



# Antenna Composite Gain Test Report

|                 |                                                                                                            |
|-----------------|------------------------------------------------------------------------------------------------------------|
| Equipment       | Cisco Catalyst Wireless 9166I Series Access Points /<br>Cisco Catalyst Wireless 9164I Series Access Points |
| Brand Name      | CISCO                                                                                                      |
| Model Name      | CW9166I-B, CW9164I-B, CW9166I-MR, CW9164I-MR                                                               |
| Applicant       | Cisco Systems Inc<br>125 West Tasman Drive San Jose California United States 95134-1706                    |
| Manufacturer    | Cisco Systems Inc<br>125 West Tasman Drive San Jose California United States 95134-1706                    |
| Sample Received | Dec. 28, 2021                                                                                              |
| Start Test Date | Jan. 05, 2022                                                                                              |
| Final Test Date | Jan. 05, 2022                                                                                              |



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## History of this test report

[illegible]

## 1. Operation Mode and Antenna Information

| Antenna Position | Port            |                        |                         |                        | Brand | P/N          | Ant. Type         | Connector | Modes of Operation                             |
|------------------|-----------------|------------------------|-------------------------|------------------------|-------|--------------|-------------------|-----------|------------------------------------------------|
|                  | R1: WLAN 2.4GHz | R1: WLAN 5GHz UNII 1~3 | R2: WLAN 5GHz UNII 2C~3 | R2: WLAN 6GHz UNII 5~8 |       |              |                   |           |                                                |
| 2G5G Ant1        | 3               | 4                      | -                       | -                      | CISCO | 95XEAJ15.G04 | Folded            | I-PEX     | WLAN 2.4GHz & WLAN 5GHz UNII 1~3               |
| 2G5G Ant2        | 4               | 3                      | -                       | -                      | CISCO | 95XEAJ15.G03 | Folded            | I-PEX     |                                                |
| 2G5G Ant3        | 2               | 2                      | -                       | -                      | CISCO | 95XEAJ15.G05 | Folded            | I-PEX     |                                                |
| 2G5G Ant4        | 1               | 1                      | -                       | -                      | CISCO | 95XEAJ15.G06 | Folded            | I-PEX     |                                                |
| 5G6G Ant1        | -               | -                      | 4                       | 4                      | CISCO | 95XEAJ15.G12 | H-POL Alford loop | I-PEX     | WLAN 5GHz UNII 2C, UNII 3 & WLAN 6GHz UNII 5~8 |
| 5G6G Ant2        | -               | -                      | 3                       | 3                      | CISCO | 95XEAJ15.G11 | H-POL Alford loop | I-PEX     |                                                |
| 5G6G Ant3        | -               | -                      | 1                       | 1                      | CISCO | 95XEAJ15.G09 | H-POL Alford loop | I-PEX     |                                                |
| 5G6G Ant4        | -               | -                      | 2                       | 2                      | CISCO | 95XEAJ15.G10 | H-POL Alford loop | I-PEX     |                                                |

R means Radio.

Note:

For 2G5G Ant1~2G5G Ant4

2.4GHz and 5GHz Operation Mode (1TX, 2TX, 4TX/4RX)

1TX:

2G5G Ant4 can be used as transmitting/receiving antenna.

2TX:

2G5G Ant3~Ant4 can be used as transmitting/receiving antenna.

2G5G Ant3~Ant4 could transmit/receive simultaneously.

4TX:

2G5G Ant1~Ant4 can be used as transmitting/receiving antenna.

2G5G Ant1~Ant4 could transmit/receive simultaneously.

For 5G6G Ant1~5G6G Ant4

5GHz and 6GHz Operation Mode (1TX, 2TX, 4TX/4RX)

1TX:

5G6G Ant3 can be used as transmitting/receiving antenna.

2TX:

5G6G Ant3~Ant4 can be used as transmitting/receiving antenna.

5G6G Ant3~Ant4 could transmit/receive simultaneously.

4TX:

5G6G Ant1~Ant4 can be used as transmitting/receiving antenna.

5G6G Ant1~Ant4 could transmit/receive simultaneously.

Antenna operation of 2G5G Ant1~Ant4 and 5G6G Ant1~Ant4 have two kinds of the operation mode of 5GHz:

Operation mode 1: 5GHz UNII 1~UNII 3 (2G5G Ant1~Ant4).

Operation mode 2: 5GHz UNII 1, UNII 2A (2G5G Ant1~Ant4)+5GHz UNII 2C, UNII 3 (5G6G Ant1~Ant4).

The antenna operation was limited to the 4x4 MIMO for each band.



## 2. Test Frequency

The listed frequency of each bands are selected to represent each frequency bands

| Band [MHz]  | Test Frequency [MHz] |
|-------------|----------------------|
| 2400-2483.5 | 2450                 |
| 5150-5250   | 5200                 |
| 5250-5350   | 5300                 |
| 5470-5725   | 5600                 |
| 5725-5850   | 5785                 |
| 5925-6425   | 6175                 |
| 6425-6525   | 6475                 |
| 6525-6875   | 6695                 |
| 6875-7125   | 6995                 |

## 3. Testing Location

| Testing Location                    |        |                                                                                            |
|-------------------------------------|--------|--------------------------------------------------------------------------------------------|
| <input checked="" type="checkbox"/> | HWA YA | ADD : No.13-1 & 14-1, Ln. 19, Wen 33rd St., Guishan Dist., Taoyuan City 333, Taiwan R.O.C. |

| Test Condition | Test Site No. | Test Engineer | Test Environment<br>(°C / %) | Test Date     |
|----------------|---------------|---------------|------------------------------|---------------|
| Radiated       | 05CH03-HY     | Rex Liao      | 19-20 / 50-55                | Jan. 05, 2022 |

Note:

Testing Site Information

Brand Name: TDK

Dimension: 11m\*6m\*6m

Characteristic: Fully Anechoic Chamber

#### 4. Test Facility and Configuration

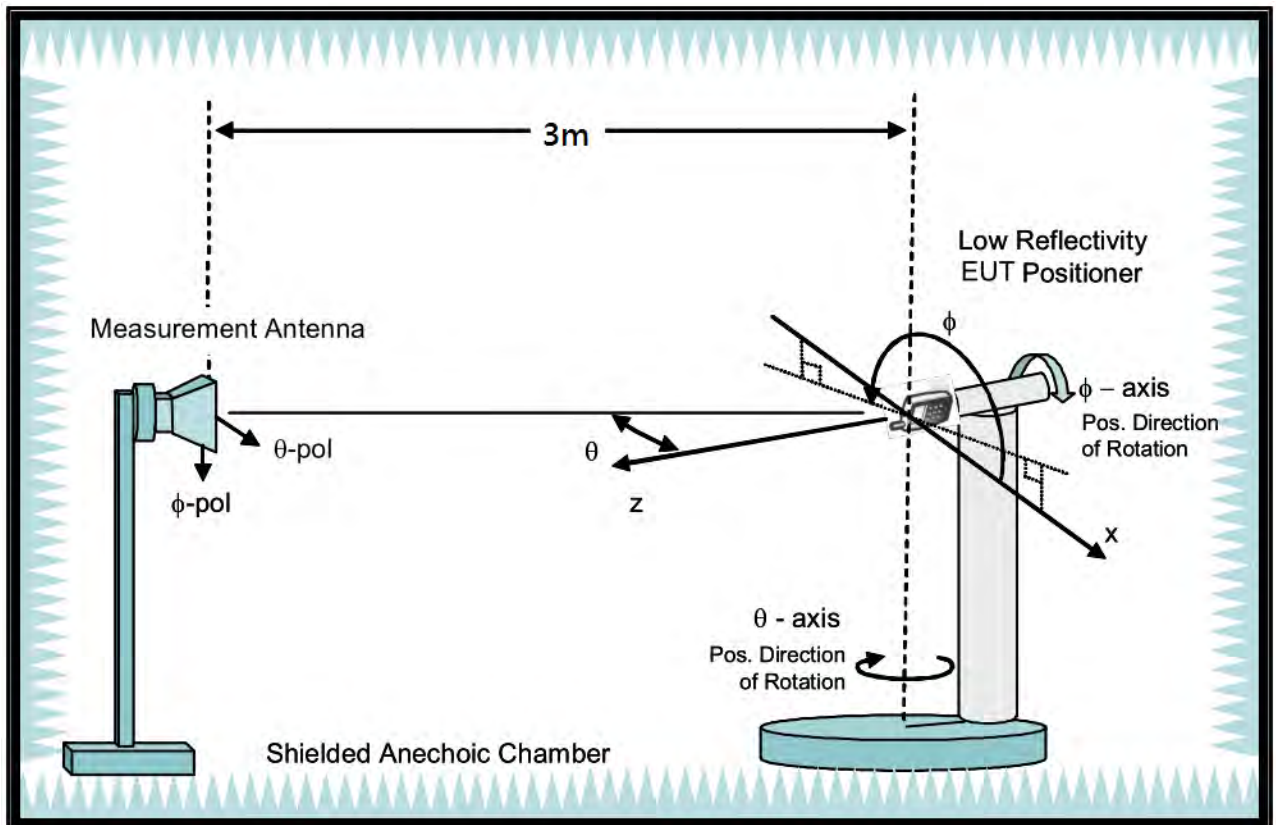
Test configuration: Reference to CITA OTA distributed-axes system configuration.

Chamber: Fully Anechoic Chamber.

Measurement antenna: Single Polarization Horn antenna calibrated according to ANSI C63.5.

Turntable: Multi-axis positioner (Theta and Phi angle).

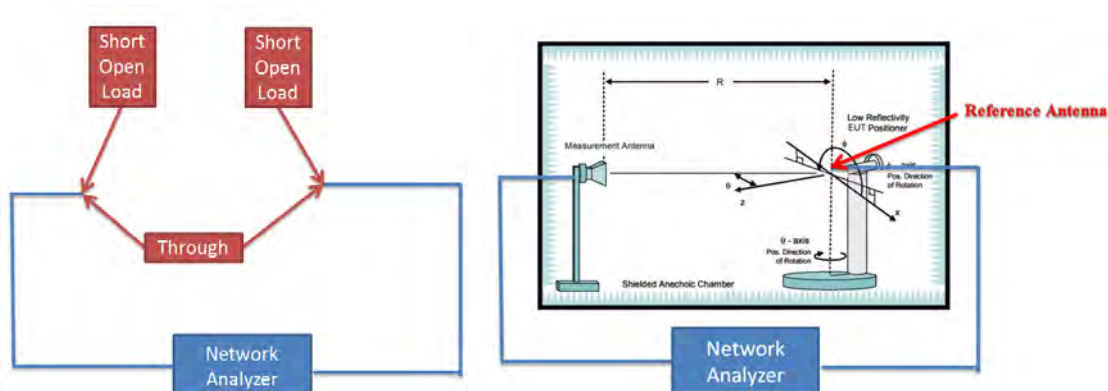
#Reference to CTIA "ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1"



## 5. Reference Calibration

Connected cables to VNA calibration kit and use network analyzer internal function to do calibration. Do short, open and load to each side. Then connect through to both side and calibrate S21 values. The cable loss is calibrated and set inside the network analyzer.

Measurement Antenna is connected to port1 of Network analyzer and reference antenna connected to port 2 of Network Analyzer. Record S21 values and used with reference antenna gain to calculate gain factor.



| Frequency (MHz)      | 2400  | 2450  | 2500  | 5150  | 5200  | 5300  | 5600  | 5750  | 5800  | 5900  | 6000  | 6500  | 7000  | 7500  |
|----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| S21 values (dBi)     | -31.4 | -31.4 | -31.3 | -31.3 | -31   | -30.7 | -30.1 | -30.5 | -30.5 | -30.8 | -31.3 | -32.8 | -34.4 | -35.4 |
| Reference gain (dBi) | 10.2  | 10.4  | 10.6  | 12.4  | 12.8  | 13.4  | 13.4  | 13.3  | 13.3  | 13.1  | 13.2  | 12.3  | 11.7  | 11.1  |
| Factor (dB)          | 41.63 | 41.81 | 41.89 | 43.72 | 43.78 | 44.12 | 43.5  | 43.78 | 43.76 | 43.88 | 44.45 | 45.14 | 46.08 | 46.51 |

## 6. Test Method

EUT set on multi-axis positioner and adjust EUT's physical center to measurement reference center. Measurement antenna set at phi polarization and 1.5 meter height. Port 1 of Network analyzer connect to antenna 1 of EUT. Record S21 value every 15 degree from 0 to 345 degree on Phi angle and 0 to 180 on theta angle of multi-axis positioner. Then set measurement antenna to theta polarization and repeat process. Repeat process to each antenna of EUT.

DG steps:

1. Each Phi and Theta polarization antenna gain are measured for all test angles.
2. Composite Phi and Theta antenna gain are computed, using formula in KDB662911 D01 d) (i) and (ii), for all angles.
3. Composite antenna gain are examined for all angles to determine max gain and Phi/Theta position. Max gain and phi/theta position are listed in section 7 tables.

## 7. Measured Values and Calculation of Maximum Gain Positions

<Antenna Position: 2G/5G Ant1~4>

For 2TX:

DG\_1SS max value position

| Frequency (Hz)      | 2.45G | 5.2G  | 5.3G  | 5.6G  | 5.785G |
|---------------------|-------|-------|-------|-------|--------|
| Ant. 3 (dBi)        | 1     | -1.93 | -0.86 | -1.24 | 0.48   |
| Ant. 4 (dBi)        | 1.55  | 5.24  | 4.53  | 3.86  | 1.77   |
| DG [1SS] (dBi)      | 4.29  | 5.39  | 5.26  | 4.69  | 4.16   |
| Polarization        | Theta | Theta | Theta | Theta | Theta  |
| $\Theta (^{\circ})$ | 60    | 75    | 60    | 60    | 60     |
| $\Phi (^{\circ})$   | 345   | 150   | 135   | 135   | 30     |

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

DG\_1SS max value position calculation

| Frequency (Hz)                        | 2.45G            | 5.2G              | 5.3G              | 5.6G              | 5.785G           |
|---------------------------------------|------------------|-------------------|-------------------|-------------------|------------------|
| Ant. 3 [ $10^{(G/20)}$ ]              | $10^{(1/20)}$    | $10^{(-1.93/20)}$ | $10^{(-0.86/20)}$ | $10^{(-1.24/20)}$ | $10^{(0.48/20)}$ |
| Ant. 4 [ $10^{(G/20)}$ ]              | $10^{(1.55/20)}$ | $10^{(5.24/20)}$  | $10^{(4.53/20)}$  | $10^{(3.86/20)}$  | $10^{(1.77/20)}$ |
| Ant. 3 [ $10^{(G/20)}$ ] value        | 1.122            | 0.801             | 0.906             | 0.867             | 1.057            |
| Ant. 4 [ $10^{(G/20)}$ ] value        | 1.195            | 1.828             | 1.685             | 1.56              | 1.226            |
| Sum All Antenna [Amax]                | 2.317            | 2.629             | 2.59              | 2.427             | 2.283            |
| DG<br>[ $10^{\log(Amax^2/N_{ant})}$ ] | 4.29             | 5.39              | 5.26              | 4.69              | 4.16             |

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

Directional gain (1SS) =  $10^{\log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^2/N_{ant}}$

**DG\_2SS max value position**

| Frequency (Hz)     | 2.45G | 5.2G  | 5.3G  | 5.6G  | 5.785G |
|--------------------|-------|-------|-------|-------|--------|
| Ant. 3 (dBi)       | 1     | -1.93 | -3.34 | -1.24 | -3.53  |
| Ant. 4 (dBi)       | 1.55  | 5.24  | 5.46  | 3.86  | 3.94   |
| DG [4SS] (dBi)     | 1.28  | 2.99  | 2.99  | 2.02  | 1.65   |
| Polarization       | Theta | Theta | Theta | Theta | Theta  |
| $\Theta(^{\circ})$ | 60    | 75    | 75    | 60    | 60     |
| $\Phi(^{\circ})$   | 345   | 150   | 150   | 135   | 135    |

Note:

The DG 2SS max value position is the maximum DG 2SS value calculated from section 11 table Gain Result.

**DG\_2SS max value position calculation**

| Frequency (Hz)                                      | 2.45G  | 5.2G   | 5.3G   | 5.6G   | 5.785G |
|-----------------------------------------------------|--------|--------|--------|--------|--------|
| Ant. 3 $((10^{(G/20)})^2)$                          | 1.2589 | 0.6412 | 0.4634 | 0.7516 | 0.4436 |
| Ant. 4 $((10^{(G/20)})^2)$                          | 1.4289 | 3.342  | 3.5156 | 2.4322 | 2.4774 |
| Sum All Antenna                                     | 2.6878 | 3.9832 | 3.9791 | 3.1838 | 2.921  |
| DG $[10 \cdot \log(\text{sum all}/N_{\text{ant}})]$ | 1.28   | 2.99   | 2.99   | 2.02   | 1.65   |

Note: Directional Gain (2SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$$g_{j,k} = 10^{(G/20)}$$

$$\text{Directional Gain (2SS)} = 10 \cdot \log((10^{(G_{\text{ant1}}/20)})^2 + (10^{(G_{\text{ant2}}/20)})^2 + (10^{(G_{\text{ant3}}/20)})^2 + (10^{(G_{\text{ant4}}/20)})^2 + \dots) / N_{\text{ant}})$$

For 4TX:

### DG\_1SS Max Value Position

| Frequency (Hz)     | 2.45G | 5.2G  | 5.3G  | 5.6G  | 5.785G |
|--------------------|-------|-------|-------|-------|--------|
| Ant. 1 (dBi)       | 2     | 2.96  | 0.86  | 0.74  | 0.76   |
| Ant. 2 (dBi)       | 0.73  | 0.64  | -0.79 | -2.26 | -2.84  |
| Ant. 3 (dBi)       | -0.06 | 0.05  | -0.86 | -1.24 | 1.65   |
| Ant. 4 (dBi)       | 0.79  | -0.14 | 4.53  | 3.86  | -0.39  |
| DG [1SS] (dBi)     | 6.92  | 6.99  | 7.25  | 6.62  | 5.97   |
| Polarization       | Theta | Theta | Theta | Theta | Theta  |
| $\Theta(^{\circ})$ | 60    | 45    | 60    | 60    | 60     |
| $\Phi(^{\circ})$   | 285   | 225   | 135   | 135   | 45     |

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

### DG\_1SS Max Value Position Calculation

| Frequency (Hz)                            | 2.45G             | 5.2G              | 5.3G              | 5.6G              | 5.785G            |
|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Ant. 1 [ $10^{(G/20)}$ ]                  | $10^{(2/20)}$     | $10^{(2.96/20)}$  | $10^{(0.86/20)}$  | $10^{(0.74/20)}$  | $10^{(0.76/20)}$  |
| Ant. 2 [ $10^{(G/20)}$ ]                  | $10^{(0.73/20)}$  | $10^{(0.64/20)}$  | $10^{(-0.79/20)}$ | $10^{(-2.26/20)}$ | $10^{(-2.84/20)}$ |
| Ant. 3 [ $10^{(G/20)}$ ]                  | $10^{(-0.06/20)}$ | $10^{(0.05/20)}$  | $10^{(-0.86/20)}$ | $10^{(-1.24/20)}$ | $10^{(1.65/20)}$  |
| Ant. 4 [ $10^{(G/20)}$ ]                  | $10^{(0.79/20)}$  | $10^{(-0.14/20)}$ | $10^{(4.53/20)}$  | $10^{(3.86/20)}$  | $10^{(-0.39/20)}$ |
| Ant. 1 [ $10^{(G/20)}$ ] value            | 1.259             | 1.406             | 1.104             | 1.089             | 1.091             |
| Ant. 2 [ $10^{(G/20)}$ ] value            | 1.088             | 1.076             | 0.913             | 0.771             | 0.721             |
| Ant. 3 [ $10^{(G/20)}$ ] value            | 0.993             | 1.006             | 0.906             | 0.867             | 1.209             |
| Ant. 4 [ $10^{(G/20)}$ ] value            | 1.095             | 0.984             | 1.685             | 1.56              | 0.956             |
| Sum All Antenna [Amax]                    | 4.435             | 4.472             | 4.607             | 4.286             | 3.978             |
| DG [ $10 \cdot \log(A_{max}^2/N_{ant})$ ] | 6.92              | 6.99              | 7.25              | 6.62              | 5.97              |

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

Directional gain (1SS) =  $10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^{1/2} / N_{ant}$

**DG\_4SS Max Value Position**

| Frequency (Hz)     | 2.45G | 5.2G  | 5.3G  | 5.6G  | 5.785G |
|--------------------|-------|-------|-------|-------|--------|
| Ant. 1 (dBi)       | 2     | 1.31  | 0.86  | 0.74  | -0.57  |
| Ant. 2 (dBi)       | 0.73  | 0.7   | -0.79 | -2.26 | -3.36  |
| Ant. 3 (dBi)       | -0.06 | -3.9  | -0.86 | -1.24 | -3.53  |
| Ant. 4 (dBi)       | 0.79  | 3.44  | 4.53  | 3.86  | 3.94   |
| DG [4SS] (dBi)     | 0.93  | 1.09  | 1.55  | 0.94  | 0.27   |
| Polarization       | Theta | Theta | Theta | Theta | Theta  |
| $\Theta(^{\circ})$ | 60    | 75    | 60    | 60    | 60     |
| $\Phi(^{\circ})$   | 285   | 165   | 135   | 135   | 135    |

Note:

The DG 4SS max value position is the maximum DG 4SS value calculated from section 11 table Gain Result.

**DG\_4SS Max Value Position Calculation**

| Frequency (Hz)                                | 2.45G  | 5.2G   | 5.3G   | 5.6G   | 5.785G |
|-----------------------------------------------|--------|--------|--------|--------|--------|
| Ant. 1 $((10^{(G/20)})^2)$                    | 1.5849 | 1.3521 | 1.219  | 1.1858 | 0.877  |
| Ant. 2 $((10^{(G/20)})^2)$                    | 1.183  | 1.1749 | 0.8337 | 0.5943 | 0.4613 |
| Ant. 3 $((10^{(G/20)})^2)$                    | 0.9863 | 0.4074 | 0.8204 | 0.7516 | 0.4436 |
| Ant. 4 $((10^{(G/20)})^2)$                    | 1.1995 | 2.208  | 2.8379 | 2.4322 | 2.4774 |
| Sum All Antenna                               | 4.9537 | 5.1424 | 5.7109 | 4.9639 | 4.2593 |
| DG $[10*\log(\text{sum all}/N_{\text{ant}})]$ | 0.93   | 1.09   | 1.55   | 0.94   | 0.27   |

Note: Directional Gain (4SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$$g_{j,k} = 10^{(G/20)}$$

$$\text{Directional Gain (4SS)} = 10*\log((10^{(G_{\text{ant1}}/20)})^2 + (10^{(G_{\text{ant2}}/20)})^2 + (10^{(G_{\text{ant3}}/20)})^2 + (10^{(G_{\text{ant4}}/20)})^2 + \dots) / N_{\text{ant}})$$



<Antenna Position: 5G6G Ant1~5G6G Ant4>

For 2TX:

## DG\_1SS Max Value Position

| Frequency (Hz)     | 5.6G | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|--------------------|------|--------|--------|--------|--------|--------|
| Ant. 3 (dBi)       | 3.21 | 4.36   | 2.34   | 2.31   | 0.99   | 0.61   |
| Ant. 4 (dBi)       | 2.39 | -0.68  | 2.4    | 0.52   | 1.24   | -0.51  |
| DG [1SS] (dBi)     | 5.82 | 5.21   | 5.38   | 4.47   | 4.13   | 3.08   |
| Polarization       | Phi  | Phi    | Phi    | Phi    | Phi    | Phi    |
| $\Theta(^{\circ})$ | 75   | 75     | 75     | 75     | 75     | 75     |
| $\Phi(^{\circ})$   | 90   | 75     | 345    | 135    | 60     | 60     |

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

## DG\_1SS Max Value Position Calculation

| Frequency (Hz)                            | 5.6G             | 5.785G            | 6.175G           | 6.475G           | 6.695G           | 6.995G            |
|-------------------------------------------|------------------|-------------------|------------------|------------------|------------------|-------------------|
| Ant. 3 [ $10^{(G/20)}$ ]                  | $10^{(3.21/20)}$ | $10^{(4.36/20)}$  | $10^{(2.34/20)}$ | $10^{(2.31/20)}$ | $10^{(0.99/20)}$ | $10^{(0.61/20)}$  |
| Ant. 4 [ $10^{(G/20)}$ ]                  | $10^{(2.39/20)}$ | $10^{(-0.68/20)}$ | $10^{(2.4/20)}$  | $10^{(0.52/20)}$ | $10^{(1.24/20)}$ | $10^{(-0.51/20)}$ |
| Ant. 3 [ $10^{(G/20)}$ ] value            | 1.447            | 1.652             | 1.309            | 1.305            | 1.121            | 1.073             |
| Ant. 4 [ $10^{(G/20)}$ ] value            | 1.317            | 0.925             | 1.318            | 1.062            | 1.153            | 0.943             |
| Sum All Antenna [Amax]                    | 2.764            | 2.577             | 2.627            | 2.366            | 2.274            | 2.016             |
| DG [ $10 \cdot \log(A_{max}^2/N_{ant})$ ] | 5.82             | 5.21              | 5.38             | 4.47             | 4.13             | 3.08              |

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

Directional gain (1SS) =  $10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^{2/N_{ant}}$

**DG\_2SS Max Value Position**

| Frequency (Hz)     | 5.6G | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|--------------------|------|--------|--------|--------|--------|--------|
| Ant. 3 (dBi)       | 3.21 | 4.36   | 2.34   | -4.05  | 0.99   | 0.61   |
| Ant. 4 (dBi)       | 2.39 | -0.68  | 2.4    | 3.96   | 1.24   | -0.51  |
| DG [4SS] (dBi)     | 2.82 | 2.53   | 2.37   | 1.59   | 1.12   | 0.09   |
| Polarization       | Phi  | Phi    | Phi    | Phi    | Phi    | Phi    |
| $\Theta(^{\circ})$ | 75   | 75     | 75     | 75     | 75     | 75     |
| $\Phi(^{\circ})$   | 90   | 75     | 345    | 45     | 60     | 60     |

Note:

The DG 2SS max value position is the maximum DG 2SS value calculated from section 11 table Gain Result.

**DG\_2SS Max Value Position Calculation**

| Frequency (Hz)                                      | 5.6G   | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|-----------------------------------------------------|--------|--------|--------|--------|--------|--------|
| Ant. 3 $((10^{(G/20)})^2)$                          | 2.0941 | 2.729  | 1.714  | 0.3936 | 1.256  | 1.1508 |
| Ant. 4 $((10^{(G/20)})^2)$                          | 1.7338 | 0.8551 | 1.7378 | 2.4889 | 1.3305 | 0.8892 |
| Sum All Antenna                                     | 3.8279 | 3.584  | 3.4518 | 2.8824 | 2.5865 | 2.04   |
| DG $[10 \cdot \log(\text{sum all}/N_{\text{ant}})]$ | 2.82   | 2.53   | 2.37   | 1.59   | 1.12   | 0.09   |

Note: Directional Gain (2SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$$g_{j,k} = 10^{(G/20)}$$

$$\text{Directional Gain (2SS)} = 10 \cdot \log((10^{(G_{\text{ant1}}/20)})^2 + (10^{(G_{\text{ant2}}/20)})^2 + (10^{(G_{\text{ant3}}/20)})^2 + (10^{(G_{\text{ant4}}/20)})^2 + \dots) / N_{\text{ant}})$$

For 4TX:

**DG\_1SS Max Value Position**

| Frequency (Hz)     | 5.6G | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|--------------------|------|--------|--------|--------|--------|--------|
| Ant. 1 (dBi)       | 2.62 | 1.36   | 1.33   | -1.43  | 1.11   | 0.77   |
| Ant. 2 (dBi)       | 2.05 | 2.09   | -0.69  | 1.2    | 0.26   | -3.16  |
| Ant. 3 (dBi)       | 3.21 | 2.59   | 2.34   | 0.27   | -1.07  | -5.42  |
| Ant. 4 (dBi)       | 2.39 | 1.66   | 2.4    | -0.2   | -0.33  | 0.33   |
| DG [1SS] (dBi)     | 8.6  | 7.96   | 7.45   | 6.03   | 6.05   | 4.51   |
| Polarization       | Phi  | Phi    | Phi    | Phi    | Phi    | Phi    |
| $\Theta(^{\circ})$ | 75   | 75     | 75     | 75     | 75     | 75     |
| $\Phi(^{\circ})$   | 90   | 180    | 345    | 210    | 315    | 315    |

Note: The DG 1SS max value position is the maximum value of section 11 table DG 1SS Result.

**DG\_1SS Max Value Position Calculation**

| Frequency (Hz)                               | 5.6G             | 5.785G           | 6.175G            | 6.475G            | 6.695G            | 6.995G            |
|----------------------------------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|
| Ant. 1 [ $10^{(G/20)}$ ]                     | $10^{(2.62/20)}$ | $10^{(1.36/20)}$ | $10^{(1.33/20)}$  | $10^{(-1.43/20)}$ | $10^{(1.11/20)}$  | $10^{(0.77/20)}$  |
| Ant. 2 [ $10^{(G/20)}$ ]                     | $10^{(2.05/20)}$ | $10^{(2.09/20)}$ | $10^{(-0.69/20)}$ | $10^{(1.2/20)}$   | $10^{(0.26/20)}$  | $10^{(-3.16/20)}$ |
| Ant. 3 [ $10^{(G/20)}$ ]                     | $10^{(3.21/20)}$ | $10^{(2.59/20)}$ | $10^{(2.34/20)}$  | $10^{(0.27/20)}$  | $10^{(-1.07/20)}$ | $10^{(-5.42/20)}$ |
| Ant. 4 [ $10^{(G/20)}$ ]                     | $10^{(2.39/20)}$ | $10^{(1.66/20)}$ | $10^{(2.4/20)}$   | $10^{(-0.2/20)}$  | $10^{(-0.33/20)}$ | $10^{(0.33/20)}$  |
| Ant. 1 [ $10^{(G/20)}$ ]<br>value            | 1.352            | 1.169            | 1.165             | 0.848             | 1.136             | 1.093             |
| Ant. 2 [ $10^{(G/20)}$ ]<br>value            | 1.266            | 1.272            | 0.924             | 1.148             | 1.03              | 0.695             |
| Ant. 3 [ $10^{(G/20)}$ ]<br>value            | 1.447            | 1.347            | 1.309             | 1.032             | 0.884             | 0.536             |
| Ant. 4 [ $10^{(G/20)}$ ]<br>value            | 1.317            | 1.211            | 1.318             | 0.977             | 0.963             | 1.039             |
| Sum All Antenna<br>[Amax]                    | 5.382            | 5                | 4.717             | 4.005             | 4.014             | 3.362             |
| DG<br>[ $10 \cdot \log(A_{max}^2/N_{ant})$ ] | 8.6              | 7.96             | 7.45              | 6.03              | 6.05              | 4.51              |

Note:

Directional Gain (1SS) is the max value of every look angle. Each position value is calculated by KDB662911 D01 d) (i).

Directional gain (1SS) =  $10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^2 / N_{ant}$

**DG\_4SS Max Value Position**

| Frequency (Hz)     | 5.6G | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|--------------------|------|--------|--------|--------|--------|--------|
| Ant. 1 (dBi)       | 2.62 | 0.52   | 1.33   | -0.35  | 1.11   | 0.77   |
| Ant. 2 (dBi)       | 2.05 | 4.72   | -0.69  | -3.44  | 0.26   | -3.16  |
| Ant. 3 (dBi)       | 3.21 | -0.49  | 2.34   | -4.05  | -1.07  | -5.42  |
| Ant. 4 (dBi)       | 2.39 | 1.85   | 2.4    | 3.96   | -0.33  | 0.33   |
| DG [4SS] (dBi)     | 2.59 | 2.12   | 1.51   | 0.27   | 0.07   | -1.19  |
| Polarization       | Phi  | Phi    | Phi    | Phi    | Phi    | Phi    |
| $\Theta(^{\circ})$ | 75   | 75     | 75     | 75     | 75     | 75     |
| $\Phi(^{\circ})$   | 90   | 165    | 345    | 45     | 315    | 315    |

Note:

The DG 4SS max value position is the maximum DG 4SS value calculated from section 11 table Gain Result.

**DG\_4SS Max Value Position Calculation**

| Frequency (Hz)                                      | 5.6G   | 5.785G | 6.175G | 6.475G | 6.695G | 6.995G |
|-----------------------------------------------------|--------|--------|--------|--------|--------|--------|
| Ant. 1 $((10^{(G/20)})^2)$                          | 1.8281 | 1.1272 | 1.3583 | 0.9226 | 1.2912 | 1.194  |
| Ant. 2 $((10^{(G/20)})^2)$                          | 1.6032 | 2.9648 | 0.8531 | 0.4529 | 1.0617 | 0.4831 |
| Ant. 3 $((10^{(G/20)})^2)$                          | 2.0941 | 0.8933 | 1.714  | 0.3936 | 0.7816 | 0.2871 |
| Ant. 4 $((10^{(G/20)})^2)$                          | 1.7338 | 1.5311 | 1.7378 | 2.4889 | 0.9268 | 1.0789 |
| Sum All Antenna                                     | 7.2593 | 6.5164 | 5.6632 | 4.2579 | 4.0614 | 3.0431 |
| DG $[10 \cdot \log(\text{sum all}/N_{\text{ant}})]$ | 2.59   | 2.12   | 1.51   | 0.27   | 0.07   | -1.19  |

Note: Directional Gain (4SS) is the max value of all position. Each position value is calculated by KDB662911 D01 (e) (ii).

$$g_{j,k} = 10^{(G/20)}$$

$$\text{Directional Gain (4SS)} = 10 \cdot \log((10^{(G_{\text{ant1}}/20)})^2 + (10^{(G_{\text{ant2}}/20)})^2 + (10^{(G_{\text{ant3}}/20)})^2 + (10^{(G_{\text{ant4}}/20)})^2 + \dots) / N_{\text{ant}})$$

## 8. Summary of Test Result

<Antenna Position: 2G/5G Ant1~4>

For 2TX:

| Frequency (Hz)                                         | 2.45G        | 5.2G         | 5.3G         | 5.6G         | 5.785G       |
|--------------------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Ant. 3 Max Gain (dBi)                                  | 2.79         | 2.78         | 2.74         | 2.66         | 1.91         |
| Ant. 4 Max Gain (dBi)                                  | 2.62         | 5.24         | 5.46         | 4.26         | 3.94         |
| Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/30/210 | Theta/75/60  | Theta/75/30  | Theta/75/60  | Theta/75/255 |
| Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/15/315 | Theta/75/150 | Theta/75/150 | Theta/75/150 | Theta/60/135 |
| Max Gain (dBi)                                         | 2.79         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [1SS] (dBi)                                         | 4.29         | 5.39         | 5.26         | 4.69         | 4.16         |
| DG [2SS] (dBi)                                         | 1.28         | 2.99         | 2.99         | 2.02         | 1.65         |

For 4TX

| Frequency (Hz)                                         | 2.45G        | 5.2G         | 5.3G         | 5.6G         | 5.785G       |
|--------------------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Ant. 1 Max Gain (dBi)                                  | 2.79         | 4.27         | 3.94         | 1.88         | 2.57         |
| Ant. 2 Max Gain (dBi)                                  | 2.43         | 5.09         | 5.16         | 2.89         | 2.72         |
| Ant. 3 Max Gain (dBi)                                  | 2.79         | 2.78         | 2.74         | 2.66         | 1.91         |
| Ant. 4 Max Gain (dBi)                                  | 2.62         | 5.24         | 5.46         | 4.26         | 3.94         |
| Ant. 1 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/0/195  | Theta/75/240 | Theta/75/240 | Theta/75/240 | Theta/60/225 |
| Ant. 2 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/60/165 | Theta/75/330 | Theta/75/330 | Theta/75/330 | Theta/75/330 |
| Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/30/210 | Theta/75/60  | Theta/75/30  | Theta/75/60  | Theta/75/255 |
| Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Theta/15/315 | Theta/75/150 | Theta/75/150 | Theta/75/150 | Theta/60/135 |
| Max Gain (dBi)                                         | 2.79         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [1SS] (dBi)                                         | 6.92         | 6.99         | 7.25         | 6.62         | 5.97         |
| DG [2SS] (dBi)                                         | 3.92         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [4SS] (dBi)                                         | 0.93         | 1.09         | 1.55         | 0.94         | 0.27         |

### Note:

- For 4TX modes. Directional Gain (2SS) = Directional Gain (1SS) – 3dB. If directional gain is less than max gain, use max gain as directional gain.
- Each antenna max gain is the max value of measurement S21 of theta and phi through all measurement angles.
- The max gain is the max value of all antennas.

**<Antenna Position: 5G6G Ant1~5G6G Ant4>**
**For 2TX:**

| Frequency (Hz)                                         | 5.6G       | 5.785G     | 6.175G    | 6.475G     | 6.695G    | 6.995G     |
|--------------------------------------------------------|------------|------------|-----------|------------|-----------|------------|
| Ant. 3 Max Gain (dBi)                                  | 3.42       | 4.36       | 2.95      | 2.31       | 0.99      | 0.61       |
| Ant. 4 Max Gain (dBi)                                  | 3.67       | 4.23       | 2.91      | 3.96       | 1.59      | 0.33       |
| Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/75/180 | Phi/75/75  | Phi/75/75 | Phi/75/135 | Phi/75/60 | Phi/75/60  |
| Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/60/0   | Phi/60/345 | Phi/75/45 | Phi/75/45  | Phi/75/45 | Phi/75/315 |
| Max Gain (dBi)                                         | 3.67       | 4.36       | 2.95      | 3.96       | 1.59      | 0.61       |
| DG [1SS] (dBi)                                         | 5.82       | 5.21       | 5.38      | 4.47       | 4.13      | 3.08       |
| DG [2SS] (dBi)                                         | 2.82       | 2.53       | 2.37      | 1.59       | 1.12      | 0.09       |

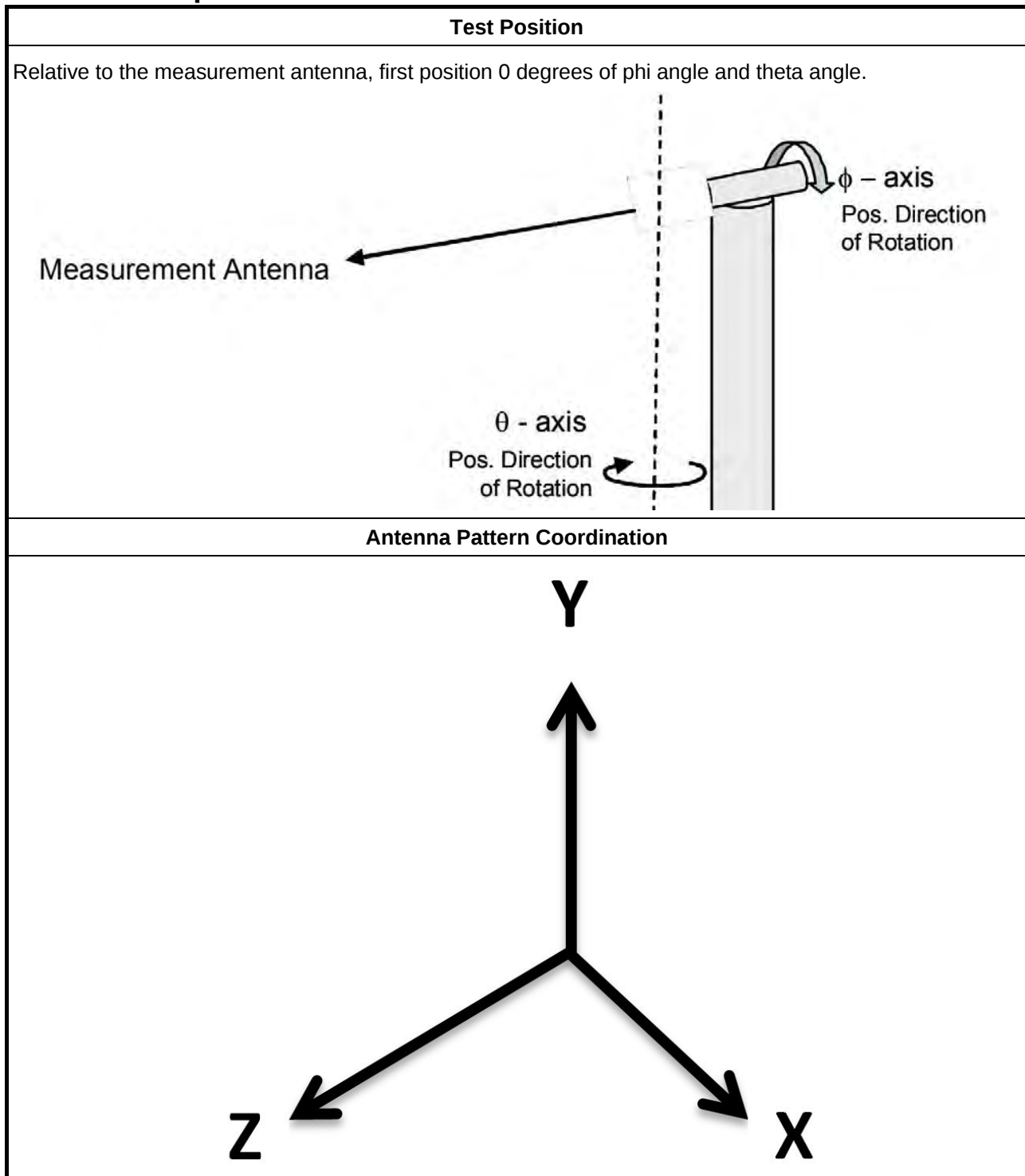
**For 4TX**

| Frequency (Hz)                                         | 5.6G       | 5.785G     | 6.175G     | 6.475G     | 6.695G     | 6.995G     |
|--------------------------------------------------------|------------|------------|------------|------------|------------|------------|
| Ant. 1 Max Gain (dBi)                                  | 2.98       | 4.19       | 2.4        | 2.41       | 1.39       | 0.77       |
| Ant. 2 Max Gain (dBi)                                  | 3.46       | 4.94       | 2.95       | 1.96       | 1.32       | 0.87       |
| Ant. 3 Max Gain (dBi)                                  | 3.42       | 4.36       | 2.95       | 2.31       | 0.99       | 0.61       |
| Ant. 4 Max Gain (dBi)                                  | 3.67       | 4.23       | 2.91       | 3.96       | 1.59       | 0.33       |
| Ant. 1 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/60/0   | Phi/75/255 | Phi/75/255 | Phi/75/315 | Phi/75/240 | Phi/75/315 |
| Ant. 2 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/75/180 | Phi/75/150 | Phi/75/165 | Phi/75/225 | Phi/75/210 | Phi/75/240 |
| Ant. 3 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/75/180 | Phi/75/75  | Phi/75/75  | Phi/75/135 | Phi/75/60  | Phi/75/60  |
| Ant. 4 Polarization/ $\Theta(^{\circ})/\Phi(^{\circ})$ | Phi/60/0   | Phi/60/345 | Phi/75/45  | Phi/75/45  | Phi/75/45  | Phi/75/315 |
| Max Gain (dBi)                                         | 3.67       | 4.94       | 2.95       | 3.96       | 1.59       | 0.87       |
| DG [1SS] (dBi)                                         | 8.6        | 7.96       | 7.45       | 6.03       | 6.05       | 4.51       |
| DG [2SS] (dBi)                                         | 5.6        | 4.96       | 4.45       | 3.96       | 3.05       | 1.51       |
| DG [4SS] (dBi)                                         | 2.59       | 2.12       | 1.51       | 0.27       | 0.07       | -1.19      |

**Note:**

- For 4TX modes. Directional Gain (2SS) = Directional Gain (1SS) – 3dB. If directional gain is less than max gain, use max gain as directional gain.
- Each antenna max gain is the max value of measurement S21 of theta and phi through all measurement angles.
- The max gain is the max value of all antennas.

## 9. Test Setup



Note:

Photos of Test Position: Please refer to the test photos in the appendix.

**10. Test Equipment and Calibration Data**

| Instrument    | Brand       | Model No. | Serial No.      | Characteristics | Calibration Date | Calibration Due Date |
|---------------|-------------|-----------|-----------------|-----------------|------------------|----------------------|
| Horn Antenna  | SCHWARZBECK | BBHA9120D | BBHA 9120D-1292 | 1GHz~18GHz      | Aug. 04, 2021    | Aug. 03, 2022        |
| Test Software | SPORTON     | SENSE-RDG | V1.0.6          | -               | N.C.R.           | N.C.R.               |

Note: Calibration Interval of instruments listed above is one year.

NCR means Non-Calibration required.



## **11. Test Results**

Please refer to the appendix.

|                                                                                              |         |
|----------------------------------------------------------------------------------------------|---------|
| Appendix A – Radiated Composite Gain of 2.4GHz, 5GHz UNII 1~3 (2G5G Ant1~Ant4).....          | Page 22 |
| Appendix B – Radiated Composite Gain of 5GHz UNII 2C, 3, 6GHz UNII 5~8 (5G6G Ant1~Ant4)..... | Page 37 |
| Appendix C – Antenna Pattern of 2.4GHz, 5GHz UNII 1~3 (2G5G Ant1~Ant4).....                  | Page 55 |
| Appendix D – Antenna Pattern of 5GHz UNII 2C, 3, 6GHz UNII 5~8 (5G6G Ant1~Ant4).....         | Page 60 |
| Appendix E – Test Photos.....                                                                | Page 66 |



| Freq(Hz)                                               | 2.45G        | 5.2G         | 5.3G         | 5.6G         | 5.785G       |
|--------------------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Ant. 3 Max Gain (dBi)                                  | 2.79         | 2.78         | 2.74         | 2.66         | 1.91         |
| Ant. 4 Max Gain (dBi)                                  | 2.62         | 5.24         | 5.46         | 4.26         | 3.94         |
| Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/30/210 | Theta/75/60  | Theta/75/30  | Theta/75/60  | Theta/75/255 |
| Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/15/315 | Theta/75/150 | Theta/75/150 | Theta/75/150 | Theta/60/135 |
| Max Gain (dBi)                                         | 2.79         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [1SS] (dBi)                                         | 4.29         | 5.39         | 5.26         | 4.69         | 4.16         |
| DG [2SS] (dBi)                                         | 1.28         | 2.99         | 2.99         | 2.02         | 1.65         |













| Freq(Hz)                                               | 2.45G        | 5.2G         | 5.3G         | 5.6G         | 5.785G       |
|--------------------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Ant. 1 Max Gain (dBi)                                  | 2.79         | 4.27         | 3.94         | 1.88         | 2.57         |
| Ant. 2 Max Gain (dBi)                                  | 2.43         | 5.09         | 5.16         | 2.89         | 2.72         |
| Ant. 3 Max Gain (dBi)                                  | 2.79         | 2.78         | 2.74         | 2.66         | 1.91         |
| Ant. 4 Max Gain (dBi)                                  | 2.62         | 5.24         | 5.46         | 4.26         | 3.94         |
| Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/0/195  | Theta/75/240 | Theta/75/240 | Theta/75/240 | Theta/60/225 |
| Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/60/165 | Theta/75/330 | Theta/75/330 | Theta/75/330 | Theta/75/330 |
| Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/30/210 | Theta/75/60  | Theta/75/30  | Theta/75/60  | Theta/75/255 |
| Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Theta/15/315 | Theta/75/150 | Theta/75/150 | Theta/75/150 | Theta/60/135 |
| Max Gain (dBi)                                         | 2.79         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [1SS] (dBi)                                         | 6.92         | 6.99         | 7.25         | 6.62         | 5.97         |
| DG [2SS] (dBi)                                         | 3.92         | 5.24         | 5.46         | 4.26         | 3.94         |
| DG [4SS] (dBi)                                         | 0.93         | 1.09         | 1.55         | 0.94         | 0.27         |



















|                               |            |            |           |            |           |            |
|-------------------------------|------------|------------|-----------|------------|-----------|------------|
| Freq(Hz)                      | 5.6G       | 5.785G     | 6.175G    | 6.475G     | 6.695G    | 6.995G     |
| Ant. 3 Max Gain (dBi)         | 3.42       | 4.36       | 2.95      | 2.31       | 0.99      | 0.61       |
| Ant. 4 Max Gain (dBi)         | 3.67       | 4.23       | 2.91      | 3.96       | 1.59      | 0.33       |
| Ant. 3 Polarization/Θ(°)/Φ(°) | Phi/75/180 | Phi/75/75  | Phi/75/75 | Phi/75/135 | Phi/75/60 | Phi/75/60  |
| Ant. 4 Polarization/Θ(°)/Φ(°) | Phi/60/0   | Phi/60/345 | Phi/75/45 | Phi/75/45  | Phi/75/45 | Phi/75/315 |
| Max Gain (dBi)                | 3.67       | 4.36       | 2.95      | 3.96       | 1.59      | 0.61       |
| DG [1SS] (dBi)                | 5.82       | 5.21       | 5.38      | 4.47       | 4.13      | 3.08       |
| DG [2SS] (dBi)                | 2.82       | 2.53       | 2.37      | 1.59       | 1.12      | 0.09       |















Radiated Composite Gain of 5GHz UNII 2C, 3, 6GHz UNII 5~8  
(5G6G Ant1~Ant4)\_4TX

| Freq(Hz)                                               | 5.6G       | 5.785G     | 6.175G     | 6.475G     | 6.695G     | 6.995G     |
|--------------------------------------------------------|------------|------------|------------|------------|------------|------------|
| Ant. 1 Max Gain (dBi)                                  | 2.98       | 4.19       | 2.4        | 2.41       | 1.39       | 0.77       |
| Ant. 2 Max Gain (dBi)                                  | 3.46       | 4.94       | 2.95       | 1.96       | 1.32       | 0.87       |
| Ant. 3 Max Gain (dBi)                                  | 3.42       | 4.36       | 2.95       | 2.31       | 0.99       | 0.61       |
| Ant. 4 Max Gain (dBi)                                  | 3.67       | 4.23       | 2.91       | 3.96       | 1.59       | 0.33       |
| Ant. 1 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Phi/60/0   | Phi/75/255 | Phi/75/255 | Phi/75/315 | Phi/75/240 | Phi/75/315 |
| Ant. 2 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Phi/75/180 | Phi/75/150 | Phi/75/165 | Phi/75/225 | Phi/75/210 | Phi/75/240 |
| Ant. 3 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Phi/75/180 | Phi/75/75  | Phi/75/75  | Phi/75/135 | Phi/75/60  | Phi/75/60  |
| Ant. 4 Polarization/ $\theta(^{\circ})/\phi(^{\circ})$ | Phi/60/0   | Phi/60/345 | Phi/75/45  | Phi/75/45  | Phi/75/45  | Phi/75/315 |
| Max Gain (dBi)                                         | 3.67       | 4.94       | 2.95       | 3.96       | 1.59       | 0.87       |
| DG [1SS] (dBi)                                         | 8.6        | 7.96       | 7.45       | 6.03       | 6.05       | 4.51       |
| DG [2SS] (dBi)                                         | 5.6        | 4.96       | 4.45       | 3.96       | 3.05       | 1.51       |
| DG [4SS] (dBi)                                         | 2.59       | 2.12       | 1.51       | 0.27       | 0.07       | -1.19      |





Radiated Composite Gain of 5GHz UNII 2C, 3, 6GHz UNII 5~8  
(5G6G Ant1~Ant4)\_4TX

Appendix B.2

|          |        |        |
|----------|--------|--------|
| Freq(Hz) | 6.475G | Pol.</ |
|----------|--------|--------|











