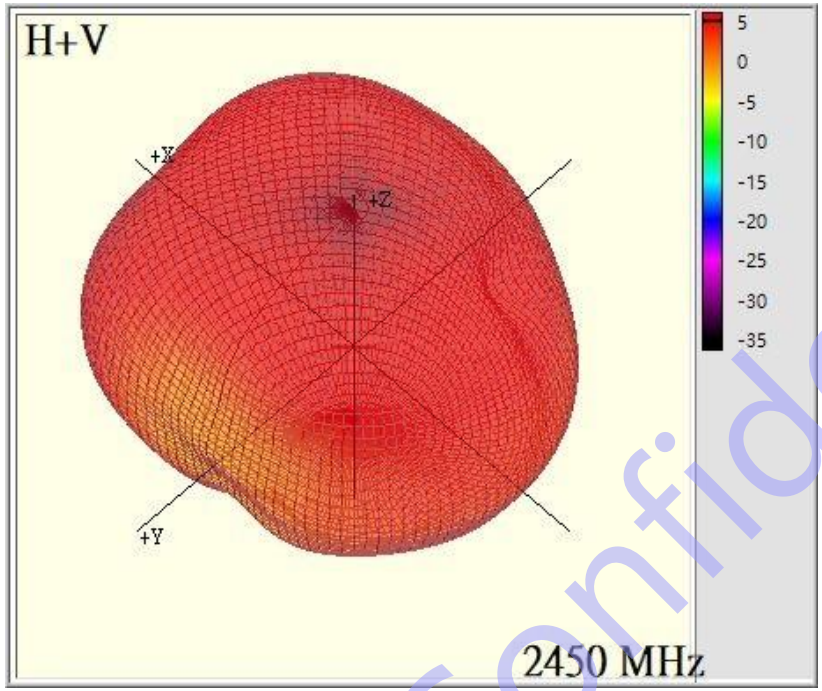
3D Radiation Pattern: ANT-3 2.45GHz



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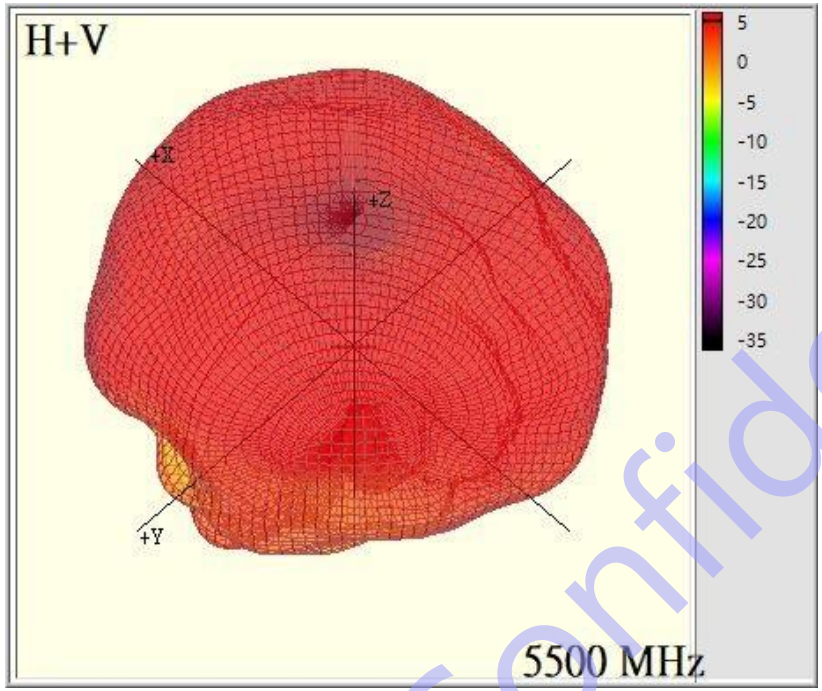
3D Radiation Pattern: ANT-3 5.5GHz



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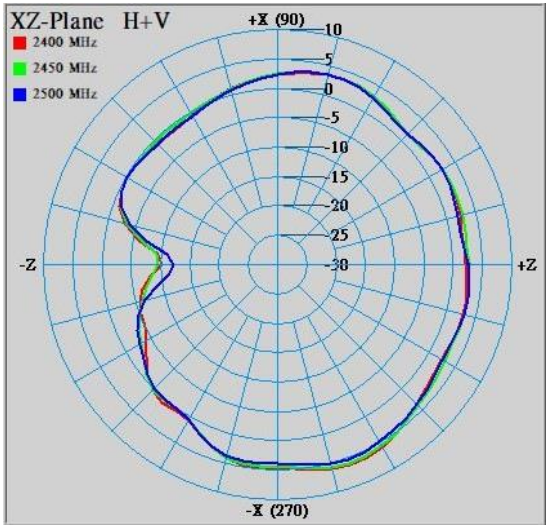
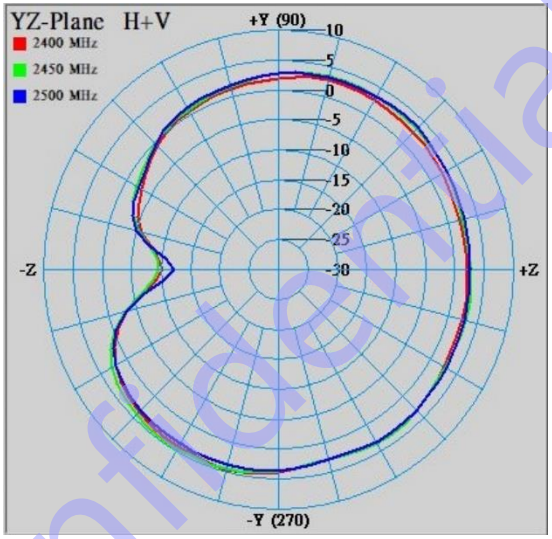
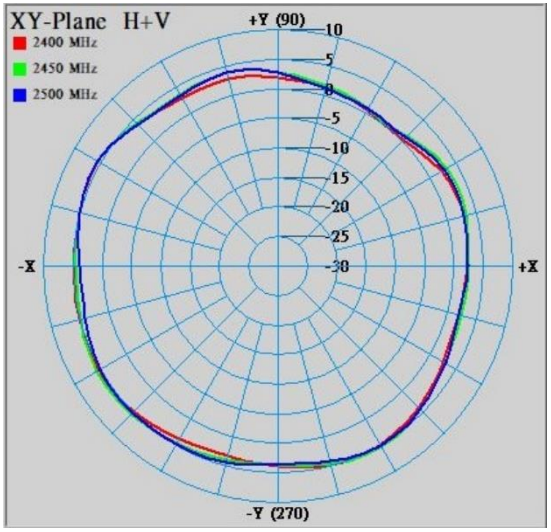
2D Correlated Radiation Pattern: 2.4GHz







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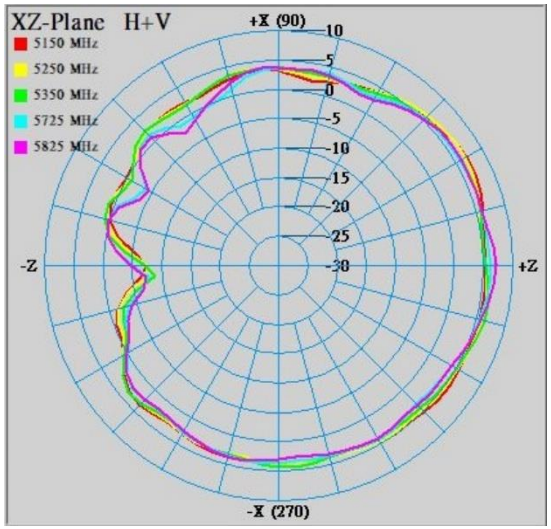
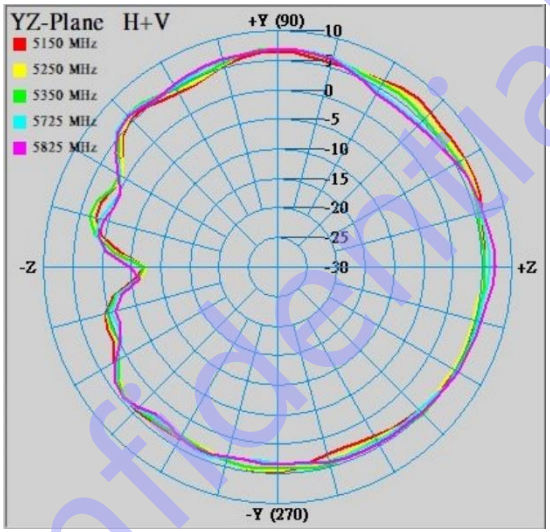
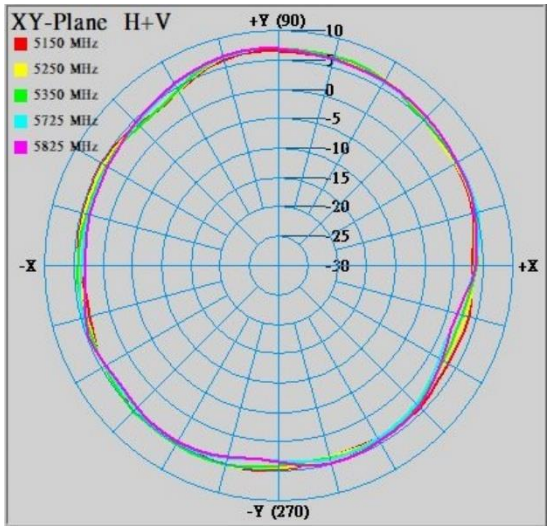
2D Correlated Radiation Pattern: 5GHz







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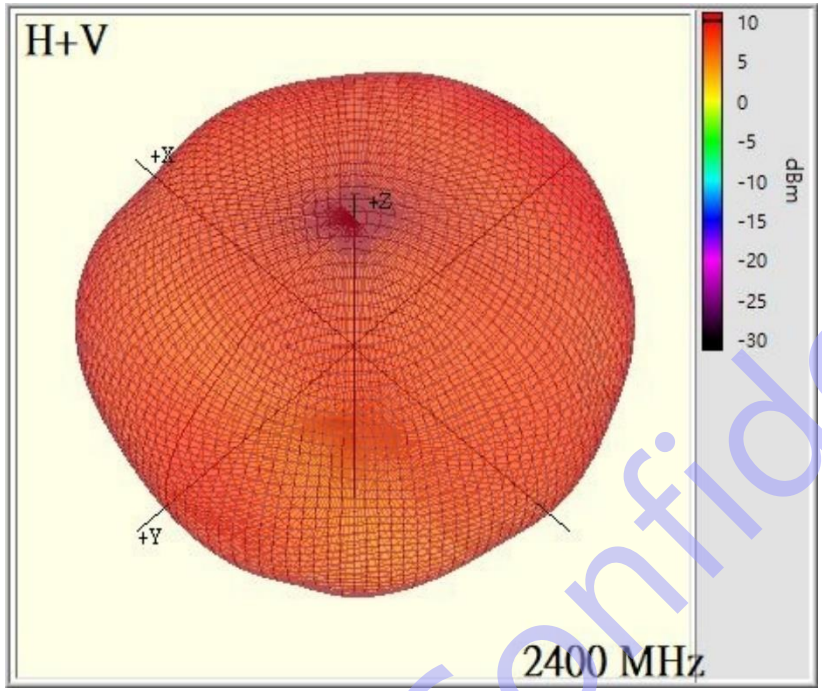
3D Correlated Radiation Pattern: 2.4GHz



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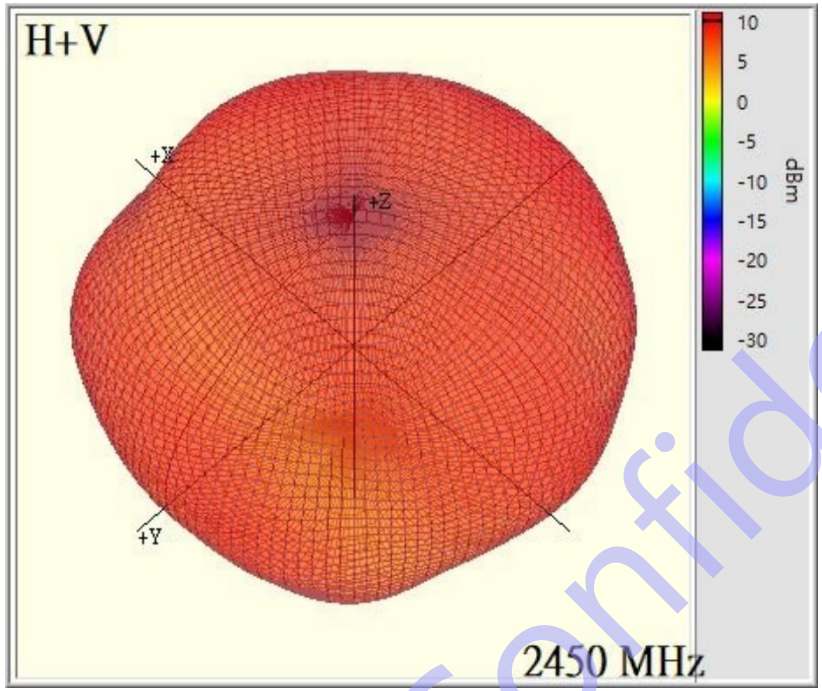
3D Correlated Radiation Pattern: 2.45GHz



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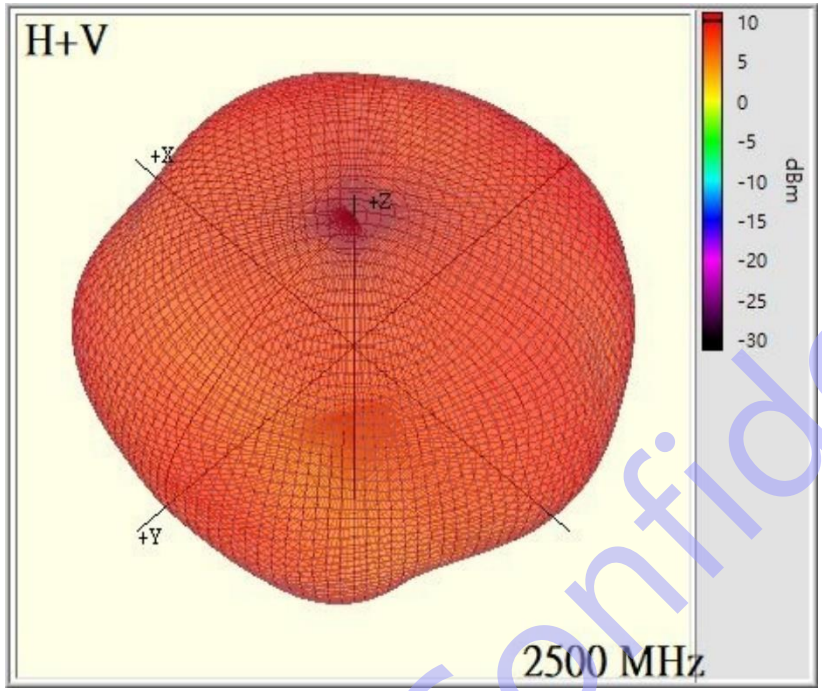
3D Correlated Radiation Pattern: 2.5GHz



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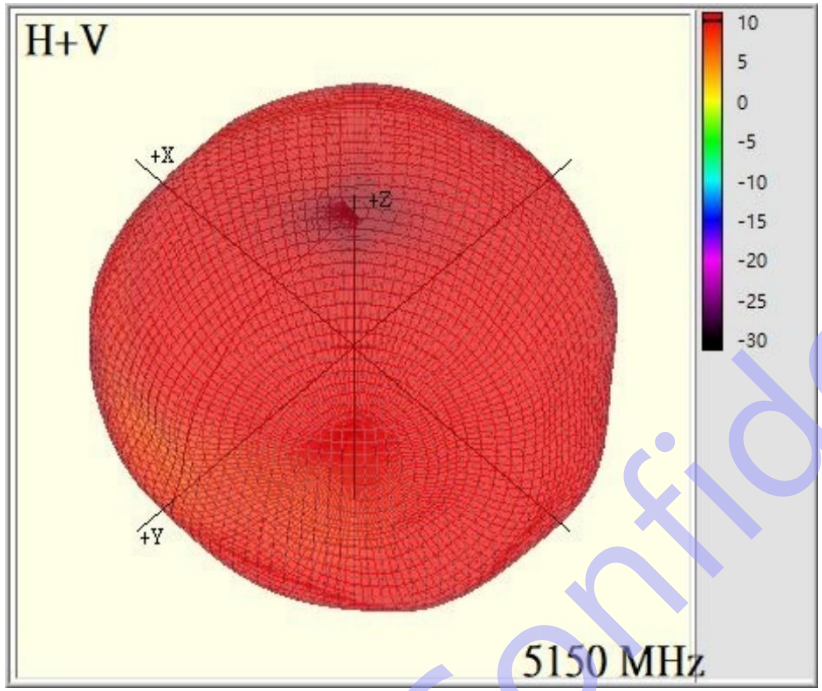
3D Correlated Radiation Pattern: 5.15GHz



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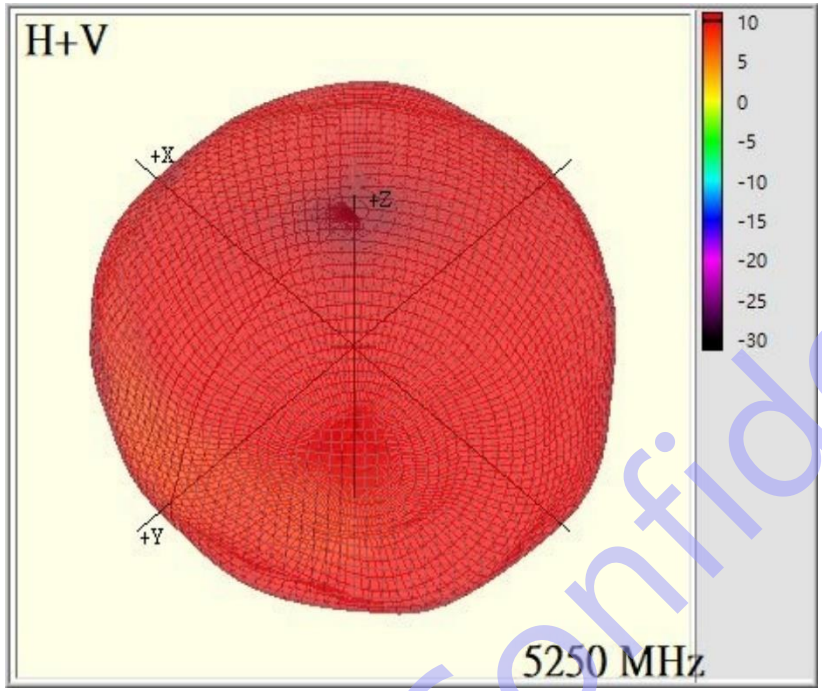
3D Correlated Radiation Pattern: 5.25GHz



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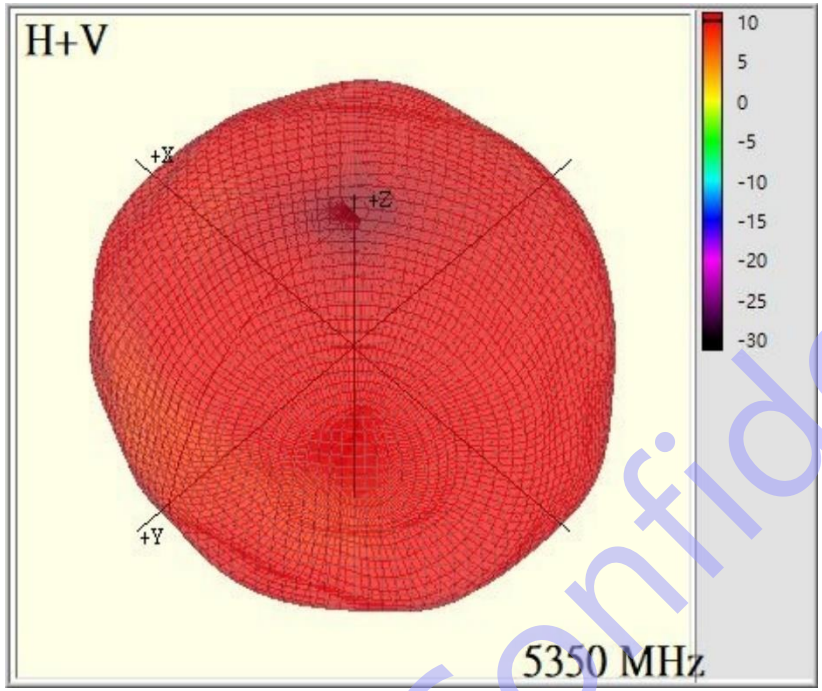
3D Correlated Radiation Pattern: 5.35GHz



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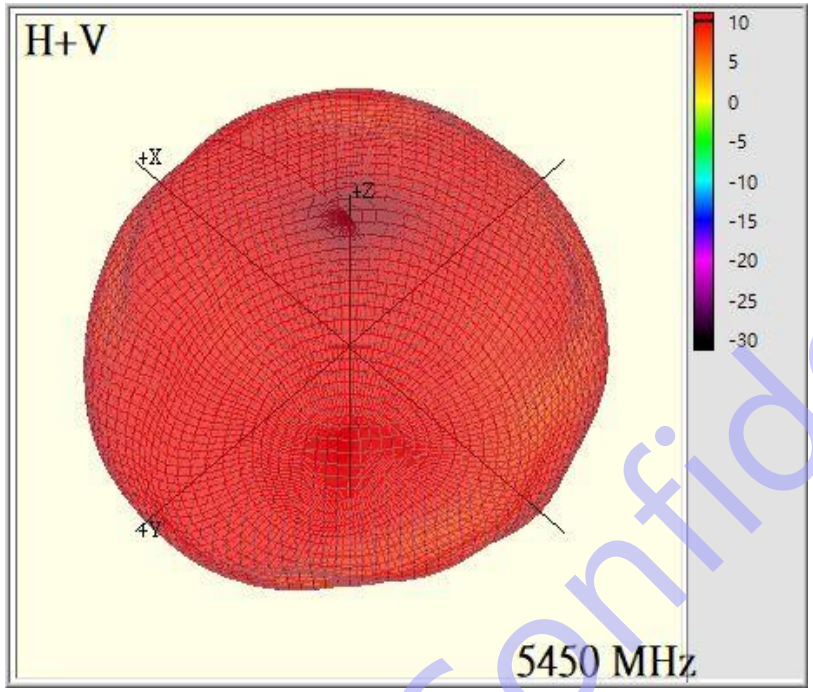
3D Correlated Radiation Pattern: 5.45GHz



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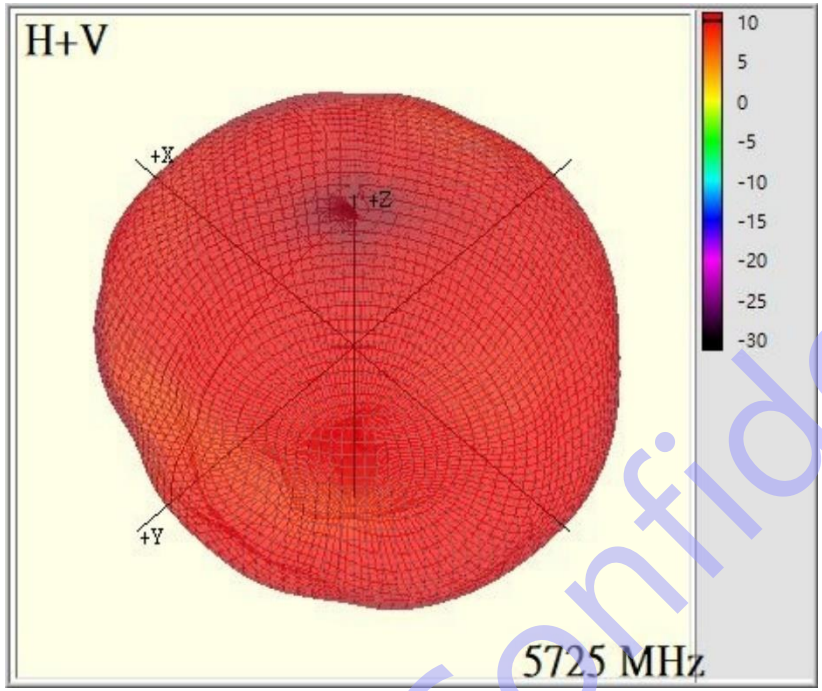
3D Correlated Radiation Pattern: 5.725GHz



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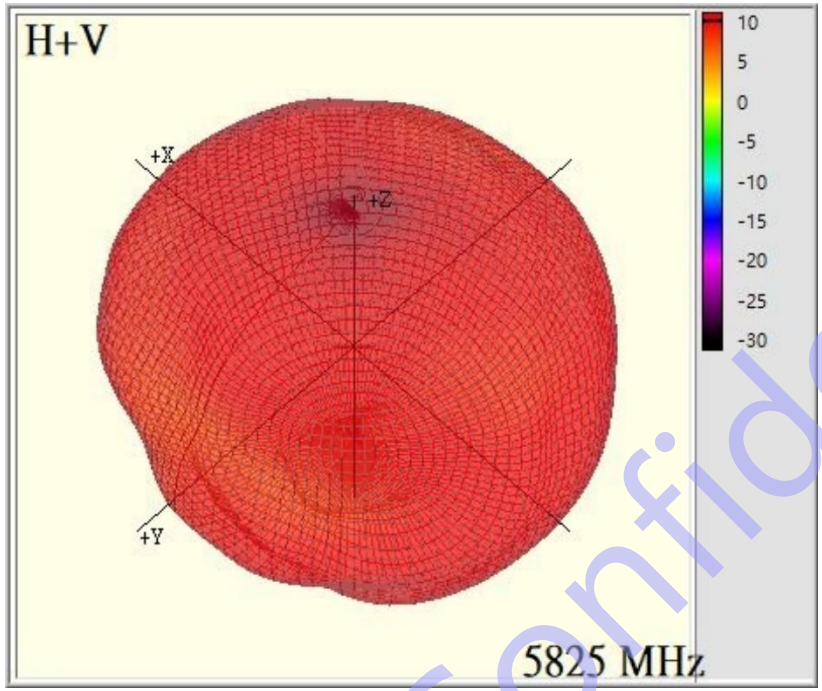
3D Correlated Radiation Pattern: 5.825GHz



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New Kinpo Group

THANK YOU FOR YOUR ATTENTION.

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INNOVATION · UNITY · GROWTH

NVG578HLX

Correlated Directional Gain

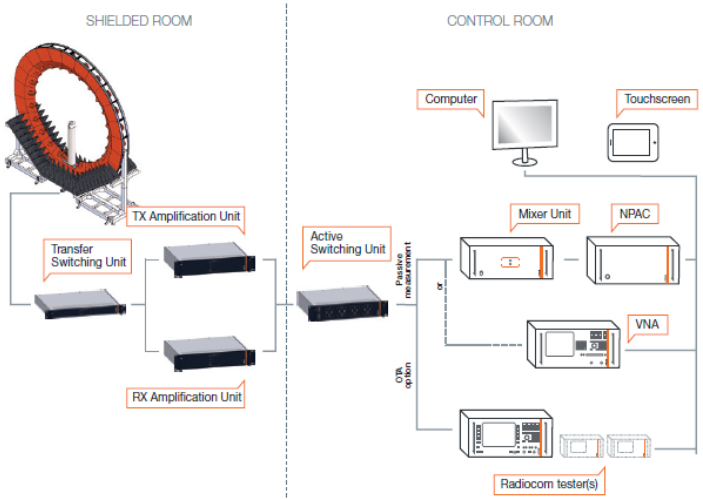
Presenter:

NKG R&D team

2022/9/23

Antenna Vendor Info & Measurement Setup

- Antenna Vendor: Walsin Technology (Inpaq)
- Test Date: 2020/9/21
- Test Engineer: Inpaq Jack Yeh
- Measurement Setup:
  - Reflection Coefficient Measurement:
    - Instrument: Network Analyzer (Keysight E5071A)
    - Setup:
      - Calibrate the Network Analyzer by one port calibration using O.S.L. calibration kits.
      - Connect the antenna under test to the Network Analyzer.
      - Measure the S11 (reflection coefficient), Return Loss …
  - Pattern Measurement
    - Chamber: Satimo SG 24
    - Satimo program: SPM1.5
    - System Overview:
  - Test Item
    - Antenna passive test 400MHz~ 6GHz



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Test Procedure

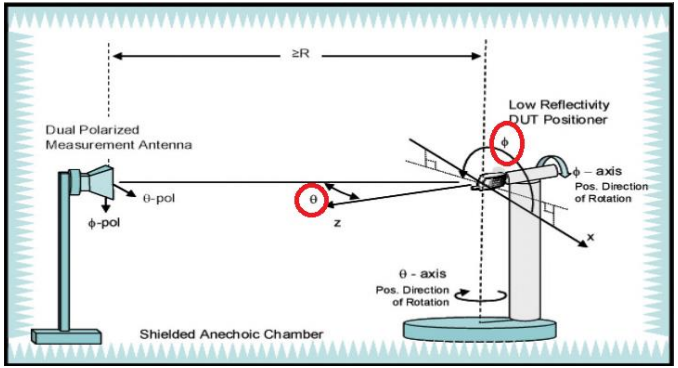
a) Sub-divide the whole sphere surface into many 2x2 degree subsections.
b) Measure the gain contributed from each antenna within each subsection position.
c) Apply the KDB 662911 D01 correlated directional gain formula to calculate directional gain for each subsection.
d) After all subsections have been evaluated, the largest calculated value among all positions evaluated is picked as the worst-case directional gain for the system and used in RF/EMC test report.

d) *Unequal antenna gains, with equal transmit powers.* For antenna gains given by $G_1, G_2, \ldots, G_N$ dBi

(i) If transmit signals are *correlated*, then
Directional gain = $10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / N_{ANT}]$ dBi [Note the "20"s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

- Method:

$$MAX[\forall(\theta,\Phi)\{\ 10\log\frac{\left(10^{\frac{G1}{20}}+10^{\frac{G2}{20}}+10^{\frac{G3}{20}}+10^{\frac{G4}{20}}\right)^2}{4}\ \}]$$



The definition of (θ, Φ) in antenna raw data.

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U-NII Directional Gain Results

The following are the positions & data which yielded the worst-case calculated directional gain:

			Gain at Position (dBi)				Calculated Directional Gain* (dBi)
Frequency	**Position (θ, ϕ)**	**Polarization**	**ANT 0**	**ANT 1**	**ANT 2**	**ANT 3**	
5150 ~ 5250 MHz U-NII-1	(50, 96)	H+V	-0.394	1.976	2.196	0.805	7.23
5250 ~ 5350 MHz U-NII-2A	(88, 98)	H+V	2.634	-1.072	1.085	0.815	6.98
5470 ~ 5725 MHz U-NII-2C	(90, 98)	H+V	3.065	-1.432	1.222	0.822	7.09
5725 ~ 5850 MHz U-NII-3	(90, 98)	H+V	3.184	-1.857	1.849	-0.149	6.99

*Directional gain = $10 \log[(10^{G0/20} + 10^{G1/20} + 10^{G2/20} + 10^{G3/20})^2 / N_{ANT}]$ dBi

Test Procedure

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