

### INTRODUCTION

The bottleneck in the research, development, manufacturing, and maintenance of phased-array antennas lies in the testing phase. The installation and testing of these antennas are both time-consuming and labor-intensive. The testing equipment, requiring a dedicated facility due to its size (occupying an area of over 200m<sup>2</sup> and exceeding 10m in height), presents a challenge in terms of both difficulty and expense in building numerous facilities. This difficulty in efficiently and precisely testing a large quantity of phased-array antennas within limited space poses a significant hindrance to their widespread adoption in the defense and aerospace sectors.

AeroGT Labs has effectively addressed the bottleneck associated with mass-producing phased-array radar systems by implementing a closed-loop verification process. This process spans from theoretical foundations and system design to simulation experiments and final product testing. The radar phased-array antenna rapid testing system, developed by AeroGT Labs, tackles the challenge of batch testing for these products. Its innovative approach ensures testing accuracy that meets formal product requirements.

Notably, the system is designed to operate 24/7 at customer sites, significantly enhancing testing efficiency by 3 to 6 times. This capability not only saves labor costs but also makes the system compatible with automated production lines. By overcoming the testing bottleneck, our solution contributes to the advancement and wider acceptance of phased-array antennas in critical sectors.

- Applicable for a phased-array antenna with an aperture up to 700mm, covering the frequency range of 2 - 110GHz
- Simultaneously perform tests for multi-frequency, multi-channel, and multi-beam in a single scan
- Compact range field calibration technology eliminates probe movement time and achieves high calibration efficiency for the phased-array antenna
- Compact design, three-cabinet assembly, transported as a whole for rapid delivery and fast integration
- Flexible hardware and software configuration, open interface, supporting user-defined functional upgrades



Figure 1: RP1200 CATR Testing Series

### TESTING FUNCTIONS

The RP1200 CATR (see figure 1) is designed to work seamlessly with phased-array antennas featuring apertures of up to 700mm and covering a frequency range from 2 to 110GHz. Customizability is a key feature, with adaptable positioner and DUT (Device Under Test) fixtures. The system's external dimensions are flexible, allowing adjustment to accommodate various user testing environments. Its testing capabilities encompass phased-array antenna calibration, as well as passive and active transmit/receive performance testing, among other functionalities (see figures 2, 3 & 4).

#### PASSIVE TESTING FUNCTIONS

- Antenna 1D/2D/3D Gain/Phase Patterns, Directivity,
- Efficiency, Cross-Polarization Ratio, Front-to-Back
- Ratio, Sidelobe levels, Null Filling, Beamwidth, Beam
- Pointing(Aim Error), Shaft Ratio, Phase Center, etc

#### ACTIVE TESTING FUNCTIONS

- Active Gain, G/T, EIRP, RF conformance, Protocol conformance

#### PHASED ARRAY ANTENNA CALIBRATION

- CATR Calibration Method, Rotating Vector Method

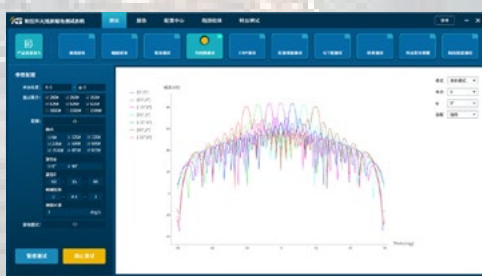


Figure 2: Antenna Pattern Testing



Figure 3: EIRP Test



Figure 4: Phase/Amplitude Calibration

TESTING PERFORMANCE

The CATR systems place significant emphasis on quiet zone performance as a key specification. In particular, it excels with internationally leading quiet zone capabilities (see figure 5) backed by core technologies such as system simulation, feed horn, reflector, absorbers, positioner, and quiet zone validation devices.

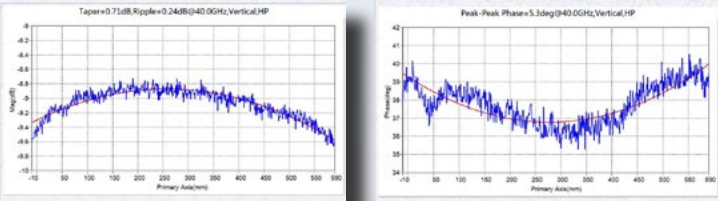


Figure 5: Quiet Zone Third-party Test Report

The exceptional efficiency of these testing systems is rooted in a deep understanding of user requirements and Device Under Tests (DUTs). AeroGT Labs consistently improves testing efficiency (see table 1) while meeting precise customer requirements, aiming for a harmonious balance between test efficiency and accuracy.

| TESTING EFFICIENCY                                                              |            |                                       |                          |
|---------------------------------------------------------------------------------|------------|---------------------------------------|--------------------------|
|                                                                                 | RP1200     | Conventional Planar Near-Field System | Conventional CATR System |
| Dut Supports Continuous Trigger Test                                            | Yes        | Yes                                   | Yes                      |
| System Supports Continuous Trigger Test                                         | Yes        | No                                    | No                       |
| System Supports The Automatic Loading And Unloading Of Dut                      | Yes        | No                                    | No                       |
| System Provides Quick-Connectors                                                | Yes        | No                                    | No                       |
| One-Click Test                                                                  | Yes        | No                                    | No                       |
| Dut Loading And Unloading Time (Take An Antenna With 900 Elements For Example)  | ~5 minutes | ~20 minutes                           | ~20 minutes              |
| Calibration Time(For Example: 900 Elements,64 Frequencies, Tx/Rx)               | ~5 minutes | ~25 minutes                           | ~5 minutes               |
| Test Time (For Example: Single Cut, 180° Range, 9 Frequencies, 9 Beams Pattern) | ~3 minutes | ~300 minutes                          | ~30 minutes              |

<sup>1</sup> Phased array antenna's element, frequency, and beam switching support continuous trigger.

Table 1: Testing Efficiency

UNIFORM-PHASE-CENTER FEED

In contrast to conventional corrugated horn feeds, GTS's CATR horn feeds showcase outstanding wide-angle cross-polarization performance. The phase center deviations on both the E-plane and H-plane are minimal, measuring less than 5°, and the Voltage Standing Wave Ratio (VSWR) is below 1.5. Through comprehensive system simulation, the accuracy of cross-polarization testing has nearly tripled, and the precision of phase testing has seen an approximate 20% increase.



Figure 6: Uniform-Phase-Center Corrugated Horn Antenna

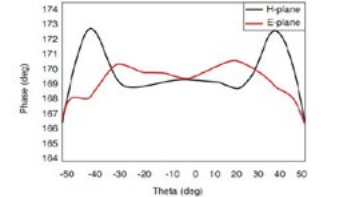


Figure 7: Wide-Angle Consistent-Phase Corrugated Horn

UNIFORM-PHASE-CENTER FEED

Unlike traditional corrugated horn feeds, GTS's CATR horn feeds demonstrate exceptional wide-angle cross-polarization performance. With minimal phase center deviations on the E-plane and H-plane (less than 5°) and a VSWR below 1.5, the comprehensive system simulation has nearly tripled the accuracy of cross-polarization testing, with phase testing precision increasing by approximately 20%.

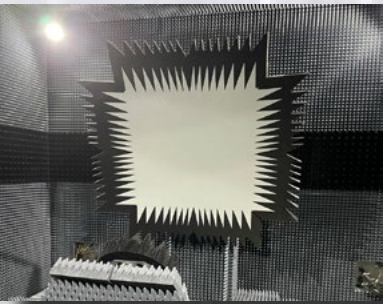


Figure 8: Absorber-Surrounding-Edge Reflector



Figure 9: Low-scattering High-precision Positioner

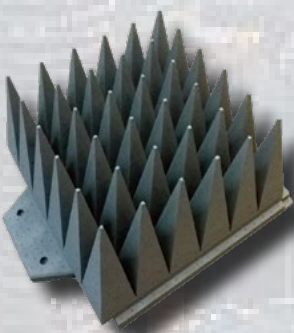


Figure 10: EPP High Performance Absorber

### LOW EDGE SCATTERING REFLECTOR

Unlike traditional serrated or rolled-edge reflectors, innovative absorber surrounding-edge reflectors efficiently reduce electromagnetic wave scattering from pure metal edges. This reduction enhances phase and amplitude uniformity within the quiet zone, surpassing international standards with a total phase variation of less than 8°. The newly designed surrounded-edge reflector allows for a larger quiet zone using a smaller metal reflector, reducing both size and weight.

### LOW-SCATTERING HIGH-PRECISION POSITIONER

Leveraging expertise in precision electromechanical technology, AeroGT Labs integrates full-wave system simulation, self-developed absorbing materials, and microsecond-level continuous triggering technology. This unique combination guarantees exceptional system mechanical precision, concurrently minimizing positioner interference in the test zone. The result is a zero accumulated error in bidirectional tests, effectively doubling testing efficiency. Additionally, AeroGT Labs offer customization options for dimensions, precision, motor travel range, and load-bearing capacity of the positioner to meet specific requirements (see figure 9).

### EPP HIGH PERFORMANCE ABSORBERS

AeroGT Labs exclusively develops, manufactures, and tests the EPP (see figure 10) absorbing material, employing environmentally friendly and durable Expanded Polypropylene (EPP) as the base material. Through comprehensive full-wave simulation and optimization design, this material ensures superior overall absorbing performance for the absorbers. The absorption rate testing technology, featuring ultra-wideband and multi-angle incidence, guarantees the exceptional quality of each absorber piece. Notably, the EPP absorber meets UL94 HF-1 standards for flame resistance and exhibits internationally leading absorption performance. Additionally, it is dust-free and moisture-free, making it suitable for various environments such as outdoors, clean rooms, PIM chambers, OTA chambers, and more.



Figure 11: Thermal-insulation Wave-transparent Mask

### THERMAL TESTING MODULE

The RP600 series is adaptable to include a thermal-insulation wave-transparent ball mask (see figure 11), facilitating high-low temperature shock and cyclic testing within the range of -10 to 55°C. This ball mask seamlessly integrates with existing positioners, necessitating minimal system upgrades. Its installation and removal are straightforward, ensuring that the original testing functionality remains unaffected.

### FULL FUNCTIONAL TESTING CONTROL SOFTWARE WITH HIGH INTELLIGENCE

AeroGT Labs offers seamless testing with versatile phased-array antenna software. Supporting diverse instruments and Devices Under Test (DUTs), it integrates functions like calibration, PROM programming, validation, testing, recording, and data analysis upload. With a user-friendly open interface for one-click testing, it boosts efficiency in existing testing processes.

### CONTINUOUS TRIGGERING CONTROLLER

The continuous triggering controller employs microsecond-level real-time continuous triggering technology, effectively synchronizing the intricate states and timing of the positioner, phased-array antenna, RF links, instruments, and software. This synchronization facilitates swift testing for multiple frequencies, multiple channels, and multiple beams.

### COMPREHENSIVE ASSURANCE FOR PHASED-ARRAY ANTENNA TESTING

In the developmental stage of phased-array antennas, specific demands like power supply, water cooling, and beam control often arise. With substantial expertise in phased-array antenna testing, we are well-equipped to tailor comprehensive and dependable solutions for power supply, water cooling, and beam control based on customer requirements.

### AUTOMATIC LOADING AND UNLOADING DUT

The integration of a robotic arm system, quick-mount fixture, and quick-connectors streamlines automatic device loading and unloading, enhancing overall testing efficiency and fault tolerance. This setup also contributes to reducing labor costs.



Figure 12: Device Automatic Loading/Unloading

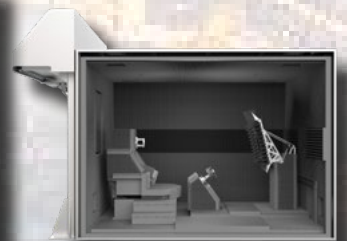


Figure 13: RP1200 Interior View

# TECHNICAL SPECIFICATIONS

|                                                                                 |                                                                                                                                             |                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Application                                                                     | Antenna test, phased-array antenna calibration, phased-array antenna test, mm-wave OTA test, RF conformance test, protocol conformance test |                                                                                                                                                                                                                |
| Frequency Range                                                                 | 2 - 110GHz                                                                                                                                  |                                                                                                                                                                                                                |
| Technology                                                                      | CATR (compact antenna test range)                                                                                                           |                                                                                                                                                                                                                |
| Max Aperture Of Phased Array                                                    | 700mm                                                                                                                                       |                                                                                                                                                                                                                |
| Orientation Of Phased Array Placement                                           | Vertical                                                                                                                                    |                                                                                                                                                                                                                |
| Max Weight Of Phased Array                                                      | 100Kg                                                                                                                                       |                                                                                                                                                                                                                |
| Measuring The Range Of Antenna Pattern                                          | Theta: -180° to +180°                                                                                                                       | Phi: 0° to 360°                                                                                                                                                                                                |
| Testing Items                                                                   | Passive                                                                                                                                     | Antenna 1D/2D/3D Gain/Phase Patterns, Directivity, Efficiency, Cross- Polarization Ratio, front-to-back ratio, Sidelobe levels, Null Filling, Beamwidth, Beam Pointing (Aim Error), Shaft Ratio, Phase Center. |
|                                                                                 | Active                                                                                                                                      | Active Gain, G/T, EIRP, RF conformance, Protocol conformance                                                                                                                                                   |
|                                                                                 | Phased-array Calibration                                                                                                                    | CATR Calibration Method, Rotating Vector Method                                                                                                                                                                |
| Quiet Zone                                                                      | Amplitude Variation                                                                                                                         | ≤1.5dB                                                                                                                                                                                                         |
|                                                                                 | Amplitude Taper                                                                                                                             | ≤1dB                                                                                                                                                                                                           |
|                                                                                 | Amplitude Ripple                                                                                                                            | ≤±0.5dB                                                                                                                                                                                                        |
|                                                                                 | Phase Variation                                                                                                                             | ≤8°                                                                                                                                                                                                            |
|                                                                                 | Phase Taper                                                                                                                                 | ≤3°                                                                                                                                                                                                            |
|                                                                                 | Phase Ripple                                                                                                                                | ≤±3°                                                                                                                                                                                                           |
|                                                                                 | Cross-Polarization                                                                                                                          | ≥28dB                                                                                                                                                                                                          |
| Shielding                                                                       | 80dB                                                                                                                                        |                                                                                                                                                                                                                |
| Calibration Time (For Example: 900 Elements,64 Frequencies, Tx/Rx)              | About 5 minutes <sup>1</sup>                                                                                                                |                                                                                                                                                                                                                |
| Test Time (For Example: Single Cut, 180° Range, 9 Frequencies, 9 Beams Pattern) | About 3 minutes <sup>2</sup>                                                                                                                |                                                                                                                                                                                                                |
| Exterior Dimensions (L x W x H)                                                 | 5 × 4 × 3.5 meters                                                                                                                          |                                                                                                                                                                                                                |
| Test Probe                                                                      | Corrugated Horn, Dual-Polarization/Single-Polarization                                                                                      |                                                                                                                                                                                                                |
|                                                                                 | VSWR                                                                                                                                        | ≤1.5 (Typical)                                                                                                                                                                                                 |
|                                                                                 | Gain                                                                                                                                        | ≥8dBi                                                                                                                                                                                                          |
|                                                                                 | Frequency Range                                                                                                                             | 6 - 8GHz; 8 - 12GHz; 12 - 18GHz; 18 - 26.5GHz; 26.5 - 40GHz; 40 - 60GHz; 60 - 90GHz; 90 - 110GHz                                                                                                               |
| Absorber                                                                        | EPP / Honeycomb (optional)                                                                                                                  |                                                                                                                                                                                                                |
|                                                                                 | Height                                                                                                                                      | 300/100/60mm                                                                                                                                                                                                   |
|                                                                                 | Absorbing Rate                                                                                                                              | ≤-40dB                                                                                                                                                                                                         |
|                                                                                 | Withstand Power                                                                                                                             | 1.2kW/m2 (EPP)/ 10kW/m2 (Honeycomb)                                                                                                                                                                            |
| Positioner                                                                      | Rotation Axes                                                                                                                               | Azimuth, Pitch, Polarization                                                                                                                                                                                   |
|                                                                                 | Rotation Range                                                                                                                              | Azimuth: -180° to +180°; Pitch: -15 to 15; Polarization: 0 to 360°                                                                                                                                             |
|                                                                                 | Rotation Accuracy                                                                                                                           | ≤0.01° (Azimuth/Polarization)                                                                                                                                                                                  |

<sup>1</sup> Phased array antenna's element switching supports continuous trigger

<sup>2</sup> Phased array antenna's frequency and beam switching support continuous trigger



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