MANTIS

Compact Phased Array Ultrasonic (PAUT) Flaw Detector
featuring TFM, TOFD and Conventional UT

KARL DEUTSCH

MANTIS - Compact Phased Array Ultrasonic (PAUT) Flaw Detector

The MANTIS is a cost-efficient, compact and powerful phased-array ultrasonic flaw detector for field operation, workshop or laboratory. Being state-of-the-art, it provides all standard phased array techniques like sector and linear scans as well as TOFD (Time Of Flight Diffraction) and real time TFM (Total Focusing Method).

Intuitive graphical user interface (GUI)

Based on the GEKKO as a benchmark in the market for high-end portable phased-array instruments, the MANTIS is fitted with exactly the same software, called “Capture”. This software is characterized by an intuitive user guidance that makes reading of the manual obsolete. Combined with a highly sensitive and precise 8.4” touch screen it enables experts as well as first-time users to configure the MANTIS for any inspection task quickly and safely.

Versatile calibration possibilities

The MANTIS provides TCG/ACG (Time Corrected Gain/Angle Corrected Gain) and DGS (Distance Gain Size) amplitude evaluation for all standard phased array applications. Both can be used for all angles. In TFM mode a manual and an automatic TCG is available. For conventional UT applications DAC (Distance Amplitude Correction) and TCG is available.

Visualization of specimen geometries

To support the inspector visually it is possible to configure and display different specimen and weld geometries with the MANTIS. Available geometries are plates, cylinders, nozzles* and T-/Y-welds*. Other, more complex geometries can be displayed by using 2D-graphs in DXF-format.

Encoder

To display the true position of the UT-data in B-, C- and D-scans there are two, respectively three* encoder inputs available. In case no position encoder is at hand, it is still possible to create time based scans.

User levels

There are three access levels available, that can be blocked by individual passwords. Lower ranked levels limit the access to change certain settings and prevent unauthorized users from amending important datasets.

Data analysis on a PC

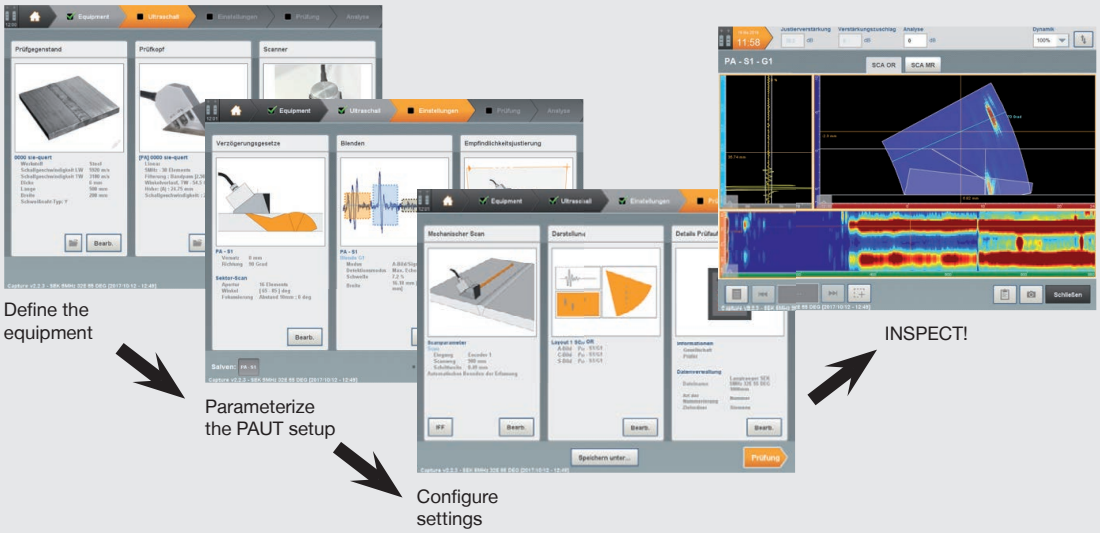
Each MANTIS (as it is with GEKKO) is delivered with one full PC software license called CAPTURE to execute offline analysis on a PC. For further detailed analysis of data an additional software package ENLIGHT is available. Moreover all inspection data can be imported and processed by CIVA and CIVA Analysis. It is also possible to record local FMC data for further processing on other platforms.

* only with packages EXPERT and MASTER (see page 7)

User guidance and simple calibration

Only a few steps guided by self-explaining wizards are necessary to setup the instrument and calibrate

- the sound velocity of specimen
- the amplitude balancing of probe elements
- wedge angle and height
- the inspection sensitivity with DAC, TCG/ACG and DGS, depending on the application.

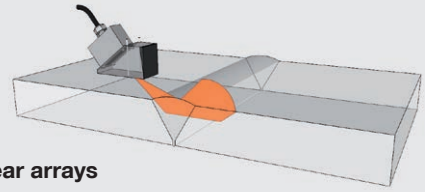


Inspection Techniques

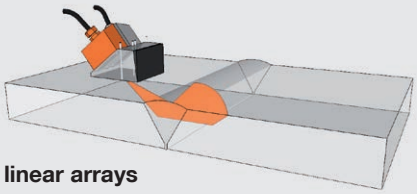
Universal PAUT flaw detector

The MANTIS provides all standard UT-inspection methods in one instrument. This includes typical phased array techniques such as linear and sector scans plus conventional UT with single and dual element transducers as well as TOFD. Additionally dual linear arrays (DLA), matrix arrays* and dual matrix arrays (DMA)* can be operated to solve more sophisticated inspection tasks. Finally, the availability of TFM completes the universal character of this cost-effective, compact, mobile instrument.

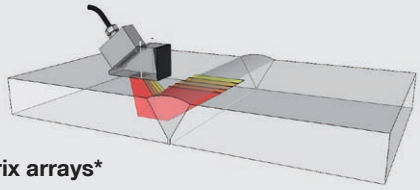
Phased array inspection techniques



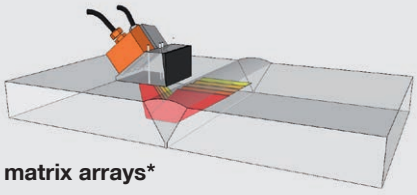
Linear arrays
for all standard phased array inspection tasks such as sector scans and linear scans



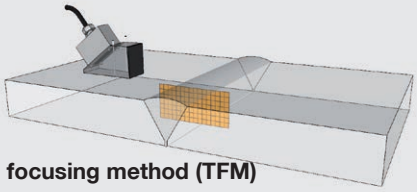
Dual linear arrays
e.g. for inspection of austenitic welds with focused sound fields



Matrix arrays*
e.g. for inspection of defects with variable orientations or on specimens with little space for coupling

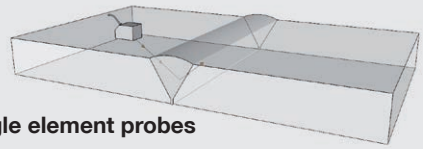


Dual matrix arrays*
e.g. for inspection of austenitic welds with point focused sound fields

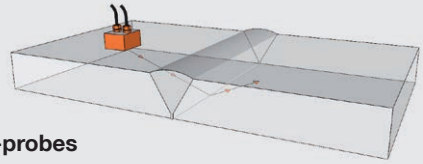


Total focusing method (TFM)
for high resolution ultrasonic inspection with phased array probes

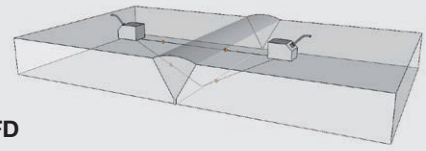
Conventional UT inspection techniques



Single element probes
for all conventional UT inspection tasks, e.g. for volumetric or weld inspection

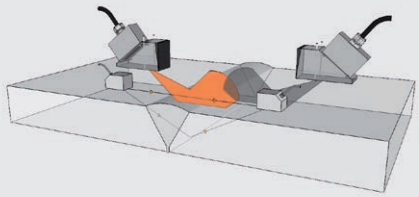


T/R-probes
for all conventional UT inspection tasks, e.g. for defects close to the inspection surface



TOFD
as an imaging method for weld inspection

Combinations (Multi Salvo)



Multiple groups (Multi Salvo)
Combination of different inspection techniques such as

- 1 or 2 phased array probes + TOFD
- 1 or 2 phased array probes + conventional UT
- 1 or 2 phased array probes in multi salvo mode (e.g. linear scan, sector scan, varying aperture, varying focuses, etc.).

* only with package MASTER (see page 7)

Applications

Weld inspection with sector scans

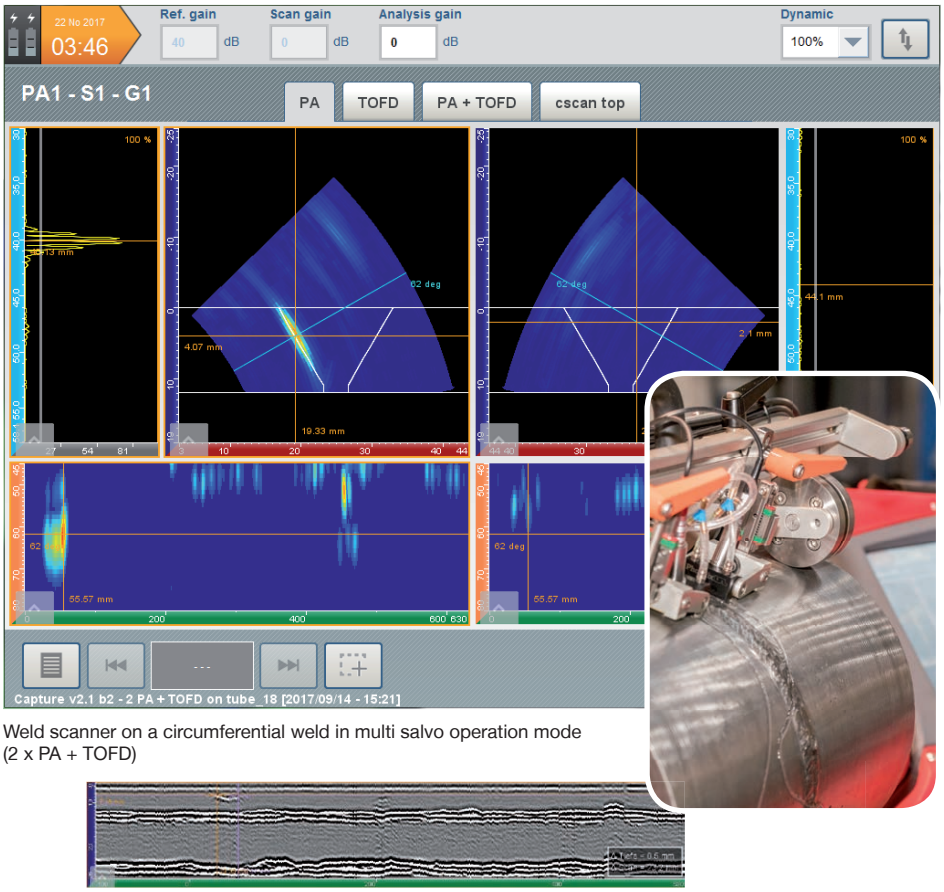
This is THE standard technique for phased array inspection of welds. Apertures of up to 16 elements can be created and sector scans can be done from 0° to 90°, depending on the used probe wedge. Sector scans can be done with all kind of PA probe types and TCG/ACG or DGS amplitude evaluation methods are available for all probe types and angles.

With suitable scanners holding more than one probe, multi group (multi salvo) configurations can be set up quickly and welds can be inspected fast and efficiently.

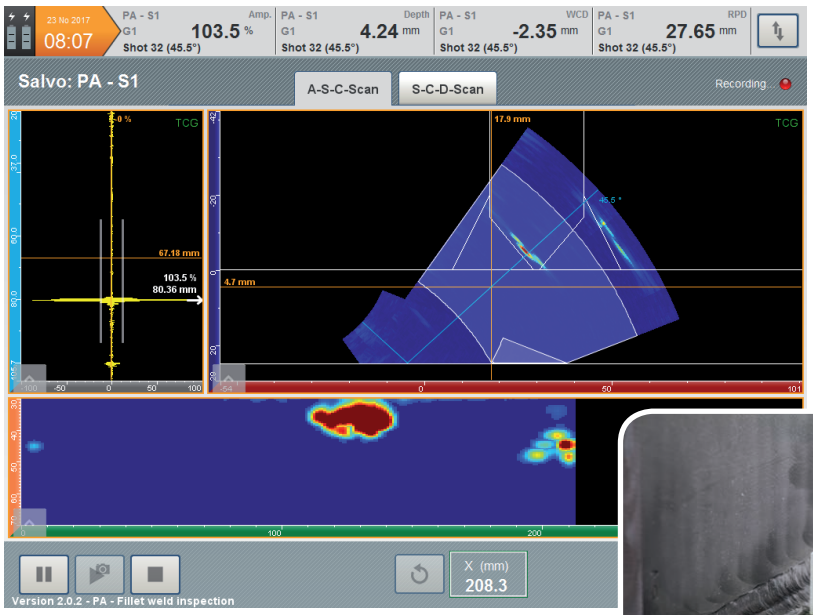
TOFD (Time Of Flight Diffraction)

The TOFD technique can be used in addition to sector scans or separately. The strength of TOFD is to visualize and size internal defects with vertical or horizontal orientation and is thus complementary to the weaknesses of phased array sector scans for these types of reflectors.

In combination, both techniques may replace X-ray inspection for some applications.



Weld scanner on a circumferential weld in multi salvo operation mode (2 x PA + TOFD)



PA-probe on a T-joint with wheel encoder

Fillet welds and nozzles*

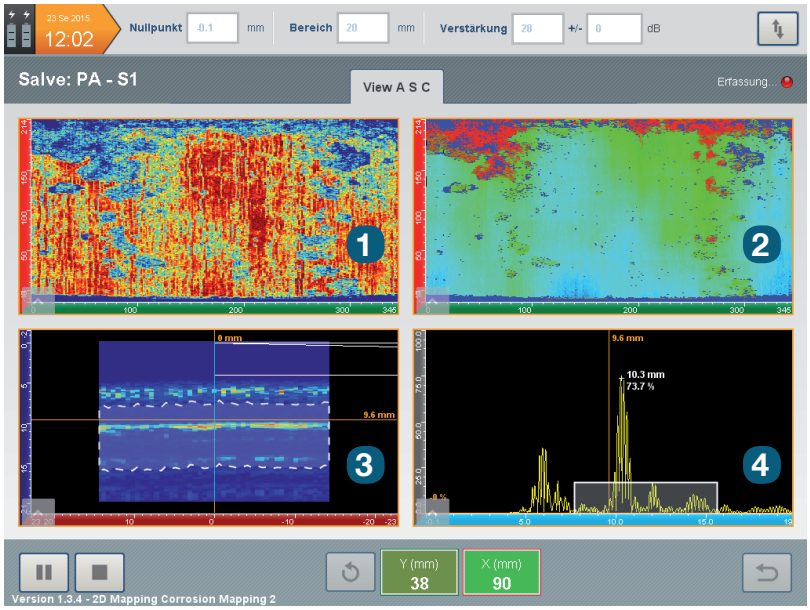
The EXPERT and MASTER packages allow the adaptation of the MANTIS for complex inspection situations. Geometries of T-, K- and Y-welds can be edited freely and will be considered directly for the calculation of the skip reflection. This gives a much better visual understanding of the UT indications and eases the interpretation of the inspection results. The use of a special 3D-nozzle scanner* makes it possible to inspect such connections on the surface shell of vessels. The probe position is monitored and transferred to the 3D-model of the nozzle. That makes a correct evaluation of the skip on changing geometries possible and will be displayed on the screen according to the position of the probe.

* only with packages EXPERT and MASTER (see page 7)

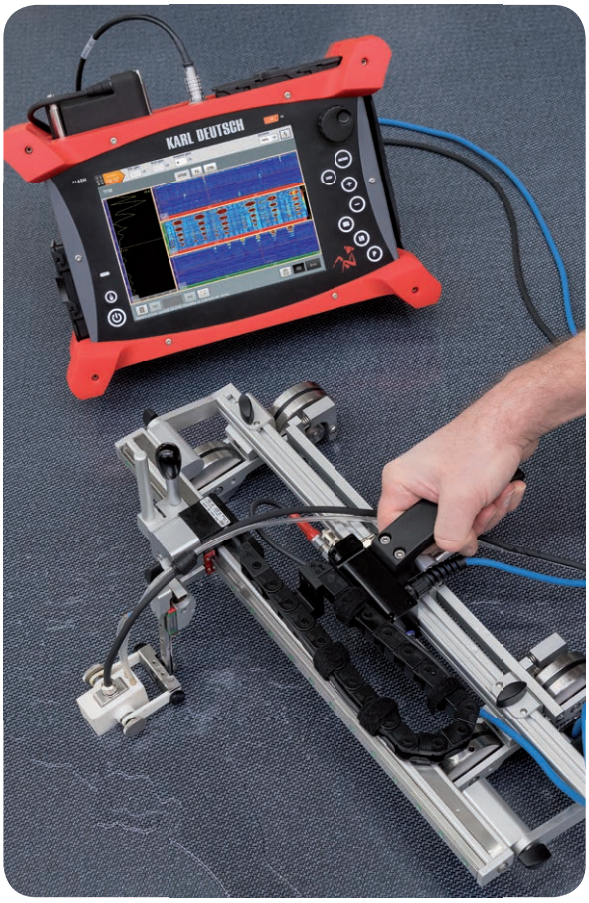
Applications

2D-Mapping for CFRP/GRP- and corrosion inspection

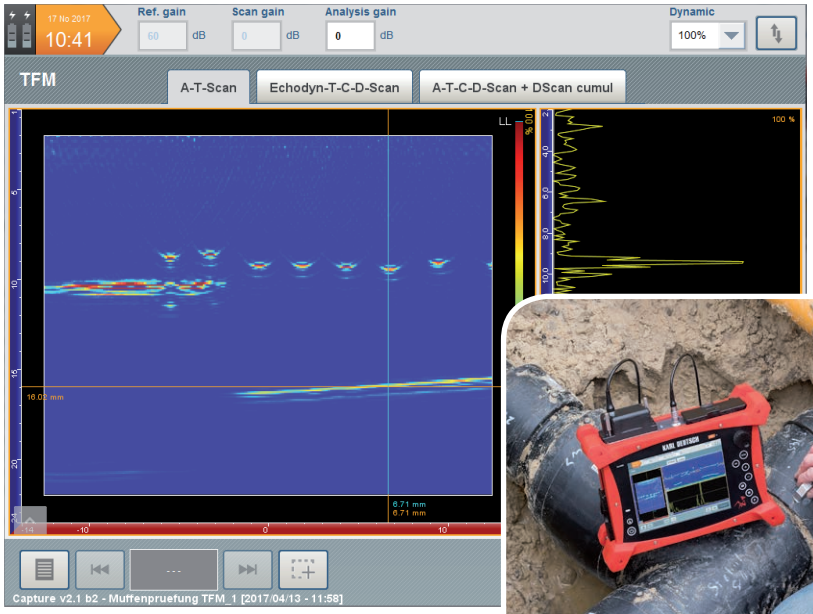
The inspection for corrosion or CFRP/GRP-material is executed with straight beam insonification. Using the linear scan technique a virtual probe is moved electronically through the whole length of the probe. With a 2D-scanner, overlapping inspection tracks are drawn on the specimen and the results are merged on the instrument screen. Thereby, also larger areas can be inspected completely, fast and reliably and defects may be directly detected in the C-scan.



1 C-scan for defects (amplitude) 2 T-scan for back wall (time of flight) 3 B-scan 4 A-scan



xy-scanner for 2D-mapping



Result: Good pipe connection

Inspection of electronically welded PE-pipe couplings

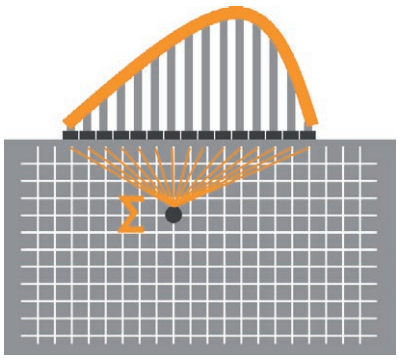
PE-pipes, e.g. being used by municipal energy suppliers for gas lines, are mostly connected and electronically welded by pipe couplings. The leak tightness of the pipe depends on the insertion depth of the pipe as well as on the quality of the welding. By using TFM (see page 6) this connection can be inspected fast and smartly. The easy handling of the instrument becomes (in most cases) even more simple – just enter the known sound velocity of the standard materials plus the inspection volume (Δx, Δy).

Result is a cross-sectional view of the sleeve, showing a clear and high-resolution image that can easily be understood and interpreted even by personnel without UT-knowledge.

Total Focusing Method (TFM)

TFM-Principle

This technique initially applies an FMC (Full Matrix Capture) where every single probe element is excited one by one consecutively, while all probe elements record the returning UT signals. Thus, a matrix of A-scans for all elements is created. The information content of this matrix is used to sum up all signals by implementing a special reconstruction algorithm called TFM. A B-scan is calculated that focuses in every single image point to provide a high resolution image to the inspector.



TFM-image of a screw by using a grey-scale, insonification from the top

Real time imaging

In the past TFM has been a powerful analysis tool, e.g. for research institutes and laboratories, as it could only be used offline in a post processing procedure. Intelligent CPU architecture allows it now to use TFM in real time with up to 80 frames per second and thus make it field proven.

Time Corrected Gain (TCG)

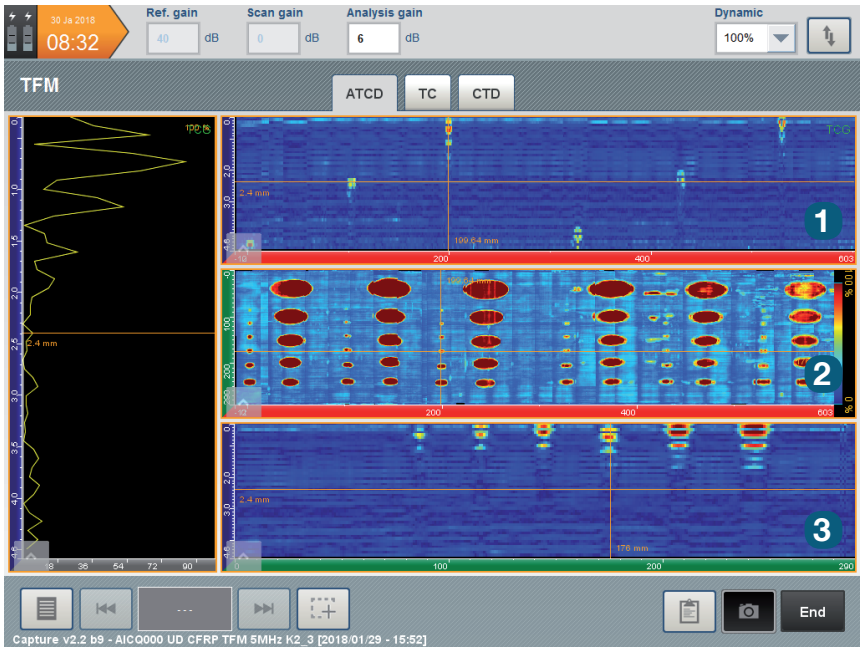
To obtain a uniform sensitivity for all image points, a TCG can be activated by using a wizard that creates the TCG-curve y pressing only a few buttons. Alternatively depth related gain values can be entered manually. This is mainly used when no suitable calibration block is available.

Easy configuration

The configuration of a TFM setup is extremely simple – select a probe, enter the sound velocity, define an inspection area (test volume, Δx, Δy) and start to inspect!

Probes for TFM

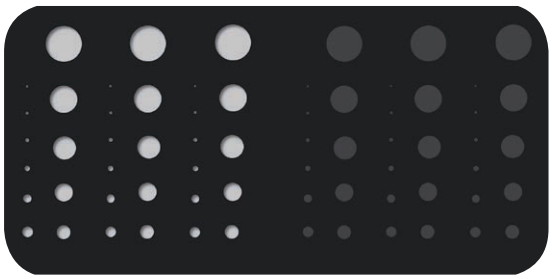
The quality of a TFM image depends on the probe frequency and the probe aperture. Larger apertures and number of elements will supply the algorithm with more information to calculate the image.



TFM-image of a CFRP plate (right: schematic image) with test reflectors of different sizes and depths, right half of the plate is covered: 1 TFM E-scan, 2 C-scan, 3 cumulated B-scan

The basic ADEPT-package of the MANTIS provides TFM with 16 elements. The full MASTER-package is able to multiplex the 16 parallel channels to conduct TFM with 64 elements and thus delivers the highest possible resolution.

KARL DEUTSCH also offers help and consultancy to develop special probes for special applications.



MANTIS Packages and Technical Data

The MANTIS is available in three different versions: A basic ADEPT package, an extended EXPERT package and the full MASTER package. Later upgrade to higher versions is possible at any time.

Technical Data

I-0	
Probes	• PA: 1 x IPEX (2 x IPEX with splitter) • UT and TOFD: 2 x LEMO 00 (1 PR - 1R)
Encoder inputs	2 (3*)
USB 2.0 / USB 3.0	1 / 1
External display	1 x mini display port
Ethernet	1 x RJ45

* only with packages EXPERT and MASTER

Analysis	
PC-software	• CAPTURE© (included) and free viewer • Enlight (option) • CIVA Analysis (option)
Views	• A-, B-, C-, T-scan • Echo dynamics • 3D • Top and side view
Miscellaneous	• 800% amplitude range • Customizable inspection report

continued on page 8

Technical Data

Phased Array / Conventional UT

Techniques	• Linear scan (E-scan) • Sector scan (S-scan) • Compound scan
Probes	• PA: linear arrays, matrix arrays**, dual linear arrays (DLA)*, dual matrix arrays (DMA)** • UT: single element, TR, TOFD
Delay laws	• up to 2048 • max. 6 probes • max. 8 groups (salvos) • CIVA-fueled delay law calculator • short calculation times
Geometries	• plate • cylinder • T*- and Y*-joints • nozzle*
Focusing	• depth • sound path • projection
Calibration	• PA: TCG/ACG-, TCG-, DGS-wizards • UT: TCG-, DAC-wizard

Real Time Total Focusing Method (TFM)

Channels	16 to 64**
Image resolution	max. 65.536 image points
Refresh rate	80 frames per second
Sound paths	• direct (L or S) • indirect (L or S)** • mode conversion**
Calibration	TCG/ACG-, TCG-wizard

Digitization

Resolution	16 Bit
Digitization rate	max. 100 MHz
Digitization depth	max. 16.000 points
A-scan range or delay	max. 65.000 points
Filter	FIR
Real time averaging	max. 32
A-scan	• full-wave (RF) • rectified • envelope
Miscellaneous	digitization and real time summation on 16 channels

* only with packages EXPERT and MASTER
** only with package MASTER

Transmitter / Receiver

Channels	• PA: 16:64 • UT and TOFD: 2
Aperture	max. 16 elements
Pulser	negative square pulse
Pulse width	• PA: 35 ns to 1250 ns • UT and TOFD: 30 ns to 1250 ns
Voltage	• PA: 12 V to 90 V in steps of 1 V • UT and TOFD: 12 V to 200 V in steps of 1 V
PRF	max. 12 kHz to 20 kHz*
Input impedance	50 Ω
Frequency range	• PA: 0.4 MHz to 20 MHz • UT and TOFD: 0.6 MHz to 25 MHz
Max. input signal	• PA: 2 Vpp • UT and TOFD: 2 Vpp
Gain	max. 120 dB in steps of 0.1 dB
Channel cross-talk	< 50 dB

Data acquisition

Gates	Hardware acquisition gates
Number of gates	4
Data acquisition	• A-scan • peak value • FMC recording**
HD space	128 GB SSD, max. 150 MB/s
Size data set	max. 10 GB
Trigger acquisition	• Time • Event • Encoder

Miscellaneous

Size (W x H x D)	320 mm x 220 mm x 100 mm
Temperatur range	• Operation: -10 °C to 45 °C • Storage: -10 °C to 60 °C (with battery)
Operating time	4 h, hot-swap possible
Screen size	8.4“, high-contrast resistive screen
Screen resolution	1024 x 768 pixels
Weight	4.4 kg (incl. battery)
Protection	IP65 according to CEI60529
Shock protection	MIL-STD-810G
Standards	• DIN EN ISO 18563-1 • DIN EN ISO 12668-1

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