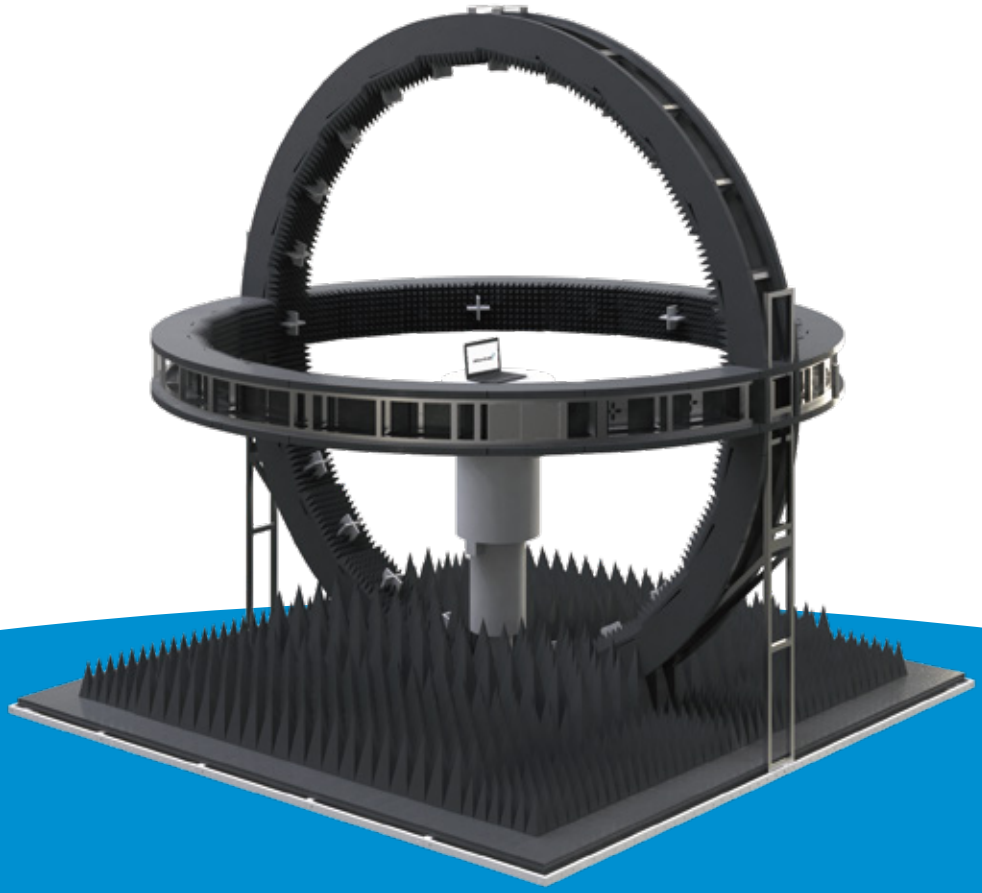
atenlab

Multi-probe wireless communication measurement system

M

- Applicable for communication, IC design and electromagnetic field of study & research.
- Best tools for phone, location-based service, antenna, handhelds and system development.
- Applicable for research, product development and production quality validation and verification



www.atenlab.com.tw

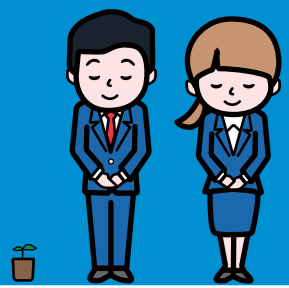
Persistence X Eternal

18 We are already here.

Atenlab X Measurement Expert

With over 18 years of experience, Atenlab has developed a wealth of expertise, high-quality equipment, and flexible service solutions.

To localize global trade, Atenlab strives to provide real-time support 24/7. To make it possible, Atenlab follows a strict review procedure and training courses to help local agent serve every customers well, and ensure every problem is taken care of instantly. That is why Atenlab is not just an industry expert, but a reliable partner good at dealing with unexpected issues and risks.



Origin X 2004

Atenlab focuses on increasing the productivity of antenna, measurement systems and RF equipment. High efficiency, cost effective and high functionality are what make us the best partner when it comes to products.

2004 atenlab

• Atenlab established

• Launched 3G-WCDMA, A class

2007

2008 CTIA

• Passed the CTIA Certification

• Launched EMC Anechoic Chamber, E class

2010

2023
CST

• Agent CST Studio Suite

B5G
2024

• Low Earth Orbits, LEO S class, Wi-Fi 7

certified
• ISO17025 •

• Planning and building TTC laboratory, Passed the ISO17025-5G qualification.

2014

• Launched 4G-LTE MIMO, M class

• Launched 5G mmWave CATR, R class

2017
EMC

• Planning and building UL laboratory, Passed the ISO17025-EMC qualification.

certified
• ISO17025 •

5G
2021

2015

Future X 2030

Atenlab has built a strong foundation based on a great amount of experience and achievements along the way. We are dedicated to diving into the core of the cutting-edge sixth-generation technology and internet of things, to integrate high-speed transmission and multi-channel technologies.

Atenlab will shape the future of the communication industry in the way it should be.

Atenlab X The Measurement Foundation

A measurement system is an applied science, there is no best, only better. It is firmly rooted in fundamental principles.

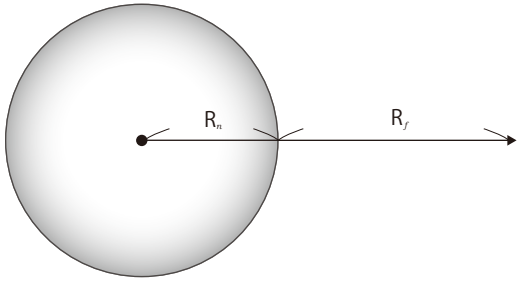
Multi-Probe X Communication

A typical single-probe system is widely used for voice communication because it requires a lower speed than data transmission. If the number of probes is increased, data transmission can be accelerated within the same period of time. This is the core technology of 4G LTE.

Multi-probe communication system utilizes multiple single probe working together within a communication system. All single probe units work together cohesively to increase the efficiency of the MIMO system.

Multiple-channel communication will be the mainstream architecture in the near future. Engineers will require higher-level development tools and the current equipment should be upgraded to accommodate the complexity and demands of MIMO.

Near-field X Far-field



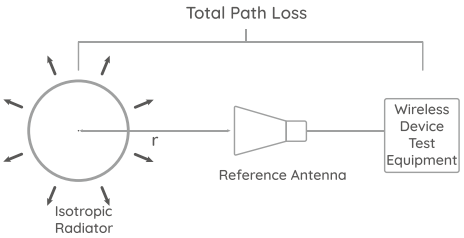
$$R_f > \frac{2D^2}{\lambda} > R_n$$

R_n : Near-field
R_f : Far-field
λ : Wavelength
D : Antenna Size

There are two types of antenna radiation patterns Near-field and Far-field. For a long time, there is no established standard to estimate the difference between the two of them. But the key factor to tell the difference is to determine if the EM wave is in planar form.
If it is plane wave then it would be Far-field, otherwise, Near-field.
The physical meaning of a plane wave is that the phase of the wave fronts is the same, which means the arrival time of the wave fronts is the same. which is the measurement range of the far field. A non-planar wave can be referred to as a spherical wave, with different arrival times of the wavefront. This range has a larger air loss and is the measurement range of the near field.

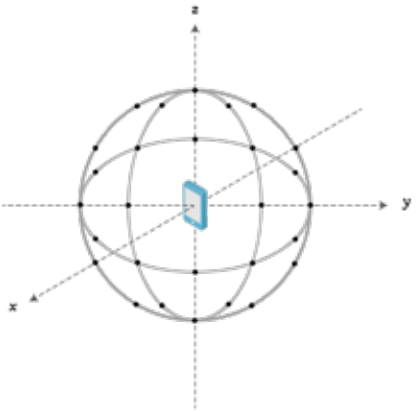
Calibration X Quality

According to CTIA, this is the standardized antenna comparison method.The measurement data of the DUT is obtained by comparing it with a standard antenna, and the measurement accuracy is based on the standard antenna. Therefore, placing the standard antenna in the system and performing path loss calibration is the core principle of the measurement method.



Calibration X Quiet Zone

The quiet zone is an imaginary space. The measurement method would be to collect the data at the boundary of the quiet zone, once the data is captured and organized, the quality of the quiet zone can be verified.



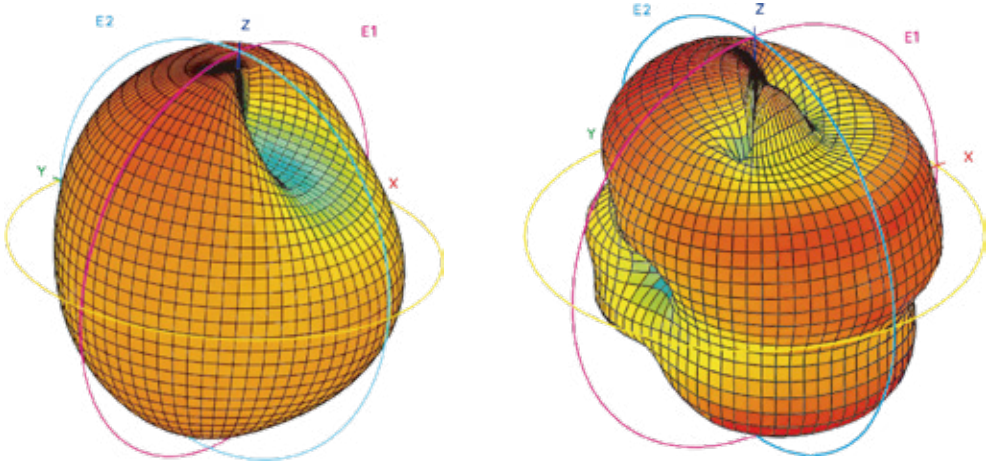
High Frequency X Development

TRP (Total Radiated Power)

Total radiated power is an important parameter in the measurement system, used to represent the total output power of the test object. When the device under test (DUT) is a terminal device, a connection is established between the simulated base station and the terminal to maintain communication. The power of the DUT is measured from different directions, and the calculated and analyzed result is TRP.

TIS (Total Isotropic Sensitivity)

Omnidirectional sensitivity refers to the sensitivity performance of the DUT in all directions. It represents the object's sensitivity to external stimuli and indicates the object's sensitivity to its surroundings. The measurement method is similar to TRP, but the power value is changed to sensitivity measurement, and the calculation analysis result is TIS. When sensitivity measurement takes more time, the communication power must be gradually reduced until the power value that affects the communication quality of the test object is reached, which is sensitivity.



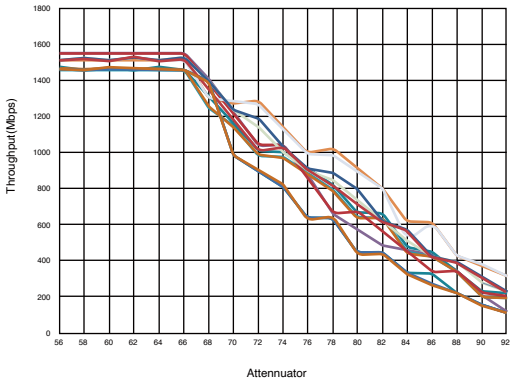
Digital X Measurement

Data Throughput

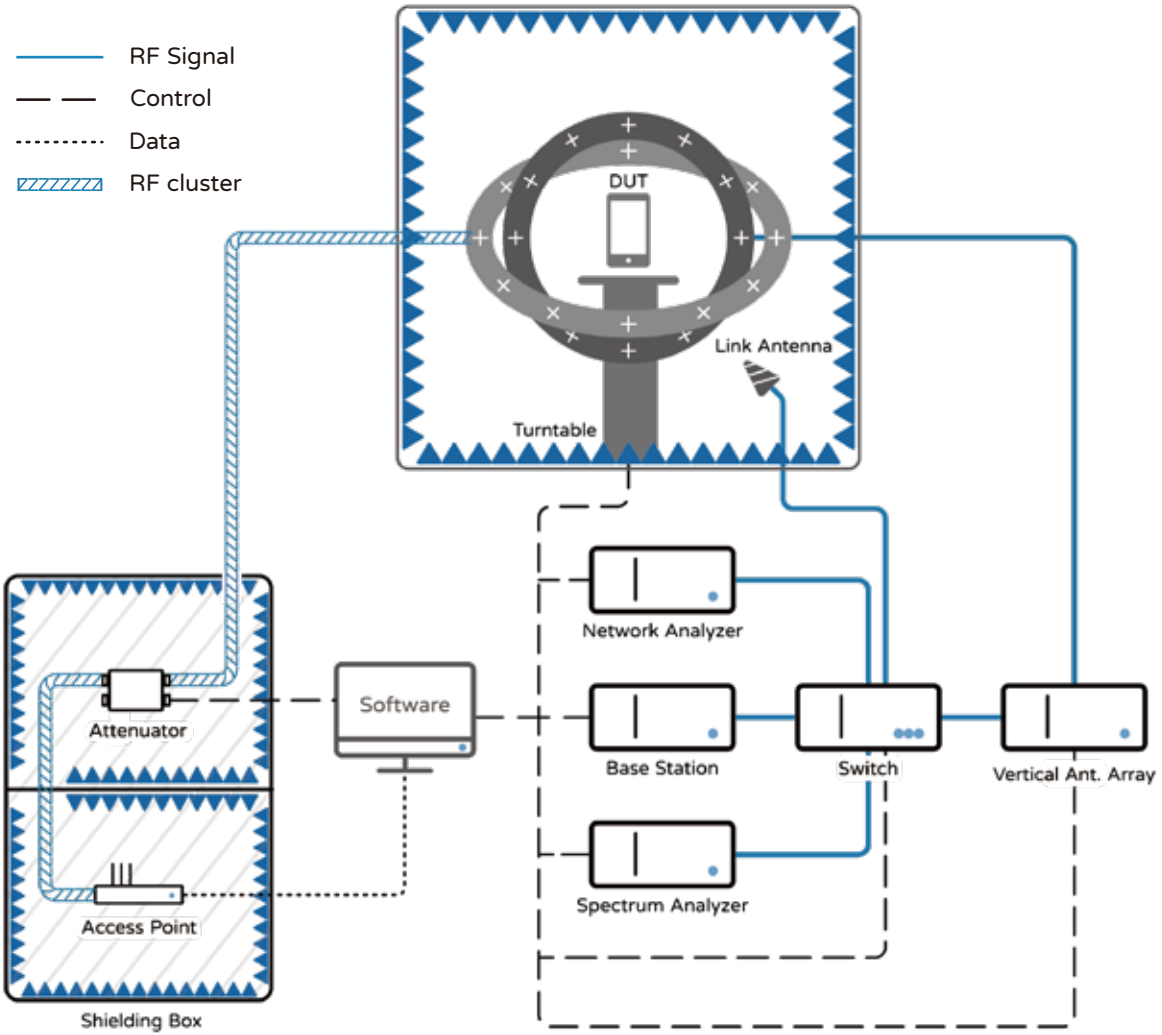
Traditional high frequency measurement can no longer meet the data communication needs. From the traditional voice communication to today's video communication, the mode has changed from single-channel (SISO) to multi-channel (MIMO), and the measurement method has shifted from power energy indicators to data throughput indicators. The core of this change is that in communication systems, the output power continues to decrease, and theoretically the transmission rate will also decrease, but due to the technology of MIMO and multiple paths, the communication system's sensitivity and transmission rate will be improved. By comparing the output power and data transmission, the system's MIMO performance can be evaluated.

Transmission immunity

Similar to the sensitivity measurement method, while maintaining a fixed output power, external noise is added to the system, and theoretically, the transmission rate will decrease. Therefore, the measurement method of digital sensitivity is different from the traditional high-frequency measurement from this perspective.



Multi-Probe X System Architecture



Atenlab X Maxwell

Maxwell's equations were developed by a Scottish-born scientist, are a set of partial differential equations of electric field, magnetic field, electric charge density and current density.

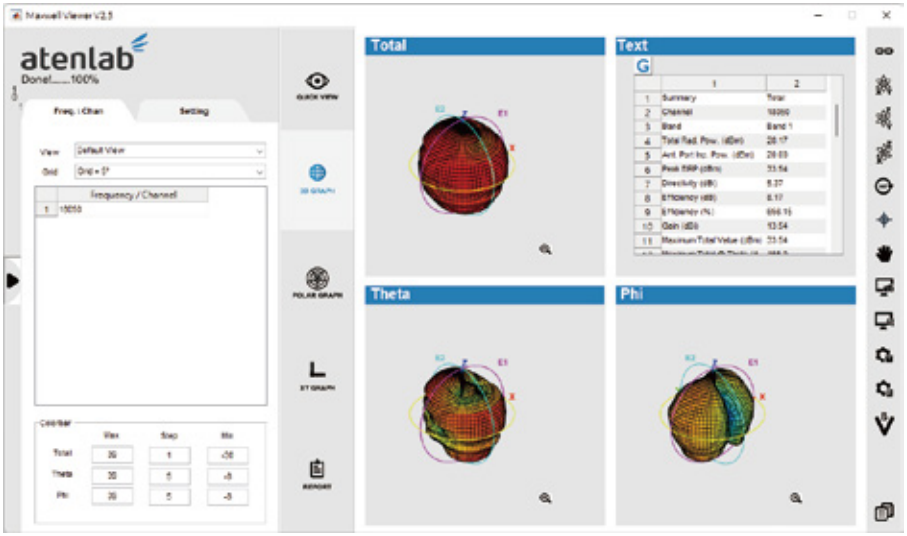
Atenlab integrates all the electromagnetic measurement technology and methods and has successfully sold hundreds of systems since 2004. Atenlab has thousands of active users in the mobile communication and Wi-Fi field. Atenlab's Maxwell family includes MWT, MW5 and MWC, and MWK for calibration and MWV for viewing. They are also constantly upgraded.

Maxwell X Software

MWV

Maxwell Viewer provides the login system, monitor data in real time with multiple infographics, and produces test reports based on particular needs . It's easy to use and also supports many specifications.

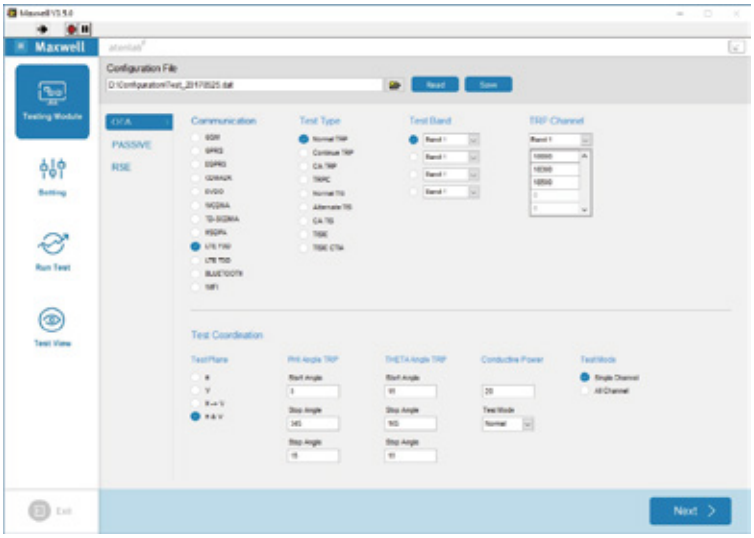
- 2D/ 3D visualization reports show measurement results.
- Varied data analyses and cross-comparison picture.
- Customizable standard reports.
- Support major magnetic simulation's data.



MW5

The most advanced OTA measurement software. Shipped with the core technology from 2G to 5G, assembled the world-renowned manufacturing firm's control command, and backed by countless user feedback, MW5 is stable and mature .

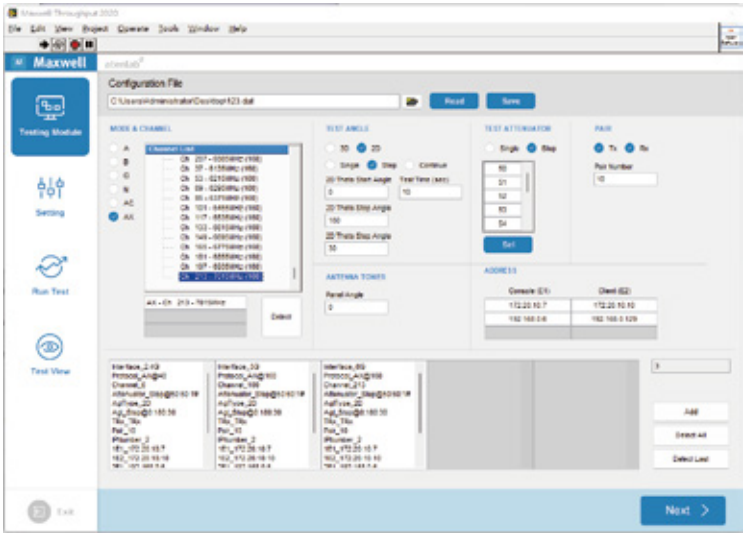
- Support GSM, CDMA, W-CDMA, TD-SCDMA, LTE, 5G FR1, FR2
- UWB, GPS, A-GPS, Bluetooth, Wi-Fi a/b/g/n/ac/ax/be
- Free trial; remote maintenance and upgrades.



MWT

Introducing a new member from the Maxwell family, Maxwell Throughput. Atenlab provides a specific measurement plan for high-speed data and multi-channel architecture, adding new performance evaluation capabilities to help developers break through existing challenges.

- Supports IxChariot, iPerf3, and chip manufacturer's core algorithms.
- Customized schedules, test items, test channels, and comply with TR-398.
- The exclusive AP brings you a more efficient measurement process.



Atenlab X Selection

If you have identified the M class as your selection, please spend some time learning the details and differences of each member of the class.

Based on the wealth of user experiences, Atenlab provides multiple specifications to suit your needs.

M class X Comparison

SISO System	M3	M4
Outside Dimension (L/W/H)	3.0 x 3.0 x 3.0 m	4.2 x 4.2 x 4.2 m
Measurement Distance	>1.0m	>1.5m
Angular Resolution	15° / 12 Antennas	15° / 23 Antennas
Antenna Array Configuration	Arch Type	Ring Type
Operating Frequency	0.68-8GHz	0.68-8GHz
Quiet Zone Characteristic	30cm SD < 1.2	50cm SD < 1.2
Shielding Effectiveness	0.03-18GHz > 100dB	
Absorber Material	Expandable Polypropylene	
System Stability	Ant. Eff. SD < 10% TRP SD < 0.5dBm TIS SD < 1dBm	
Test Time	Ant. Eff. < 60s TRP < 120s / Ch. TIS < 300s / Ch.	Ant. Eff. < 40s TRP < 100s / Ch. TIS < 300s / Ch.
Test Function	Antenna Performance / Receiver Sensitivity / Transmit Power Communication Coexistence / Carrier Aggregation	
Test Item	EIRP / EIS / TRP / TIS Ant. Eff. / Antenna Pattern / Gain	
Communication Protocol	GSM / CDMA / TD-SCDMA / WCDMA / LTE 5GNR FR1 / BT / Wi-Fi / NB-IoT	

MIMO System	M3			M4		
Measurement Distance	>1.0m			>1.5m		
Numbers of Antenna	4	8	16	4	8	16
Antenna Array Configuration	Directional			Directional / Isotropic		
Antenna Horizontal spacing	+/- 67.5 °			+/- 180 °		
Antenna Vertical spacing	+/- 22.5 °			+/- 22.5 °		
Communication channel	4T4R / 8T8R / 16T16R					
Test Funcation	Maximum Throughput Test Range Versus Rate Test Spatial Consistency Test AP Coexistence Test Stabillity TR-398 Compliance					
System Stability	Data Throughput SD < 10% in Average					
Insertion Attenuation	0-110 dB, step 1dB					
Path Loss(Include Attenuator)	53dB @ 2.4GHz; 60dB @ 6GHz			57dB @ 2.4 GHz; 64dB @ 6 GHz		
Support Software	IPerf3 / IxChariot					

M class X Size

	M3-1.0	M3-1.5
Outside Dimension (L/W/H)	3.0 x 3.0 x 3.0 m	4.2 x 4.2 x 4.2 m
Working Dimension(L/W/H)	3.2 x 4.3 x 3.3 m	4.4 x 5.5 x 4.5 m
Electrical	220VAC 50Hz 32A	220VAC 50Hz 32A
Regular Lead Time (Working Days)	45	45
Temporary Storage Spaceing	27 x 27 m	48 x 48 m

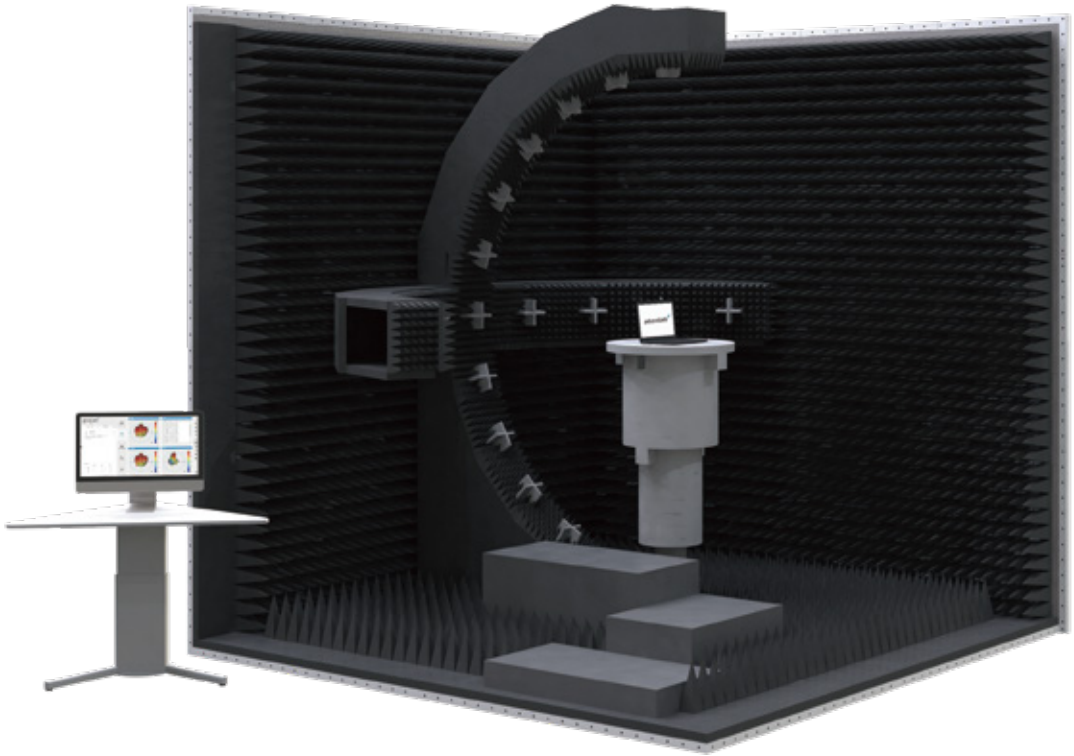
	M4-1.0	M4-1.5
Outside Dimension (L/W/H)	3.0 x 3.0 x 3.0 m	4.2 x 4.2 x 4.2 m
Working Dimension(L/W/H)	3.2 x 4.3 x 3.3 m	4.4 x 5.5 x 4.5 m
Electrical	220VAC 50Hz 32A	220VAC 50Hz 32A
Regular Lead Time (Working Days)	45	45
Temporary Storage Spaceing	27 x 27 m	48 x 48 m

M3 X Delicate

The M3 Multi-probe OTA Measurement System Standard package is designed for user who does not have enough budget and space but pursue complete measurement capabilities . This package does not compromise on the accuracy and fullfil customer's needs.

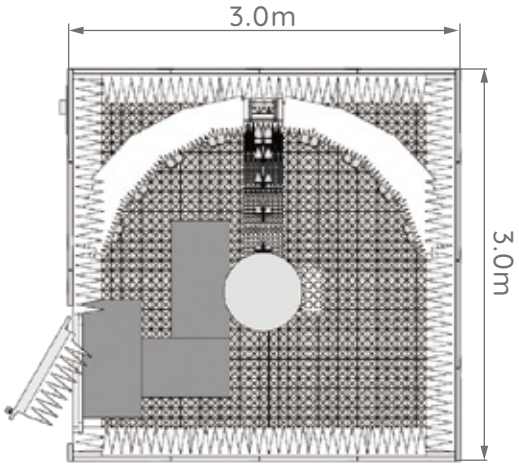
M3 X Appearance

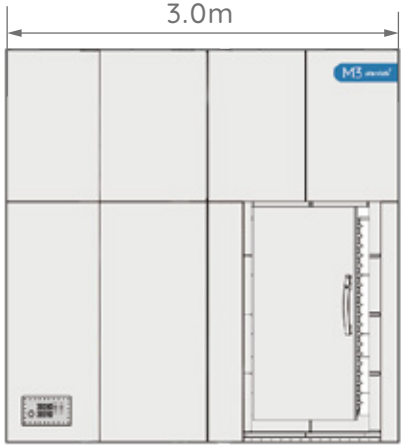
- Affordable
- Space Saving
- Fully Functional

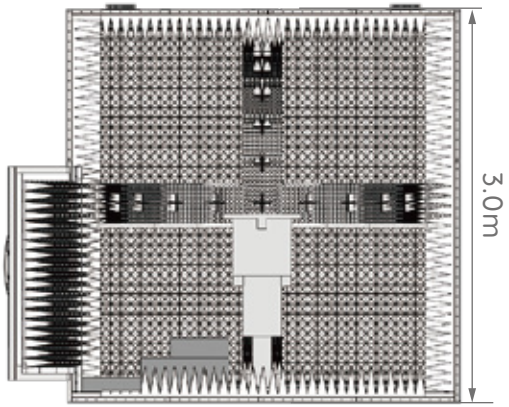


M3 X Three-View-Drawing

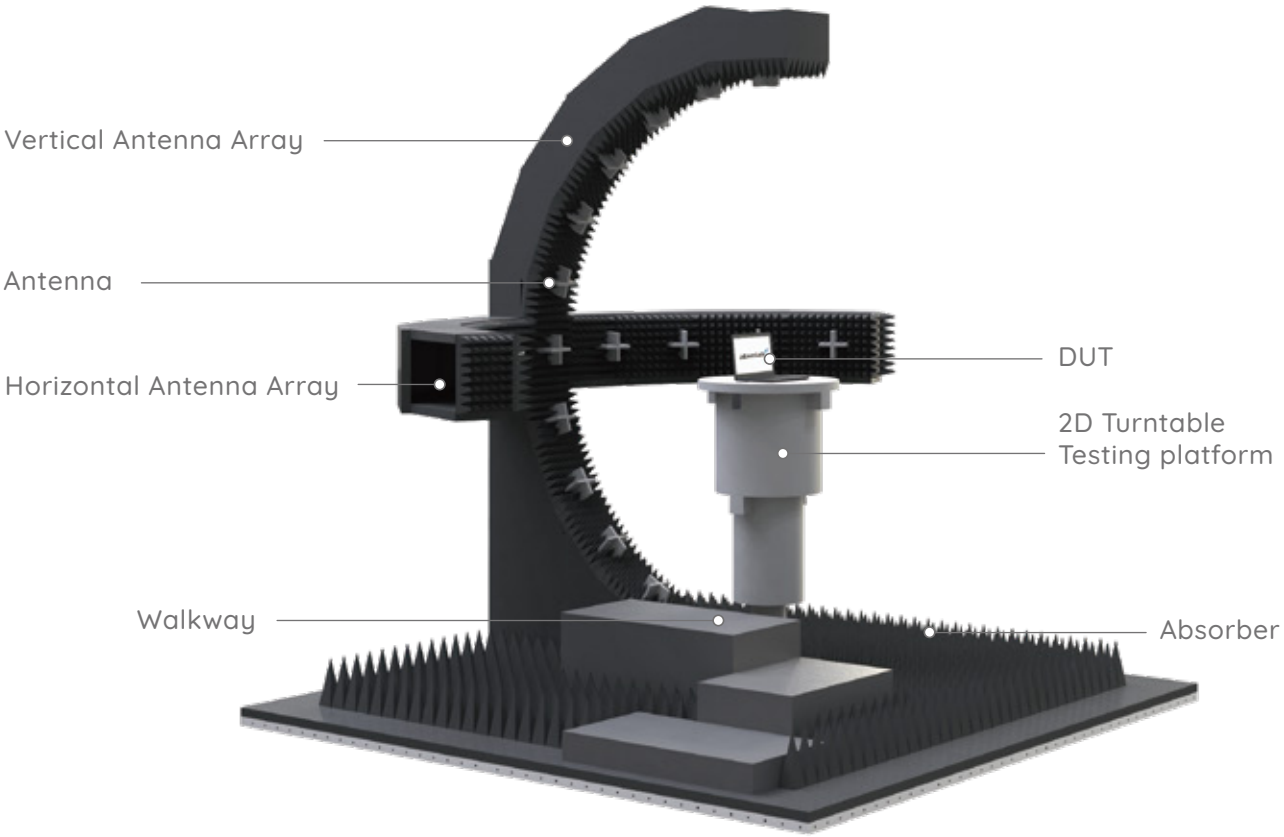
- Size: L3.0 x W3.0 x H3.0 m
- Weight: 4,000kg
- Built space: L3.2 x W4.3 x H3.3 m
- Floor-loading capacity: 250kg/m^2







M3 X Internal



M3 X Specifications

SISO System	M3	
Measurement Distance	> 1.0m	> 1.5m
Mlaximum Tested Object	0.5m	0.7m
Quiet Zone Size	0.3m	0.5m
Quiet Zone Characteristics	SD < 1.2	SD < 1.2
Operating Frequency	0.68 - 8GHz / 2 - 18GHz	
Number of Antennas	12 Antennas	
Antenna Array Configuration	Arch Type	
Antenna Framework	Vertical Array	
Angular Resolution	15°	
Passive Test Time	Ant. Eff. < 60s	
TRP Test Time	TRP < 120s / Channel	
TIS Test Time	TIS < 300s / Channel	
Test Funcation	Antenna Performance / Receiver Sensitivity / Transmit Power Communication Coexistence / Carrier Aggregation	
Test Item	EIRP / EIS / TRP / TIS / Ant. Eff. / Antenna Pattern / Gain	
Communication Protocol	5GNR FR1 / LTE TDD / FDD / LTE Cat-M / NB-IoT / Bluetooth Wi-Fi 802.11a / b / g / n / ac / ax / be WCDMA / HSDPA / HSPA / HSPA+ / HSUPA TD-SCDMA / TD-HSDPA / GSM / GPRS / EDGE CDMA2000 / CDMA 1xRTT / CDMA 1xEVDO	
System Stability	Ant. Eff. SD < 10% TRP SD < 0.5dBm ; TIS SD < 1dBm	

MIMO System	M3					
Measurement Distance	> 1.0m			> 1.5m		
Number of Antennas	4	8	16	4	8	16
Communication Channel	4T4R	8T8R	16T16R	4T4R	8T8R	16T16R
Operation Frequency	2-18GHz					
Antenna Array Configuratior	Directional					
Antenna Horizontal Spacing	+/- 67.5 °					
Antenna Vertical Spacing	+/- 22.5 °					
Test funcation	Maximum Throughput Test / Range Versus Rate Test Spatial Consistency Test / AP Coexistence Test Stability / TR-398 Compliance					
System stability	Data Throughput SD < 10% in Average					
Insertion Attenuation	0-110dB , step 1dB					
Path Loss	53dB @ 2.4GHz ; 60dB @ 6GHz			57dB @ 2.4GHz ; 64dB @ 6GHz		
Support Software	IPerf3 / IxChariot					

M3 X Hardware Specifications

Anechoic Chamber	M3	
Outside Dimension(L/W/H)	3.0 x 3.0 x 3.0 m	4.2 x 4.2 x 4.2 m
Inside Dimension(L/W/H)	2.9 x 2.9 x 2.9 m	3.9 x 3.9 x 3.9 m
Shielding Effectiveness	0.03-18GHz > 100dB	
Shielding Steel Sheet Thickness	2mm	
Shielding Door	Electric Auto Latching	
Shielding Door Dimension(W/H)	1.0 x 2.0 m	
Air Vent	0.3 x 0.3 m	
Power Source Filter	1P2W 100-280 VAC / 16A	
Signal Filter	USB 3.0 / RS-232 / RS-485 / RJ-45 1Gbps / RJ-45 10Gbps (Optional)	
Lighting	LED	
Laser Line	3 laser red line	
CCTV	2560 x 1440 @30fps PTZ Joystick Controller (Optional)	

Communication Antenna		
Operating Frequency	0.45 - 8GHz	0.65 - 8GHz
Antenna Gain	4 dBi	6 dBi
Number of Polarization	Single Polarization	Single Polarization
Polarization Direction	Circular Polarization	Circular Polarization
Max. Watt	4 Watt CW	4 Watt CW
Connector	SMA	SMA

Positioner		
DUT Platform Diameter	0.5m	0.8m
Turntable Diameter	0.2m	
Turntable Load	30kg	
Max. Turntable Speed	3 RPM	
Turntable Resolution	0.1°	
Turntable Accuracy	±0.5°	
Rated Power	200W	

SISO Switching Box	Passive	Passive / Cellular	Passive / Cellular BT / Wi-Fi	All in one
Passive DRE	0.5-18GHz	0.5-18GHz	0.5-18GHz	0.5-18GHz
Active DRE Frequency	N/A	N/A	0.5-8GHz	0.5-8GHz
Active DRE Function	N/A	N/A	BT / Wi-Fi or FR1	BT / Wi-Fi and FR1

Installation Requirement	M3-1.0	M3-1.5
Working Dimension(L/W/H)	3.2 x 4.3 x 3.3 m	4.4 x 5.5 x 4.5 m
Electrical	220VAC 50Hz 32A	220VAC 50Hz 32A
Regular Lead Time (Working Days)	45	45
Temporary Storage Spaceing	27 x 27 m	48 x 48 m

Absorber

Material	Expandable Polypropylene
Power Density Susceptibility	750 V/m
Operating Temperature	-15 C to +60 C
Operating Humidity	30% to 70%
ISO Dust-Free	100,000 Clean Room
RoHS & REACH	Compliant
Fire-Retardant Performance	NRL 8093 Test 1&3, UL94 HBF, ISO 4589-2
Waterproof Rating	IPX5

Control Unit

CPU	Intel Core i5	Intel Core i9	Intel Core i9
Operating System	Windows 10 Enterprise 64 bit	Windows 10 Enterprise 64 bit	Windows 10 Enterprise 64 bit
Hard Drive	1TB HDD	256GB M.2	256GB M.2
Ram	16GB	16GB	16GB
Monitor	24”	24”	24”
I/O Interface	GPIB	GPIB	N/A
Instrument Rack	19”41U	19”41U	19”25U

Shielding Box

Outside dimension(L/W/H)	0.7 x 0.9 x 1.2 m	0.7 x 0.9 x 1.8 m
Chambers	2 Chambers	3 Chambers
Shielding effectiveness	2GHz-8GHz > 100dB	
Air Vent	0.1 x 0.1 m	
Access Panel	0.3 x 0.3 m	
Shielding door(W/H)	60 x 40 cm, auto latching	
Power source filter	100-280VAC Single Phase 2 Wire 6A	
Signal filter	USB 3.0 / RS-232 / RS-485 / RJ-45 1Gbps / RJ-45 10Gbps (Optional)	

Programmable Attenuator

Channels	4	8	16
Operating Frequency	DC-18GHz		
Attenuation Range	0 - 121dB		
Attenuation step	1 dB		
Insertion Loss	2.5dB @ 6GHz		
Connector	SMA		

M4 X Regular

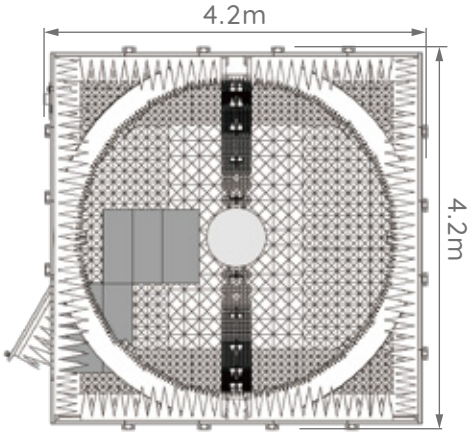
It helps conduct MIMO multi-cluster equipment testing by using standard instruments to simulate realistic environments, complies with CTIA standards, and is equipped with additional test functions; the integration of channel emulators further enhances measurement accuracy and cost-effectiveness.

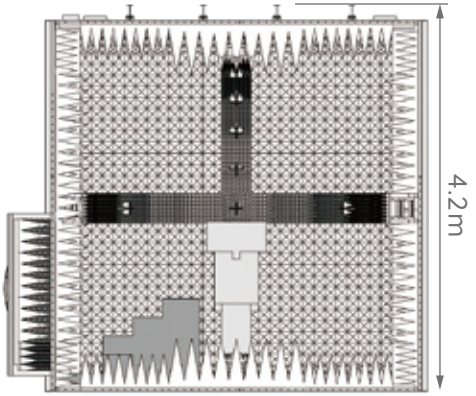
M4 X Appearance

- Standard
- Precise Measurement
- CTIA MIMO Compliance

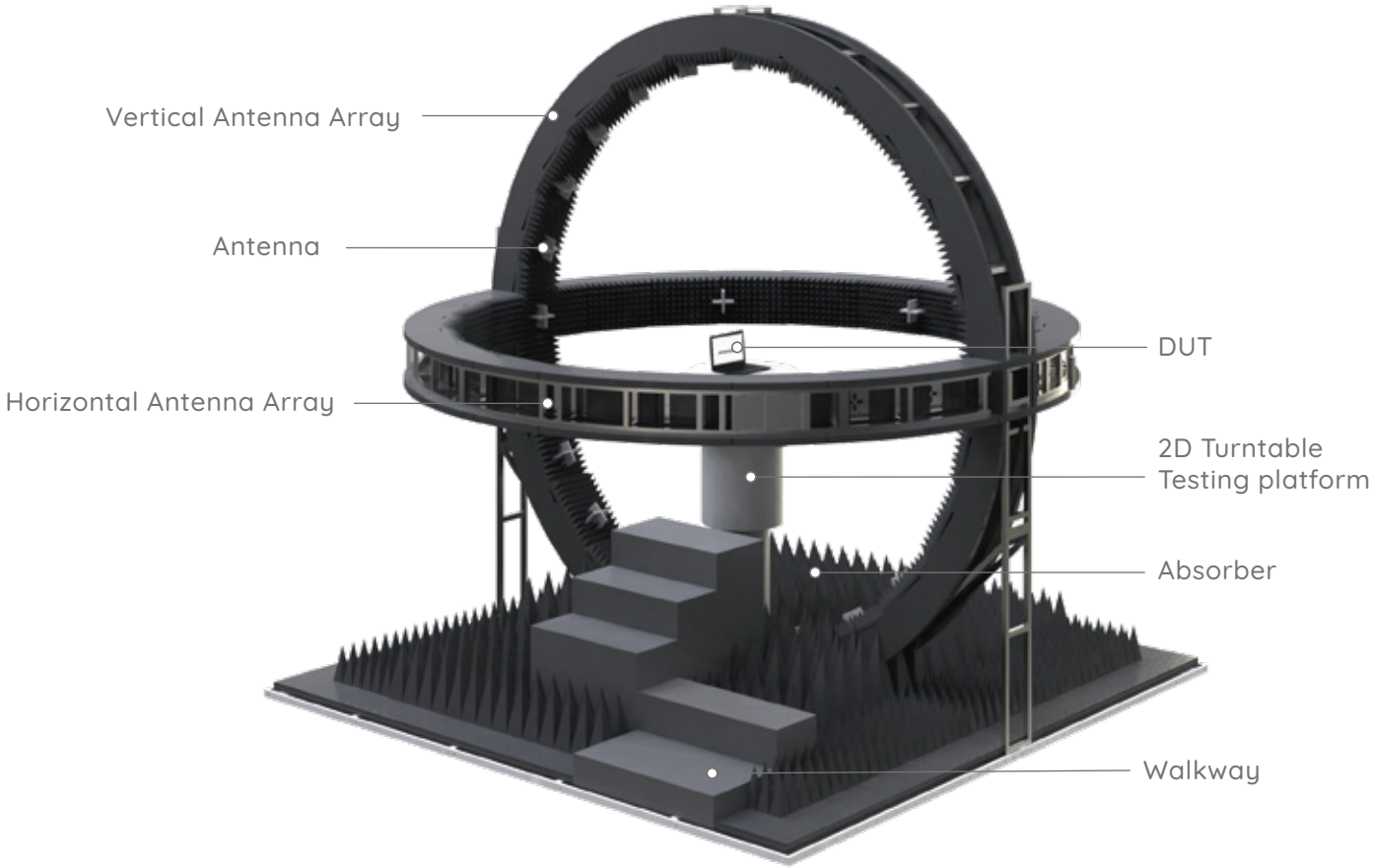
M4 X Three-View-Drawing

- Size: L4.2 x W4.2 x H4.2 m
- Weight: 6,500 kg
- Built space: L4.4 x W5.5 x H4.5 m
- Floor-loading capacity: 250kg/m^2





M4 X Internal



M4 X Specifications

SISO System	M4	
Measurement Distance	> 1.0m	> 1.5m
Mlaximum Tested Object	0.5m	0.7m
Quiet Zone Size	0.3m	0.5m
Quiet Zone Characteristics	SD < 1.2	SD < 1.2
Operating Frequency	0.68-8GHz / 2-18GHz	
Number of Antennas	23 Antennas	
Antenna Array Configuration	Ring Type	
Antenna Framework	Vertical Array	
Angular Resolution	15 °	
Passive Test Time	Ant. Eff. < 40s	
TRP Test Time	TRP < 100s / Channel	
TIS Test Time	TIS < 300s / Channel	
Test Funcation	Antenna Performance / Receiver Sensitivity / Transmit Power Communication Coexistence / Carrier Aggregation	
Test Item	EIRP / EIS / TRP / TIS / Ant. Eff. / Antenna Pattern / Gain	
Communication Protocol	5GNR FR1 / LTE TDD / FDD / LTE Cat-M / NB-IoT / Bluetooth Wi-Fi 802.11a / b / g / n / ac / ax / be WCDMA / HSDPA / HSPA / HSPA+ / HSUPA TD-SCDMA / TD-HSDPA / GSM / GPRS / EDGE CDMA2000 / CDMA 1xRTT / CDMA 1xEVDO	
System Stability	Ant. Eff. SD < 10% TRP SD < 0.5dBm ; TIS SD < 1dBm	

MIMO System	M4					
Measurement Distance	> 1.0m			> 1.5m		
Number of Antennas	4	8	16	4	8	16
Communication Channel	4T4R	8T8R	16T16R	4T4R	8T8R	16T16R
Antenna Array Configuratior	Directional	Directional or Isoropic		Directional	Directional or Isoropic	
Operation Frequency	2 - 18GHz					
Antenna Horizontal Spacing	+/- 180 °					
Antenna Vertical Spacing	+/- 22.5 °					
Test funcation	Maximum Throughput Test / Range Versus Rate Test Spatial Consistency Test / AP Coexistence Test Stability / TR-398 Compliance					
System stability	Data Throughput SD < 10% in Average					
Insertion Attenuation	0-110dB , step 1dB					
Path Loss	53dB @ 2.4GHz ; 60dB @ 6GHz			57dB @ 2.4GHz ; 64dB @ 6GHz		
Support Software	IPerf3 / IxChariot					

M4 X Hardware Specifications

Anechoic Chamber	M4	
Outside Dimension (L/W/H)	3.0 x 3.0 x 3.0 m	4.2 x 4.2 x 4.2 m
Inside Dimension (L/W/H)	2.9 x 2.9 x 2.9 m	3.9 x 3.9 x 3.9 m
Shielding Effectiveness	0.03-18GHz > 100dB	
Shielding Steel Sheet Thickness	2mm	
Shielding Door	Electirc Auto Latching	
Shielding Door Dimension (W/H)	1.0 x 2.0 m	
Air Vent	0.3 x 0.3 m	
Power Source Filter	1P2W 100-280 VAC / 16A	
Signal Filter	USB 3.0 / RS-232 / RS-485 / RJ-45 1Gbps / RJ-45 10Gbps (Optional)	
Lighting	LED	
Laser Line	3 Laser Red Line	
CCTV	2560 x 1440 @30fps PTZ Joystick Controller (Optional)	

Communication Antenna		
Operating Frequency	0.45-8GHz	0.65-8GHz
Antenna Gain	4 dBi	6 dBi
Number of Polarization	Single Polarization	Single Polarization
Polarization Direction	Circular Polarization	Circular Polarization
Max. Watt	4 Watt CW	4 Watt CW
Connector	SMA	SMA

Positioner		
Turntable Diameter	0.2m	
DUT Platform Diameter	0.5m	0.8m
Turntable Load	30kg	
Max.Tturntable Speed	3 RPM	
Turntable Resolution	0.1°	
Turntable Accuracy	±0.5°	
Rated Power	200W	

SISO Switching Box	Passive	Passive / Cellular	Passive / Cellular BT / Wi-Fi	All in one
Passive DRE	0.5-18GHz	0.5-18GHz	0.5-18GHz	0.5-18GHz
Active DRE Frequency	N/A	N/A	0.5-8GHz	0.5-8GHz
Active DRE Function	N/A	N/A	BT / Wi-Fi or FR1	BT / Wi-Fi and FR1

Installation Requirement	M4-1.0	M4-1.5
Working Dimension(L/W/H)	3.2 x 4.3 x 3.3 m	4.4 x 5.5 x 4.5 m
Electrical	220VAC 50Hz 32A	220VAC 50Hz 32A
Regular Lead Time (Working Days)	45	45
Temporary Storage Spaceing	27 x 27 m	48 x 48 m

M4

Absorber	
Material	Expandable Polypropylene
Power Density Susceptibility	750 V/m
Operating Temperature	-15 C to +60 C
Operating Humidity	30% to 70%
ISO Dust-Free (Class)	100,000 Clean Room
RoHS & REACH	Compliant
Fire-Retardant Performance	NRL 8093 Test 1&3 UL94 HBF ISO 4589-2
Waterproof Rating	IPX5

Control unit			
CPU	Intel Core i5	Intel Core i9	Intel Core i9
Operating System	Windows 10 Enterprise 64 bit	Windows 10 Enterprise 64 bit	Windows 10 Enterprise 64 bit
Hard Drive	1TB HDD	256GB M.2	256GB M.2
Ram	16GB	16GB	16GB
Monitor	24”	24”	24”
Interface Connector	GPIB	GPIB	N/A
Instrument Rack	19”41U	19”41U	19”25U

Shielding Box

Outside Dimension(L/W/H)	0.7 x 0.9 x 1.2 m	0.7 x 0.9 x 1.8 m
Chambers	2 Chambers	3 Chambers
Shielding effectiveness	2GHz-8GHz > 100dB	
Air Vent	0.1 x 0.1 m	
Access Panel	0.3 x 0.3 m	
Shielding door	W60 x H40 cm, auto latching	
Power Source Filter	100-280VAC Single Phase 2 Wire 6A	
Signal Filter	USB 3.0 / RS-232 / RS-485 / RJ-45 1Gbps / RJ-45 10Gbps (Optional)	

Programmable Attenuator

Channels	4	8	16
Operating Frequency	DC-18GHz		
Attenuation Range	0 - 121dB		
Attenuation step	1 dB		
Insertion Loss	2.5dB @ 6GHz		
Connector	SMA		

Appendix

Everything you need is already here for you to utilize.

Appendix/

2G Band List Guide

GSM band scope (3GPP TS 45.005 OCW= 200 kHz or others)

Band System	Uplink(MHz)		OBW	Downlink(MHz)		Related
	F_{low}	F_{high}	(MHz)	F_{low}	F_{high}	LTE Band
380 T-GSM	380.2	389.8	9.6	390.2	399.8	
410 T-GSM	410.2	419.8	9.6	420.2	429.8	
450 GSM	450.6	457.4	6.8	460.6	467.6	31
480 GSM	479	485.8	6.8	489	496	
710 GSM	698.2	716.2	18	728.2	746.2	12
750 GSM	777.2	793.2	16	777.2	792.2	
810 T-GSM	806.2	821.2	15	851.2	866.2	27
850 GSM	824.2	848.8	24.6	869.2	894.2	5
900 P-GSM	890.2	914.8	24.6	935	960	
900 E-GSM	880.2	914.8	34.6	925	960	8
900 R-GSM	876.2	914.8	38.6	921	960	
900 T-GSM	870.4	876	5.6	915.4	921	
1800 DCS	1710.2	1784.8	74.6	1805.2	1879.8	3
1900 PCS	1850.2	1909.8	59.6	1930.2	1989.8	2

Appendix/

3G Band List Guide

UMTS FDD/TDD band scope (3GPP TS 25.101 OCW=5 MHz)

FDD Band #	Name	Uplink		Downlink		OBW
		F_{low} (MHz)	F_{high} (MHz)	F_{low} (MHz)	F_{high} (MHz)	(MHz)
1	2100 IMT	1920	1980	2110	2170	60
2	1900 PCS	1850	1910	1930	1990	60
3	1800 DCS	1710	1785	1805	1880	75
4	1700 AWS	1710	1755	2110	2155	45
5	850 CLR	824	848.9	869	893.9	25
6	No name	830	839.9	875	884.9	10
7	2600 IMT-E	2500	2570	2620	2690	70
8	900 E-GSM	880	915	925	960	35
9	No name	1749.9	1784.9	1844.9	1879.9	35
10	900 E-AWS	1710	1770	2110	2170	60
11	1500 LPDC	1427.9	1447.9	1475.9	1495.9	20
12	700 LSMH	699	716	729	746	25
13	700 USMH-C	777	787	746	756	10
14	700 USMH-D	788	798	758	768	10
19	No name	830	845	875	890	15
20	800 EUDD	832	862	791	821	30
21	1500 UPDC	1447.9	1462.9	1495.9	1510.9	15
22	No name	3410	3490	3510	3590	80
25	1900 EPCS	1850	1915	1930	1995	65
26	850 ECLR	814	849	859	894	35
32	1500 L-band	downlink only		1452	1496	44

Appendix/

4G-FDD Band List Guide

E-UTRA band scope (3GPP TS 36.101 R16)

FDD Band #	Name	Uplink		Downlink		OBW
		F_{low} (MHz)	F_{high} (MHz)	F_{low} (MHz)	F_{high} (MHz)	(MHz)
1	2100	1920	1980	2110	2170	60
2	1900 PCS	1850	1910	1930	1990	60
3	1800+	1710	1785	1805	1880	75
4	AWS-1	1710	1755	2110	2155	45
5	850	824	849	869	894	25
6	No name	830	839.9	875	884.9	25
7	2600	2500	2570	2620	2690	70
8	900 GSM	880	915	925	960	35
9	1800	1749.9	1784.9	1844.9	1879.9	35
10	AWS-1+	1710	1770	2110	2170	60
11	1500 Lower	1427.9	1447.9	1475.9	1495.9	20
12	700 a	699	716	729	746	17
13	700 c	777	787	746	756	10
14	700 PS	788	798	758	768	10
17	700 b	704	716	734	746	12
18	800 Lower	815	830	860	875	15
19	800 Upper	830	845	875	890	15
20	800 DD	832	862	791	821	30
21	1500 Upper	1447.9	1462.9	1495.9	1510.9	15
22	3500	3410	3490	3510	3590	80
23	No name	2000	2019.9	2180	2199.9	20
24	1600 L-band	1626.9	1660.9	1525	1559	34
25	1900+	1850	1915	1930	1995	65
26	850+	814	849	859	894	35

E-UTRA band scope (3GPP TS 36.101 R16)

FDD Band #	Name	Uplink		Downlink		OBW
		F_{low} (MHz)	F_{high} (MHz)	F_{low} (MHz)	F_{high} (MHz)	(MHz)
27	800 SMR	807	824	852	869	17
28	700 APT	703	748	758	803	45
29	700 d	-	-	717	728	11
30	2300 WCS	2305	2315	2350	2360	10
31	450	452.5	457.5	462.5	467.5	5
32	1500 L-band	-	-	1452	1496	44
65	2100+	1920	2010	2110	2200	90
66	AWS-3	1710	1780	2110	2180	70
67	700 EU	-	-	738	758	20
68	700 ME	698	728	753	783	30
69	DL 2500	-	-	2570	2620	50
70	AWS-4	1695	1710	1995	2010	15
71	600	663	698	617	652	35
72	450 PMR/PAMR	451	456	461	466	5
73	450 APAC	450	455	460	465	5
74	L-band	1427	1470	1475	1518	43
75	DL 1500+	-	-	1432	1517	85
76	DL 1500-	-	-	1427	1432	5
85	700 a+	698	716	728	746	18
87	410	410	415	420	425	5
88	410+	412	417	422	427	5

Appendix/

4G-TDD Band List Guide

E-UTRA band scope (3GPP TS 36.101 R16)

TDD Band #	Name	F_{low} (MHz)	F_{high} (MHz)	OBW(MHz)
33	TD 1900	1900	1920	20
34	TD 2000	2010	2025	15
35	TD PCS Lower	1850	1910	60
36	TD PCS Upper	1930	1990	60
37	TD PCS Center	1910	1930	20
38	TD 2600	2570	2620	50
39	TD 1900+	1880	1920	40
40	TD 2300	2300	2400	100
41	TD 2600+	2496	2690	194
42	TD 3500	3400	3600	200
43	TD 3700	3600	3800	200
44	TD 700	703	803	100
45	TD 1500	1447	1467	20
46	TD Unlicensed	5150	5925	775
47	TD V2X	5855	5925	70
48	TD 3600	3550	3700	150
49	TD 3600r	3550	3700	150
50	TD 1500+	1432	1517	85
51	TD 1500-	1427	1432	5
52	TD 3300	3300	3400	100
52		2483.5	2495	11.5

Appendix/

5G-FR1 FDD Band List Guide

5G NR (3GPP TS 38.101)

FR1 FDD Band #	Name	Uplink		Downlink		OBW
		F_{low} (MHz)	F_{high} (MHz)	F_{low} (MHz)	F_{high} (MHz)	(MHz)
n1	IMT	1920	1980	2110	2170	60
n2	PCS	1850	1910	1930	1990	60
n3	DCS	1710	1785	1805	1880	75
n5	CLR	824	849	869	894	25
n7	IMT-E	2500	2570	2620	2690	70
n8	Extended GSM	880	915	925	960	35
n12	Lower SMH	699	716	729	746	17
n14		788	798	758	768	10
n18		815	830	860	875	15
n20	Digital Dividend (EU)	832	862	791	821	30
n25	Extended PCS	1850	1915	1930	1995	65
n26		814	849	859	894	35
n28	APT	703	748	758	803	45
n30		2305	2315	2350	2360	10
n65		1920	2010	2110	2200	90
n66	Extended AWS	1710	1780	2110	2200	70
n70	AWS-4	1695	1710	1995	2020	15
n71	Digital Dividend (US)	663	698	617	652	35
n74	Lower L-Band(US)	1427	1470	1475	1518	43

5G NR (3GPP TS 38.101)

FR1 FDD Band #	Name	Uplink		Downlink		OBW
		F_{low} (MHz)	F_{high} (MHz)	F_{low} (MHz)	F_{high} (MHz)	(MHz)
n85		698	716	728	746	18
n91		832	862	1427	1432	30
n92		832	862	1432	1517	30
n93		880	915	1427	1432	35
n94		880	915	1432	1517	35

Appendix/

5G-FR1 TDD Band List Guide

5G NR (3GPP TS 38.101)

FR1 TDD Band #	Name	F_{low} (MHz)	F_{high} (MHz)	OBW(MHz)
n34	IMT	2010	2025	15
n38	IMT-E	2570	2620	50
n39	DCS–IMT Gap	1880	1920	40
n40	S-Band	2300	2400	100
n41	BRS	2496	2690	194
n46		5150	5925	775
n47		5855	5925	70
n48		3550	3700	150
n50	L-Band (EU)	1432	1517	85
n51	Extended L-Band(EU)	1427	1432	5
n53		2483.5	2495	11.5

5G NR (3GPP TS 38.101)

FR1 TDD Band #	Name	F_{low} (MHz)	F_{high} (MHz)	OBW(MHz)
n77	C-Band	3300	4200	900
n78	C-Band	3300	3800	500
n79	C-Band	4400	5000	600
n90		2496	2690	194
n96		5925	7125	1200


atenlab