Plume Design, Inc.
325 Lytton Ave.,
Palo Alto, CA 94301

Applicant	Plume Design, Inc.
Product Type	SuperPod with WiFi 6E
Model Number	J2X

WLAN Antenna Summary Report

1. Measurement information

- Measurement: Plume HW lab
- Equipment: MVG SG24 chamber , ANRITSU MS46522B VNA

* Test Equipment list

Description	Manufacturer	Model	S/N	Cal Date
Network Analyzer	ANRITSU	MS46522B	1745103/M1:72950015	2021-12-10

2. Measurement Method

To measure the far field in a large anechoic chamber.

3. Measurement Environment

To use anechoic chamber with full 3D far field measurement capability. Detail please refer to the Appendix at the end of the report.

3.1 . Radiation Pattern Test

Antennas tested for Gain and Efficiency must be assembled into the enclosure and tested in the fully assembled and operating J2X. The antenna is tested in free space in the full 3D anechoic chamber in the H, E1 and, E2 planes. The radiation patterns are measured at the center of transmit and receive bands.

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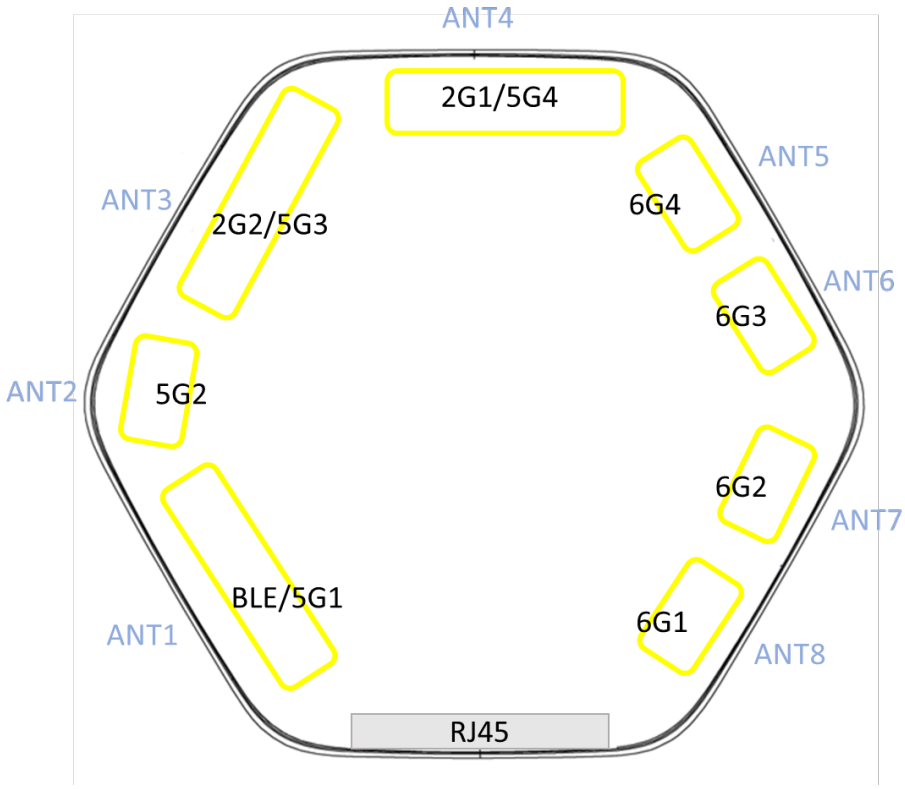
4. Equipment Configuration

4.1. EUT supports bands.

	Frequency Band		Frequency Range (MHz)	Number of Channels
Operate Frequency (WLAN 2.4G)	IEEE 802.11b IEEE 802.11g IEEE 802.11n 20 MHz (64QAM) IEEE 802.11n 20 MHz (256QAM) IEEE 802.11ax 20 MHz		2412 - 2462	11
	IEEE 802.11n 40 MHz (64QAM) IEEE 802.11n 40 MHz (256QAM) IEEE 802.11ax 40 MHz		2422 - 2452	9
Operate Frequency (WLAN 5G)	IEEE 802.11a IEEE 802.11n 5 GHz 20 MHz / IEEE 802.11ac 20 MHz / IEEE 802.11ax 20 MHz	U-NII Band I	5180 – 5240	4
		U-NII Band II-A	5260 – 5320	4
		U-NII Band II-C	5500 – 5720	12
		U-NII Band III	5745 – 5825	5
	IEEE 802.11n 5 GHz 40 MHz / IEEE 802.11ac 40 MHz / IEEE 802.11ax 40 MHz /	U-NII Band I	5190 – 5230	2
		U-NII Band II-A	5270 – 5310	2
		U-NII Band II-C	5510 – 5710	6
		U-NII Band III	5755 – 5795	2
	IEEE 802.11ac 80 MHz / IEEE 802.11ax 80 MHz /	U-NII Band I	5210	1
		U-NII Band II-A	5290	1
		U-NII Band II-C	5530 – 5690	3
		U-NII Band III	5775	1
Operate Frequency (WLAN 6G)	IEEE 802.11a IEEE 802.11n HT20 / IEEE 802.11ac VHC20 / IEEE 802.11ax HE20	U-NII Band 5	5955 – 6415	24
		U-NII Band 6	6435 – 6515	5
		U-NII Band 7	6535 – 6855	17
		U-NII Band 8	6875 – 7155	13
	IEEE 802.11n HT40 / IEEE 802.11ac VHT40/ IEEE 802.11ax HE40	U-NII Band 5	5965 – 6405	12
		U-NII Band 6	6445 – 6485	2
		U-NII Band 7	6525 – 6845	9
		U-NII Band 8	6885 – 7085	6
	IEEE 802.11ac VHT80 / IEEE 802.11ax HE80	U-NII Band 5	5985 – 6385	6
		U-NII Band 6	6465 – 6545	2
		U-NII Band 7	6625 – 6785	2
		U-NII Band 8	6865 – 7025	3
	IEEE 802.11ac VHT160 / IEEE 802.11ax HE160	U-NII Band 5	6025 – 6345	2
		U-NII Band 6	6505	1
		U-NII Band 7	6665	1
		U-NII Band 8	6985	1

4.2. EUT Antenna Configuration



4.3. EUT Antenna System Description:

Ant.	Ant. Type
1	IFA Antenna
2	IFA Antenna
3	IFA Antenna
4	IFA Antenna
5	IFA Antenna
6	IFA Antenna
7	IFA Antenna
8	IFA Antenna

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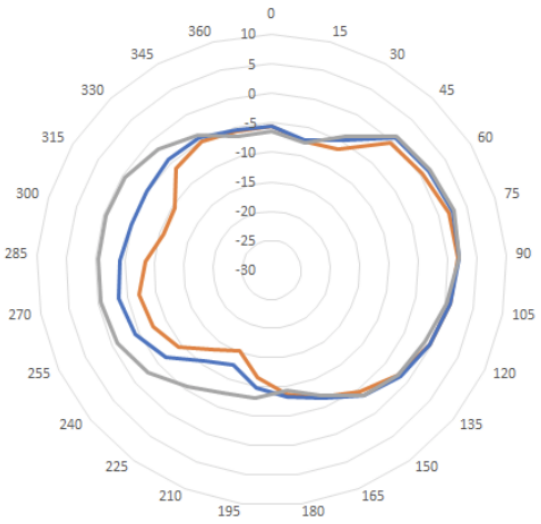
5. Result Summary and Pattern Plots

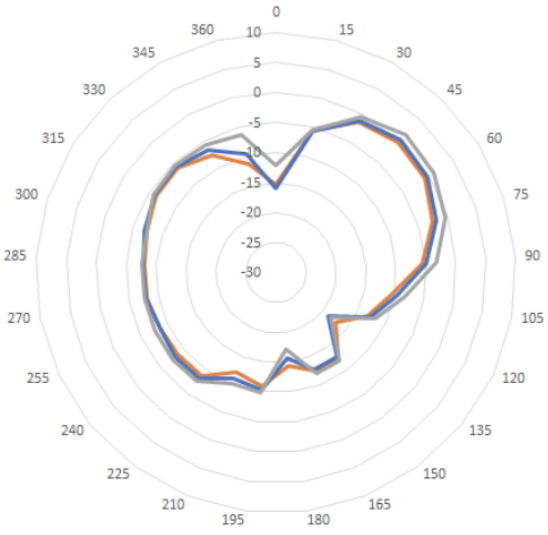
5.1. 2.4G

	Antenna 1(dBi)	Antenna 2(dBi)
2420 MHz	1.7	-0.2
2450 MHz	2.4	0.3
2480 MHz	2.6	1.4

Antenna 1



Antenna 2



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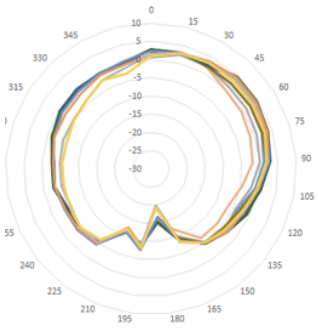
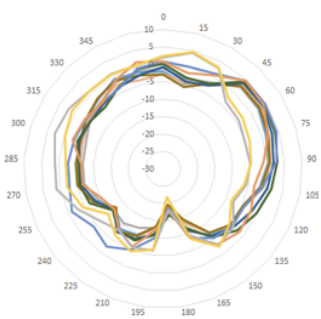
5.2. 5G

	Antenna 1 (dBi)	Antenna 2 (dBi)	Antenna 3 (dBi)	Antenna 4 (dBi)
5100 MHz	2.5	2.4	2.1	1.8
5200 MHz	3	2.7	2.3	2.2
5250 MHz (Added Point)	3	2.8	2.4	2.3
5300 MHz	3.2	3.1	2.3	2.6
5400 MHz	4.1	3.8	2.4	2.3
5500 MHz	4.6	4.4	2.5	2.5
5600 MHz	4.3	4.8	2.7	2.3
5700 MHz	4.3	4.7	2.4	2.2
5800 MHz	3.8	4.3	2.4	2.6
5900 MHz	3.1	4.6	2	2.1

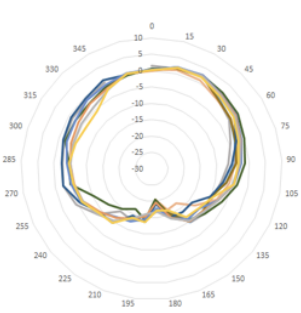
Antenna 1



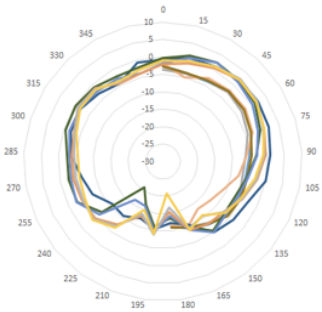
Antenna 2



Antenna 3



Antenna 4



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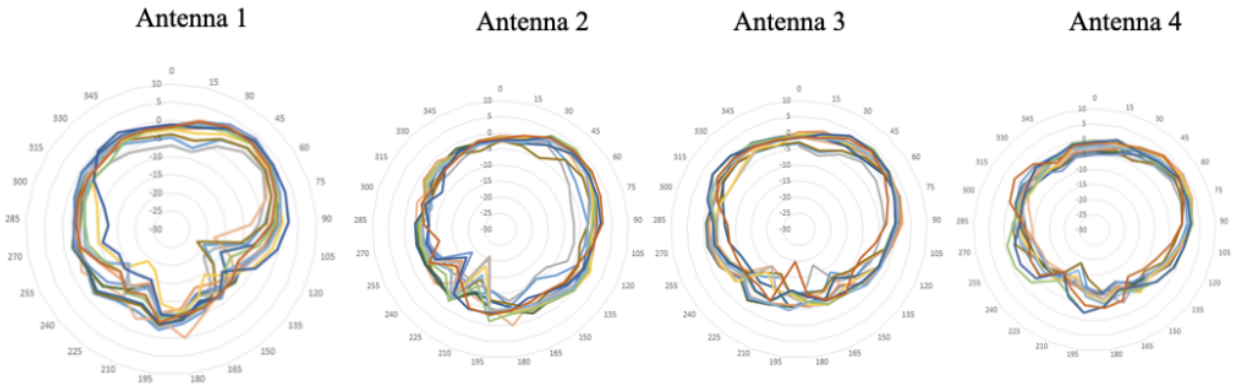
5.3. 6G

	Antenna 1(dBi)	Antenna 2 (dBi)	Antenna 3 (dBi)	Antenna 4 (dBi)
5900 MHz	-0.4	-0.1	1.4	0
6000 MHz	0.7	1	2.9	1.5
6100 MHz	0.6	0.3	2.5	1.5
6200 MHz	2.4	1.8	3	3.2
6300 MHz	3.4	2.3	2.3	3.1
6400 MHz	3.3	3.5	3	4
6500 MHz	4	3.3	3	3.8
6600 MHz	3	4.2	3.4	4.4
6700 MHz	3.7	3	2.9	3.9
6800 MHz	2.1	3.6	2.5	3.8
6900 MHz	3	3.1	2.7	2.8
7000 MHz	2.2	4.2	4	3.2
7100 MHz	3.4	3	3.5	2.5
7200 MHz	2.6	3.7	3.2	3.4



The SG 24 is ideal for the OTA testing of mobile device conformance, particularly for LTE, 5G (<10 GHz) and WiFi protocols. It offers a measurement speed up to 3 times faster and a considerably higher dynamic range in passive antenna measurement mode than the previous version. Available in 3 sizes, with the standard and large models CTIA certifiable.

- **LTE 4G and 5G NR FR1 testing**
- **CTIA certifiable**

SOLUTION FOR

- **Antenna Measurement**
- **OTA Testing**
- **CTIA Certifiable Measurement**
- **Linear Array Antenna Measurement**

Main features

Technology

- Near-field / Spherical
- Far-field

Measurement capabilities

- Gain
- Directivity
- Beamwidth
- Cross polar discrimination
- Sidelobe levels
- Front to back ratio (SG 24 - L)
- 1D, 2D and 3D radiation patterns
- Radiation pattern in any polarization (linear or circular)
- Antenna efficiency
- TRP, TIS, EIRP and EIS

Frequency bands

- SG 24 - C (Compact): 650 MHz to 6 GHz
- SG 24 - S (Standard): 400 MHz to 6 GHz
- SG 24 - L (Large): 400 MHz to 6 GHz

Option to extend the frequency band up to 10 GHz

Max. size of DUT

- 1.79 m for SG 24 - L

Max. weight of DUT

- 5 kg on polystyrene mast
- 25 kg on fiberglass mast
- 50 kg on metal mast

Typical dynamic range

- Under 6 GHz: 70 dB
- Above 6 GHz: 50 dB

Oversampling

- Elevation tilt by goniometer

System configurations

Software

Measurement control, data acquisition and post processing

■ MVG WaveStudio

Near-field/far-field transform

■ MV-Sphere

OTA measurement suite

□ MVG WaveStudio

Advanced post processing

□ Insight

Equipment

■ Amplification unit
■ Transfer switching unit
■ Uninterruptible power supply
■ DUT positioner
■ NPAC
□ Instrumentation rack
□ Vector Network Analyzer (VNA)

Add-ons

□ MIMO upgrade
○ Shielded anechoic chamber*

OTA equipment

□ Radio communication tester
□ Active switching unit

Accessories

■ Polystyrene mast
■ PC
○ Reference antennas (horns, sleeve dipoles, loops, linear array)
□ Touchscreen
□ Hand and head phantoms
□ PVC chair
□ Laptop interface
□ Positioning laser pointer
□ Linear antenna pole mast
□ Polystyrene platform mast for wide devices (tv, laptop)
□ Fiberglass mast
□ Metal mast

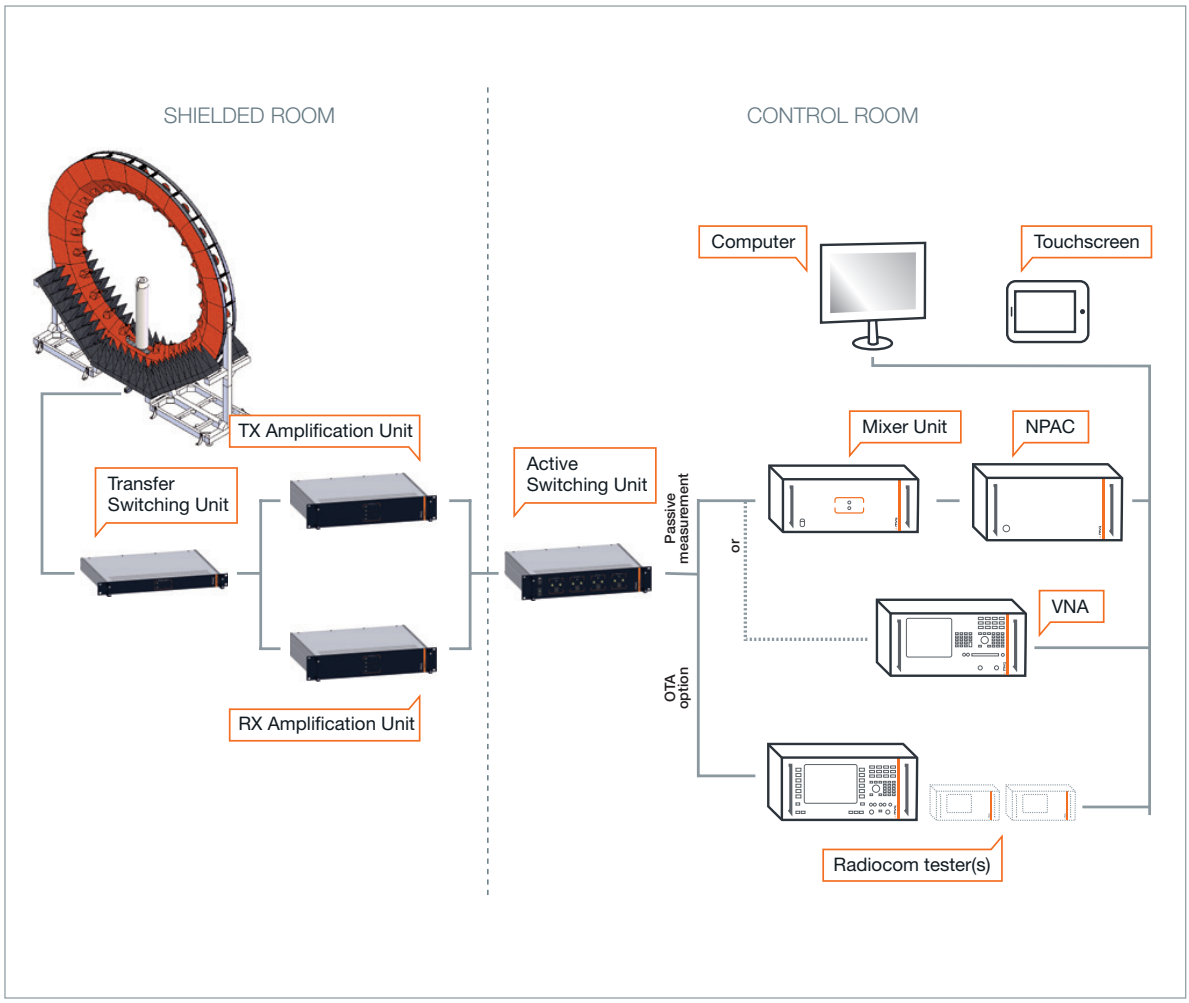
Services

■ Installation and calibration
■ Warranty
■ Project management
■ Training
□ Post warranty service plans
□ CTIA certification assistance

* See www.mvg-world.com/EMC for more information

■ Included □ Optional ○ Required

System overview



SG 24 uses analog RF signal generators to emit EM waves from the probe array to the antenna under test (AUT) or vice versa. It uses the NPAC as an RF receiver for antenna measurements. The NPAC also drives the electronic scanning of the probe array. The NPAC includes the fastest and most accurate sources and receivers on the market.

For OTA measurements, the tests are performed through the radio communication tester. The amplification units amplify the signal on transmission/reception channels to achieve optimum dynamic range. The Transfer Switching Unit is used to switch between the emission and reception modes of the AUT.

Adding the NPAC to your configuration is a great way to boost your SG 24 system capabilities. Alternatively, an existing VNA can be used if dedicated to the SG 24 system.

It allows users to perform the following measurements:

- Passive antenna complex measurements with near-field to far-field transformation
- Active CW signals measurement with near-field to far-field transformation (active CW module needed)
- Modulated signal measurements (up to 25 MHz bandwidth) with NF to FF transformation (phase recovery option needed)
- Pulsed measurements

System specifications*

	COMPACT			STANDARD			LARGE		
	10 dBi AUT	20 dBi AUT	30 dBi AUT	10 dBi AUT	20 dBi AUT	30 dBi AUT	10 dBi AUT	20 dBi AUT	30 dBi AUT
- 10 dB SIDELOBES ACCURACY									
0.4 GHz - 0.8 GHz	-	-	-	± 1.1 dB	± 0.7 dB	-	± 1.0 dB	± 0.6 dB	-
0.8 GHz - 1 GHz	± 1.0 dB	± 0.6 dB	-	± 0.9 dB	± 0.6 dB	-	± 0.8 dB	± 0.5 dB	± 0.4 dB
1 GHz - 6 GHz	± 0.8 dB	± 0.5 dB	± 0.4 dB	± 0.7 dB	± 0.5 dB	± 0.4 dB	± 0.7 dB	± 0.5 dB	± 0.4 dB
6 GHz - 10 GHz	± 0.8 dB	± 0.5 dB	± 0.4 dB	± 0.7 dB	± 0.5 dB	± 0.4 dB	± 0.7 dB	± 0.5 dB	± 0.4 dB
- 20 dB SIDELOBES ACCURACY									
0.4 GHz - 0.8 GHz	-	-	-	± 3.5 dB	± 1.1 dB	-	± 3.2 dB	± 1.0 dB	-
0.8 GHz - 1 GHz	± 3.0 dB	± 1.0 dB	-	± 2.7 dB	± 0.9 dB	-	± 2.4 dB	± 0.8 dB	± 0.5 dB
1 GHz - 6 GHz	± 2.4 dB	± 0.8 dB	± 0.5 dB	± 2.1 dB	± 0.7 dB	± 0.5 dB	± 2.1 dB	± 0.7 dB	± 0.5 dB
6 GHz - 10 GHz	± 2.4 dB	± 0.8 dB	± 0.5 dB	± 2.1 dB	± 0.7 dB	± 0.5 dB	± 2.1 dB	± 0.7 dB	± 0.5 dB
- 30 dB SIDELOBES ACCURACY									
0.4 GHz - 0.8 GHz	-	-	-	-	± 3.5 dB	-	-	± 3.2 dB	-
0.8 GHz - 1 GHz	-	± 3.0 dB	-	-	± 2.7 dB	-	-	± 2.4 dB	± 0.8 dB
1 GHz - 6 GHz	-	± 2.4 dB	± 0.8 dB	-	± 2.1 dB	± 0.7 dB	-	± 2.1 dB	± 0.7 dB
6 GHz - 10 GHz	-	± 2.4 dB	± 0.8 dB	-	± 2.1 dB	± 0.7 dB	-	± 2.1 dB	± 0.7 dB

* Specifications given according to the following assumptions:
- Controlled temperature and humidity during measurement
- Specifications on radiation pattern are given for a normalized pattern
- Measurements inside an anechoic chamber
- Usage of an Agilent PNA with 1kHz IF BW
- Peak gain is given for a ± 0.3 dB of gain error on the reference antenna
- DUT phase center does not exceed 15 cm from arch center
- Measurement performed with a suitable mast depending on the load and directivity of the DUT

** No oversampling, no averaging

Mechanical characteristics*

	COMPACT	STANDARD	LARGE
Probe array diameter (int/ext)	1.5 / 2.5 m	2.4 / 3.52 m	3.2 / 4.194 m
Shielded anechoic chamber size	3.5 x 3.5 x 2.7 m	4.0 x 4.0 x 4.0 m	5.0 x 5.0 x 5.0 m
Angle between probes	15°	15°	15°
Azimuth accuracy	0.02°	0.02°	0.02°
Azimuth max. speed	30°/s	30°/s	30°/s
Oversampling capability	Goniometer	Goniometer	Goniometer
DUT MAX. WEIGHT			
Styrofoam mast	50 kg	50 kg	50 kg
Ultra rigid mast	200 kg	200 kg	200 kg
PVC chair	Not applicable	100 kg	100 kg
Linear antenna pole mast	Not applicable	Not applicable	Option

* Centered load without oversampling

RF equipment characteristics

Number of probes	23 + 1 ref. channel	23 + 1 ref. channel	23 + 1 ref. channel
Frequency range	650 MHz to 6 GHz	0.4 GHz to 6 GHz	0.4 GHz to 6 GHz

Maximum diameter of the DUT* (m)

FREQUENCY (GHz)	NUMBER OF OVERSAMPLING x 1	x 2	x 3	x 5	x 10
0.4	1.20	1.20	1.20	1.20	1.20
1	1.15	1.20	1.20	1.20	1.20
2	0.57	1.15	1.34	1.34	1.34
3	0.38	0.76	1.15	1.34	1.34
4	0.29	0.57	0.86	1.34	1.34
5	0.23	0.46	0.69	1.15	1.34
6	0.19	0.38	0.57	0.95	1.34
10	0.11	0.23	0.34	0.57	1.15

* For standard model

OTA performance testing

SG 24 can perform both TRP and TIS measurements according to CTIA specifications. The SG 24 Compact, due to its size, is not CTIA certifiable but its performances are such that it can be defined as CTIA comparable. The SG 24 Standard and Large are CTIA certifiable.

OTA performance measurement specifications*

	COMPACT	STANDARD	LARGE
ACCORDING TO CTIA SPECIFICATIONS			
TRP accuracy free space	<± 1.6 dB	<± 1.5 dB	<± 1.4 dB
TRP accuracy talk position	<± 1.7 dB	<± 1.6 dB	<± 1.5 dB
TRP repeatability	± 0.3 dB	± 0.3 dB	± 0.3 dB
Typical TRP measurement time**	< 1 min	< 1 min	< 1 min
TIS accuracy free space	<± 1.7 dB	<± 1.6 dB	<± 1.5 dB
TIS accuracy talk position	<± 1.8 dB	<± 1.7 dB	<± 1.6 dB
TIS repeatability	± 0.5 dB	± 0.5 dB	± 0.5 dB
Typical TIS measurement time***	5 min → 20 min	5 min → 20 min	5 min → 20 min
CTIA COMPARABLE			
• GSM/WCDMA PROTOCOLS:			
TIS based on Rx Level accuracy	<± 2.3 dB	<± 2.3 dB	<± 2.3 dB
TIS based on Rx Level repeatability	<± 1.5 dB	<± 1.5 dB	<± 1.5 dB
Typical TIS based on Rx level measurement time***	< 5 min	< 5 min	< 5 min

* Specifications given according to the following assumptions:
- Controlled temperature and humidity during measurement
- Measurements inside an anechoic chamber
- DUT phase center does not exceed 15 cm from arch center
- Calibration done with dipole efficiency reference values

Specifications also depend on Radio Communication Tester and Protocol

** One channel, 15 deg sampling, one time each probe, measurement time depends on protocol

*** One channel, 30 deg sampling, one time each probe, measurement time depends on protocol

MVG - Testing Connectivity for a Wireless World

The Microwave Vision Group offers cutting-edge technologies for the visualisation of electromagnetic waves. Enhancing the speed and accuracy of wireless connectivity testing, as well as the performance and reliability of anechoic and EMC technologies, our systems are integral to meeting the testing challenges of a fully connected world.

WORLDWIDE GROUP, LOCAL SUPPORT

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