TOYO

RayRobo® 3000/4500
Automotive OTA Testing System
PRODUCT BROCHURE

INTRODUCTION

The automotive industry is undergoing a profound change with Intelligent connected vehicles (ICVs) being widely viewed as the future of mobility. With the convergence of vehicle information communication, AI, the internet, and other technologies, the ICV enters a new stage of rapid technology evolution with a variety of communication devices (including wireless transceiver, antenna, and corresponding software).

To ensure the reliability and integrity of the entire vehicle operation, it is necessary to test the entire vehicle's wireless communication performance in an actual working environment, to ensure its communication performance meets specific technical requirements. Thus OTA test for vehicle wireless devices becomes critical for future automotive wireless performance test, something called full vehicle OTA test.

Our solution is an innovative test system designed around a mobile robotic arm. The system is an integrated design that is a movable full vehicle OTA testing system. It can be an independent test system or be integrated into an existing automotive EMC chamber, so the EMC chamber can become a dual-functional system. When starting the automotive OTA test, the electric unit with the robotic arm and its test probe, moves into the EMC chamber underneath the electrical controls.

MOVABLE-ROBOTIC-ARM, SPHERICAL NEAR FIELD SCANNING, MULTI-FUNCTION AND WIDE COVERAGE FOR FULL-VEHICLE WIRELESS PERFORMANCE TESTING

FREQUENCY RANGE: 0.6 -7.5GHZ (EXTENDABLE TO 12GHZ)

TEST FUNCTIONS

- Passive antenna test – antenna of V2X, cellular, GNSS etc.
- Full-vehicle SISO performance test– TRP/TIS of V2X, 2G/3G/4G/5G, (A) GNSS, Wi-Fi, Bluetooth etc.
- Full-vehicle MIMO performance test– throughput of 4G/5G 2x2/4x4 MIMO, supports 2D/3D channel models and field test simulation
- Full-vehicle dynamic performance diagnosis– test and diagnosis for car motion states & self-interference

DUT TYPE: LARGE SCALE DEVICES UNDER 6M

SYSTEM COMPATIBILITY: APPLICABLE FOR EMC CHAMBER UPGRADE, ONE CHAMBER WITH DUAL-FUNCTION(EMC+OTA)

FLEXIBLE CONFIGURATION: OPTIONS FOR SISO/MIMO/ DESENSE/MMWAVE TESTING

The test software automatically search and find the initial test point; the whole test process is automated. After the testing, the OTA system can move to the designated location, avoid any impact on EMC testing, ensure dual function compatible with each other.

With its precise "visual-recognition & assisted-positioning system", the system can even perform the whole OTA measurement without a turntable. It will save the turntable construction and simplify system structure dramatically.

A single set of robotic arm can perform the full vehicle antenna and SISO performance testing. With the other four sets of robotic arms, the system can fulfill the full vehicle MIMO and self-interference testing. This is a total solution for ICV OTA testing with the comprehensive application, powerful function, and flexible configuration. Its specifications meet certification requirements of 3GPP, CTIA, and other national test standards. It is the optimal choice for certification labs, research institutes, automotive manufacturers, and antenna suppliers in the automotive certification and R&D testing industries.

SYSTEM OVERVIEW

The system is composed of an electric-powered car, a retractable robotic arm, and a clamped test probe. It is a high-precision full vehicle OTA testing system, which is guided by a visual recognition system and calibrated by an assisted-positioning system. It has 4 major parts.

First is the electric mobile platform (car), which uses AC 220V/110V 32A power supply, supports both wired/wireless control modes. There are four wheels under the platform and they can move in an arbitrary direction. The car has an electronic lifting cylinder that supports the car's body and stabilizes the chassis. The car chassis is equipped with a visual-positioning system and its barcodes can navigate the platform to move around. There is a level on the car. When moving to the specified place, the body's level can be detected then automatically adjusted by its feedback. Four supporting legs outstretch and body level adjustment can be completed by pressing one button.

The robotic arm, Swiss manufactured, is an industrial-grade product that has been widely used in vehicle, ship, and aircraft industries.

The test pole, which connects the end of a robotic arm and test probe fixture, is made of carbon fiber with characteristics of lightweight, high precision, and good strength. Test pole has four components: connector A holds the test probe, the cables pass through it; connector B is connected to the end of robotic arm; high definition(HD) visual recognition and calibration module on connector B can calibrate the positions in X/Y/Z axis and angles in rx/ry/rz for the ground marks; HD camera of the visual positioning can perform the accurate position calibration for the end of connector B.

(4) test probe, which was dedicatedly designed for automotive antenna testing, has the characteristics of low RCS, wide beamwidth, high cross-polarization ratio, low VSWA.

The unit's mobile robotic arm has a small footprint and can move easily. The system has two sets of extension mechanisms: the robotic arm has 6 degrees of freedom (DOF). When fully retracted there are 3rd/4th/5th DOF. The overall height of the robotic arm can be shrunk to less than 2.5m, so the system can fit through a 3m-height-door; the other set of extension mechanism is the four supporting legs under the mobile platform. They can extended to 2.5mx2.5m wide, which expends the stress-area and stabilizes the scanning of the robotic arm (*See Figure 1*).

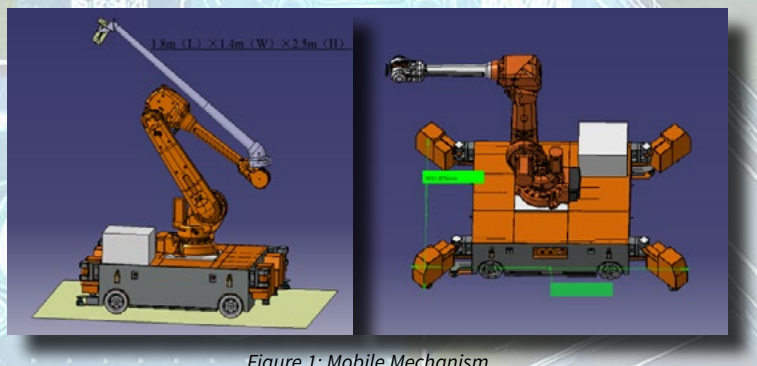


Figure 1: Mobile Mechanism

The system supports high-precision hemispherical scanning(-0.5°<θ<96°), with millimeter-level motion accuracy. The rotation accuracy of the scanning mechanism can be better than ±0.15° which fully meets test requirements in current communication frequency bands. This scanning method applies to any vehicles less than 6mx2mx2m, which can support various communication antenna tests. High-performance EPP rigid foaming absorbers cover all critical surfaces of the robotic arm, mobile platform as well as the ground.

The absorbers can be moved and relocated repeatedly without deformation, powder dropping, and performance deterioration. It ensures the stability and reliability of the test system performance. The system provides many configuration options, it is upgradable for wider test requirements in the future. For example, exchanging test probe to test the mmwave antenna; upgrading MIMO function to perform future 5G key test cases.

WIDE-BEAM, HIGH CROSS-POLARIZED TEST PROBE

Automotive testing has issues with near-field eccentricity. To pursue test accuracy, the main lobe of the test probe must effectively (fully) cover the AUT's whole radiation area (usually the entire vehicle), as shown in *Figure 2*.

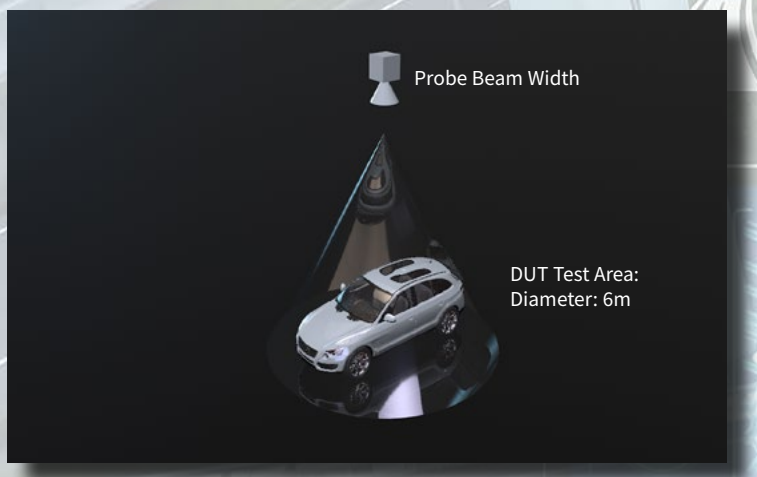


Figure 2: Main-lobe Effective Coverage of Test Probe

In addition, the cross-polarization of the effective coverage beam is critical for correct NF-FF transformation, since an eccentric system requires high cross-polarization isolation for NF-FF transformation. The automotive test requires NF-FF transformation, and a precondition for NF-FF transformation is to accurately distinguish the energy of H/V polarization.

Practically, the cross-polarization ratio of the entire test probe's main lobe should be higher than 18dB which can satisfy the transformation accuracy requirements. To achieve high test precision, we designed a special probe for automotive test with detailsin the table below.

TEST PROBE SPECIFICATIONS	
Frequency	600MHz - 7.5GHz
Dimensions	300 × 300 ×250mm
VSWR	< 2.4 @600M - 7.5GHz
Beam width	> 60°@600MHz - 3GHz
	> 60°@3GHz - 6GHz
Cross-polarization Isolation	> 25dB @Zenith-angle
	> 18dB @60° Beam-width
Sub 6G in-band flatness	< 0.8dB

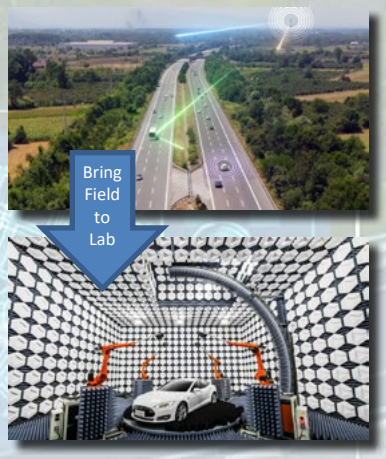
RTS MIMO TEST

The automotive communication system's reliability in various driving scenarios is directly related to life safety. How to effectively reproduce the vehicle's driving scenario and perform the MIMO test in the lab is the key issue in evaluating the vehicle communication system's reliability under real driving conditions.

Radiated-Two-Stage (RTS) is one of the two approved MIMO test methods of the 3GPP. Another organization CTIA is considering approval of the method as well.

A core RTS patent has been granted. According to the characteristics of automotive testing, we developed a special MIMO test solution. Using the RTS method, we can perform accurate and efficient automotive multi-antenna performance tests in a sophisticated electromagnetic environment. This solution supports 2x2/4x4 MIMO testing of LTE and 5G sub-6G (NSA/SA) systems.

With a channel emulator, this system can perform dynamic MIMO testing under standard channel models, and even simulated environments such as rain, fog, terrain, motion state, and road test.



- ✓ Controllable parameters
- ✓ Repeatable scenarios
- ✓ Standard models
- ✓ Efficient test

ERROR-ANALYSIS-BASED NF-FF TRANSFORMATION

The near-field to far-field (NF-FF) transformation algorithm is the core of a spherical NF testing system. GTS optimized the conventional NF-FF transformation process, designed a unique test probe, then creatively solved the following three challenges in full vehicle OTA testing:

- Large device-under-test (DUT) NF eccentricity issues
- Effective radiation coverage, cross-polarization, and beam symmetry issue of test probe
- Test probe factor's calibration issue in NF&FF restoration

Thus the accurate performance evaluation for automotive wireless communication systems can be achieved.

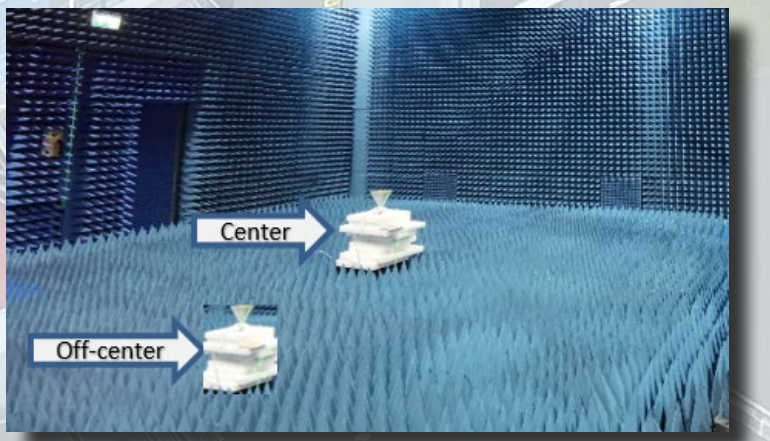


Figure 3: Eccentricity test with a standard horn antenna

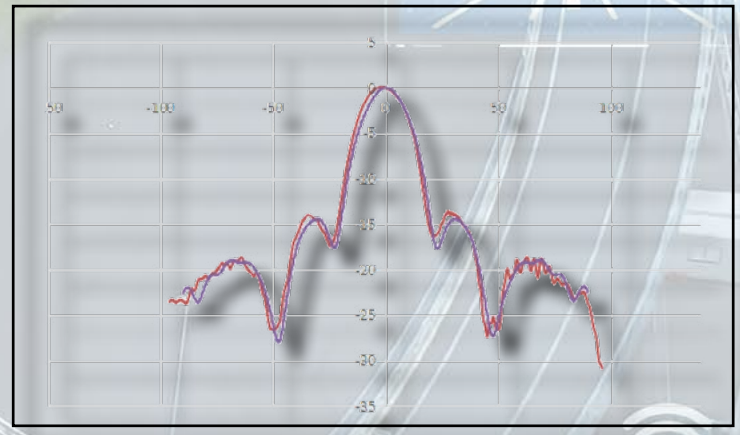


Figure 4: Transformed FF value vs. standard value

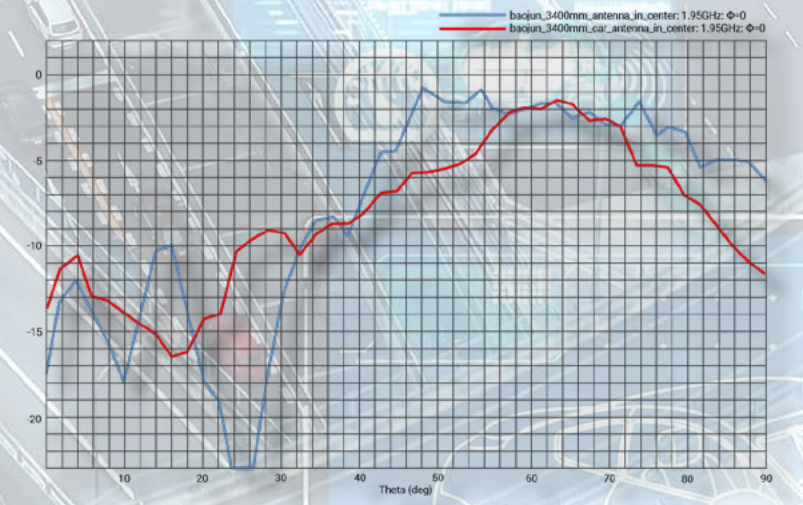


Figure 5: Car antenna@center vs. Car@center，large deviation in direct NF results

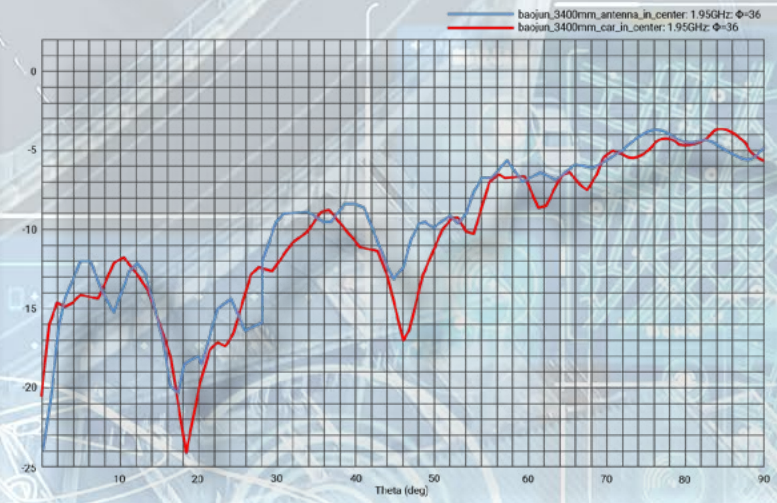


Figure 6: Car antenna@center vs. Car@center (small deviation in transformed FF results)

DESENSE COEXISTENCE TEST

When a car is in motion, various internal sub-systems will influence each other. The wireless communication system's receiving sensitivity will face interference from a variety of noises, and to combat this, all sensitivity-related tests can use the desense test method (*see Figure 7*).

To accurately analyze the mutual influence between each module within a car and improve the automotive wireless communication performance, the desense test becomes very critical in a full vehicle test.

The desense test can help to evaluate the impact of:

- Vehicle status on various communication systems
- In-vehicle equipment on communication systems
- Vehicle power supply on communication systems
- Vehicle motion

EPP RIGID FOAM ABSORBER

Absorbing material (*see Figure 8)* is one of the core components of an anechoic chamber, and its performance and quality have a direct impact on the overall system performance.

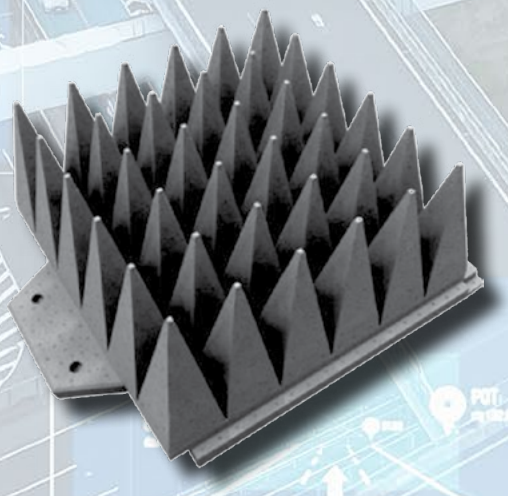


Figure 8: EPP-300 foam absorber

Our chambers use 4th generation, high performance, and environmentally-friendly absorbers made of RayBond EPP (Expanded Polypropylene) foams, which has several advantages over traditional PU (Polyurethane) foams. The EPP absorber is water-resistant, frame-retardant, stable, and dust-free.

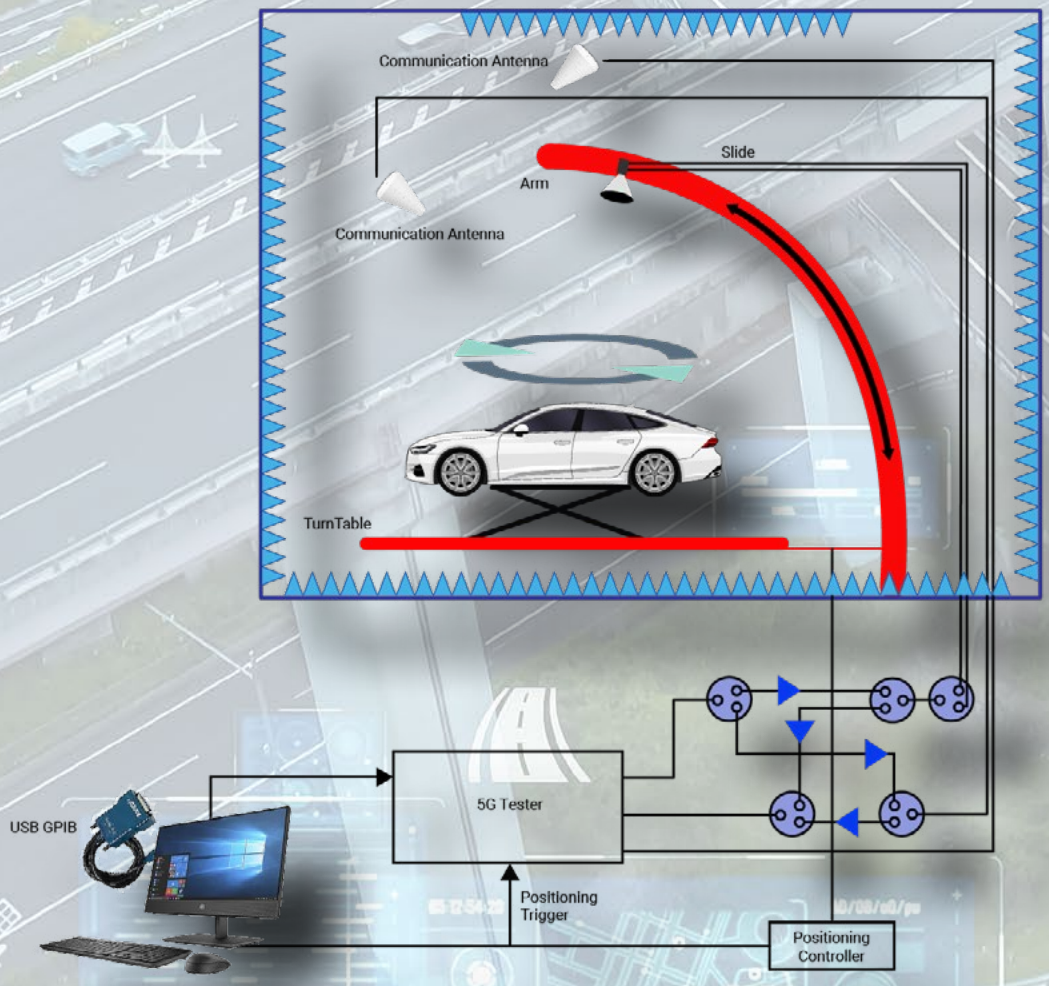


Figure 7: Desense Test Diagram

WAVEX® AUTO OTA TESTING SOFTWARE

Full vehicle measurement requires high-precision (≥0.1°) sampling. Labs developed a set of highly efficient and enduring data models. This technology can ensure accuracy and stability during measurement, and provide super reliable measurement for customers. Meanwhile, to improve test speed and reduce measurement costs, the system adopts a fast-testing algorithm, which can help to obtain highly reliable test results in the shortest time.

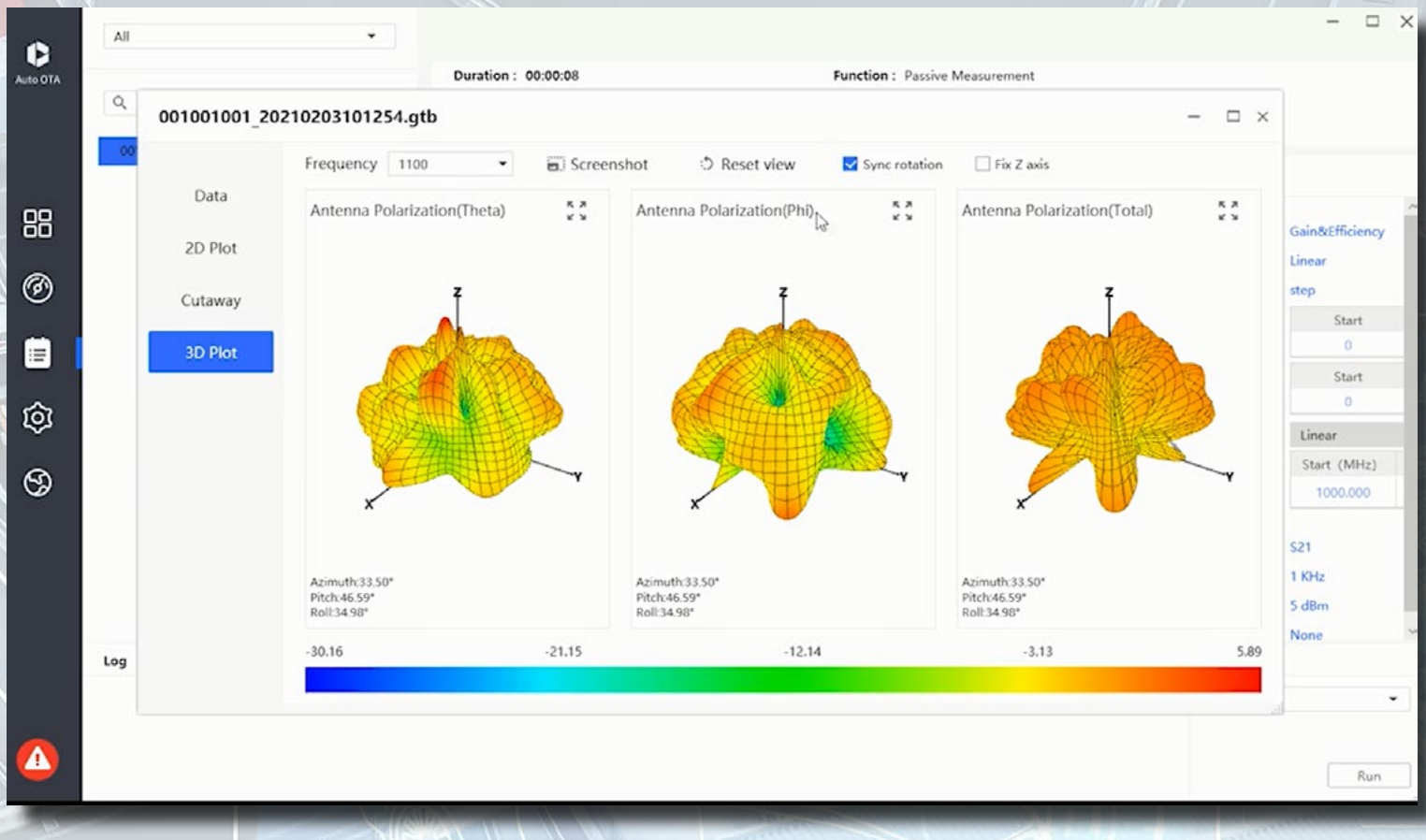
The software provides a friendly user interface to display result data and includes 3D/2D polar coordinates, 2D cartesian coordinates, test data, raw data, test templates, etc.

The software adopts plug-in development models, has a highly abstract underlying architecture, and easily adapts to hardware changes. The system provides various test instrument drivers with corresponding templates, and software operation is simple and easy. Test templates are automatically linked and pre-set with basic parameters, which can reduce system configuration difficulty and help the user for quick usage. The system supports self-defined task queues, which can allow for unattended continuous testing. Raw data and log data management are comprehensive, and the entire test process is fully traceable.

The software was developed in partnership with GTS, and the software can cover a variety of tests, including passive antenna, SISO, or MIMO for 3G/4G/5G, Wi-Fi, BT, V2X, and GNSS.

It also provides a result analysis and comparison tool dedicated to automotive testing, which can be used to analyze and compare many kinds of test results on a common computer, including:

- NF test data and FF transformed data comparison
- Different vehicles test data comparison
- Simulated data and tested data comparison
- Different angles 2D and 3D comparison
- Multi-angle and multi-frequency data comparison
- Self-defined comparison



TECHNICAL SPECIFICATIONS

		RRB3000	RRB4500
General	Frequency Range	0.6 - 7.5GHz (12GHz expandable)	
	Functions	EMC Chambers Seamlessly Upgrade OTA Capabilities (EMC+OTA),Antenna Test, SISO/MIMO Test, Desense Test	
	Technologies	Spherical Near–Field Scanning, RTS MIMO	
	Test Probe	Dual–polarized; Low RCS Vivaldi antenna	
	Dynamic Range	60dB (Typical)	
DUT	Max. Size (L×W×H)	5 × 2 × 2m	6 × 2.5 × 2.5m
	Diameter	≤ 6m	≤ 9m
Turntable	Rotation Range (Φ)	NA	
	Φ Positioning Precision	NA	
	Scissor Lifter Travel	NA	
Test Zone Specifications	Positioning System	AGV electronically controlled robotic arm	
	Rotation Range (θ)	-1–110°	
	θ Positioning Pecision	±0.1°	
	Test Radius	3m (Typical)	4.5m (Typical)
	Robotic Arm Size (L×W×H)	3 × 1.6m (AGV Standby Status)	4 × 3m (AGV Standby Status)
Physical Specifications	Exterior Dimensions (L×W×H)	NA	
	Shielding Effectiveness	>100dB (Recommended)	
	Door Size (H×W)	≥ 3×1.6m	≥ 3×2.6m
Rigid Absorbers	Base Material	EPP (Expanded Polypropylene)	
	Height	300mm	
	Absorbing Rate	≤-40dB	
	Fire Resistance	Class B1 (Option) (per GB8624–2012 with 3rd party test report)	
	Oxygen Index	>28% (per GB/T 2406.2–2009 with 3rd party test report)	
	GHS Classifications	Non–hazardous. (per IEC62321 with 3rd party test report)No volatilization, no odor, no toxicity, no harmful gas (formaldehyde etc.) release	

SYSTEM HARDWARE	
Robotic arm	RRB3000; RRB4500
Absorber	EPP300: 600x600x300mm EPP200: 600x600x200mm
Test probe	MA-5000: 0.6 - 7.5GHz dual-polarized antenna
Communication antenna	CA-5000: 0.6 - 7.5GHz
Calibration kit	AT-5000: 0.6 - 7.5GHz standard gain horn antenna
RF Unit	Multi-channel switches and amplifiers module
System controller	System synchronization and controlling module

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

AUTO OTA TEST SOFTWARE	
Wavex Auto OTA test software with basic functions	System Control /Instrument Drivers/ Passive Test/Test Report Generator
3D PatternPad	3D Data Viewer
GSM/GPRS/EGPRS/CDMA/CDMA 1xRTT	TRP/TIS/EIRP/EIS/ICS
WCDMA/CDMA 1xEVDO	TRP/TIS/EIRP/EIS/ICS
TD-SCDMA	TRP/TIS/EIRP/EIS/ICS
Wi-Fi	UE/AP TRP/TIS/Throughput
LTE SISO (FDD/TDD)	TRP/TIS/EIRP/EIS/ICS
5G FR1 SISO(NSA/SA)	TRP/TIS/EIRP/EIS/ICS
LTE/5G FR1	Passive ECC/Active ECC
GNSS/A-GNSS	Cno /EIS/TIS
Desense	Wi-Fi/Cellular/GPS
NB-IoT/Cat-M	TRP/TIS/EIRP/EIS
LTE/5G FR1 RTS MIMO	2x2/4x4 Data Throughput (Android Platform)
V2X	TRP/TIS/EIRP/EIS
NF-FF conversion	Spherical near field to far field transformation with source reconstruction function

INSTRUMENTS SUPPORTED	
Wireless Test Sets	Keysight UXM E7515A/B/E, Keysight 8960 (E5515C), R&S CMW270/500, CMX500, CMU200, Anritsu MT8820C/8821C, MT8860C, MT8000A, StarPoint SP6010/8315/9500
Vector Network Analyzers	Keysight, R&S, Anritsu, etc.
Signal Generators	Keysight E4438C, Keysight MXG N5182B, Spirent GSS6100/6300/6560/6700/7000, etc.
Channel Emulators	Anite F32/F64/FS16, Spirent VR5/ Vertex

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