



Antenna Composite Gain Test Report

Equipment	Cisco Catalyst Wireless 9166I Series Access Points / Cisco Catalyst Wireless 9164I Series Access Points
Brand Name	CISCO
Model Name	CW9166I-B, CW9164I-B, CW9166I-MR, CW9164I-MR
Applicant	Cisco Systems Inc 125 West Tasman Drive San Jose California United States 95134-1706
Manufacturer	Cisco Systems Inc 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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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		
☒	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 (°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

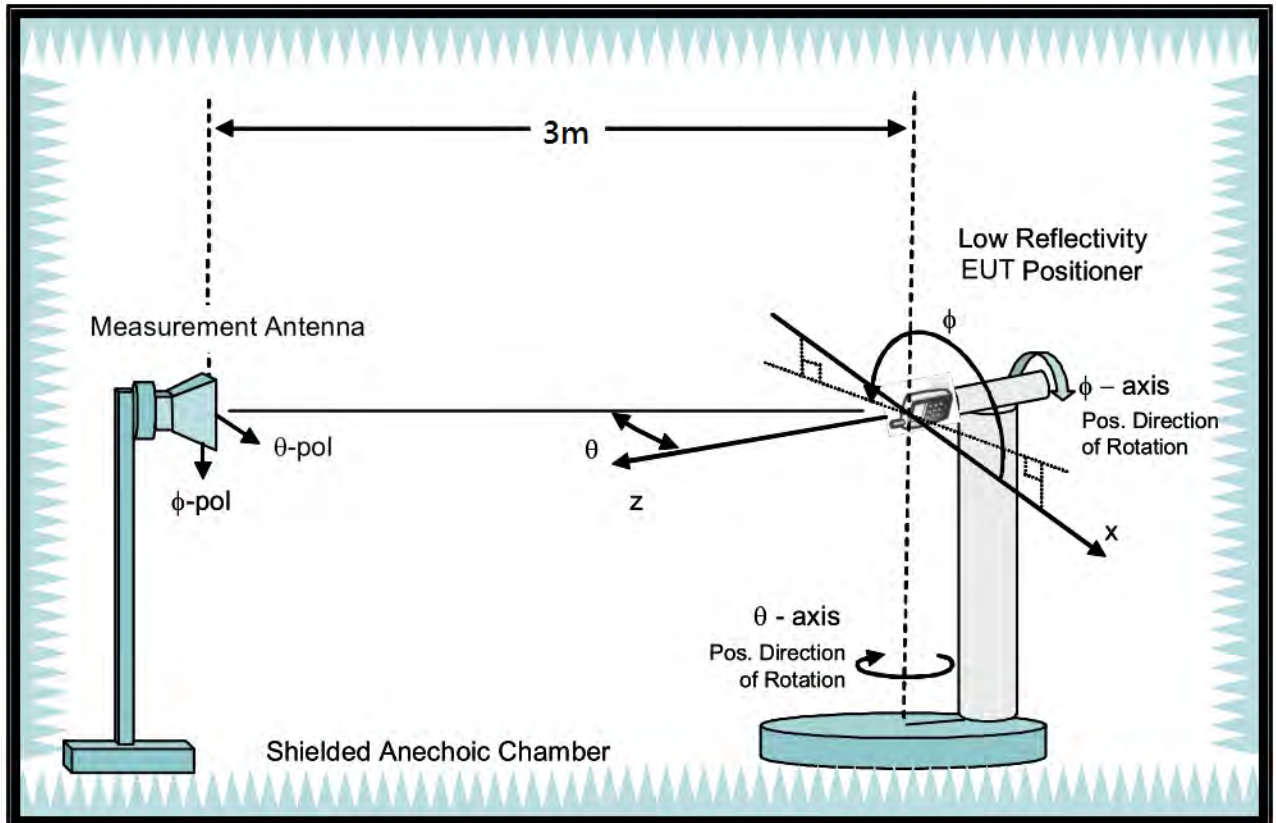
Test configuration: Reference to CITA OTA distributed-axes system configuration.

Chamber: Fully Anechoic Chamber.

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

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

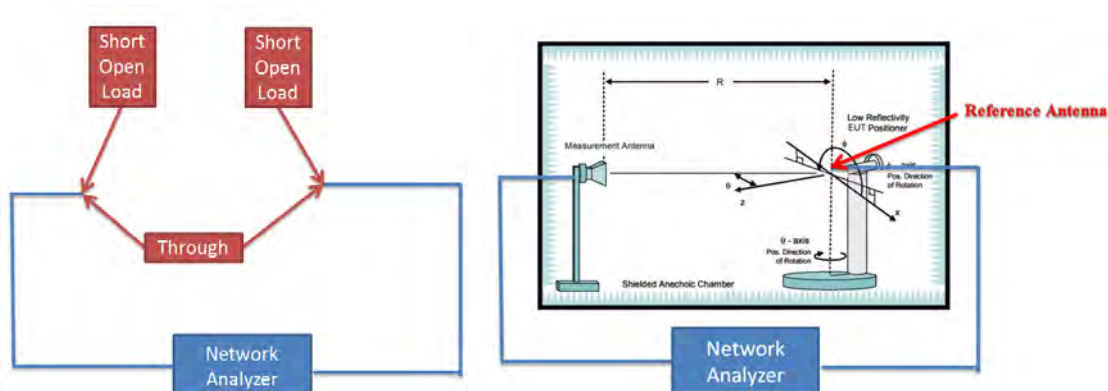
#Reference to CTIA "ctia-test-plan-for-wireless-device-over-the-air-performance-ver-3-7-1"



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 [$10^{\log(Amax^2/Nant)}$]	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) = $10 \cdot \log(10^{(G_{ant1}/20)} + 10^{(G_{ant2}/20)} + 10^{(G_{ant3}/20)} + 10^{(G_{ant4}/20)} + \dots)^{1/2} / N_{ant}$

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 [$10^{(G/20)}$] value	1.352	1.169	1.165	0.848	1.136	1.093
Ant. 2 [$10^{(G/20)}$] value	1.266	1.272	0.924	1.148	1.03	0.695
Ant. 3 [$10^{(G/20)}$] value	1.447	1.347	1.309	1.032	0.884	0.536
Ant. 4 [$10^{(G/20)}$] value	1.317	1.211	1.318	0.977	0.963	1.039
Sum All Antenna [Amax]	5.382	5	4.717	4.005	4.014	3.362
DG [$10 \cdot \log(A_{max}^2/N_{ant})$]	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

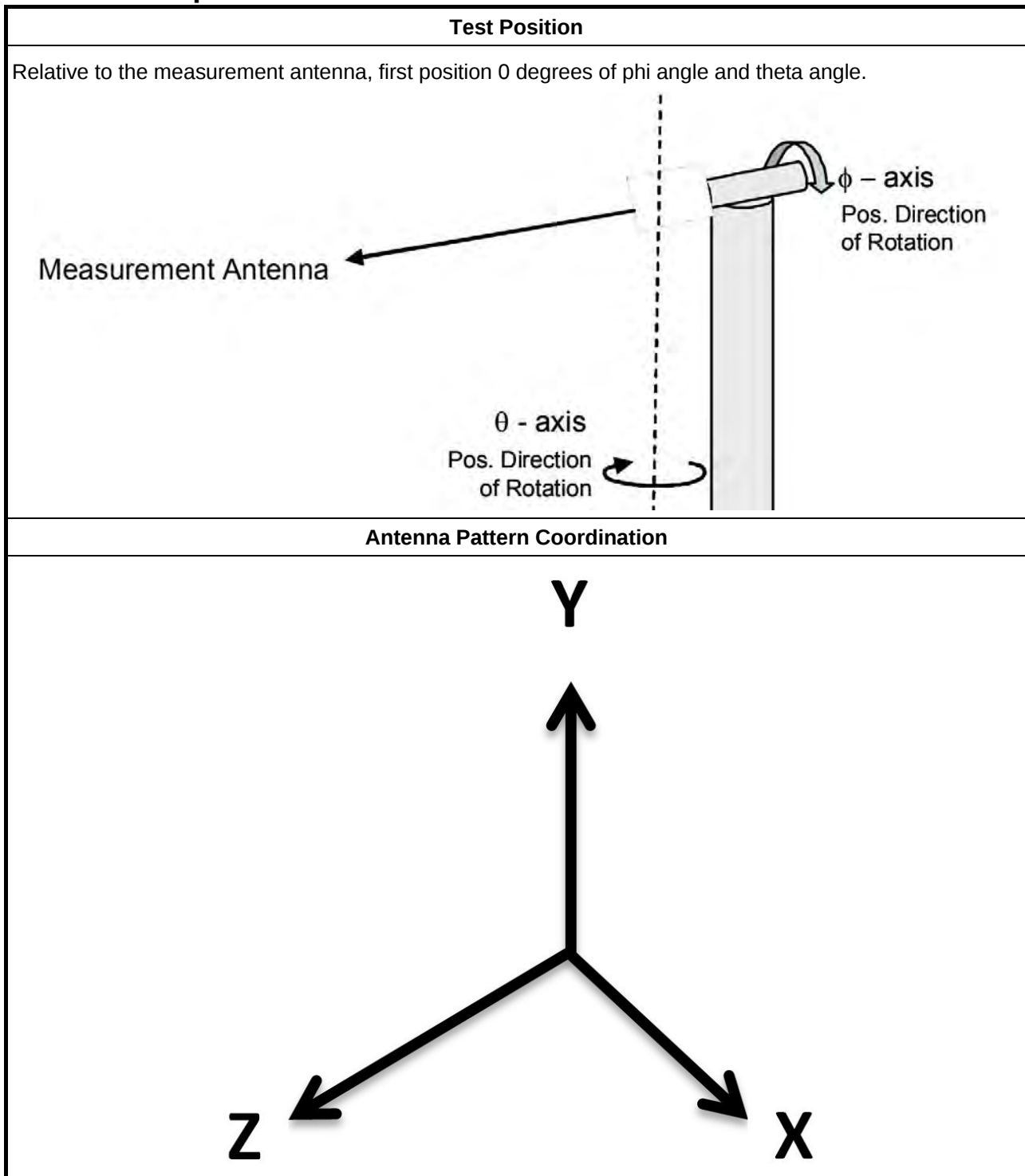
For 4TX

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



Θ(180°)	-11.74	-14.86	-11.76	-11.91	-10.66	-10.27	-10.34	-12.13	-10.28	-10.03	-8.39	-8.57	-9.74	-10.83	-8.59	-7.32	-7.43	-9.42	-11.95	-10.02	-10.16	-9.35	-9.32	-8.8
Freq(Hz)	5.6G	Pol.	Phi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DG(dBi)	Φ(0°)	Φ(15°)	Φ(30°)	Φ(45°)	Φ(60°)	Φ(75°)	Φ(90°)	Φ(105°)	Φ(120°)	Φ(135°)	Φ(150°)	Φ(165°)	Φ(180°)	Φ(195°)	Φ(210°)	Φ(225°)	Φ(240°)	Φ(255°)	Φ(270°)	Φ(285°)	Φ(300°)	Φ(315°)	Φ(330°)	Φ(345°)
Θ(0°)	-5	-7.53	-5.98	-5.9	-6.7	-7.89	-8.71	-8.73	-10.73	-11.19	-8.89	-6.5	-6.14	-5.03	-4.29	-5.24	-6.05	-8.94	-9.42	-10.51	-10.36	-10.73	-8.61	-7.58
Θ(15°)	-4.47	-4.01	-4.42	-2.87	-3.79	-8.25	-10.09	-8.57	-9.48	-7.35	-6.74	-10.15	-9.08	-8.23	-9.75	-10.46	-10.51	-7.46	-7.22	-6.77	-7.93	-9.84	-11.92	-9.36
Θ(30°)	-6.7	-2.7	-6.71	-9.08	-3.09	-6.97	-6.24	-12.17	-9.27	-14	-10.42	-8.41	-11.16	-8.1	-9.25	-11.61	-13.75	-7.16	-5.68	-7.3	-6.1	-8.65	-8.06	-9.09
Θ(45°)	-7.18	-7.75	-7.52	-2.76	-2.35	-4.47	-8.91	-11.54	-8.05	-8.46	-7.9	-7.17	-9.47	-10.71	-11.3	-8.88	-9.9	-6.65	-10.23	-9.88	-7.92	-6.88	-9.27	-6.99
Θ(60°)	-7.48	-6.88	-5.33	-4.32	-4.84	-4.13	-4.4	-10.12	-9.86	-7.37	-8.39	-7.87	-7.54	-10.83	-13.55	-9.97	-11.37	-7.46	-8.69	-10.77	-8.8	-8.11	-8.71	-8.83
Θ(75°)	-8.67	-7.83	-8.21	-4.01	-4.83	-2.57	-4.23	-4.44	-8.94	-6.24	-11.71	-13.1	-8.64	-14.81	-14.12	-9.48	-12.25	-8.25	-10.97	-9.14	-10	-7.89	-9.18	-8.87
Θ(90°)	-9.22	-11.18	-11.59	-8.91	-5.86	-5.81	-7.25	-6.39	-11.08	-10.84	-14.23	-13.24	-9.32	-14.07	-14.41	-12.17	-12.67	-10.57	-10.89	-11.96	-13.09	-10.19	-9.83	-8.2
Θ(105°)	-10.47	-8.58	-9.53	-10.5	-7.34	-9.23	-7.88	-8.13	-10.11	-13.01	-14.47	-11.24	-9.49	-12.52	-12.56	-13.49	-10.97	-11.46	-12.32	-12.49	-14.45	-12.31	-9.68	-10.4
Θ(120°)	-9.61	-13.72	-12.82	-10.66	-13.54	-6.48	-7.88	-9.07	-10.4	-13.89	-13.85	-11.84	-11.35	-13.74	-9.61	-9.59	-14.19	-10.41	-11.13	-12.1	-14.19	-13.55	-14.03	-10.86
Θ(135°)	-8.99	-9.3	-9.71	-14.41	-9.95	-10.27	-11.09	-14.96	-11.24	-11.61	-12.24	-9.53	-8.15	-9.09	-12.1	-8.02	-11.71	-11.21	-11.36	-13.7	-11.01	-14.35	-11.51	-15.12
Θ(150°)	-14.24	-12.66	-13.87	-13.15	-10.28	-10.35	-6.05	-11.92	-10.03	-11.46	-14.45	-12.99	-11.45	-13.59	-8.84	-12.97	-11.4	-9.58	-10.6	-12.87	-9.64	-9.25	-9.59	-6.98
Θ(165°)	-14.12	-14.01	-11.76	-12.98	-9.68	-12.53	-9.75	-8.22	-9.6	-10.16	-11.87	-13.51	-9.36	-10.74	-11.02	-10.51	-9.96	-11.29	-7.98	-7.82	-8.77	-11.41	-14.14	-9.7
Θ(180°)	-11.91	-11.94	-12.79	-14.54	-13.69	-14.09	-12.2	-10.95	-8.92	-8.75	-8.17	-8.68	-9.69	-9.94	-11.99	-12.03	-12.45	-10.14	-8.77	-9.67	-9.71	-11.45	-12.62	-12.83
Freq(Hz)	5.6G	Pol.	Theta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DG(dBi)	Φ(0°)	Φ(15°)	Φ(30°)	Φ(45°)	Φ(6																			



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/Θ(°)/Φ(°)	Theta/0/195	Theta/75/240	Theta/75/240	Theta/75/240	Theta/60/225
Ant. 2 Polarization/Θ(°)/Φ(°)	Theta/60/165	Theta/75/330	Theta/75/330	Theta/75/330	Theta/75/330
Ant. 3 Polarization/Θ(°)/Φ(°)	Theta/30/210	Theta/75/60	Theta/75/30	Theta/75/60	Theta/75/255
Ant. 4 Polarization/Θ(°)/Φ(°)	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



**Radiated Composite Gain of 5GHz UNII 2C, 3, 6GHz UNII 5~8
(5G6G Ant3~Ant4)_2TX**

Appendix B.1

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

Appendix B.2

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

