

INTRODUCTION

RayPack (see Figure 1) is a high-performance and fast delivery CATR (Compact Antenna Test Range) system for 5G NR FR2 OTA tests. Typically, CATR systems are applied to the aerospace and defense sectors with large-scale-antenna measurements and a radar scattering cross-section (RCS) test. But this type of system has many weaknesses, such as huge size, low quiet zone efficiency, long test time, and high cost.

The RayPack 5G NR FR2 OTA test provides not only high accuracy, but also fast test speed, compact size, and adaptability to 5G standard evolution. We strive to drive 5G international standards and we provide high efficiency, plug & play, and an open interface test solution for mmWave test.

TOYO abandoned the conventional reflector and feed design, and improved key quiet zone specifications by 50%. The effective reflection area can be up to 70% of the whole reflector surface (see Table 1); the controlling software, test instruments, RF link, and turntable are designed to function as an integrated system. Thus test efficiency can be 60% better than that of conventional chambers; the absorbing materials, reflector, feed, and anechoic chamber were also designed to operate closely with each other.



Figure 1: RayPack

- Comply with 5G NR FR2 3GPP and CTIA Wireless Standards, cover 6~110GHz
- Maximum 100cm quiet zone, applicable to 5G mmWave UE, laptop, CPE, small cell base station and antenna, automotive radar
- Improve the ratio between area of quiet-zone and reflector from 50% to 70%
- Compact size, a whole transportation, fast delivery, plug & play
- Open software/hardware interface, support self-define test cases
- High precision, mechanical accuracy $\pm 0.01^\circ$
- Active/passive SISO, RF conformance, out-band spurious and automotive radar OTA test

REFLECTOR TYPES AND THEIR CHARACTERISTICS

Reflector Type	Test Accuracy	Quiet Zone Quality	Delivery Efficiency	Cost-Performance Ratio
Serrated edge	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Blended rolled edge	★★★★☆	★★★★☆	★★★★☆	★★★★☆
GTS Absorber-surrounded edge	★★★★★	★★★★★	★★★★☆	★★★★★

Table 2: Reflector Types and their Characteristics

This new generation CATR chamber (see Figure 2) is characterized by its compact structure, small dimensions, ease of transport, and ease of installation. The entire system undergoes quiet zone verification and calibration at the factory for fast on-site turn-up.

Both the turntable and RF link have open user interfaces where customers can self-define different test cases to meet various mmWave test requirements.

Our technical team provides 24/7 remote and onsite technical support to all our global customers.

Differing from the conventional serrated or blended rolled edge CATR chamber, TOYO adopted an absorber-surrounded reflector. This new technology can reduce edge scattering as well as improve quiet zone quality.

In addition, TOYO designed a new consistent-phase-center feed and high-quality mmWave absorbers. We designed and optimized the whole system and made the reflector, source and chamber

interact with each other properly. This CATR test system combines the characteristics of several high performance, low cost, compact size, and cutting-edge technologies. .

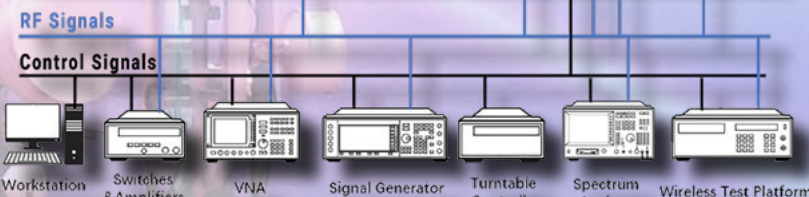
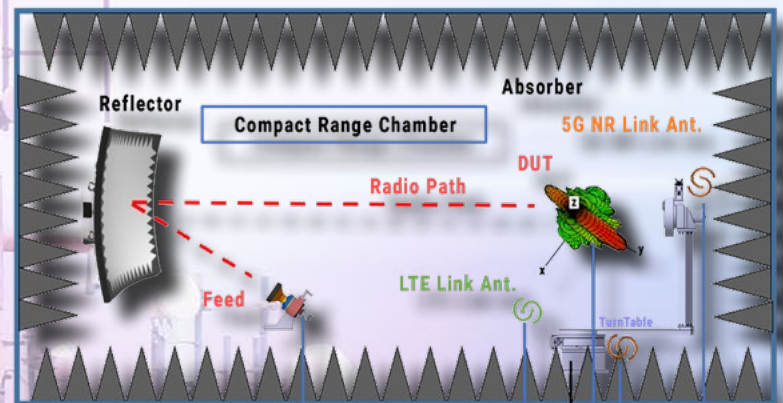


Figure 2: RayPack Chamber Characteristics

CONSISTENT-PHASE-CENTER FEED

With a conventional corrugated horn antenna (see Figure 3), the phase centers of the E and H planes are different and can cause a large deviation in V/H polarization (see Figure 4). We designed a corrugated horn (feed) with a wide frequency range, broad angle and low cross-polarization. On the E/H planes, the center phase varies less than 5° . And in the 24~40GHz range, the cross-polarization is less than -30dB and the antenna VSWR is under 1.5.

The wide frequency range and high stable phase center ensure a slight phase fluctuation in the quiet zone. Further, the high-edge radiation level (wide beam) guarantees a small amplitude fluctuation in the quiet zone. The horn is designed integrally with absorber (covered on the outside) and the feed has the characteristic of low RCS.



Figure 3: Corrugated Horn Antenna

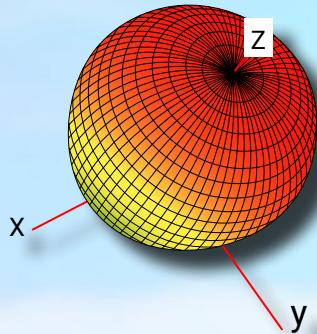


Figure 4: V/H Polarization

LOW-EDGE-SCATTERING REFLECTOR

Our products are engineered to surround reflectors with absorbers by intentionally embedding the reflector into the chamber's absorbing wall. This design dramatically reduces the reflector edge's scattering, while increasing the ratio between the area of the quiet zone and the reflector; this improves the quiet zone quality.

This new reflector type can not only effectively reduce the electromagnetic wave scattering from the metal edge, or weaken the scattered signal interference to the quiet zone, but also improve the quiet zone phase and amplitude stability. This new type of surrounded-edge method creates a larger quiet zone with a smaller metal reflector, thus reducing the reflector size and height.



Figure 5: RayPact Reflector

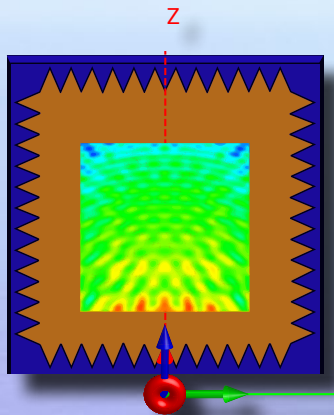


Figure 6: RayPact Reflector

FAST, PRECISE & LESS-BLOCKAGE TURNTABLE

RayPact series models are equipped with a multi-dimensional turntable with different motion modes: azimuth, elevation, polarization or horizontal. mmWave test has many challenges, such as narrow beam, long test time and turntable blockage. We designed a precise, fast-sampling and less-blockage multi-dimensional turntable for the mmWave test.

RayPact series turntables use a worm drive system which provides superior positioning accuracy. It uses high-quality cross roller bearing to achieve excellent motion performance. Its repeat positioning accuracy is within $\pm 0.02^\circ$, with a resolution of 0.01° . The turntable can be widely used for precise testing of various mmWave devices.

The higher test accuracy requires a higher test point density, which can worsen the test efficiency. Using the continuous hardware trigger and dynamic compensation, the RayPact turntable is able to implement continuous fast measurement. Compared to conventional stepping measurements, the test time can be shortened by 70%.

Compared to the centimeter wave test, the mmWave test is vulnerable to the signal blocking. The backlobe radiation information of the DUT is easy to lose due to the turntable's blocking, and this causes the whole DUT's test result to be affected. RayPact's less-blockage turntable adopts the advanced low-RCS-design which is used by stealth aircraft, and high-quality absorbers which are developed and manufactured by GTS. It can effectively reduce the direct blocking and indirect scattering to the DUT. It also has less interference to the DUT measurement and a wider testable angle than a conventional mmWave turntable.

CUSTOMIZED HIGH-PERFORMANCE ABSORBER

We patented a high-performance small pyramid absorber which is made of EPP (Expanded polypropylene). The material is environment-friendly and has a reliable lifespan. It has the characteristics of being moisture-free, dust-free in-deformable, and specification stable. The absorber is 6cm in height providing a high rate of absorption while reducing the total occupied volume which makes the inner chamber larger.

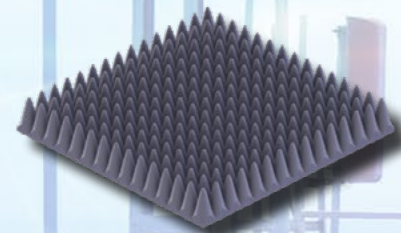


Figure 7: RayPact Absorber

Every electromagnetic specification of the absorbers is guaranteed, and its shape is customizable. The product can be traced from the initial design simulation to the manufacturing process. From the process of quality assurance, performance test, transportation to installation, everything is managed and controlled by a dedicated professional team. Our mmWave absorbers come with a lifetime warranty.

SYSTEM TEST CAPABILITY

The RayPact mmWave CATR test system is composed of a reflector, feed, absorbers, shielding case, test instruments, switching matrix, mechanical turntable and test controlling software. Every RF link has been carefully designed and optimized. The RayPact series includes four types of products, which are 600B/C and 1000B/1500B; they can meet different 5G NR FR2 test requirements.

Here are the basic test functions that are available:

- Antenna 1D/2D/3D gain/phase pattern
- Directionality, Efficiency, Beam width, Beam pointing direction
- Linear polarization and circular polarization antenna measurement
- Cross polarization ratio, side-lobe level, null-fill
- TRP, EIRP, TIS, EIS, ACLR, EVM, SEM
- In-band blocking, spurious emission
- Automotive OTA
 - EIRP, Duty cycle, Frequency range, OBW
 - Pulse, CW and Modulated continuous wave measurement
 - OOB EIRP
- Transmitter/Receiver spurious EIRP
- Phase/Amplitude calibration for Phased array antenna element
- Automatic test

RAYPACT TEST PERFORMANCE

Before being shipped out, every RayPact CATR system has to complete the quiet-zone verification and be pre-assembled, so that it can be directly delivered to customer without complicate on-site integration. RayPact CATR is optimized to be a plug & play system where every precision system component has been designed and adjusted carefully.

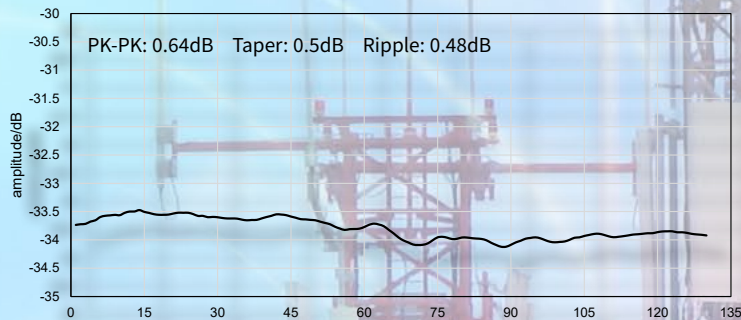


Figure 8: Quiet Zone Amplitude Curve @24GHz

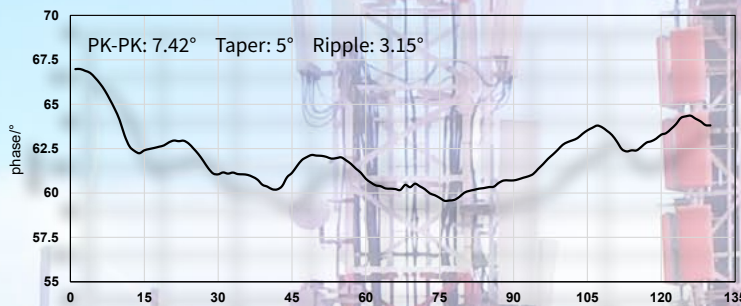


Figure 9: Quiet Zone Phase Curve @24GHz

In order to overcome the mmWave path loss issue, we optimized the system layout, maximized the use of the inner space, and effectively reduced signal loss (see Figures 8 & 9). Meanwhile, the system is upgradable for the various test requirements of different DUTs (flexible fixture options, redundant link-budget design, etc.). This system is compatible with most test instruments, and it also has an open software interface that meets the demands of wireless standard evolution and test upgrade. Please also refer to Figures 10 and 11.

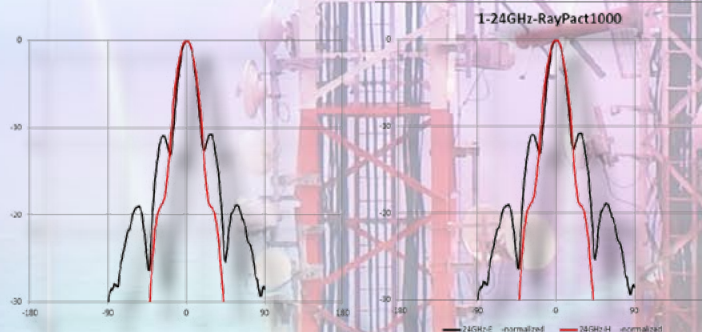


Figure 10: Passive Test Comparison: Reference Pattern of a Standard Antenna (left) compared with RayPact Actual Tested Pattern (right)

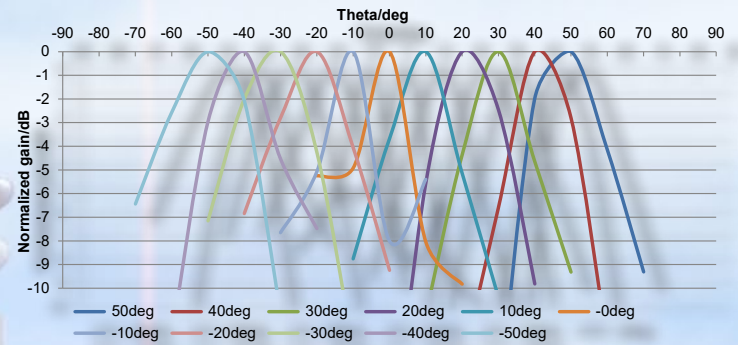


Figure 11: Active Phased Array Antenna Beam Sweep Test

MAXSIGN100 PROFESSIONAL ANTENNA/OTA TEST SOFTWARE

MaxSign100 system's control and test automation software (see Figure 12) is fully compliant with CTIA test standards and is also kept up to date with the latest specifications.

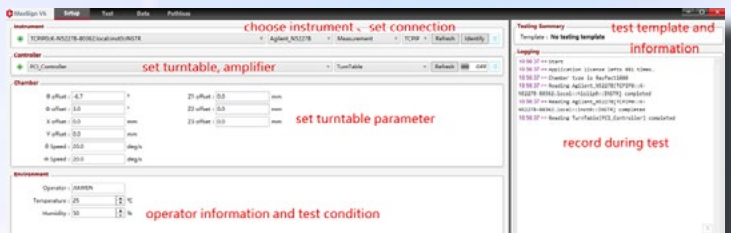


Figure 12: MaxSign100 Professional Antenna/OTA Test Software

MaxSign100 provides a wide range of applications, flexible configurations, smooth test processes, stable operation, as well as a simple but friendly GUI. It can meet different test requirements at different product stages and cover the whole product life cycle from R&D, pre-certification, and conformance to QA in manufacturing.

- Supports 3D measurements, cut selectable 2D measurements, and single point measurements (see Figure 13)
- User-defined test step, test angle, and test configuration
- Arbitrary selection of test point to review all test data of it
- Wide variety of assistant functions including anti-drop-call, auto-recall, and abnormal situation warnings. Improves test processes' reliability and fluency
- Comprehensive raw test data and log files management. Traceable and non-modifiable test process
- Batch processing function supports creating task list for continuous and automated unattended tests
- Built-in templates and preconfigured parameters compatible with different instruments and test platforms. Simple operations prevent pilot/user errors
- Supports 3D display, antenna pattern arbitrary angle rotation, viewing and cutting to help R&D engineer to visually analyze and diagnose problem

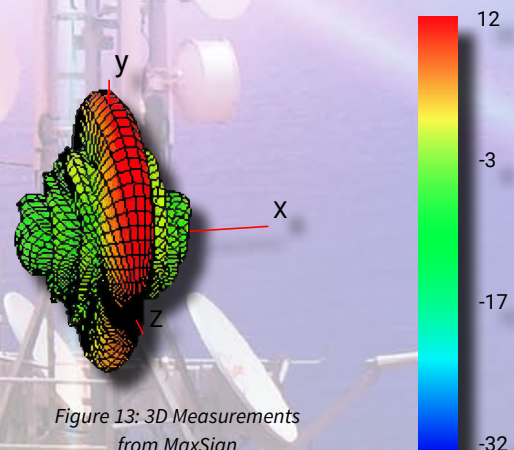


Figure 13: 3D Measurements from MaxSign

TECHNICAL SPECIFICATIONS								
General		RayPact 600B		RayPact 1000B		RayPact 1500B		RayPact 600C
	Application	Antenna/UE (user equipment)		Antenna/UE/BS (base station)		Antenna/UE/BS		Antenna/UE/small cell BS/Automotive Radar/Spurious Emission
	Test Methodology	CATR (compact antenna test range)						
	Frequency	24-40GHz (extendable)						6-110GHz(extendable)
	Test Cases	Antenna passive test, EIRP,TRP,TIS,EIS etc.						Antenna passive test, EIRP, TRP, TIS, EIS; Radar antenna test, out-band-spurious test
	Dynamic Range	60dB (typical)						
	Exterior dimensions	2100 x 960 x 1850 mm		3500 x 1600 x 2200 mm		4900 x 2500 x 3000 mm		2100 x 960 x 1850 mm
	Shielding	-100dB						
TurnTables	Azimuth axis	Infinite rotation, speed 0-20°/s, repeatability accuracy±0.01°						
	Polarization axis							
	Horizontal axis	N/A				Stroke customizable. Speed: 0-50mm/s, repeatability accuracy: ±0.05mm		
	Elevation axis					Elevation stroke: ±30°, speed: 0-10°/s, repeatability accuracy: ±0.01°		
DUT	Max. Size	35 x 35 cm		60 x 60 cm		100 x 100 cm		35x35 cm
	Max. Weight	5kg		15kg		30kg		5kg
Quiet Zone	Dimensions	Φ0.4×0.4m	Φ0.3×0.3m	Φ0.7×0.7m	Φ0.5×0.5m	Φ1.0×1.0m	Φ0.7×0.7m	Φ0.3×0.3m
	Amplitude Variation	<2dB	<1.5dB	<2dB	<1.5dB	<2dB	<2dB	<1.5dB
	Amplitude Taper	<1.2dB	<1dB	<1.2dB	<1dB	<1.2dB	<1.2dB	<1dB
	Amplitude Ripple	≤±0.5 dB	≤±0.5dB	≤±0.5dB	≤±0.5dB	≤±0.5dB	≤±0.5dB	≤±0.5dB
	Phase Variation	<20°	<8°	<20°	<8°	<15°	<20°	<8°
	Phase Taper	<5°	<3°	<5°	<3°	<5°	<5°	<3°
	Phase Ripple	<±4°	<±3°	<±4°	<±3°	<±4°	<±4°	<±3°
	Cross Polarization	≥28dB	≥30dB	≥28dB	≥30dB	≥28dB	≥28dB	≥30dB
Probe Antenna	Type	Corrugated horn						
	Polarization	Dual polarization						
	Frequency	24GHz~40GHz (extendable)						6GHz~110GHz (extendable)
Absorber	Base Material	EPP /Honeycomb (optional)						
	Height	60mm/100mm (optional)						
	Absorbing Rate	≥40dB (typical)						
	Withstand Power	1.2kW/m2 (EPP) / 10kW/m2 (honeycomb)						

SERVICE & SUPPORT	
System calibration	One free calibration at system delivery
Maintenance	Free for the first year
Software upgrade	Free for the first year

INSTRUMENTS SUPPORTED (OPTIONAL)	
Network Analyzer	Keysight N5227B
Signal Generator	Keysight M9383B; R&S SMW200A
Spectrum Analyzer	R&S FSW/FSU; Keysight PXA/PXB; Anritsu MS2850
Wireless Test Set	E7515B UXM 5G; Anritsu MT8000A
Radar Simulator	R&S AREG100A

RAYZONE SOFTWARE MODULES	
Shielding enclosure	RayPact600: 2100 x 960 x 1850 mm RayPact1000: 3500 x 1600 x 2200 mm Raypact1500: 4900 x 2500 x 3000 mm
Reflector	RayPact600: 600mm x 600mm RayPact1000: 1000mm x 1000mm Raypact1500: 1500mm x 1500mm
Absorber	EPP mmwave absorbers
Turn table	2D turn table (upgradeable)
Measurement probe	Corrugated horn antennas covering 6~110GHz (multiple)
System integrated controller	Including RF switches, turn table controller, system controller, etc.
RF Cable	High performance RF cables
Power system	220V/110V,2000W with AC power filter and DUT power supply.
Laser positioner	Test zone center cross
CCTV	High resolution camera and monitor
Air conditioner (optional)	Inner chamber temperature and humidity control



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