Automated Ultrasonic Testing Equipment for Pultruded Panel Production Line MPAUT-MTB01

Functional Description

MPAUT-MTB01 is a professional automated non-destructive testing (NDT) system independently developed by MITECH Co.,Ltd. ,specifically for pultruded plates used in the main girders of wind turbine blade. Based on phased array ultrasonic technology, it integrates high-precision scanning devices,

intelligent control systems and data analysis software, establishing a full-process quality assurance system covering automated testing, precise imaging and data traceability. This system is widely used for the automated in-line inspection of pultruded glass fiber plates, carbon fiber plates, and carbon-glass hybrid plates during production.

Equipped with a multi-degree-of-freedom servo scanning module, the system can automatically plan the path according to the width and thickness of the plate, achieving full-surface coverage scanning. Through electronic focusing and beam deflection of the phased array probes, it can accurately identify defects such as delaminations, pores, inclusions,voids, and impregnation defects. Meanwhile, it generates real-time A/B/C/S-scan images, clearly presenting the position, morphology, and size of defects. Its detection resolution and sensitivity are superior to the traditional ultrasonic methods.

The system supports real-time acquisition, automatic storage of inspection data, and report generation. It can also interface with the production line's MES (Manufacturing Execution System), enabling quality traceability and process optimization. It provides reliable technical support for ensuring the process stability and product quality of pultruded plates used in wind turbine blades.

Core Components of the Equipment

- Phased Array Ultrasonic Testing (PAUT) Module

Composed of a phased array inspection main unit, multi-element probes and fixtures, it serves as the core of the system for accurate defect identification.

- Automatic Scanning and Conveying Module

Integrated the adjustable frame, lifting platform, multi-dimensional motion mechanism and stable feeding & positioning device (rollers and limit wheels), it is responsible for automatic loading, centering, and conveying of the plates to achieve full-coverage scanning.

- Electrical and Motion Control Module

Centralized the installation of control units such as servo drives, controllers and PLC (Programmable Logic Controller), it coordinates mechanical movements and inspection triggering to ensure stable system operation.

- Water-coupled Circulation Supply Module

Including the local water immersion device, water level control system, circulation pipelines and filtration system, it provides a stable coupling environment and realizes water recycling.

- Intelligent Data Processing Module

Integrated the real-time imaging, analysis software and an alarm system, it enables signal acquisition, image generation, automatic defect recognition, report generation and data management.

Core Values

- Comprehensive and Accurate Quality Control

Effectively detects internal defects of pultruded plates such as dry fiber, delaminations, inclusions, voids, and impregnation defects; accurately identifies poor infusion in splice joint areas; precisely measures key dimensions including adhesive width and thickness to promptly detect dimensional deviations. It fully covers the core quality control checkpoints of the pultruded plates used in the main girders of wind turbine blade

- Digital and Traceable Quality Data

Based on high-definition phased array imaging technology, it realizes real-time visual presentation of defects. Inspection data is automatically collected, stored, and linked with production information to build a complete quality database. It supports full-process traceability and statistical analysis, driving intelligent upgrading of the quality management.

- Full-Process Automatic Operation

Integrates automatic conveying, water coupling, electrical control and other modules to achieve unmanned operation throughout the entire process—from plate positioning, coupling medium filling, and defect inspection to result output. It not only reduces interference of human factors but also improves detection efficiency and consistency.

- Excellent Lifecycle Return on Investment (ROI)

Replaces manual sampling inspection with 100% automatic full inspection, ensuring superior quality while significantly reducing labor costs and misjudgment risks. The equipment operates stably and reliably, guaranteeing low long-term maintenance costs and high utilization rates.

- Driving Process Optimization and Quality Prediction

The system converts massive inspection data into structured process assets. Through long-term data accumulation and analysis, it accurately locates process fluctuations, providing quantitative basis for key parameter optimization. It realizes closed-loop quality management from "post-inspection" to "pre-prediction and optimization."

Application Scenarios

This equipment is designed for automatic non-destructive testing (NDT) applications in the industrial continuous production lines of various pultruded plates, including glass fiber pultruded plates, carbon fiber pultruded plates, carbon-glass hybrid pultruded plates, fiberglass-reinforced plastic (FRP) and carbon fiber-reinforced composite materials.

Working Principle

Based on Phased Array Ultrasonic Testing (PAUT) technology, the system achieves focusing, deflecting and scanning of the ultrasonic beams by electronically controlling the transmission timing sequence of the probe elements, thereby obtaining high-definition images of the material's interior. Equipped with an external high-definition display screen, the system supports real-time data acquisition, storage, processing and defect image display.

Product Features

- Automatic, Intelligent and Efficient Inspection

Featured with flexible mechanical structure/scanning frame, it can perform continuous and stable full-coverage scanning on the pultruded plates. Equipped with intelligent defect recognition technology, it significantly reduces labor input while improving inspection efficiency and data reliability.

- High-Definition Phased Array Imaging

Equipped with multi-element probes and utilizing electronic focusing technology, it can generate clear A/B/C/S-scan images, intuitively presenting the position, shape, and size of internal defects in the plates. It features high detection resolution and sensitivity.

- Strong Compatibility and Adaptability

With adjustable height of the main frame, it can flexibly adapts to the detection height requirements of different production lines. It is compatible with various plate detection scenarios (e.g., glass fiber pultruded plates, carbon fiber pultruded plates) and supports both Chinese and English, with other languages customizable.

- Highly Integrated Intelligent Detection System

Integrated ultrasonic non-destructive testing (NDT) and digital control technology, combined with a high-definition display and rapid analog measurement system, it achieves high-precision control of the inspection process.

- Automatic Water-coupled Circulation Supply

Equipped with the local water immersion device, combined with the water level control and circulating filtration system, it forms the stable water-coupled environment during inspection and realizes water resource recycling.

- AI-Powered Intelligent Defect Recognition

Based on intelligent algorithms, it realizes automatic defect evaluation and alarm , supporting two alarm modes of gate alarm and TCG (Time-Corrected Gain) curve alarm. It can automatic send inspection reports to the preset email addresses in real time for remote viewing and filing management. Equipped with professional offline analysis software, it supports multi-dimensional analysis of A/B/C/D/S-scan images, automatic defect size calculation, defect information traceability and generates standardized reports which can be exported in EXCEL or PDF format.

- Stable Conveyance and Precise Positioning

The workpiece conveying platform is composed of rollers and limit wheels, which smoothly conveys the tested material into the detection area and effectively prevents left-right deviation. After the plate is in place, the pressing cover automatically fixes the inspection station to avoid shaking up and down, ensuring stable imaging.

- Flexible Storage and Easy Operation

It supports two data storage modes of full mode (full-data storage) and lite mode (image-only storage) to

meet different needs for data management. The user-friendly software interface allows flexible parameter configuration and automatic report generation, lowering the operation threshold.

- System Expandability and Remote Maintenance

The system supports modular expansion and remote maintenance, enabling remote diagnosis and rapid response. Equipped with online software update capability, it effectively reduces long-term maintenance costs and its downtime.

- Environmental and Safety Design

Adopted low-noise and low power consumption components, coupled with water recycling, the system complies with green manufacturing requirements. The electrical part is equipped with overload and leakage protection to ensure safe and reliable long-term operation.

Applicable Standards

Ultrasonic Testing Standards

ISO 18563-1: Non-destructive testing of composite materials — Ultrasonic testing — Part 1: General principles
ISO 18563-2: Non-destructive testing of composite materials — Ultrasonic testing — Part 2: Contact method
ISO 18563-3: Non-destructive testing of composite materials — Ultrasonic testing — Part 3: Immersion method
CNAS JJF 1338: Calibration Specification for Phased Array Ultrasonic Testing Systems
GB/T 42592-2023: Wind turbine generator systems—Ultrasonic nondestructive testing methods for rotor blades

Other Standards

CE Standards: Standards related to the EU CE Marking for product safety compliance
ISO 9001: Quality Management Systems
ISO 14001: Environmental Management Systems
ISO 45001: Occupational Health and Safety Management Systems

Main Technical Parameters

Integrated Equipment (Customizable)

Inspection Range	Tested material width ≤ 120mm (expandable to 230mm) thickness 3.0～8.0mm
Maximum Inspection Speed	15 m/min (higher than the production and winding speed of the pultruded plates)
Defect Reflector Diameter	≥ Φ2mm flat-bottomed hole diameter (e.g., dry fiber, delamination, cavity, foreign matter)
Alarm Setting	Gate or TCG curve alarm
Protection Grade	IP55
Power Supply	220V 50Hz
Data Storage Mode	Supports switching between full mode (full-data storage) and lite mode (image-only storage)
System Dimensions	800mm*800mm*1900mm (Customization supported)
Total Machine Weight	Approximately 250 kg

Phased Array Acquisition Unit

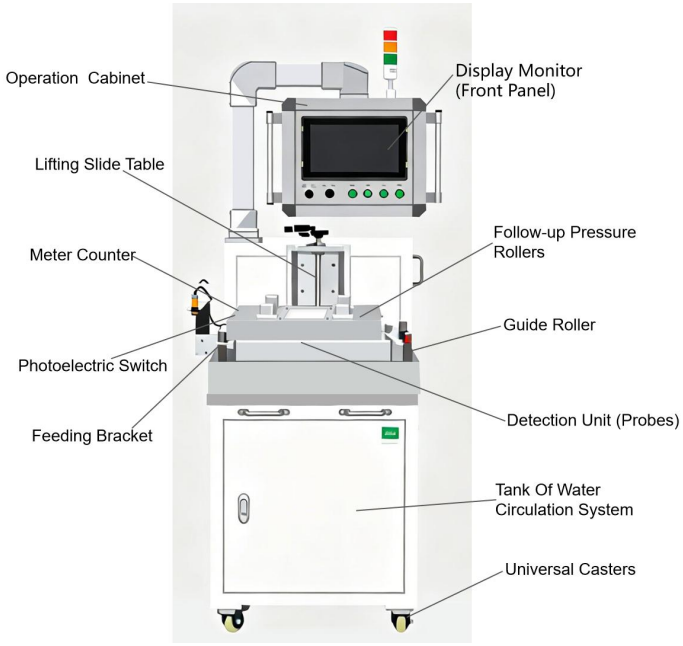
Configuration	Receive/Transmit	16/64, 16/128, 32/128
	Detection Range	9900 μs
	Sound Velocity	340-15240 m/s
Pulse Generator	Inspection Mode	PE/PC
	Pulse Voltage	50V/100V
	Pulse Mode	Negative Square Wave
	Pulse Width	30-1000ns, step 2.5ns
	Pulse Rise Time	<8ns
	PRF	20kHz
	Delay	0-20 μs / 2.5ns
	Damping	NA
Receiver	Gain Range	0－120 dB (analog 80 dB)
	Bandwidth	0.5-15MHz
	Input Impedance	200 Ω
	Input Capacitance	60pF
	Receive Delay	0-20 μs / 2.5ns
Data Acquisition	Sampling Rate	100MHz(50MHz for Robust-64/128)
	ADC Resolution	10bit
	Maximum A-Scan Length	8192
	Focus Law Count	512
	Focus Type	Real Depth / Half Path/ Projection / Arbitrary Plane

	Detection	FW/HW+HW/RF
	Synchronization	Initial Pulse or Gate
Scan & Display	Scan Type	Sector / Linear Scan
	Display Mode	A/B/S/C/3D/TopC
	Measurement Unit	mm
Adaptive Filtering		Yes
Bandpass Filter		Full-Time Data Averaging
DAC	Point Count	16
TCG	Point Count	16
	Maximum Gain	40dB
	Maximum Gain Slope	40dB/μs
Gate	Gate Count	A/B/I
	Gate Threshold	0-98%
	Gate Trigger Mode	Peak / Leading Edge
Inspection Report		WORD Format
I/O Interface	Ethernet	1000Mb/s
	Encoder	LEMO 16-pin
Language		Chinese/English, with other languages customizable
Power Supply	DC (Direct Current)	15V/4.2A
Ambient Temperature	Operating Temperature	-10~45° C
	Storage Temperature	-40~60° C
	Relative Humidity	20%~90%RH (+40° C)

Equipment Structure

Overall Composition

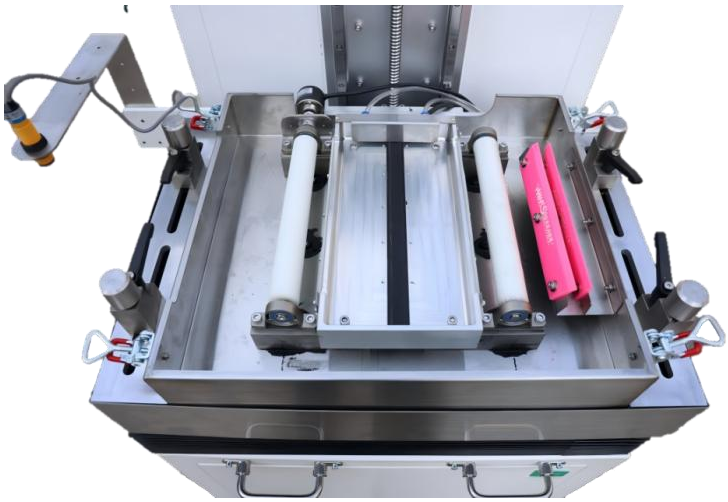
The entire equipment is composed of a phased array ultrasonic testing instrument, ultrasonic phased array probes, an operation cabinet, an industrial personal computer (IPC), a display, a workpiece roller table, a water-coupled system, a meter counter, a feeding bracket, a workpiece pressing device, follow-up pressure rollers, a water circulation system, an equipment control cabinet, universal casters, etc.



Equipment Structure Diagram

Workpiece Rolling Table

The workpiece rolling table is composed of rolling wheels and limit wheels which can ensure smooth sliding of the workpiece and prevent the plate from shaking left and right during inspection via the limit wheels. After the plate is positioned, the pressing cover secures it at the inspection station and ensure no shaking up and down during the inspection process.

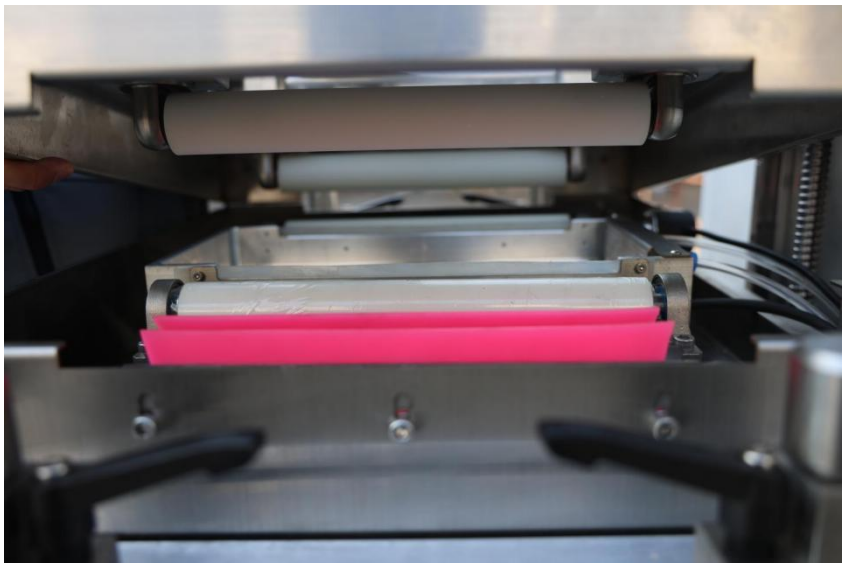


Water-coupled Circulation System Device

This system provides stable and sufficient coupling water for phased array ultrasonic testing, and enables water recycling. It mainly consists of a water storage tank, circulating water pump, water supply pipeline, water trough, water receiving tray, filter and sensors. It ensures good coupling between the PAUT probe and the workpiece. When the sensor (photoelectric switch) detects a passing workpiece, it will send the command "1" to the ultrasonic inspection software via the PLC to initiate the inspection.

Workpiece Downward-pressing Device

This device is used to stabilize the workpiece to avoid shaking up and down during ultrasonic inspection, ensuring the accuracy and consistency of the inspection position. It consists of compression rollers and an incoming material measurement sensor.



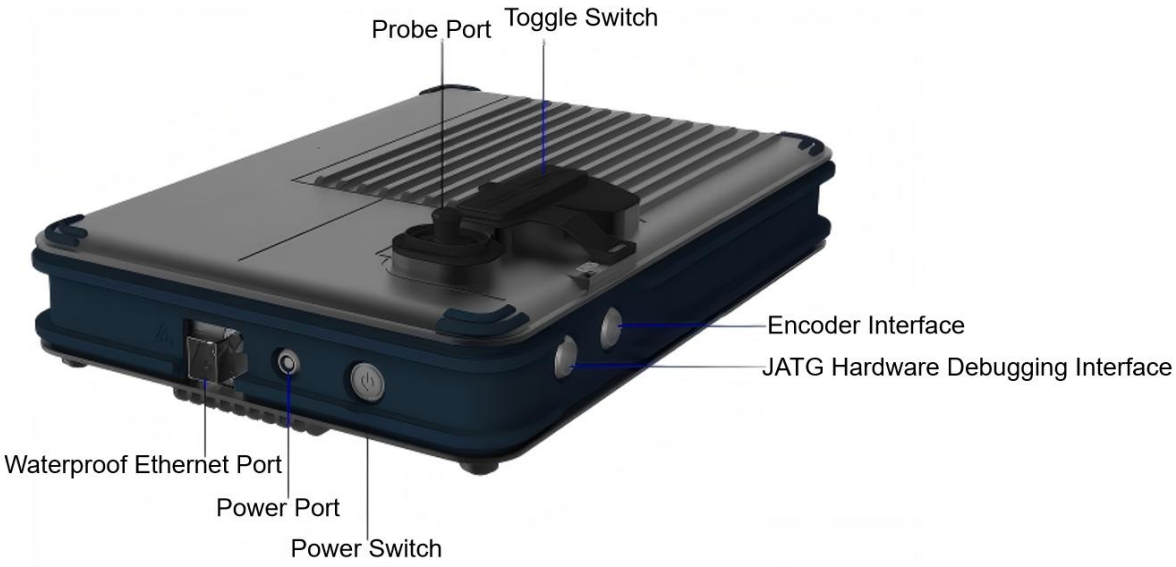
Phased Array Ultrasonic Testing (PAUT) System

Adopting high-performance phased array ultrasonic technology, this inspection system is specifically designed for quality control of pultruded composite plates. With the array ultrasonic inspection board as the core hardware, the system is equipped with specialized inspection and analysis software, forming an accurate, efficient, and automated non-destructive testing (NDT) system.

Core Hardware and Functional Features

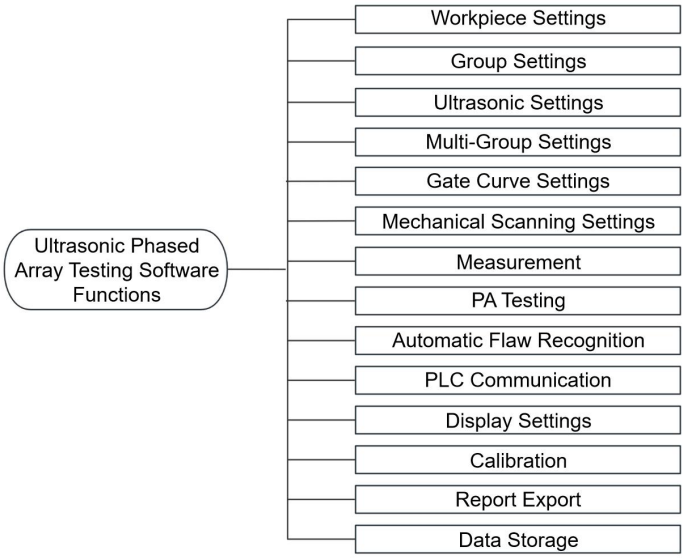
Array Ultrasonic Inspection Card

- High-performance Architecture
  The board is equipped with 64 or 128 independent physical channels, supporting full parallel transmission and reception to ensure inspection speed and data density.
- Precise Acoustic Beam Control
  With a delay precision of up to 2.5 nanoseconds, it enables flexible electronic focusing, deflection, and scanning. The acoustic beam control is highly accurate, resulting in high imaging resolution.
- High-speed Data Transmission
  It supports real-time high-speed communication with the host computer, realizing real-time upload, display, and processing of inspection data, which seamlessly integrates into the automatic workflow.
- High Reliability and Wide Applicability
  Its performance reaches the international advanced level with high stability and reliability. It has been widely applied in high-end fields such as nuclear power, aerospace, rail transit and special equipment. It has been successfully verified in various scenarios including industrial sites, military industry, and scientific research.



Hardware Interface Settings

Core Software and Functional Features



Specialized Phased Array Ultrasic Testing (PAUT) and Analysis System

Developed based on advanced algorithms and engineering design, the pultruded plate phased array ultrasonic inspection software is specifically tailored for efficient, precise, and automatic inspection for composite plates. Its core functional features are as follows:

- Comprehensive Imaging and Analysis Functions

(1) Full-featured Phased Array Platform fully supports multiple scanning and imaging modes (A/B/C/S/D), meeting the comprehensive requirements from real-time monitoring to in-depth

analysis.

(2) Integrated Array Probe Scanning supports integrated scanning of array probes and synchronous generation of multi-view images. The software is equipped with baseline and measurement tools, facilitating intuitive positioning and quantitative analysis of defects.

(3) Customizable Inspection Parameters allows user-defined settings of inspection methods and defect judgment thresholds (e.g., size, amplitude), flexibly adapting to the quality requirements of different product standards and process stages.

- Intelligent Defect Recognition and Grading

(1) Real-time Online Inspection and Analysis enables instant defect detection during the inspection process.

(2) Targeted Defect Feature Recognition deeply integrates the characteristics of typical pultruded plate defects (e.g., dry fiber, delaminations, inclusions) in A-scan, S-scan, and C-scan signals. Through multi-modal signal fusion analysis algorithms, it achieves intelligent identification and automatic judgment of defects.

(3) AI-powered Defect Grading further integrates an AI analysis module to automatically grade and classify identified defects, significantly reducing reliance on operator's experience, improving the consistency and reliability of defect interpretation.

- Automatic Closed-loop and Production Integration

(1) PLC Communication and Actuator Linkage: The software integrates a PLC communication interface, enabling linkage with automatic actuators (e.g., marking devices). When identifying defects that exceed the standard, the system automatically triggers a command to complete precise position marking, realizing an integrated closed-loop operation of "inspection-judgment-marking" that seamlessly connects with the production line.

(2) Batch Information Binding: It supports binding of inspection tasks with production batch information to ensure traceability of quality data.

- Standardized Reporting and Data Management:After inspection, the system automatically generates structured inspection reports, covering defect images, positions, sizes, grades and other information. Reports can be exported in Excel or PDF formats for easy archiving and quality audits.
- Stable System Architecture and Maintainability

(1) Robust Technical Foundation Developed: Based on the Windows system using C# language in the Visual Studio environment, featuring a stable architecture.

(2) Reliable Development Process: Integrates structured methods and agile iteration in the development process to ensure reliable functionality and continuous optimization.

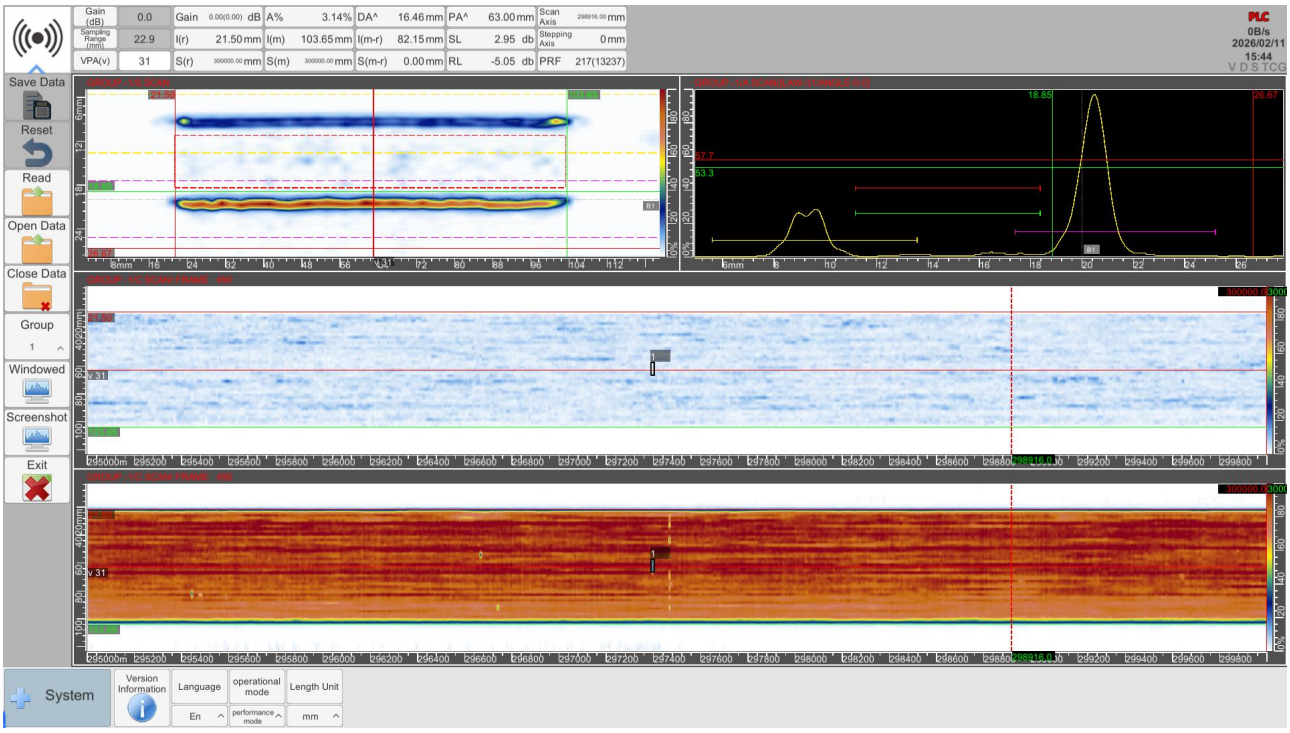
(3) Remote Monitoring and Maintenance: The device host supports network connection and remote desktop access, facilitating centralized monitoring and remote technical support. It enables single-point monitoring of multiple devices, improving operation and maintenance efficiency.

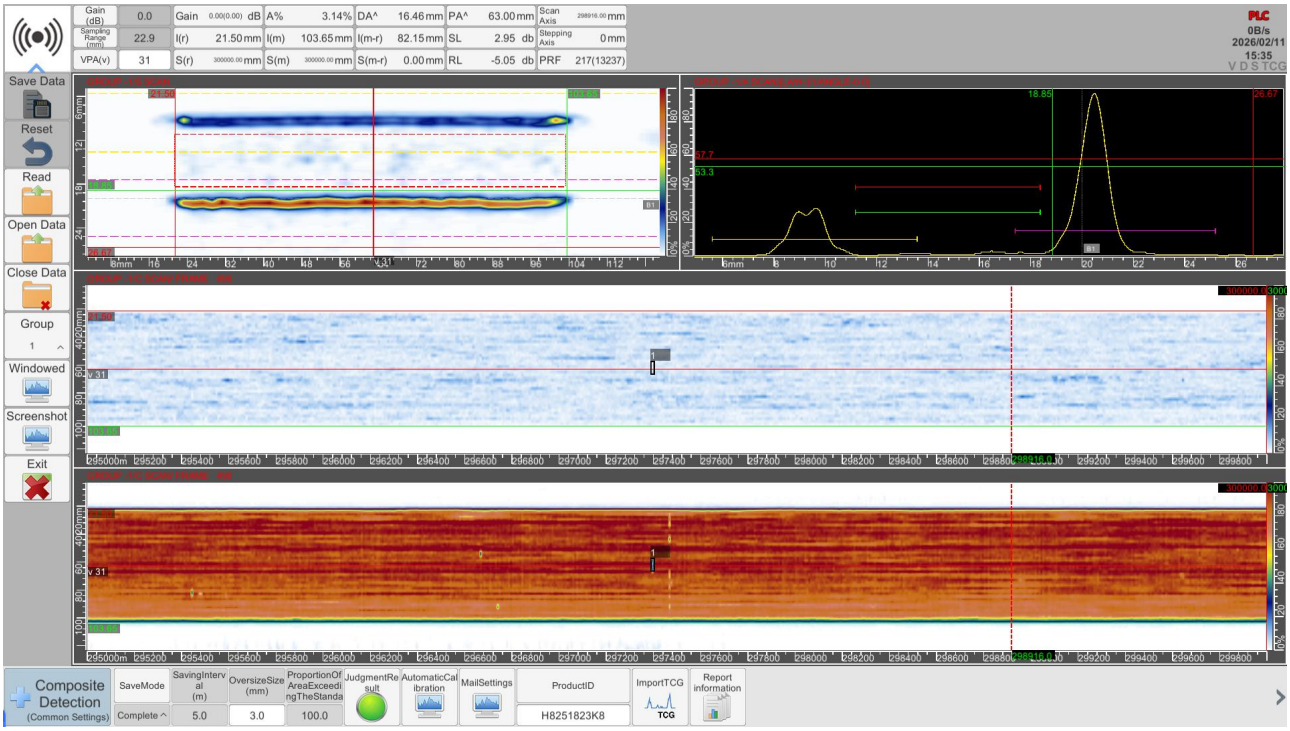
- User-friendly Experience:Provides a concise and intuitive graphical user interface (GUI), lowering the learning and operation threshold.

Design Principle

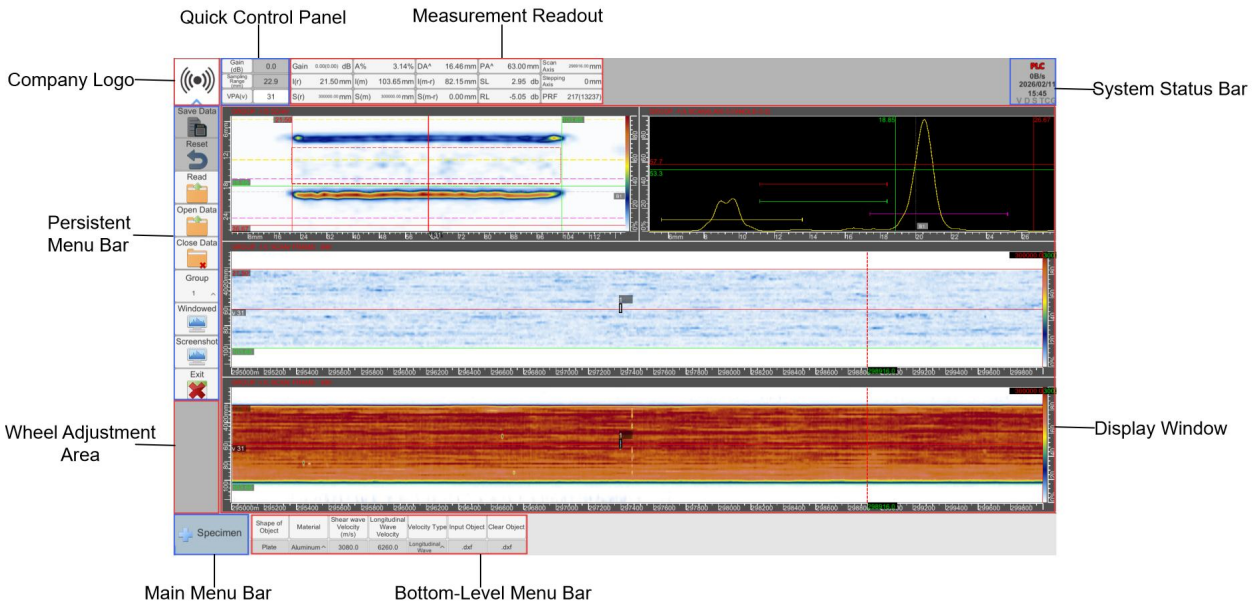
The system software adopts phased array ultrasonic testing probes to perform full-coverage and dead-angle-free inspection on carbon fiber plates. To ensure the comprehensiveness and accuracy of inspection, the system sets the PAUT linear scan mode as the focus law, accomplishes real-time acquisition and synchronous recording of PAUT inspection data through encoder counting.

The software processes and analyzes the collected data, and finally generates three types of imaging views including A-scan, S-scan, and C-scan. When defects exist in the inspection area, the signals of the three views will show obvious abnormal characteristics. Precise defect judgment can be completed through comprehensive analysis and judgment of the signal characteristics of multiple views. The specific imaging views are as follows:



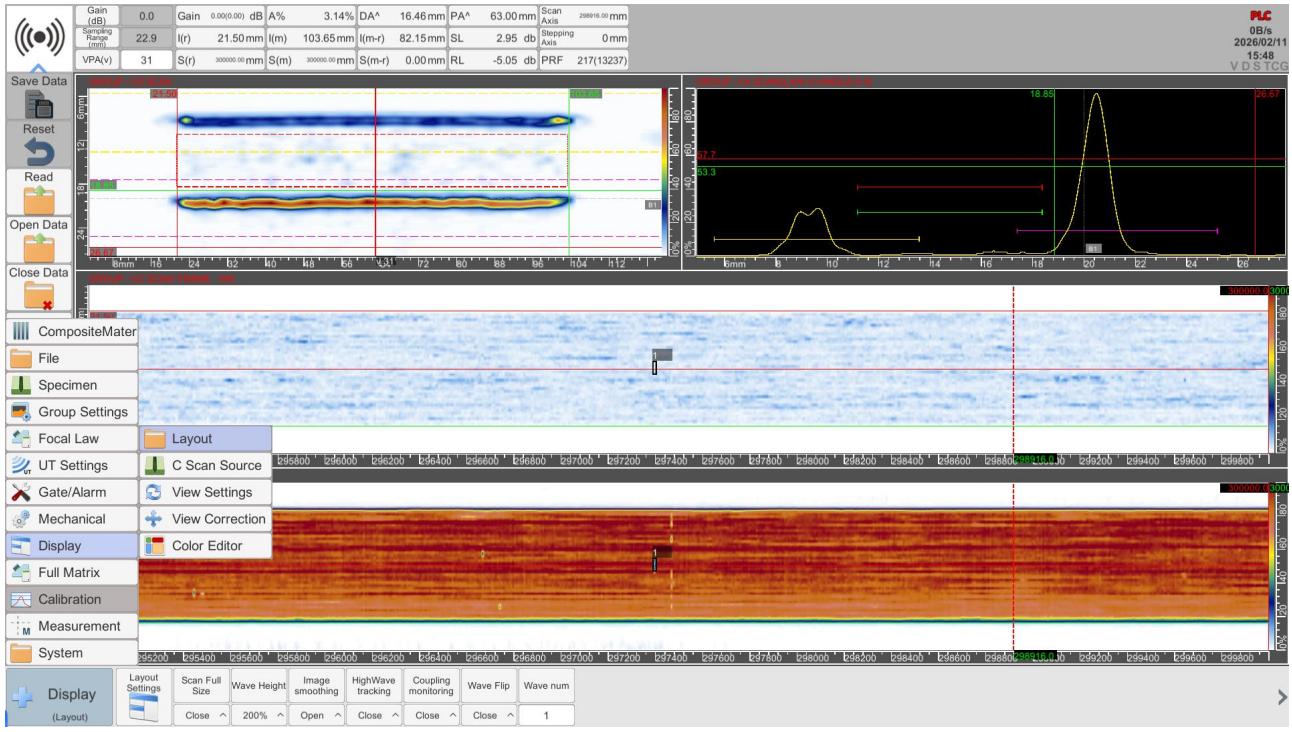


Main Interface Introduction



Software Main Interface

Display Windows



Display Windows

Important Notes for Use

Operation Requirements

- To ensure safe and standardized operation, operators must receive systematic training to fully proficient in the equipment operation methods and safety procedures. Before operation, read this manual carefully and thoroughly.
- Operate the equipment in accordance with the operating procedures with moderate force. Don't touch the touch screen with any objects other than fingers. Ensure the touch screen surface is clean, dry and free of oil, sludge, or water.
- During the equipment operation, strictly prohibit inserting hands or other body parts into the moving components area. Before feeding the plate, confirm that the lifting platform has been adjusted to an appropriate position and there are no foreign objects in the detection area.

Environment and Power Supply

- Use the equipment in a clean environment free of strong magnetic fields and severe vibrations. Avoid extreme temperature conditions.
- Must use the power cord provided with the product. Connect the equipment to an AC220V±10% power supply and ensure reliable grounding. Test the functionality of the leakage protection switch in the distribution box at least once a month.
- To avoid the risk of electric shock and ensure safe operation, the equipment must be reliably grounded via the three-core power cord. Before connecting to any interface, ensure the grounding connection is secure and effective.

Maintenance and Upkeep

- Daily Cleaning: Wipe all components of the equipment with a brush or dry cloth to keep the surface clean and prevent corrosion. Meanwhile, avoid contact with hard objects or heavy loads on the screen to prevent damage.
- Water Circulation System: Regularly replace the water in the water tank and clean or replace the filter cotton at the water pump inlet to prevent pipeline blockage that may affect water flow.
- Professional Maintenance: In case of malfunctions, immediately press the emergency stop button to eliminate the fault. Contact our company if necessary. To ensure the equipment and personal safety, unauthorized disassembly or maintenance by non-professionals is strictly prohibited. Electrical and mechanical inspections must be performed by professional personnel with the power disconnected. Damage caused by unauthorized disassembly, repair, or third-party maintenance will not be covered by our company's warranty.

Warning

Strictly adhere to all rated values and safety warnings marked on the equipment to avoid fire or electric shock hazards.

Never perform any maintenance work while the equipment is in operation.