

# GALTRONICS

WHEN CONNECTIONS COUNT

## Antenna Measurement data



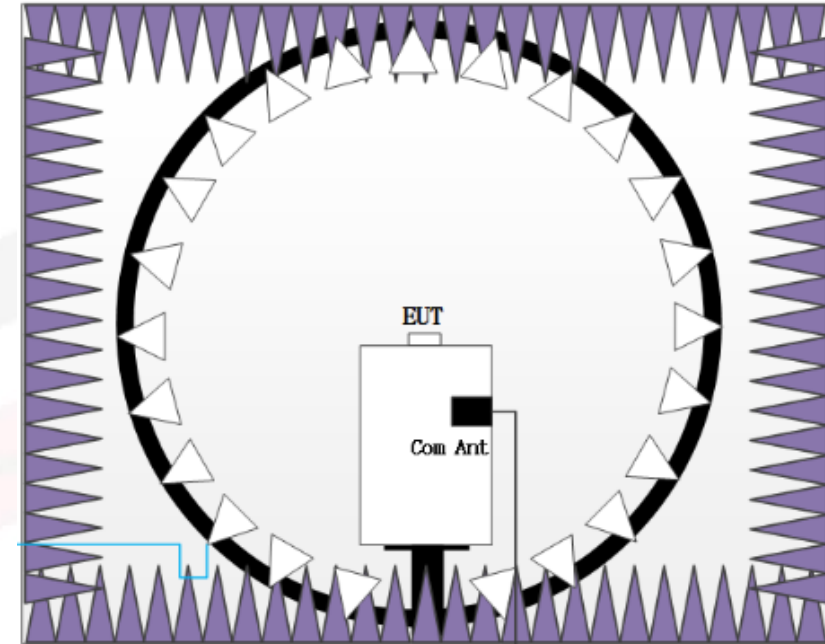
# Introduction

This report provides Wi-Fi antenna passive measurement results which include:

- » General Information
- » Antenna Measurement System Information
- » Test Procedure
- » Far Field Test Method Judgment
- » DUT Information
- » Single Antenna Test Result
- » Directional Gain Result
- » Set-up Photo

# General Information

- Antenna Vendor : HWA-TECH
- Test Date : 20260430
- Test Engineer : Zack
- Measurement System : HWA-TECH SP24
- Software Name : Quick OTA
- Software Version : 2.0.3.829

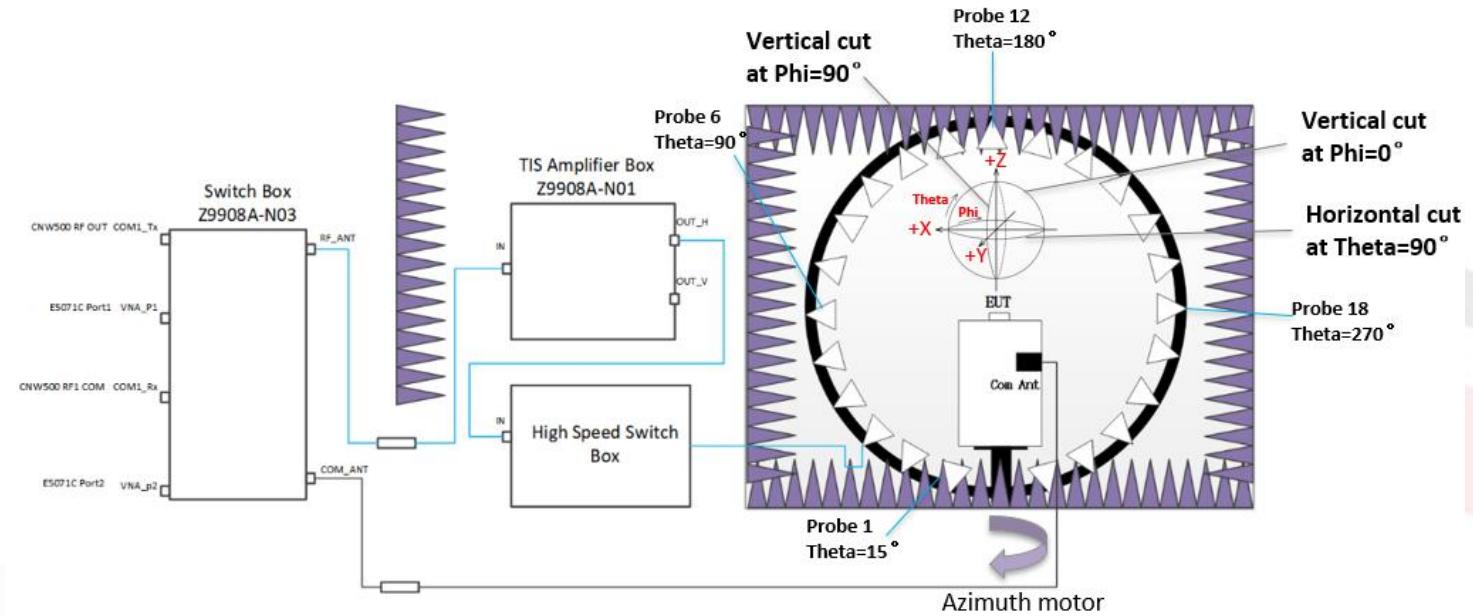


# Antenna Measurement System Information

- Measurement System: HWA-TECH SP24 Chamber

## Measurement setup:

- Pattern & Gain measurement
  1. HWA-TECH chamber (SP24)
  2. HWA-TECH program (Quick OTA)
  3. System overview
- Test item
  1. Antenna passive test 400MHz~7.5GHz

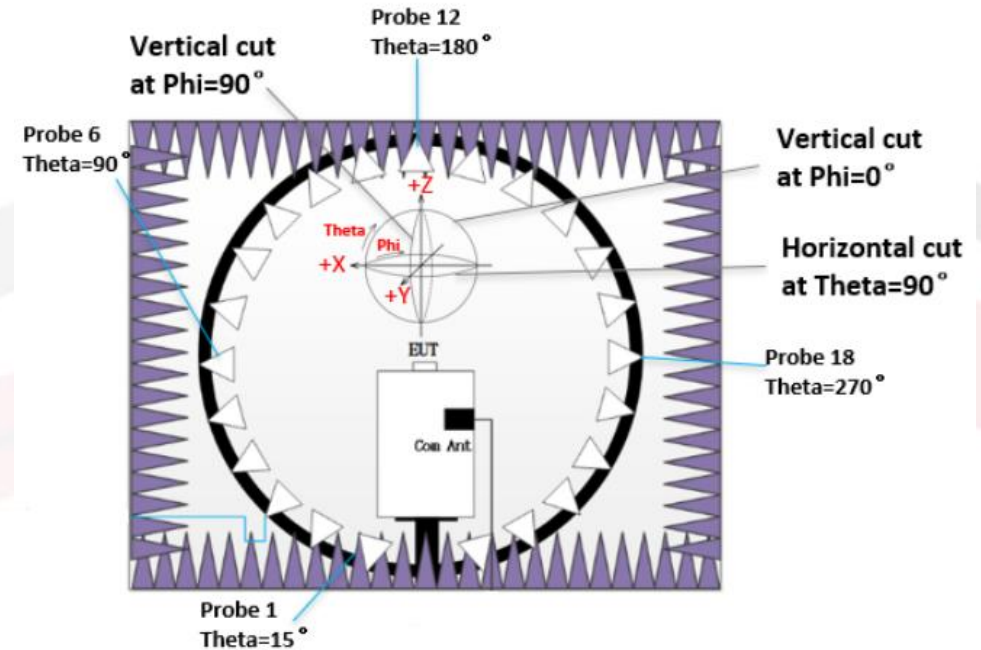


- Calibration Information

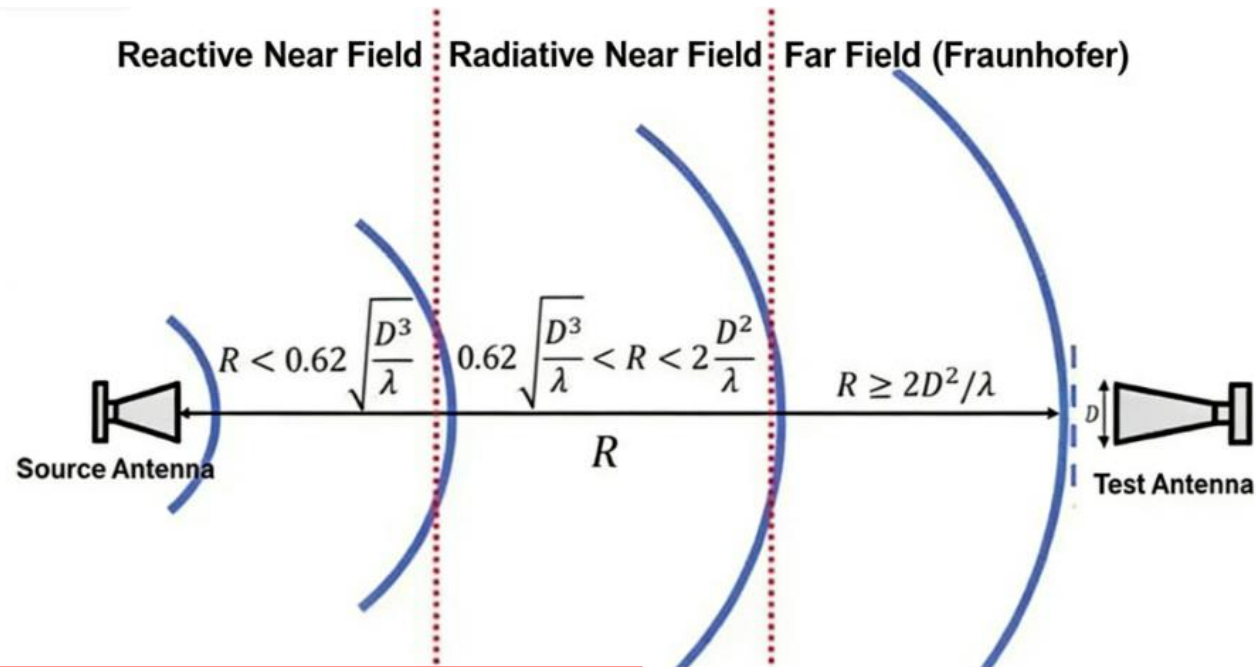
| Description      | Model No.       | Serial #   | Calibration Date | Calibration Until |
|------------------|-----------------|------------|------------------|-------------------|
| Chamber          | HWA-TECH SP24   | NA         | HWA-TECH         | 20260703          |
| Network Analyzer | Keysight E5071C | MY46730234 | Keysight         | 20270316          |

# Test Procedure

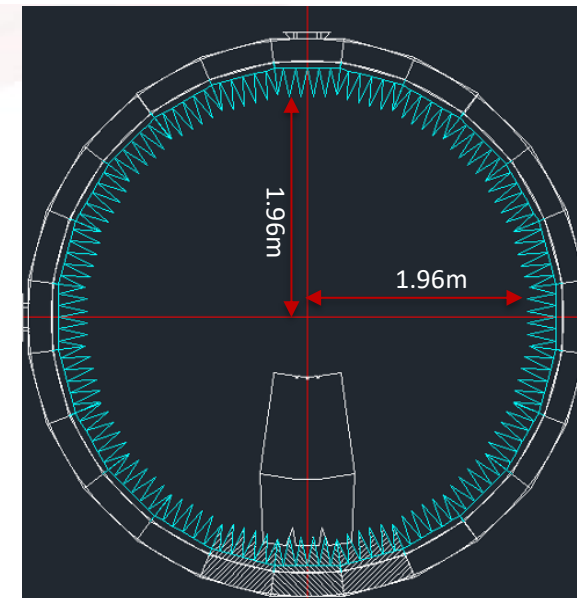
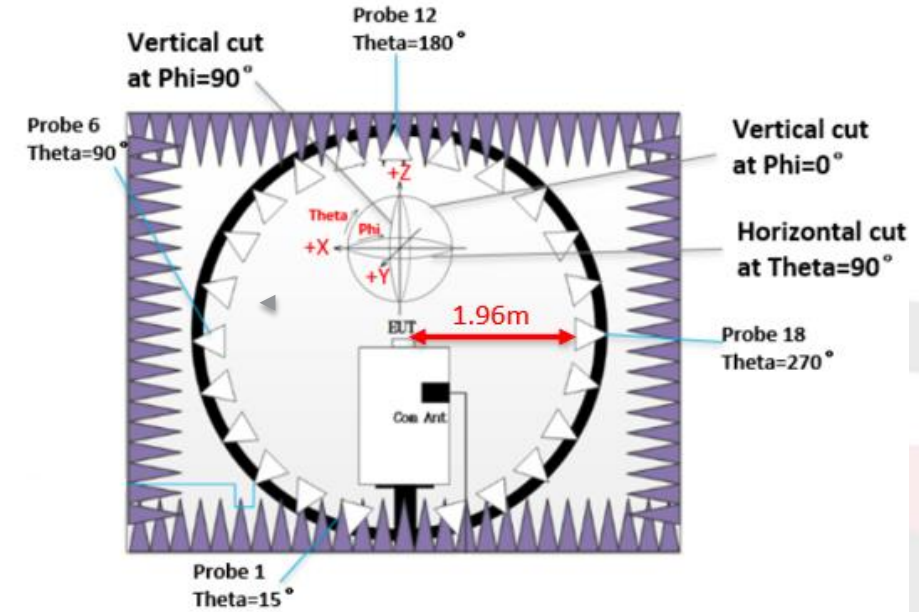
1. Place the device to be tested on the fixture and align it with the center of the chamber.
2. Connect the antenna cable to the RF connector of the chamber.
3. Use the SW to configure parameters (antenna name, frequency points, measurement angles, antenna dimension), and then run the test SW (Quick OTA).
4. By phi from  $0^\circ$  to  $360^\circ$  and theta from  $0^\circ$  to  $180^\circ$  with a step size of 15 degrees, get the 3D data, including efficiency, peak gain, 2D and 3D radiation patterns.
5. This is far field test for antenna verification.
6. This is passive measurement, which means the device is off and not in any operating mode.



# Far Field Test Method Judgment



R: Far-field starting distance  
 $\lambda$  : operating wavelength ( $\lambda=c/f$ )  
 D: Antenna Size



| Frequency (MHz) | Near Field          | Far Field              | EUT to Measurement antenna distance |
|-----------------|---------------------|------------------------|-------------------------------------|
| 2500MHz         | $R < 0.037\text{m}$ | $R \geq 0.037\text{m}$ | $R = 1.96\text{m}$                  |
| 5895MHz         | $R < 0.086\text{m}$ | $R \geq 0.086\text{m}$ | $R = 1.96\text{m}$                  |
| 7125MHz         | $R < 0.025\text{m}$ | $R \geq 0.025\text{m}$ | $R = 1.96\text{m}$                  |

# DUT Information - DUT Operation Mode

| Support band | TX/RX   | Operation mode         | Operation Antenna in MIMO Function                         |
|--------------|---------|------------------------|------------------------------------------------------------|
| 2.4G         | 2TX-2RX | 11b/11g/11n/11ax/11be  | Ant 1 + Ant 2                                              |
| 5G UNII-1    | 2TX-2RX | 11a/11n/11ac/11ax/11be | Ant 1 + Ant 2                                              |
| 5G UNII-2a   | 2TX-2RX | 11a/11n/11ac/11ax/11be | Ant 1 + Ant 2                                              |
| 5G UNII-2c   | 2TX-2RX | 11a/11n/11ac/11ax/11be | Ant 1 + Ant 2                                              |
| 5G UNII-3    | 2TX-2RX | 11a/11n/11ac/11ax/11be | Ant 1 + Ant 2                                              |
| 5G UNII-4    | 2TX-2RX | 11a/11n/11ac/11ax/11be | Ant 1 + Ant 2                                              |
| 6G UNII-5    | 2TX-2RX | 11a/11ax/11be          | Ant 3 + Ant 5, Ant 3 + Ant 6, Ant 4 + Ant 5, Ant 4 + Ant 6 |
| 6G UNII-6    | 2TX-2RX | 11a/11ax/11be          | Ant 3 + Ant 5, Ant 3 + Ant 6, Ant 4 + Ant 5, Ant 4 + Ant 6 |
| 6G UNII-7    | 2TX-2RX | 11a/11ax/11be          | Ant 3 + Ant 5, Ant 3 + Ant 6, Ant 4 + Ant 5, Ant 4 + Ant 6 |
| 6G UNII-8    | 2TX-2RX | 11a/11ax/11be          | Ant 3 + Ant 5, Ant 3 + Ant 6, Ant 4 + Ant 5, Ant 4 + Ant 6 |
| BT           | 1TX-1RX | Bluetooth              | Ant 7                                                      |

# DUT Information - DUT Operations Mode

| Band   | Modulation Mode   | CDD mode    | Beamforming mode |
|--------|-------------------|-------------|------------------|
| 2.4GHz | 802.11b           | Nss1        | Not Support      |
|        | 802.11g           | Nss1        | Not Support      |
|        | 802.11n (HT20)    | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11n (HT40)    | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11n (VHT20)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11n (VHT40)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE20)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE40)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT20)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT40)  | Nss1 / Nss2 | Nss1 / Nss2      |
| 5GHz   | 802.11a           | Nss1        | Not Support      |
|        | 802.11n (HT20)    | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11n (HT40)    | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ac (VHT20)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ac (VHT40)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ac (VHT80)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ac (VHT160) | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE20)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE40)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE80)   | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11ax (HE160)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT20)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT40)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT80)  | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT160) | Nss1 / Nss2 | Nss1 / Nss2      |
|        | 802.11be (EHT240) | Nss1 / Nss2 | Nss1 / Nss2      |

| Band | Modulation Mode   | CDD mode    | Beamforming mode |
|------|-------------------|-------------|------------------|
| 6GHz | 802.11a           | Nss1        | Not Support      |
|      | 802.11ax (HE20)   | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11ax (HE40)   | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11ax (HE80)   | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11ax (HE160)  | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT20)  | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT40)  | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT80)  | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT160) | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT240) | Nss1 / Nss2 | Nss1 / Nss2      |
|      | 802.11be (EHT360) | Nss1 / Nss2 | Nss1 / Nss2      |

# DUT Information - Antenna System information

| Antenna No. | RF Chain No. | Brand      | Model            | Support Function | Antenna Type | Connector Type |
|-------------|--------------|------------|------------------|------------------|--------------|----------------|
| Ant 1       | 0            | Galtronics | 02129140-08099-2 | 2.4G + 5G        | Monopole     | I-PEX          |
| Ant 2       | 1            | Galtronics | 02129140-08099-1 | 2.4G + 5G        | Monopole     | I-PEX          |
| Ant 3       | 0            | Galtronics | 02129475-08099-7 | 6G               | Monopole     | I-PEX          |
| Ant 4       | 1            | Galtronics | 02129475-08099-4 | 6G               | Monopole     | I-PEX          |
| Ant 5       | 2            | Galtronics | 02129475-08099-6 | 6G               | Monopole     | I-PEX          |
| Ant 6       | 3            | Galtronics | 02129475-08099-8 | 6G               | Monopole     | I-PEX          |
| Ant 7       | 0            | Galtronics | 02102073-08099-3 | 2.4G             | Alford loop  | I-PEX          |

# DUT Information - Antenna Placement



# Single Antenna Test Result - Antenna Peak Gain

| Antenna NO. | Model            | Test Frequency (MHz) | Peak Gain (dBi) |
|-------------|------------------|----------------------|-----------------|
| Ant 1       | 02129140-08099-2 | 2400                 | 2.68            |
|             |                  | 2450                 | 2.20            |
|             |                  | 2500                 | 2.13            |
|             |                  | 5150                 | 1.45            |
|             |                  | 5200                 | 1.97            |
|             |                  | 5250                 | 2.49            |
|             |                  | 5300                 | 2.61            |
|             |                  | 5350                 | 3.13            |
|             |                  | 5470                 | 3.64            |
|             |                  | 5600                 | 4.17            |
|             |                  | 5725                 | 4.25            |
|             |                  | 5785                 | 4.11            |
|             |                  | 5850                 | 4.58            |
|             |                  | 5865                 | 3.74            |
|             |                  | 5895                 | 4.37            |
| Ant 2       | 02129140-08099-1 | 2400                 | 2.54            |
|             |                  | 2450                 | 2.57            |
|             |                  | 2500                 | 3.40            |
|             |                  | 5150                 | 2.34            |
|             |                  | 5200                 | 3.06            |
|             |                  | 5250                 | 3.77            |
|             |                  | 5300                 | 3.84            |
|             |                  | 5350                 | 3.82            |
|             |                  | 5470                 | 2.93            |
|             |                  | 5600                 | 3.27            |
|             |                  | 5725                 | 3.72            |
|             |                  | 5785                 | 3.56            |
|             |                  | 5850                 | 3.78            |
|             |                  | 5865                 | 3.59            |
|             |                  | 5895                 | 4.12            |

# Single Antenna Test Result - Antenna Peak Gain

| Antenna NO. | Model            | Test Frequency (MHz) | Peak Gain (dBi) |
|-------------|------------------|----------------------|-----------------|
| Ant 3       | 02129475-08099-7 | 5925                 | 3.69            |
|             |                  | 6175                 | 3.85            |
|             |                  | 6425                 | 3.52            |
|             |                  | 6475                 | 3.59            |
|             |                  | 6525                 | 4.63            |
|             |                  | 6695                 | 4.44            |
|             |                  | 6875                 | 3.67            |
|             |                  | 6995                 | 3.39            |
|             |                  | 7115                 | 2.97            |
| Ant 4       | 02129475-08099-4 | 5925                 | 3.92            |
|             |                  | 6175                 | 4.86            |
|             |                  | 6425                 | 5.84            |
|             |                  | 6475                 | 5.37            |
|             |                  | 6525                 | 5.79            |
|             |                  | 6695                 | 4.80            |
|             |                  | 6875                 | 3.55            |
|             |                  | 6995                 | 3.77            |
|             |                  | 7115                 | 4.05            |

| Antenna NO. | Model            | Test Frequency (MHz) | Peak Gain (dBi) |
|-------------|------------------|----------------------|-----------------|
| Ant 5       | 02129475-08099-6 | 5925                 | 3.42            |
|             |                  | 6175                 | 3.11            |
|             |                  | 6425                 | 2.22            |
|             |                  | 6475                 | 2.95            |
|             |                  | 6525                 | 3.54            |
|             |                  | 6695                 | 4.45            |
|             |                  | 6875                 | 3.64            |
|             |                  | 6995                 | 3.67            |
|             |                  | 7115                 | 2.98            |
| Ant 6       | 02129475-08099-8 | 5925                 | 4.33            |
|             |                  | 6175                 | 3.97            |
|             |                  | 6425                 | 4.40            |
|             |                  | 6475                 | 4.77            |
|             |                  | 6525                 | 4.87            |
|             |                  | 6695                 | 4.42            |
|             |                  | 6875                 | 5.03            |
|             |                  | 6995                 | 6.00            |
|             |                  | 7115                 | 4.31            |

# Single Antenna Test Result - Antenna Peak Gain

| Antenna NO. | Model            | Test Frequency (MHz) | Peak Gain (dBi) |
|-------------|------------------|----------------------|-----------------|
| Ant 7       | 02102073-08099-3 | 2400                 | 2.43            |
|             |                  | 2450                 | 2.19            |
|             |                  | 2500                 | 2.03            |

# Single Antenna Test Result - 2D Radiation Pattern

- ◆ Refer to the attached file: Single Antenna Test Result - 2D Radiation Pattern



# Single Antenna Test Result - Raw Data

- ◆ Refer to the attached file: Single Antenna Test Result - Raw Data

# Directional Gain Result - Procedure

- Sub-divide the whole sphere surface into many 2x2 degree subsection.
- Measure the gain contributed from each antenna within each subsection position.
- Apply the KDB 662911 D01 correlated directional gain formula to calculate directional gain for each subsection.
- 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.

## KDD 662911 D01 correlated directional gain formula

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

(i) If transmit signals are *correlated*, then

Directional gain =  $10 \log[(10^{G_1/20} + 10^{G_2/20} + \dots + 10^{G_N/20})^2 / N_{ANT}]$  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.]

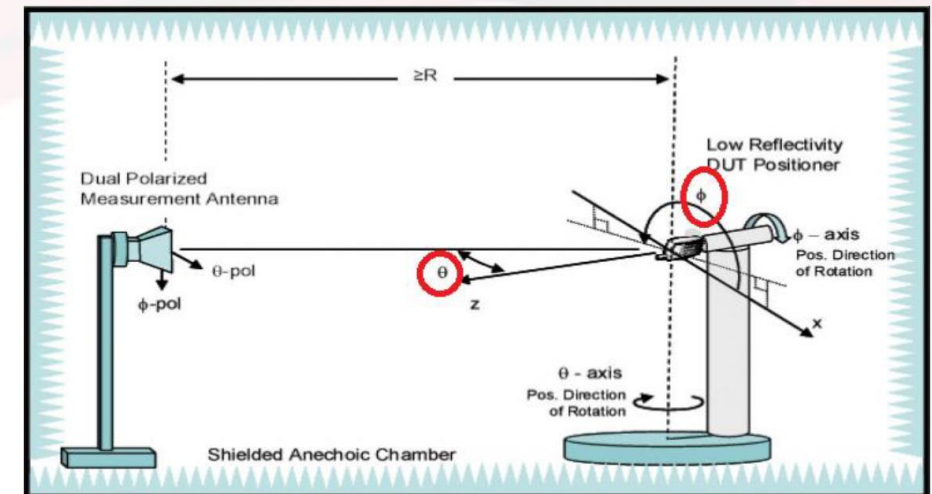
### Example:

Frequency: 2400MHz

Ant1 Max Gain: 1.81 at (90,0)

Ant2 Max Gain: 1.99 at (90,0)

Directional Gain =  $10 \log[(10^{(1.81/20)} + 10^{(1.99/20)})^2 / 2TX] = 4.91$  dBi



The definition of  $(\theta, \Phi)$  in antenna raw data.

# Directional Gain Result - Summary of Single antenna

| Individual Antenna Maximum Peak Gain |                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Frequency (MHz)                      |                 | 2400  | 2450  | 2500  | 5150  | 5200  | 5250  | 5300  | 5350  | 5470  | 5600  | 5725  | 5785  | 5850  | 5865  | 5895  |
| Ant 1                                | Max. Gain (dBi) | 2.68  | 2.20  | 2.13  | 1.45  | 1.97  | 2.49  | 2.61  | 3.13  | 3.64  | 4.17  | 4.25  | 4.11  | 4.58  | 3.74  | 4.37  |
|                                      | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                      | Axis: Theta(°)  | 60    | 60    | 60    | 45    | 45    | 45    | 60    | 45    | 45    | 45    | 45    | 45    | 45    | 45    | 45    |
|                                      | Axis: Phi(°)    | 120   | 120   | 105   | 135   | 135   | 135   | 135   | 135   | 150   | 150   | 150   | 150   | 150   | 150   | 150   |
| Ant 2                                | Max. Gain (dBi) | 2.54  | 2.57  | 3.40  | 2.34  | 3.06  | 3.77  | 3.84  | 3.82  | 2.93  | 3.27  | 3.72  | 3.56  | 3.78  | 3.59  | 4.12  |
|                                      | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                      | Axis: Theta(°)  | 75    | 75    | 135   | 90    | 90    | 90    | 90    | 90    | 90    | 120   | 120   | 120   | 75    | 90    | 90    |
|                                      | Axis: Phi(°)    | 15    | 15    | 240   | 90    | 90    | 90    | 90    | 90    | 90    | 270   | 270   | 270   | 90    | 90    | 90    |

| Individual Antenna Maximum Peak Gain |                 |       |       |       |       |       |       |       |       |       |
|--------------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Frequency (MHz)                      |                 | 5925  | 6175  | 6425  | 6475  | 6525  | 6695  | 6875  | 6995  | 7115  |
| Ant 3                                | Max. Gain (dBi) | 3.69  | 3.85  | 3.52  | 3.59  | 4.63  | 4.44  | 3.67  | 3.39  | 2.97  |
|                                      | Polarization    | Theta | Phi   | Phi   | Theta | Phi   | Phi   | Phi   | Phi   | Phi   |
|                                      | Axis: Theta(°)  | 30    | 30    | 30    | 30    | 45    | 45    | 45    | 45    | 45    |
|                                      | Axis: Phi(°)    | 270   | 195   | 195   | 270   | 195   | 195   | 195   | 195   | 195   |
| Ant 4                                | Max. Gain (dBi) | 3.92  | 4.86  | 5.84  | 5.37  | 5.79  | 4.80  | 3.55  | 3.77  | 4.05  |
|                                      | Polarization    | Theta | Phi   | Phi   | Phi   | Phi   | Phi   | Phi   | Phi   | Phi   |
|                                      | Axis: Theta(°)  | 60    | 15    | 15    | 15    | 15    | 15    | 15    | 15    | 15    |
|                                      | Axis: Phi(°)    | 180   | 300   | 300   | 300   | 300   | 315   | 315   | 315   | 300   |
| Ant 5                                | Max. Gain (dBi) | 3.42  | 3.11  | 2.22  | 2.95  | 3.54  | 4.45  | 3.64  | 3.67  | 2.98  |
|                                      | Polarization    | Theta | Phi   | Theta | Theta | Phi   | Phi   | Theta | Theta | Theta |
|                                      | Axis: Theta(°)  | 135   | 45    | 30    | 30    | 45    | 45    | 45    | 45    | 45    |
|                                      | Axis: Phi(°)    | 270   | 30    | 105   | 105   | 45    | 45    | 75    | 75    | 75    |
| Ant 6                                | Max. Gain (dBi) | 4.33  | 3.97  | 4.40  | 4.77  | 4.87  | 4.42  | 5.03  | 6.00  | 4.31  |
|                                      | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                      | Axis: Theta(°)  | 60    | 30    | 90    | 90    | 30    | 30    | 15    | 15    | 15    |
|                                      | Axis: Phi(°)    | 315   | 330   | 345   | 345   | 330   | 330   | 330   | 345   | 345   |

# Directional Gain Result - Summary

| Directional Gain _ Maximum Gain Value and Positions |                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Frequency (MHz)                                     |                 | 2400  | 2450  | 2500  | 5150  | 5200  | 5250  | 5300  | 5350  | 5470  | 5600  | 5725  | 5785  | 5850  | 5865  | 5895  |
| Ant 1 + Ant 2                                       | Max. Gain (dBi) | 4.91  | 4.15  | 3.77  | 4.29  | 4.89  | 5.39  | 5.71  | 5.90  | 5.45  | 5.11  | 5.49  | 5.75  | 5.75  | 5.39  | 5.60  |
|                                                     | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                                     | Axis: Theta(°)  | 90    | 90    | 45    | 90    | 90    | 90    | 90    | 90    | 90    | 105   | 105   | 105   | 105   | 75    | 75    |
|                                                     | Axis: Phi(°)    | 0     | 0     | 90    | 90    | 90    | 90    | 90    | 90    | 90    | 285   | 270   | 270   | 270   | 90    | 90    |

| Directional Gain _ Maximum Gain Value and Positions |                 |       |       |       |       |       |       |       |       |       |
|-----------------------------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Frequency (MHz)                                     |                 | 5925  | 6175  | 6425  | 6475  | 6525  | 6695  | 6875  | 6995  | 7115  |
| Ant 3 + Ant 5                                       | Max. Gain (dBi) | 4.70  | 4.03  | 4.44  | 4.95  | 4.88  | 5.41  | 4.50  | 4.51  | 3.84  |
|                                                     | Polarization    | Theta | Phi   | Theta | Theta | Phi   | Phi   | Phi   | Phi   | Phi   |
|                                                     | Axis: Theta(°)  | 90    | 45    | 90    | 90    | 45    | 45    | 45    | 30    | 30    |
|                                                     | Axis: Phi(°)    | 120   | 180   | 60    | 60    | 195   | 195   | 195   | 15    | 165   |
| Ant 3 + Ant 6                                       | Max. Gain (dBi) | 5.76  | 5.55  | 5.23  | 5.60  | 5.80  | 5.75  | 5.10  | 4.98  | 3.53  |
|                                                     | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                                     | Axis: Theta(°)  | 150   | 60    | 60    | 60    | 150   | 135   | 135   | 90    | 120   |
|                                                     | Axis: Phi(°)    | 135   | 315   | 315   | 315   | 120   | 120   | 135   | 60    | 120   |
| Ant 4 + Ant 5                                       | Max. Gain (dBi) | 4.09  | 4.84  | 4.77  | 4.50  | 4.48  | 3.69  | 3.88  | 3.93  | 3.74  |
|                                                     | Polarization    | Theta | Theta | Phi   | Phi   | Theta | Theta | Theta | Theta | Theta |
|                                                     | Axis: Theta(°)  | 60    | 60    | 15    | 15    | 90    | 75    | 90    | 90    | 90    |
|                                                     | Axis: Phi(°)    | 180   | 195   | 315   | 315   | 240   | 180   | 60    | 60    | 60    |
| Ant 4 + Ant 6                                       | Max. Gain (dBi) | 4.84  | 4.78  | 5.12  | 5.35  | 5.98  | 5.18  | 5.47  | 5.68  | 5.07  |
|                                                     | Polarization    | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta | Theta |
|                                                     | Axis: Theta(°)  | 60    | 15    | 75    | 15    | 15    | 90    | 90    | 90    | 90    |
|                                                     | Axis: Phi(°)    | 345   | 330   | 210   | 330   | 330   | 150   | 150   | 60    | 60    |

Note: If Directional Gain is less than individual antenna maximum peak gain, use individual antenna maximum peak gain as directional gain.

# Directional Gain Result - 2D Radiation Pattern

- ◆ Refer to the attached file: Directional Gain Result - 2D Radiation Pattern



# Directional Gain Result - Raw Data

- ◆ Refer to the attached file: Directional Gain Result – Raw Data

# Set-up Photo

