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

WLAN Antenna Summary Report

Applicant	:	Plume Design, Inc.
Product Type	:	SuperPod with WiFi 6
Model Number	:	F3A, F4A

1. Equipment Configuration

1.1. 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

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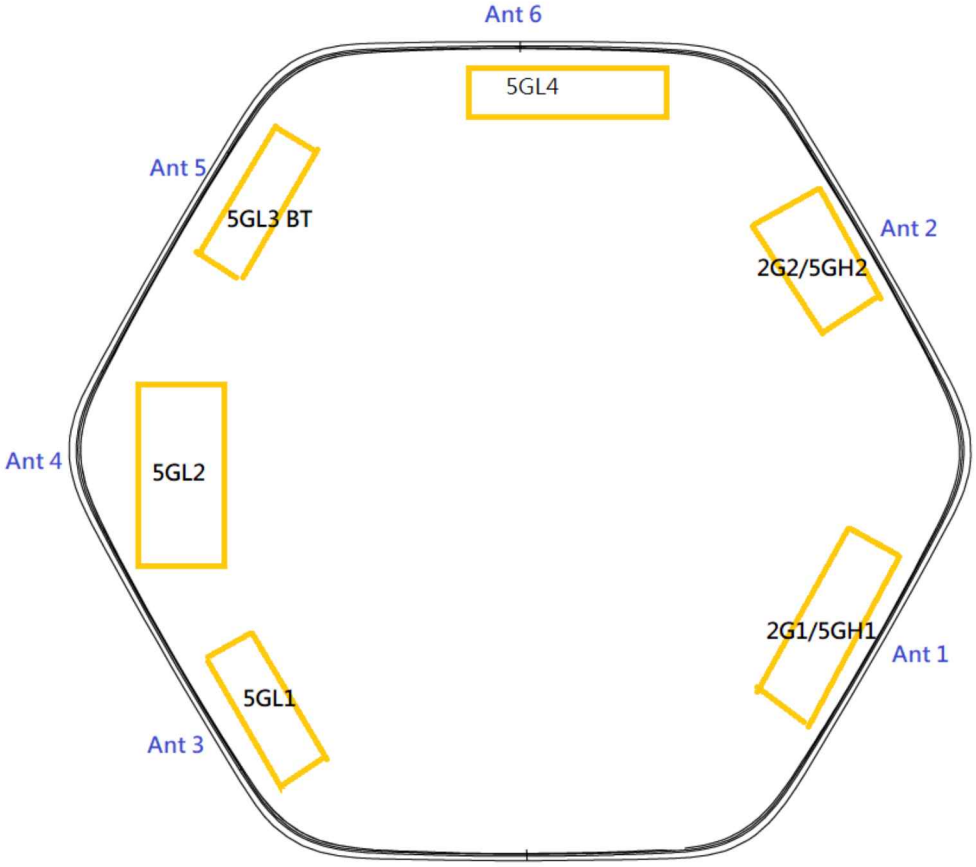
1.2. EUT Antenna Configuration



1.3. EUT Antenna System Description:

Ant.	Ant. Type
1	PIFA Antenna
2	PIFA Antenna
3	PIFA Antenna
4	PIFA Antenna
5	PIFA Antenna
6	PIFA Antenna

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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. The detail refers to the Appendix.

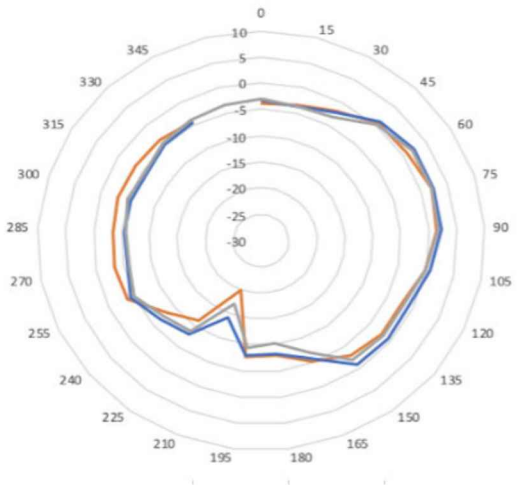
https://www.mvg-world.com/upload/media/products_document/0001/01/33c73d0de678c128f7650172d73ace3d3d86422a.pdf

4. **Result Summary and Pattern Plots**

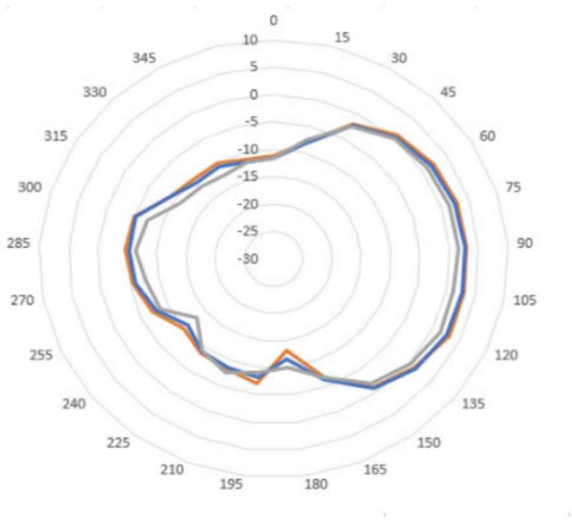
4.1. 2.4G

	Antenna 1(dBi)	Antenna 2(dBi)
2420 MHz	2.2	3.1
2450 MHz	2.5	2.7
2480 MHz	1.7	1.6

Antenna 1



Antenna 2



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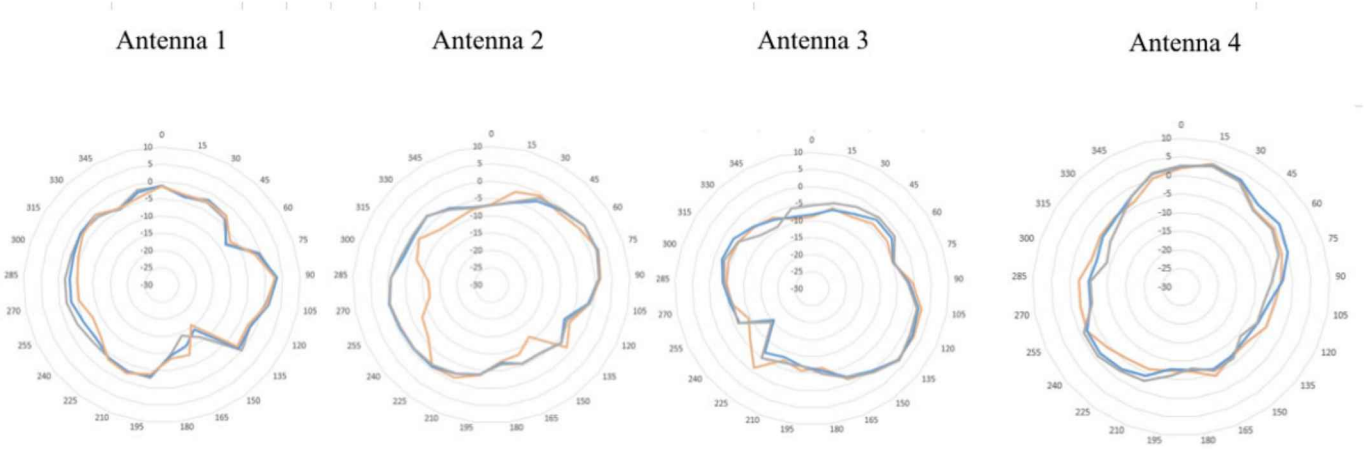
4.2. 5GLB

	Antenna 1 (dBi)	Antenna 2 (dBi)	Antenna 3 (dBi)	Antenna 4 (dBi)
5100 MHz	3	2.5	2.9	4.2
5200 MHz	3.3	2.2	3	3.7
5250 MHz (Added Point)	3.2	2.1	3.1	3.7
5300 MHz	2.7	2	3	3.4



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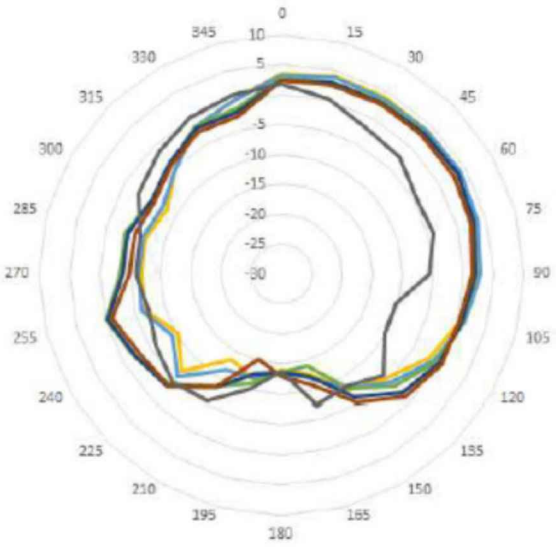
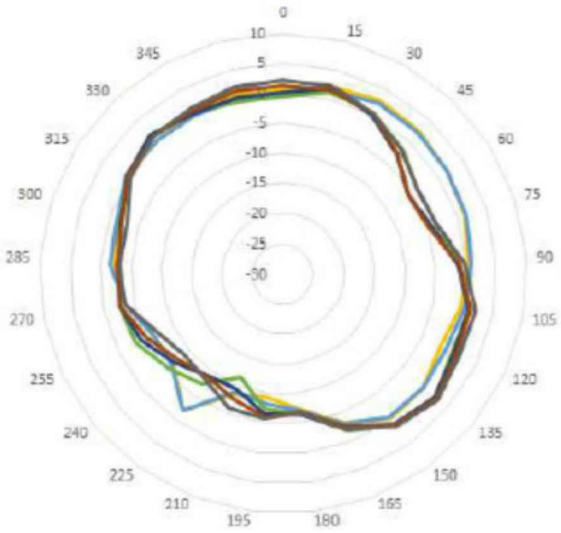
4.3. 5GHB

	Antenna 1(dBi)	Antenna 2(dBi)
5400 MHz	4.1	2.9
5500 MHz	4.1	2.2
5600 MHz	3.7	2.3
5700 MHz	3.5	2.1
5800 MHz	2.8	2.4
5900 MHz	1.7	2.8

Antenna 1



Antenna 2



SG 24

A Multi-Probe Antenna Measurement System Ideal for OTA Testing

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

- 200 kg

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

□ SatSim
□ 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

■ Styrofoam mast
■ PC
○ Reference antennas (horns, sleeve dipoles, loops, linear array)
□ Touchscreen
□ Hand and head phantoms
□ PVC chair
□ Laptop interface
□ Ultra rigid mast
□ Linear antenna pole mast
□ Positioning laser pointer
□ TV mast

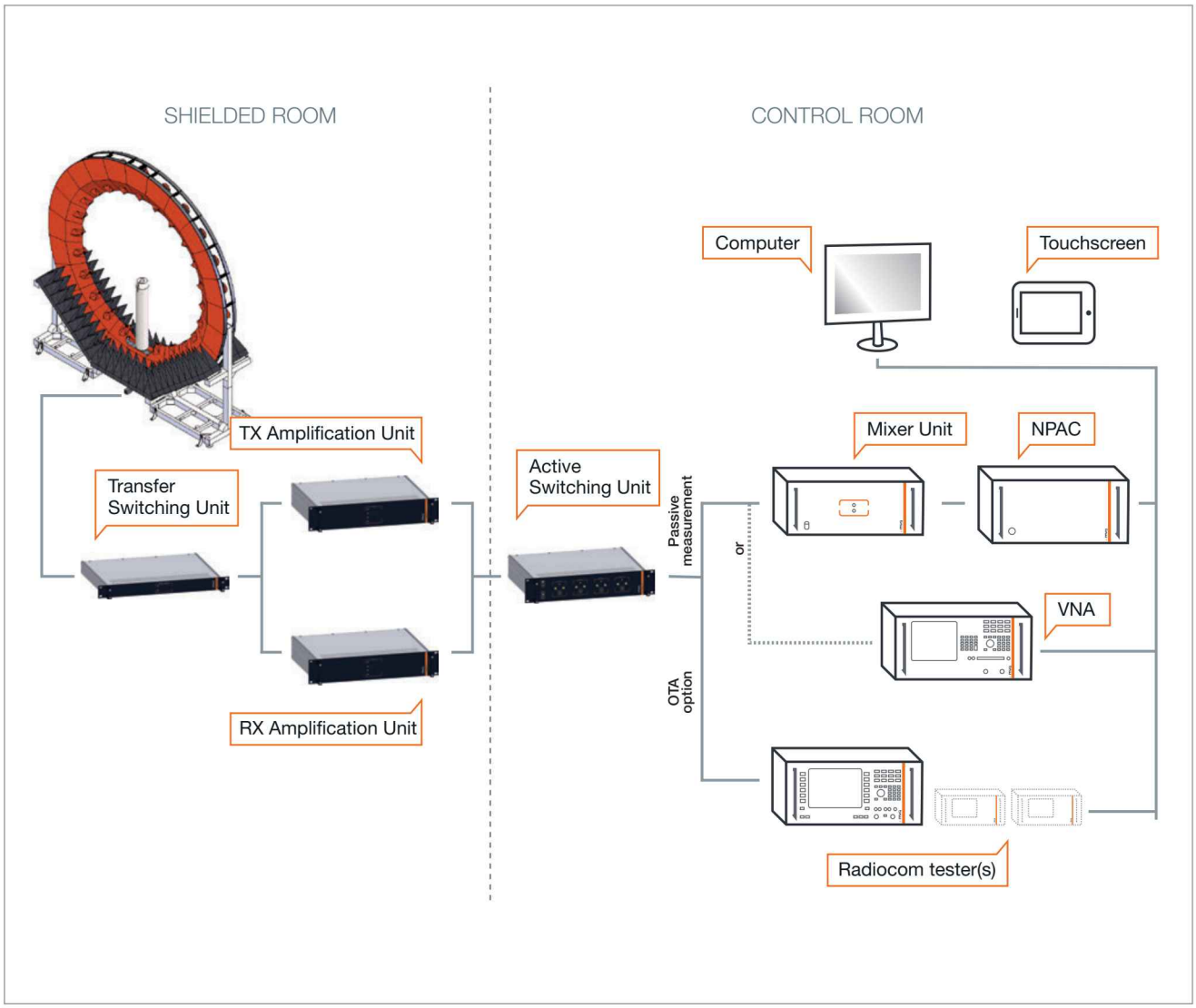
Services

■ 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.

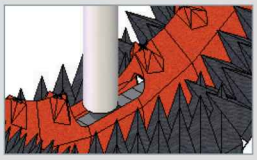
For OTA measurements, the tests are performed through the radio communication tester. The amplification units amplify the signal on transmission/reception channels to achieve optimum dynamic range. The Transfer Switching Unit is used to switch between the emission and reception modes of the AUT.

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:

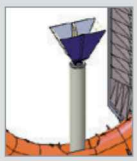
- Passive antenna complex measurements with near-field to far-field transformation
- Active CW signals measurement with near-field to far-field transformation (active CW module needed)
- Modulated signal measurements (up to 25 MHz bandwidth) with NF to FF transformation (phase recovery option needed)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

Standard system components



1 Arch

- Probes: DP 400 - 6000



2 Mast

- Styrofoam mast
- Linear antenna mast
- PVC chair
- Laptop interface
- TV mast

3 Patented Oversampling

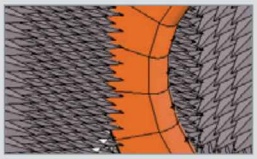
Goniometers are used to perform oversampling.

- A choice of goniometers depending on the size of the arch, the max. weight of the DUT and the frequency range.

4 Antennas

- A choice of reference antennas (horns, dipoles and loops)

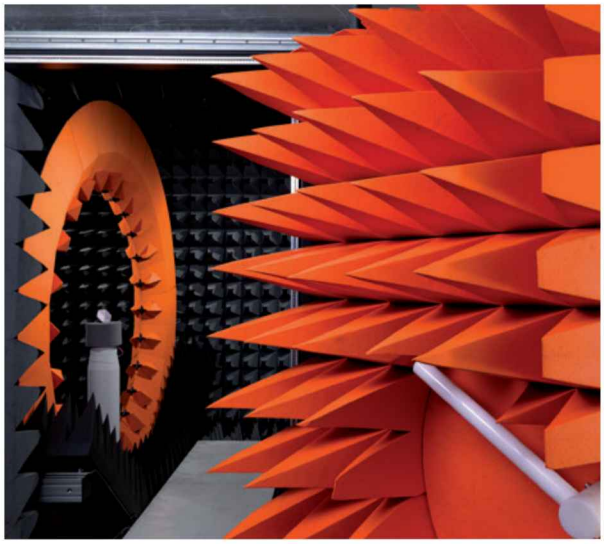
Antenna Product Overview
https://www.mvg-world.com/antennas

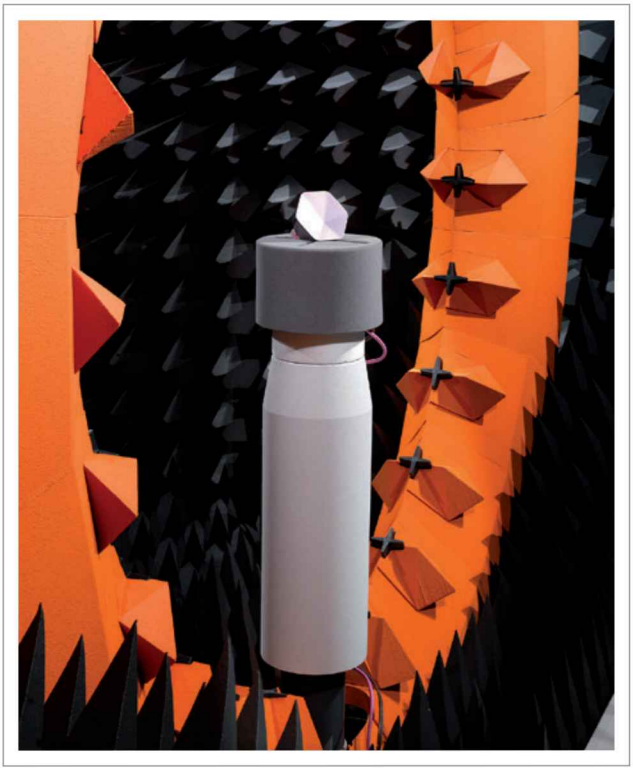


5 Absorbers and anechoic chambers

- A choice of standard, adapted and specialty absorbers
- Anechoic chambers with integrated design, production, installation and testing services

Absorber Product Overview
https://www.mvg-world.com/absorbers





System specifications*

	COMPACT			STANDARD			LARGE		
Measurement time for 11 frequencies**	~ 1 min			~ 1 min			~ 1 min		
Typical dynamic range 0.4 GHz - 6 GHz	70 dB			70 dB			70 dB		
Typical dynamic range 6 GHz -10 GHz	50 dB			50 dB			50 dB		
	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**
PEAK GAIN ACCURACY									
0.4 GHz - 0.8 GHz	-	-	-	± 1.1 dB	± 1.0 dB	-	± 1.0 dB	± 0.9 dB	-
0.8 GHz - 1 GHz	± 0.8 dB	± 0.7 dB	-	± 0.6 dB	± 0.6 dB	-	± 0.6 dB	± 0.6 dB	± 0.5 dB
1 GHz - 6 GHz	± 0.8 dB	± 0.7 dB	± 0.6 dB	± 0.6 dB	± 0.6 dB	± 0.5 dB	± 0.6 dB	± 0.6 dB	± 0.5 dB
6 GHz - 10 GHz	± 0.8 dB	± 0.7 dB	± 0.6 dB	± 0.6 dB	± 0.6 dB	± 0.5 dB	± 0.6 dB	± 0.6 dB	± 0.5 dB
Peak gain repeatability	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB	± 0.3 dB

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

Our teams, in offices around the world, guide and support you from purchase, through design, to delivery and installation. Because we are local, we can assure speed and attention in project follow through. This includes customer support and maintenance once the system is in place. For the exact addresses and up-to-date contact information: **www.mvg-world.com/contact**

Contact your local sales representative for more information

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salesteam@mvg-world.com